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# BIOLOGY OF CONSERVATION OF ENDANGERED SPECIES *Salvia ceratophylloides* Ard. (Lamiaceae) and *Pimpinella anisoides* V.Brig. (Apiaceae)

Ph.D. THESIS
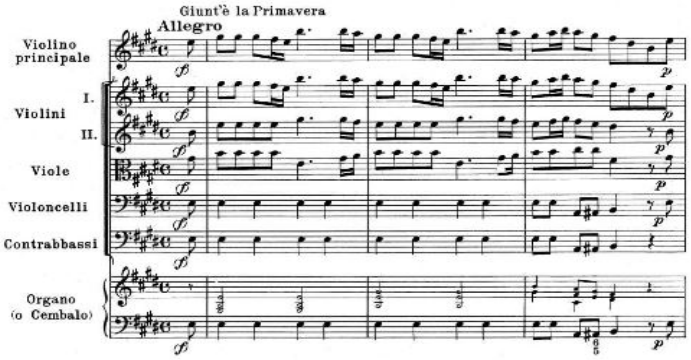
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# Summary

**CHAPTER 1:** Introduction ..... 1
**1.1 Factors of biodiversity loss** ..... 5
*1.1.1. Land-use change* ..... 6
*1.1.2. Over-exploitation of resources* ..... 6
*1.1.3. Global warming* ..... 8
*1.1.4. "Alien" species* ..... 9
*1.1.5. Pollution* ..... 10
**1.2. Conservation biology** ..... 12
**1.3. Conservation strategies** ..... 13
**1.4. References** ..... 17
**Aim of the PhD thesis** ..... 36
**References** ..... 38
**CHAPTER 2.** *Salvia ceratophylloides* Ard.: a rare endemism of southern Italy. ..... 40
**2.1. Introduction** ..... 40
**2.2. Historical vicissitudes** ..... 41
**2.3. Species description** ..... 46
**2.4. Habitat** ..... 47
**2.5. References** ..... 48
**CHAPTER 3.** Analysis of the Population Structure and Dynamic of Endemic *Salvia ceratophylloides* Ard. (Lamiaceae) ..... 52
**CHAPTER 4.** Current and Potential Future Distribution of Endemic *Salvia ceratophylloides* Ard. (Lamiaceae) ..... 75
**CHAPTER 5.** Seed Priming in *Salvia Ceratophylloides* Ard.: Plant Development and Ecophysiology and Responses to Combined Abiotic Stress ..... 97
**CHAPTER 6.** Threats Posed to the Rediscovered and Rare *Salvia ceratophylloides* Ard. (Lamiaceae) by Borer and Seed Feeder Insect Species... 126
**CHAPTER 7.** *Pimpinella anisoides* V. Brig ..... 143
**7.1. Introduction** ..... 143
**7.2. Historical vicissitudes** ..... 144
**7.3. Species description** ..... 145

**7.4. Habitat** ..... 146

**7.5. References** ..... 147

**CHAPTER 8.** Carpological analysis of two endemic Italian species: *Pimpinella anisoides* and *Pimpinella gussonei* (Apiaceae) ..... 150

**CHAPTER 9.** Morphological and phytochemical features in fruits of *Pimpinella anisoides* V.Brig. (Apiaceae) ..... 162

**Conclusions and Future Perspectives** ..... 175

**APPENDIX I: Additional papers** ..... 177

**Alien Flora**

**Native flora**

**Habitat**

**Etnobotany**

**Physiology**

## Abstract

Biological diversity represents nature in all its forms and is the fundamental pillar on which life on Earth rests and is perpetuated over time. This richness is the result of slow evolutionary processes that, under the impetus of natural selection, act on the genetic characteristics of species, thus enabling life forms to gradually adapt to changing environmental conditions. Global changes, mainly due to anthropogenic causes, are reducing this adaptive capacity and causing a very rapid decrease in planetary biodiversity. At this juncture, conservation biology has an active and fundamental role to play in the conservation of biodiversity in all its forms, and sets as its foundation the assessment of the conservation status of species and the possibility of survival of populations, facilitating the identification of strategies for their long-term protection.

The aim of this thesis was to investigate the conservation biology of two endemic Italian species at risk of extinction: *Salvia ceratophylloides* Ard. and *Pimpinella anisoides* V.Brig. The first is a punctiform endemism exclusive to southern Calabria, "Critically Endangered" (CR), according to IUCN criteria and categories, as a consequence not only of anthropogenic pressure and threats, but also of parasite attacks. The second species is an endemism of southern Italy, which, despite being considered "Least Concern" (LC), risks becoming an endangered species in the near future, as it is subject to intensive harvesting for its fruits used to flavour sweets and liqueurs.

Analyses were undertaken on *Salvia ceratophylloides* concerning its population dynamics in relation to anthropogenic and phytosanitary impacts, its current and future potential distribution in relation to climate change, and its phenological and ecophysiological responses to abiotic, single and combined stresses. For this species, the population analysis showed that it consists of 1555 individuals, and that, the dynamics are not stable over time and are profoundly influenced by anthropogenic and phytosanitary pressures and threats, which compromise habitat quality and the reproductive capacity of the species. The current and future potential distribution models generated with MaxEnt®, in relation to climate change, have shown that the habitat suitable for the species will not shift

significantly, but will decrease in 2021-2040 and 2041-2060 in the SSP245 scenario, and increase in the SSP585 scenario. However, the current potential distribution is severely limited not only by bioclimatic parameters but also by geological substrate and land use. Analyses of phenological and ecophysiological responses to single and combined stresses revealed that individuals whose seeds were exposed to priming treatments (Osmopriming and Hydropriming) developed healthy, well-functioning plants that responded early and actively to the simulated stresses of future climate change.

On *Pimpinella anisoides*, the specific carpological and phytochemical characteristics of the ripe fruit were analysed. These distinctive characters are essential to avoid adulteration of the sold material with immature fruits or fruits of other species of inferior quality. Furthermore, the carpological analysis clarified taxonomic doubts concerning the only two Italian endemic species of the genus *Pimpinella*, allowing easy differentiation between *P. anisoides* and the related *P. gussonei.*

Overall, the results obtained lay the scientific basis for the planning of protection strategies capable of reducing and eliminating, over time, the pressures and threats that adversely affect the species, through specific in situ and ex situ conservation measures.

**Keywords:** endemism; demography; population structure; climate changes; endangered species; carpology; drought stress; heat stress; combined stresses; insect pests.

## Riassunto

La diversità biologica rappresenta la natura in tutte le sue forme ed è il pilastro fondamentale su cui poggia e si perpetua nel tempo la vita sulla Terra. Questa ricchezza è il frutto di lenti processi evolutivi che, sotto la spinta della selezione naturale, agiscono sulle caratteristiche genetiche delle specie, permettendo così alle forme di vita di adattarsi progressivamente al cambiamento delle condizioni ambientali. I cambiamenti globali imputabili prevalentemente a cause antropiche, stanno riducendo questa capacità adattativa e causando un rapidissimo decremento della biodiversità planetaria. In questo frangente la biologia della conservazione ha un ruolo attivo e fondamentale nella conservazione della biodiversità in tutte le sue forme e pone come fondamento la valutazione dello stato di conservazione delle specie e la possibilità di sopravvivenza delle popolazioni, agevolando l'individuazione di strategie per la loro protezione a lungo termine.

Scopo di questa tesi è stato quello di approfondire la biologia della conservazione di due specie endemiche italiane a rischio di estinzione: *Salvia ceratophylloides* Ard. e *Pimpinella anisoides* V.Brig. La prima è endemismo puntiforme esclusivo della Calabria meridionale, "Gravemente minacciata" (CR), secondo i criteri e le categorie IUCN, in conseguenza non solo della pressione antropica e delle minacce, ma anche degli attacchi parassitari. La seconda specie è un endemismo dell'Italia meridionale, che, nonostante sia considerato "Minor preoccupazione" (LC), rischia di diventare una specie a rischio nel prossimo futuro, in quanto soggetta a raccolta intensiva per i suoi frutti utilizzati per aromatizzare dolci e liquori.

Su *Salvia ceratophylloides* sono state avviate analisi che riguardano la dinamica delle popolazioni in relazione agli impatti antropici e fitosanitari, la sua distribuzione potenziale attuale e futura in relazione ai cambiamenti climatici e le risposte fenologiche ed ecofisiologiche in risposta a stress abiotici, singoli e combinati. Per questa specie l'analisi della popolazione ha evidenziato che essa consiste di 1555 individui, e che, le dinamiche non sono stabili nel tempo e sono profondamente influenzate dalle pressioni e dalle minacce antropiche e fitosanitarie, che compromettono la qualità dell'habitat, la capacità riproduttiva della specie. I modelli di distribuzione potenziale attuale e futura generati con

MaxEnt, in relazione ai cambiamenti climatici hanno mostrato che l'habitat idoneo alla specie non subirà spostamenti significativi ma diminuirà nel 2021-2040 e nel 2041-2060 nello scenario SSP245, e aumenterà nello scenario SSP585. L'attuale distribuzione potenziale risulta invece fortemente limitata oltre che dai parametri bioclimatici anche dal substrato geologico e dall'uso del suolo. Le analisi delle risposte fenologiche ed ecofisiologiche a stress singoli e combinati hanno rivelato che gli individui i cui semi sono stati esposti a trattamenti di priming (Osmopriming e Hydropriming) hanno sviluppato piante sane e ben funzionanti che hanno risposto precocemente e attivamente agli stress simulati del futuro cambiamento climatico.

Su *Pimpinella anisoides* sono state analizzate le caratteristiche carpologiche e fitochimiche specifiche dei frutti maturi. Questi caratteri distintivi sono fondamentali per evitare che il materiale venduto venga adulterato con frutti immaturi o frutti di altre specie di qualità inferiore. Inoltre, l'analisi carpologica ha chiarito i dubbi tassonomici relativi alle uniche due specie endemiche italiane del genere *Pimpinella*, consentendo una facile differenziazione tra *P. anisoides* e l'affine *P. gussonei.*

Nel complesso, i risultati ottenuti pongono le basi scientifiche per la pianificazione di strategie di protezione in grado di ridurre ed eliminare, nel tempo, le pressioni e le minacce che influenzano negativamente le specie, attraverso specifiche misure di conservazione *in situ* ed *ex situ*.

**Keywords:**endemismo; demografia; struttura di popolazione; cambiamenti climatici; specie a rischio; carpologia; stress da siccità; stress da calore; stress combinati; insetti parassiti.

# **CHAPTER 1:** Introduction

*"[…] ché ci vuole una specie di forza geniale e di coraggio spirituale a trovarsi faccia a faccia con la natura colta nella folla delle sue innumerevoli produzioni, senza rimanerne sorpresi, credendo anzi di essere capaci di riconoscerle e paragonarle, così come quello di amarle è un particolare gusto ben più profondo di quello che si prefigge quale ultimo scopo, l'oggetto particolare. E si può dire che l'amore per lo studio della natura presupponga nello spirito due qualità in apparenza opposte: i vasti orizzonti di un genio ardente che abbraccia con un sol colpo d'occhio tutto, e le minute osservazioni di chi non si interessa che a un solo aspetto della natura."*

*Georges-Louis Leclerc, Conte di Buffon, Histoire naturelle 1749: 8 tr. it.*

Biological diversity, better known as biodiversity, is synonymous with invaluable universal wealth and heritage. The term biodiversity was first coined, in 1988, by the American entomologist Edward O. Wilson [1]. The United Nations Intergovernmental Organization (UN) Convention on Environment, Development and Biological Diversity, done in Rio de Janeiro in 1992, defined biodiversity as: "the variability of living organisms from all sources, including, *inter alia*, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species (genetic), among species in ecosystems (specific) and between ecosystems (ecosystemic)" [2]. This definition, as previously seen, has three focal points: genetic diversity, specific diversity, and ecosystem diversity. "Genetic diversity" ensures the perpetuation of species and their resilience. Genetically strong individuals will be able to respond appropriately to the external stresses to which they are subjected thus succeeding in ensuring the continuity of a population. This principle underlies life on Earth and enables diversity at the specific and ecosystem levels [3-7]. "Specific diversity" is understood as the totality of species occupying a given territory and the interactions among them. The most immediate and direct way to assess the quality of a habitat is the numerical assessment of the species present (species richness) by monitoring their presence/absence on the territory [8-12]. When we speak of an ecosystem, however, we are referring to a functional unit, that is, a dynamic complex given by the interaction of communities of plants,

animals and micro-organisms and their physical environment. The interactions between them make the system resilient, able to conserve itself over time and space [13, 14].

In other words, it can be said that biological diversity represents nature in all its forms and consequently is the fundamental pillar on which life on Earth rests and is perpetuated over time. To date, this heritage is represented by 8.7 million species (± 1.3 million), according to the most commonly cited figure [15,16]. While Díaz & Malhi [17] estimate about 10,100,000 species, of these, about 7.7 million are animals, and 298,000 are plants (Table 1). However, this estimate is still uncertain because most of the living things on our planet have yet to be described.

**Table1.** Estimated total number of species on Earth in the seven kingdoms of life (From Díaz & Malhi [17]).

| (Super)Kingdom | When evolved | Structure | Number of species (total) | Number of species (marine) | Number of species (terrestrial) |
|---|---|---|---|---|---|
| **Superkingdom Prokaryota** | | | | | |
| Bacteria | 3–4 Gyr | Unicellular | 1,250,000 (0.8–1.7 million) | NA | NA |
| Archaea | 3–4 Gyr | Unicellular | 105,000 (70,000–140,000) | NA | NA |
| **Superkingdom Eukaryota** | | | | | |
| Protozoa | 1.5 Gyr | Unicellular | 36,400 | 36,400 | 0 |
| Chromista | 1.2 Gyr | Unicellular | 27,500 | 7,400 | 20,100 |
| Fungi | 1 Gyr | Unicellular or multicellular | 611,000 | 5,320 | 605,680 |
| Animalia | 700 Myr | Multicellular | 7,770,000 | 2,150,000 | 5,620,000 |
| Plantae | 500 Myr | Multicellular | 298,000 | 16,000 | 281,400 |
| **Total species** | | | **10,100,000** | **2,210,000** | **6,540,000** |

This wealth is the result of slow evolutionary processes, which, under the impetus of natural selection, act on the genetic characteristics of species, thus enabling life forms to gradually adapt to changing environmental conditions. It is, therefore, an unparalleled resource for humankind. Ensuring its conservation is an issue that affects the quality of life and survival of each of us [10].

The climatic and physical changes that have affected our planet over the geological eras have led to the disappearance of a large number of species and habitats and to the survival of other, more resistant ones that have evolved by adapting to the new environmental conditions. One must, however, consider that

species extinction is as much a natural phenomenon as the emergence of new species and is the result of a evolutionary process. As the fossil evidence shows, five great mass extinctions have taken place on our planet [18]. The first took place in the Late Ordovician, about 450 million years ago, and led to the extinction of 25 % of existing species [19]; the second great extinction, occurred in the Upper Devonian, about 375 million years ago with a loss of 19% of species [20]; the third, which is considered to be the largest mass extinction ever, took place in the late Permian, 245 million years ago and resulted in the loss of 54% of existing species [21]; the fourth occurred about 210 million years ago in the late Triassic and caused the loss of 23% of the existing species [22]; the fifth great mass extinction took place 65 million years ago at the end of the Cretaceous period, and caused the extinction of 17 percent of existing species, including dinosaurs [23]. of natural origin, resulting from endogenous and exogenous activities on our planet. These activities completely and rapidly altered global climatic conditions, affecting atmospheric and oceanic biochemical conditions in the biosphere, such as: meteorite impacts, eutrophication and anoxic events in ocean waters, increased volcanism and often the resulting tectonic phenomena and rising/lowering of the seas, and glaciations [18], that did not allow some species to adapt, leading them to extinction.

What we are currently experiencing is the sixth great mass extinction and can be attributed exclusively to anthropogenic causes. Our globalized society has begun to destroy species and habitats at an extremely accelerated rate, thus initiating an unprecedented mass extinction [24-27,17,28]. Rates of biodiversity loss are related to human population size and growth [26], reaching 8 billion people in 2022, with an estimated increase of 1.5 billion more by 2080 (9.5 billion people) [29]. The increase in human population predicts the consequent increase in demand for consumer goods, creating greater economic inequity between rich and poor people [30]. The global impact of humankind has, as previously mentioned, increased species extinction rates, which are, to date, 1,000 times higher than natural baseline extinction rates (estimated on fossil record) and future rates are likely to be 10,000 times higher [31]. Through constant monitoring provided by the International Union for Conservation of Nature (IUCN), the

disappearance of species and consequent decline in biodiversity is documented each year. Recent results reveal that out of 142,517 species assessed, 40,084 are found to be threatened with extinction (~28%) [32]. In detail, 21 % of all known mammals, 30 % of all known amphibians, 12 % of all known birds and 28 % of reptiles, 37 % of freshwater fish, 70 % of plants and 35 % of invertebrates assessed so far are at risk. These figures are probably underestimated because species that disappeared before they were described, those still undescribed but extant, and those not yet on the IUCN “Red List” are not considered [32]. It is also noteworthy that the rate of species extinction has increased very sharply in the post-industrial era with extinctions up 45% more since the early 1900s' [33]. According to some scholars, by the end of the 21st century, between one-third and one-half of the total number of species on the planet (mainly vascular plants, mollusks, mammals, and birds) will have disappeared at a rate 10,000 times higher than that of other mass extinctions [31]. This will depend on multiple factors that are bound to increase as the population grows [33].

Multiple ecosystem services, or the properties, processes, and functions of nature that humans directly or indirectly benefit from through the functioning of ecosystems and natural resources, will be lost as biodiversity decreases [34-36]. The decrease in biodiversity will especially interfere with essential ecological services such as pollination, maintenance of soil fertility, flood control, water purification, assimilation of carbon dioxide [37].

Paradoxically, in a world where the demand for goods increases, they will be increasingly limited, affecting human well-being and survival. On a human time scale (which corresponds to about three generations), this loss would indeed be permanent because in the aftermath of past mass extinctions, it has taken the living world from hundreds of thousands, to millions of years to diversify again [26].

Marine biodiversity is also significantly affected by human activities and the resulting global warming. This especially endangers extremely fragile habitats such as coral reefs, brackish wetlands, mangrove swamps and underwater grasslands [38]. 70% of the Earth's surface is covered by the oceans, which are, therefore, an essential part of the biosphere, profoundly affecting the cycles

affecting the hydrosphere and conditioning climate on local and global scales [38, 39]. Sixty-six percent of the oceans are affected by multiple anthropogenic pressures: these are greatly increasing the loss of ocean biodiversity [40].

Biodiversity loss is not spread equally across the globe. 36 biodiversity hotspots have been identified (Figure 1), regions where there is a higher concentration of species and endemics (≥ 1500 endemic plants) that are severely threatened by human behaviour (70% of the original vegetation destroyed) and therefore require more urgent protection measures. The identified hotspots correspond to 24.83 million km², 16.7% of the earth's surface. The remaining natural vegetation covers only 3,563,850 km² or 2.39% of the earth's surface. The 36 hotspots contain 153,816 endemic vascular plant species (about 39% of the described species) and 16,403 endemic vertebrates (about 25% of the described species) [41].

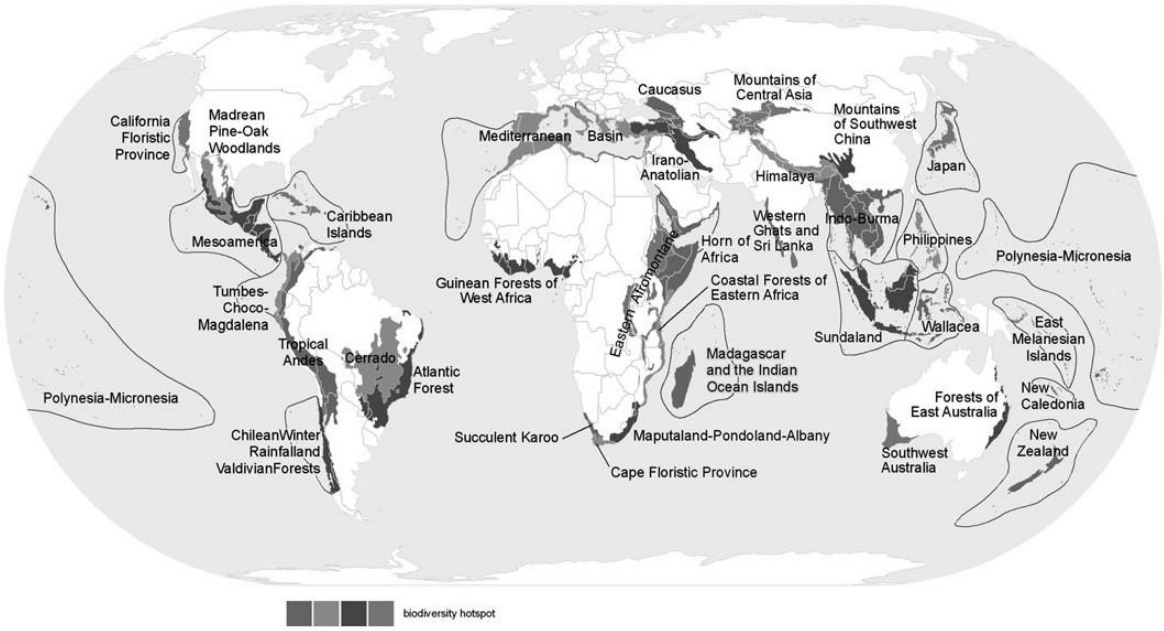



**Figure 1**. Global biodiversity hotspots. From Mittermeier *et al.* [41].

### 1.1 Factors of biodiversity loss

According to leading United Nations experts and multiple scholars, there are five main drivers of biodiversity loss: land use changes, inordinate exploitation of natural resources, global warming, the spread of invasive species, and pollution [42, 37, 17]. Of these factors, land-use change (mainly for large-scale food

production), is the one with the most violent impact: it causes, in fact, 30 % of global biodiversity decline. The second driver, which causes about 20 % of biodiversity loss, is the overexploitation of natural resources (immoderate fishing and hunting, immoderate harvesting, including all mining activities, to produce food, medicines, timber and fossil fuels). Climate change is the third most significant direct factor, which together with pollution causes 14 % of biodiversity loss. Invasive exotic species, on the other hand, account for 11 % [43, 37].

### *1.1.1. Land-use change*

The main factor in the loss of biodiversity is the continuous transformations of the land by humans [42, 44]. Land use change affects about three-quarters of the land mass free of ice and is expected to increase further in extent and intensity in tandem with rapid human population growth, economic growth in developing countries, and changes in the lifestyle and diet of humankind [45]. Growing urbanization and industrialization, expansion of grazing and farmland [46], aquaculture, deforestation and water extraction [47], are the main causes of habitat loss and always occur at the expense of ecosystems essential for biodiversity conservation [47,48]. Habitat fragmentation has caused in many species a sharp reduction in intraspecific genetic variability that underlies the ability of plant populations to adapt to changing environmental conditions, new pathogens, diseases, and global climatic variations and thus to perpetuate themselves over time [4]. In addition, deforestation for the production of raw materials leads to a permanent change in land use [49]. It must be considered that forest lands that are home to a high wealth of endemic and/or threatened species will experience a severe reduction in their range, resulting in a 45% decline in their original distribution [50].

### *1.1.2. Over-exploitation of resources*

Early humans coexisted harmoniously with other species, using only the primary goods necessary for survival: that represented a dynamic balance between biodiversity and humans. Cultural evolution, agriculture, animal domestication, and technological advancement have led to the rapid expansion and growth of the

human population, resulting in increased demand for goods, and ever-increasing pressure on biodiversity [51, 52].

When we talk about the “exploitation” (overharvesting or overexploitation) of resources we are referring to the removal of species from the surrounding environment, at higher rates than the ability of natural populations to recover [17].

Overfishing mainly affects loss of genetic diversity [3-7], but also on the abundance of species, understood both as individuals and as groups interacting with each other [11]. The population size may be reduced, in addition, by the structure given by age (poor populations of young individuals) [53] or by the composition of the genders [17].

Overexploitation of resources poses a threat to many plant and animal species, but particularly aquatic species. Uncontrolled fishing has significantly reduced the biomass of fish in the oceans, which is one-tenth of what it was at the beginning of the 20th century [54]. This affects the survival of all marine organisms and their balances.

Special attention should be focused on the world's forest biomes, most of which are characterized by endangered and/or threatened species [55]. Tropical forests, consisting of virgin forests also known as “primary forests”, are the cradle of the earth's biodiversity and hold about 50 % of the world's species [56, 57]. At the same time, they provide exclusive and fundamental ecosystem services such as tree biomass production, soil carbon storage, production of primary materials and goods, and recreational services [58, 59].

Increased demand for resources, from an ever-increasing population, is causing severe depletion of tropical and subtropical forests and woodlands. Globally, this degradation is mainly driven by deforestation, agricultural expansion, and biofuel production [17, 40, 60-63,].

Twenty-seven % of forest biodiversity loss is attributable to deforestation for primary production, which leads to permanent land use change. Bad forestry practices result in 26% of biodiversity loss, agricultural expansion 24%, and arson 23% (this practice is usually used to clear land for agriculture) [61].

Primary forests are increasingly being converted to plantations, typically monoculture, especially in Asian forests and most of the Amazon, where demand for palm oil is a main cause of deforestation [64, 65].

It must also be considered that deforestation of tropical forests contributed to nearly one-fifth of global anthropogenic greenhouse gas emissions during the 1990s and the first decade of the 2000s (~1,5 Gt C, o 5,5 Gt $CO_2$ $anno^{-1}$; [66, 67].

### *1.1.3. Global warming*

As previously seen, the primary cause of extinction of species is mainly due to disruptions of the climate of the biosphere [18-23], and to the consequent modification of ecosystems [13, 14]. To understand these causes and consequences of ancient global warming episodes has obvious useful significance in predicting the evolution and repercussions of current climate change [68]. Current global warming is associated with human activities, and is to date a primary cause of habitat and biodiversity loss [69-72], seriously threatening the survival of many species, especially those with limited distribution and especially endemic species [73-80].

The 20th century has seen the strongest warming trend in the last millennium, with average temperatures increasing by about 0.6°C compared to the pre-industrial era (1850-1900) [68, 81-84]. Estimations suggest that future temperature increases could exceed this, with an expected increase of between 0.1 and 0.2 °C per decade [68]. These changes will result in relatively major alterations in community composition in almost every ecosystem on the planet [85-87], going to particularly affect the growth and survival of vascular plants [88].

The steady increase in intensity and frequency of various abiotic stresses, including drought, temperature extremes, and flooding, the expected increase in soil-related stresses, salinity, inorganic nutrient imbalances, and heavy metals, and in many cases the combination of these stresses [89-92], will endanger the survival of species, compromising the ability of ecosystems to respond.

Ongoing climate change is, in addition, causing changes in the biogeographic ranges of living organisms; there is a shift toward higher latitudes, with an average rate of 16.9 kilometres per decade [93-95]. In addition to

latitudinal shifts, different organisms are also changing their altitudinal ranges. Some species, especially those in the temperate zones of the Northern Hemisphere are extending their upper limit at an average rate of 11.0 meters per decade. These rates are about two (latitude) and three (altitude) times faster than those recorded in previous years [93-95].

### *1.1.4. "Alien" species*

We must also, consider that climate change, combined with economic globalization, rapid infrastructure development, and human activities, has favored the spread of alien species that, by rapidly expanding their areal [96, 97], are colonizing natural habitats and driving native species, especially those with limited range, to extinction [98-103]. This problem is also associated with heavy and growing economic repercussions [104].

Alien, or allochthonous, species are those deliberately or accidentally moved by humans outside their natural range (geographic area within which a species is distributed) [105-108]. These are called "casual" when they occasionally reproduce away from cultivation areas. Their persistence in the territory results from a continuous input of propagules by humans: failure to do so leads to the extinction of the species, as it is unable to form self-reproducing populations. Species considered "naturalized" allochthonous, on the other hand, are able to form self-reproducing populations without direct human intervention; in fact, they are able to reproduce autonomously by gamic and agamic means.

"Invasive" species are defined as naturalized species that produce reproductive offspring capable of spreading in a short time to large distances from the site of introduction [105, 106, 109-111]; "Invasive" behaviour is often associated with the absence of predators, parasites and competitors in the areas where the species has been introduced [112, 113]. Instead, the IUCN and the European Commission, define "invasive" species as those that have a detrimental effect on the economy, the environment, ecosystem services and human health [114- 116]. Current biological invasions represent a unique form of global environmental evolution; this evolution overcomes natural factors of species selection and dispersal, going on to create new biological communities that would never have existed through natural processes [117, 118].

A study [96] found that more than one-third of all introductions in the past 200 years occurred after 1970, and the rate of introductions shows no signs of slowing: in fact, the number of alien species is expected to increase by 36 % between 2005 and 2050 [119].

### *1.1.5. Pollution*

Pollution is causing 14% global biodiversity loss [43, 37], the most macroscopic examples of this problem are plastic contamination [120-122], noise pollution [123] and bright [124] and chemical pollution [125]. These emerging factors are very different from each other in physical nature, but they share some basic peculiarities, which make them a real threat to biodiversity [126]. Although they are relatively recent, they are ubiquitous in the biosphere in very high amounts with a rapidly increasing trend [122] and globally involve all ecosystems. Moreover, their rapid expansion has not given living organisms time to adapt to them [17].

Since the 1950s, industrial plastic production has grown rapidly, with a current output of 368 million tons per year [120, 127]. Because of its low price, it has become one of the most widely used materials in the world; over the years, about 8.3 million tons of plastic has been thrown away, about 80% do not undergo a recycling process and end up in dumps or in nature [17, 120, 127]. Plastic is one of the most widespread and persistent forms of pollution, its ability to resist degradation (chemical or biological processes) due to chemical stability causes it to accumulate in sediments and organisms (bioaccumulation) [128-131].

If the current trend continues, at current rates, by 2050, an estimated 12,000 T of plastic waste will be released into nature [132]. Assuming that these are evenly distributed over our planet, this number would equal about 24 tons of waste per square kilometer of land and sea surface, reaching a level of pollution unprecedented in human history [133].

The socio-economic costs caused by discarded waste in the wild are considerable [134], but it is the ecological consequences that create greater public attention and awareness. The strongest evidence of the harmful effects of plastics on living things can be attributed to macroplastics. Khun *et al.* [135] have highlighted, through the analysis of numerous studies, that litter discarded in the

sea has affected 914 species of vertebrates (turtles mostly) and invertebrates in recent years through entanglement and/or ingestion. Ingestion has been recorded for 701 species, entanglement has been documented for 354 species [135].

A much more pervasive form of plastic contamination is that related to the spread of micro- and nanoplastics. We talk of microplastics to indicate fragments between 0.1 and 5,000 micrometers in size, while we talk of nanoplastics when we are faced with microscopic fragments, from 0.001 to 0.1 micrometers [136].

Micro and nano plastics are generated due to the slow deterioration of waste consisting of polymers by weathering [17]. Because of their extraordinary lightness, they are able to be moved over very long distances, through atmospheric dispersion and via the flows of marine currents. For this reason, their presence is widespread throughout the planet affecting all environmental matrices (water, air, soil) and their cycles [17, 136], coming to bioaccumulate in many organisms (especially in megafauna) [128-131]. Nanoplastics, moreover, are able to permeate through biological membranes, causing damage to the health of living things [136]. However, the potential effects on human health are poorly understood, as there are difficulties in quantifying exposure and related harm; in addition, interactions (biological, physical, and chemical) in organisms are not yet known [17, 128, 136].

Rapid population development has stimulated the increase of two other types of pollution, noise and light pollution. These factors affect all living organisms by affecting individual behaviour, communication, and the fitness and structure of many communities of terrestrial and aquatic organisms [137-140]. These disturbances are also referred to as “sensory pollutants” [141]. Urban centers, road, industrial and energy infrastructure, aircraft, and boat sonar are just some of the main sources of noise pollution [142].

Light pollution involves about 80 % of the earth, with a significant peak throughout the Northern Hemisphere [143]: this is increasing rapidly in spatial, temporal, and spectral extent [144].

The impacts of light pollution mainly affect the phenology, physiology, and behaviour of living things [145-149]. In particular, it has been seen that they tend

to be more pronounced at the physiological and individual level and less pronounced at the population and community level [150].

## 1.2. Conservation biology

Researcher Scribner [151] described conservation biology as "a multidisciplinary field whose main purpose is to understand the complexity of intra- and inter-population processes in order to estimate the viability, short-term and evolutionary, of natural populations and communities. It is based primarily on theoretical knowledge and empirical research derived from specific disciplines including population and behavioural ecology, population genetics, and resource management"

This discipline is based on three main objectives: document and quantify the entire biological diversity on Earth;

- Study anthropogenic impacts on genetic variation, species and ecosystems;
- develop practical approaches to prevent the extinction of species, maintain their genetic diversity, and protect and restore biological communities and associated ecosystem functions.
- The first two objectives are based solely on scientific research. The third, on the other hand, defines conservation biology as a normative discipline, which through scientific research lays the legislative foundation for safeguarding the planet [152].

The three basic principles that guide this scientific discipline are [153]:

- evolution, i.e., the benchmark for understanding and knowledge of all biology: this must be placed at the center of conservation actions;
- ecological systems, i.e., living and dynamic complexes: their conservation must aim to maintain their dynamism;
- *Homo sapiens*, as an integral part of the natural world, must be included in conservation actions.

This discipline is recent and predominantly Anglo-Saxon in origin; it was established in the 1980s and developed in response to the increasingly pressing challenge of preserving species, ecosystems and, consequently, human health and

survival. It was defined, in fact, as a “crisis discipline” as a result of the severe environmental situation in the 20th century [154].

Conservation biology is a multidisciplinary science: indeed, it includes several scientific branches related to ecology, biogeography, landscape ecology, genetics, taxonomy, evolution and population study (population analysis), forestry, and wildlife management [79, 155-157]. During the years, its background has expanded to gradually include new technologies in the fields of molecular biology [158, 159] and bioinformatics, computer science, such as environmental modeling [160-165], and GIS (Geographical Information System) mapping [166], but also subjects relating to sociology, economics, philosophy (ecotheology), and political science [167-169]. Conservation biology uses these applied disciplines and provides a more general theoretical approach to biodiversity protection. It differs from other scientific disciplines in that it plays an active role in the conservation of biological diversity in all its forms and sets as its foundation the assessment of the conservation status of species and the long-term viability of populations, facilitating the identification of strategies for their long-term management and protection.

Therefore, we can define conservation biology as a dynamic science that throughout the years has never ceased to incorporate and adapt to the directions coming from a rapidly changing scientific world in order to promote environmental awareness and advance scientific evidence-based solutions to environmental problems.

In addition, the ideas, theories, experimental data, and discussions occurring within the scientific community are increasingly entering the political debate, popular culture, and public opinion [170].

### 1.3. Conservation strategies

The loss of an ever-increasing number of species and the loss of biological diversity at all levels has assumed such emergency characteristics as to require worldwide conservation strategies. During the Earth Summit held in Rio de Janeiro, Brazil, in 1992, representatives of 178 countries formulated, and eventually signed, the Convention on Biological Diversity (CBD), ratified by Italy in 1994. The CBD is a legally binding international treaty obligating countries to

protect their biodiversity, founded on three main targets: conservation of biodiversity, sustainable use of biodiversity, and fair and equitable sharing of benefits arising from the use of genetic resources [2]. The purpose is to encourage actions by state signatories that will ensure a sustainable future. In April 2002, the Parties to the Convention developed a Strategic Plan intended for implementation at regional, national and global levels, committing to achieve a significant reduction in the current rate of biodiversity loss by 2010. At its 10th meeting held in Nagoya, Japan, in October 2010, the Conference of the Parties to the CBD adopted an additional strategic plan for biodiversity (2011-2020) ratified by more than 50 countries: the “Global Strategic Plan”, also referred to as "Living in Harmony with Nature." The plan included 20 targets, the “Aichi Biodiversity Targets”, divided into 56 indicators, which set the framework for setting national or regional targets and promoting the CBD's core objectives. The main novelty of this plan, compared to the Convention's old strategic plan, was that it represented a benchmark for all countries of the United Nations and not only for the signatory nations of the 1992 Convention on Biological Diversity [171]. The EU, in accordance with the Aichi Biodiversity Targets, had proposed the “European Union Biodiversity Strategy” in place until 2020, just as Italy had adopted its own National Biodiversity Strategy (2011-2020) in 2010.

At the latest global conference on biodiversity (COP15) held in Montreal, Canada in December 2022, the Parties to the Convention adopted the Kunming-Montreal Global Biodiversity Framework. This commits the global community to concrete actions to protect and restore nature and remove pollution during the period 2030-2050. The proposed targets will be clear and measurable, and progress for individual countries can be continuously monitored, reported on, and reviewed as we go along. By 2030, 30 % of globally degraded ecosystems are expected to be restored, 30 % of areas (terrestrial, inland water, coastal and marine) to be conserved and managed, pesticide use to be reduced by at least 50 %, and at least 50 % reduction in nutrient losses to the environment. Also expected is the reduction of pollution and its negative impacts to levels that are not harmful to biodiversity and ecosystems, and the related reduction in consumption. Also expected is the proper sustainable use of areas for agriculture, aquaculture,

fisheries and forestry, in accordance with the principles of agroecology, the reduction by at least 50 percent of the rate of introduction and establishment of invasive alien species, and the safe, legal and sustainable use and trade of wild species.

In addition, one of the goals proposed by the Kunming-Montreal Global Biodiversity Framework is to halt the extinction of known species and by 2050 reduce the risk and rate of extinction of all species by a factor of ten [172].

The European Union has unveiled its 2030 Biodiversity Conservation Strategy, which is a key element of the European Green Deal. This is a set of policy initiatives that aims to reach climate neutrality in Europe by 2050. It provides for an impact assessment aimed at reducing EU greenhouse gas emissions by at least 50 % by 2030 or 55% above 1990 levels. It also provides for the creation of protected areas comprising at least 30 % of the EU's land and sea area, expanding those already in the Natura 2000 network, restoration of degraded ecosystems through specific measures such as reducing pesticide use by 50 % and planting 3 billion trees within EU territories [173].

The Ministry of Ecological Transition, with the support of ISPRA, has prepared a first version of the “National Biodiversity Strategy 2030”: this represents the tool through which Italy intends to contribute to the international goal of ensuring that by 2050 all the planet's ecosystems are restored, resilient and appropriately protected [174].

European strategies have been supported by the establishment of the “Nature Directives” namely the 92/43/EEC “Habitats” Directive and the “Birds” Directive 79/409/EEC, now replaced by 2009/147/EC.

The Natura 2000 network is, to date, the main instrument for the protection and conservation of biodiversity. It is an ecological network spread throughout the territory of the European Union to ensure the maintenance of natural habitats and species of flora and fauna that are threatened or rare at the community level [175-178].

The Natura 2000 network consists of Sites of Community Interest (SCIs), identified by Member States in accordance with the terms of the Habitats Directive 92/43/EEC, which are thereafter designated as Special Areas of

Conservation (SACs), and also includes Special Protection Areas (SPAs) established under the 2009/147/EC Birds Directive concerning the conservation of wild birds [179]. The Habitats Directive aims to ensure nature protection while also "taking into account economic, social and cultural needs, as well as regional and local particularities" (Art. 2), so its areas are not rigidly protected, and human activities are allowed [180].

The Directive aims to conserve not only natural habitats but also semi-natural habitats (such as used forests, grazing lands, etc.). In Italy, SCIs, SACs and SPAs together cover about 19% of the national land area and more than 13% of the marine area.

Another of the main international agreements on environmental protection is the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC is one of two multilateral environmental conventions entered into during the Rio Earth Summit in 1992 and ratified by almost all the countries of the world (to date 196 Contracting Parties). It has as its main objective to stabilize greenhouse gas concentrations in the atmosphere, which are the greatest contributors to the planet's rising temperature. It entered into force on March 21, 1994.

In 1997, the member countries of the UNFCCC entered into the Kyoto Protocol, which is an international treaty that places legal constraints on emission limits for industrialized countries to reduce greenhouse gases by 5.2 percent compared to 1990 emissions over the five-year period 2008-2012. According to the Kyoto Protocol, countries also had to set up projects to protect forests, woodlands and farmland, as they are carbon sinks, i.e., reservoirs that absorb carbon dioxide.

The Kyoto Protocol has been ratified by both the European Union and its member states. The European Union as a whole is committed to reducing its greenhouse gas emissions by 8 percent from 1990 levels. This commitment has been distributed differentially among member countries.

Italy ratified the Kyoto Protocol in 2002 (Law 120/2002), committing to reduce its emissions by 6.5 % from 1990 levels in the period 2008-2012, amounting to 483,3 $MtCO_2$/year [181]. In 2015, 195 members countries of the UNFCCC during the Paris Climate Conference (COP21) adopted the first universal and legally

binding global climate agreement. The agreement entered into force on November 4, 2016, and is the framework for global action to reduce greenhouse gas emissions. The agreement sets out a global plan of action and sets the goal of limiting global warming well below 2 ºC and preferably within 1.5 ºC, with the fulfillment of the condition of ratification by at least 55 countries representing at least 55 % of global greenhouse gas emissions. All EU countries have ratified the agreement [182].

A few decades ago, no one was fully aware of the deleterious effects of pollution, the global decline in wildlife populations, rates of habitat conversion, the insidious effects of alien species, and the ability humans have to alter the Earth's climate. In the last years the public has become increasingly aware and active in this area. This awareness has already produced many changes in society, altering individual behaviors (e.g., eating habits, waste separation and recycling); there are now a large number of nongovernmental environmental organizations, and there has been on the part of individual citizens a very strong rapprochement with nature (hiking, birdwatching, whale watching) [183, 184].

In 2020, the COVID-19 crisis has demonstrated that humans depend on and are themselves part of our planet's biodiversity. A single virus was able to alter global population behavior, deepen social inequalities, and disrupt the world economy [185, 186]. Despite the significance of this event, however, the crisis ahead is much deeper. Nature's ability to contribute to the good quality of our lives is rapidly decreasing [42]. The severity of these threats requires ambitious objectives and immediate science-based conservation actions [17].

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## Aim of the PhD thesis

In the context of global changing and the necessity to implement concrete biodiversity conservation policies based on scientific studies, in this doctoral thesis, the objective was to investigate the conservation biology of two endemic species of the Italian flora: *Salvia ceratophylloides* Ard. and *Pimpinella anisoides* V.Brig.

*Salvia ceratophylloides* (Salvia incisa) is a punctiform endemism exclusive to the suburban periphery of Reggio Calabria (southern Italy). It grows in the hilly zone, on slope between 250 and 450 m a.s.l. in peculiar habitats characterized by sandy soils [1]. Even in the early 1900s, the species was already extremely rare [2]; the intense environmental transformations suffered by the territory resulted in the extinction of this species in the places mentioned in the literature, therefore, in 1997 it was included in the "Red Book of the flora of Italy" among the extinct species [3] data confirmed by Del Carratore *et al.* [4]. Subsequent research between 2008 to the present has ascertained 17 new locations approximately 10 km away from those reported in the literature [1, 5, 6]. Laface *et al.* [6] and Spampinato *et al.* [1] evidence that the population consisted of about 1100 breeding individuals with an "Extent of Occurrence" (EOO) of 4.2 $km^2$ and an "Area of Occupancy" (AOO) of seven $km^2$. The application of the IUNC criteria allowed the conservation status of this species to be assessed as "Critically Endangered" (CR), or nearing extinction [1, 6]. The threats to the survival and spread of this species are multiple, in fact its disappearance locally would coincide with its extinction globally. Its preservation is therefore of paramount importance to prevent its extinction and contribute to the maintenance of our planet's biodiversity.

Several types of studies have been carried out to this end:

1. An initial work involved habitat analysis and population dynamics of *S. ceratophylloides*, aimed at understanding the issues that prevent micropopulations of this species from growing and expanding in the territory. In addition, the analysis of the different phenological stages made it possible to define population types in relation to the age of the

individuals and to correlate these types with the different habitats occupied by the species.

2. A second study focused on modeling, using the MaxEnt model, the current and future potential range of *S. ceratophylloides*, considering possible climate change. Two different future climate scenarios were used and the current potential range was also estimated in relation to geological substrates (to which the species is bound) and land use map.
3. A third study inended laboratory simulation of some single and combined abiotic stresses to which the species might be subjected in anticipation of climate change. For this purpose, the phenological and ecophysiological responses of *S. ceratophylloides* to four stress treatments were studied: drought, heat, drought+heat and control. The seeds used for the experiments were, treated with different priming methods: control priming (CP) i.e., untreated seeds, hydropriming (HP) i.e., seeds treated with deionized water, and osmopriming (OP) i.e., seeds treated with PEG 8000 with a concentration of 10%.
4. A fourth work involved the study of pathogens of the species. Indeed, field research showed that many plants were under severe stress affecting reproductive activity as a whole. For this purpose, taxonomic and molecular studies were conducted on the parasitic entomofauna of *S. ceratophylloides*.

   These studies make it possible to assess the conservation status of the species and its ability to survive in the long term and are therefore aimed at defining management strategies useful for the conservation of the species under study.

*Pimpinella anisoides* V.Brig. is an endemic species of southern Italy found in Basilicata, Calabria, Campania, Latium, Apulia and Sicily [7], distributed mainly in the montane belt affected by mesophilic and acidophilic formations of *Quercus cerris* L. or *Castanea sativa* Mill., at elevations between 700 and 1300 m s l m [8]. This species is related to *Pimpinella gussonei* an endemic species of Sicily, with which it has often been confused and placed in synonymy.

Although the species is currently considered LC (Least Concern) [9], it is indiscriminately collected for commercial use. In Calabria (but also in other regions) there is a widespread practice of harvesting its fruit to flavor various traditional baked goods and liqueurs [8, 10], this is compromising the reproductive potential of the species with negative impacts on the population size and conservation status of the species.

The studies performed aimed to characterize the fruits of *P. anisoides* and distinguish this species from related species:

1. An initial study involved the analysis of morphological characteristics and phytochemical composition of *P. anisoides* fruits in order to use them to distinguish this species from others of commercial interest, and to avoid commercial sophistications.
2. A second study revealed the carpological characteristics of *P. anisoides* and *P. gussonei,* which are the only two endemic species of the genus *Pimpinella* found in Italy. This was done in order to clarify the taxonomic doubts that have arisen over the centuries about the two species.

These studies are directed at suggesting just conservation and preservation practices for *P. anisoides;* in fact, although it does not appear to be endangered, bad unregulated harvesting practices are increasingly reducing the population, going to affect the survival of the species.

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# CHAPTER 2. *Salvia ceratophylloides* Ard.: a rare endemism of southern Italy.

## 2.1. Introduction

*Salvia ceratophylloides* Ard. is a precious endemic exclusive to the suburban periphery of Reggio Calabria (southern Italy).

It is part of the Lamiaceae family, one of the largest groups of plants with medicinal and aromatic properties given by their abundant composition in essential oils, considered, for this reason, an important group of Medicinal Aromatic Plants (MAP) [1, 2], also appreciated as ornamental, food plants of considerable ethnobotanical interest [3].

The genus *Salvia* (Subfamily *Nepetoideae,* Tribe *Mentheae*) counts almost 1,000 species, making it one of the largest genera in this family [4]. It is present in the pharmacopoeia of many countries of the world, where it takes on a very important economic role; numerous species are used for medicinal, food and ornamental purposes [5, 6]. The genus *Salvia* has a very wide range, from Central and South America with 500 species, to Central Asia/Mediterranean (250 species), to East Asia (90) [4]. According to Flora Europea [7] the genus *Salvia* occurs in Europe with 36 species, three subspecies, three hybrids and two aliens. In a more recent study, Nikolova & Aneva [8] have counted 39 species and one subspecies for Europe. The Italian flora, to date, includes 28 species and six subspecies of the genus Salvia, of which 11 taxa are allochthonous and 22 are native, including four endemics [9]; these include *Salvia ceratophylloides* Ard. (Figure 1). Hedge [7] e Nikolova & Aneva [8] do not identify *S. ceratophylloides* as a species in itself, but they regard it as synonymous with *S. pratensis.* Pignatti [10, 11], on the opposite, it recognizes it as an endemic species, exclusive to southern Calabria.

*Salvia ceratophylloides* belongs to the subgenus *Sclarea* (Moench) Benth., sez. *Plethiosphace* Benth., characterized by a bell-shaped calyx, above two grooves, concave, with three conniving teeth and corolla with a crescent-shaped compressed upper lip [12].

It is part of the *S. pratensis* group, present in Italy with a few entities: *S. pratensis* L. subsp. *pratensis*, *S. pratensis* L. subsp. *saccardina* (Pamp.) Poldini, *S.*

*haematodes* L., *S. virgata* Jacq. e *S. ceratophylloides* Ard. [11]. Del Carratore and Garbari [12], in their study of the section *Plethiosphace*, report for Italy: *Salvia clandestina* L., *S. haematodes* L., *S. pratensis* L., *S. saccardiana* (Pamp.) Del Carr. and Garbari, *S. verbenaca* L., *S. virgata* Jacq., and consider *S. ceratophylloides* extinct, as it has not been found in recent decades.




**Figure 1**. *Salvia ceratophylloides* Ard. and iconography drawn by V.L.A. Laface

## 2.2. Historical vicissitudes

The earliest records of this species date back to the pre-lynnean period and are due to Cupani [13], a Franciscan friar expert on Sicilian flora who, in his monumental work "*Panphyton siculum"* of 1713, published the iconography and description of this species. The work published posthumously by the publisher [14], indeed, contains an iconography (t 186) clearly referable to *S. ceratophylloides* (Figure 2) which Cupani describes with the phrase "*Sclarea verbenae petalis purpurates florae"*. Cupani described in his book many species collected wild in Sicily, but also non-native species that were grown at the Misilmeri botanical garden in Sicily, of which he was curator [15]. This has created confusion among Sicilian botanists who have long attributed *S. ceratophylloides* to the Sicilian flora [16].

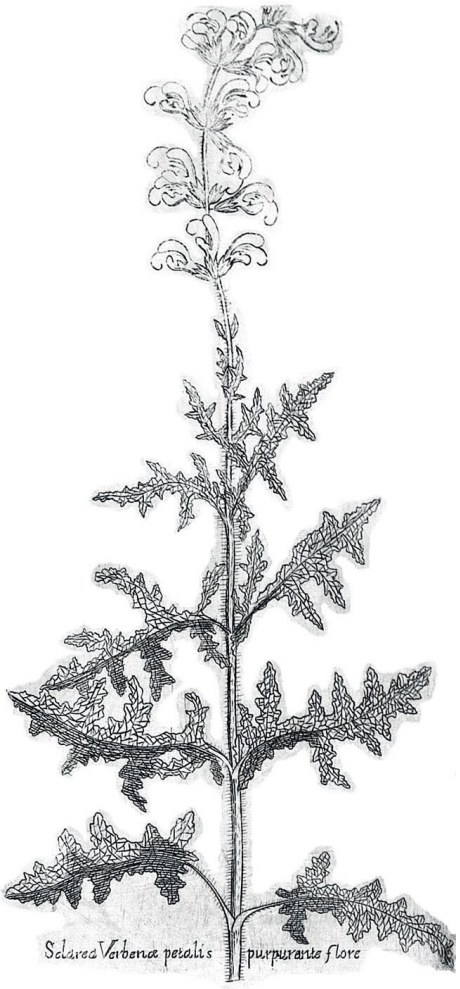



**Figure 2.** Iconography from the "*Panthyton Siculum*" by Cupani of 1713 related to *Salvia ceratophylloides* Ard.

The species has been described using the Linnean binomial system by Pietro Arduino (1728-1805) [17] as *Salvia ceratophylloides*, in "*Animadversionum botanicarum specimen alterum"*. Arduino described the species using plants grown at the Botanical Garden of Padua, obtained from some seeds he had received from a Sicilian friend as he says: "*Ex seminibus e Sicilia ab amico delatis, et in horto hoc nostro satis quinque anni sab hinc nata est"* (Figure 3, [17]). For this reason, too, Sicily has long been considered the place of origin of this species, although no one has ever collected samples in the wild. Arduino attributed the epithet "*ceratophylloides*" to this *Salvia* to emphasize the similarity that, in his opinion, this species has with *Salvia ceratophylla* L., a species distributed in the Iranian-Turanian region absent in Italy (*ceratophylloides*: from

*ceratophyllum* from Greek κέρας, -ατος *chéras, -atos* horns and φύλλον *phýllon* leaves: with leaves of horny texture and from Greek εἶδος eidos appearance: similar to *Salvia ceratophylla* L., *Irano-Turanian* areal species). Arduino describes the species as: "*Salvia ceratophylla sed luxuriantis similis; forte diversa ac distincta"*.



SALVIA *ceratophylloides* foliis rugosis, pinnatifidis: caule brachiato, ramosissimo. Tab. 2.

EX seminibus e Sicilia ab Amico delatis, & in horto hoc nostro satis, quinque ab hinc annis nata est speciosa & odorata hæc nova species, & distincta ab aliis Salviarum speciebus; radice perenni, digito crassiore, externe rugosa, subnigra, parum ramosa, ex qua caules plures sexquipedales, bipedales, & altiores emittit, initio erectos, brachiatos, deinde diffusos, brachiato — ramosos, obtuse quadrangulos, pilosos, superne punctis atro — purpureis adspersos, præcipue inter florum verticillos. Rami oppositi cauli similes, modo breviores, modo longiores.

In summitate caulis & ramorum flores laxe verticillatim nascuntur.

FOLIA opposita, patentia, pinnatifida, rugosissima, subhirsuta, supra læte viridia, subtus pallidiora: inferiora petiolata, profundius pinnatifida: summa sessilia, limbo sinuato — crenata, reflexa: pinnulis duabus inferioribus auriculatis. (vid. fig. a. a.)

BRACTEIS sub unoquoque verticillo sex, quarum duæ laterales cordato — acuminatæ, foliaceæ; aliæ autem minimæ, lanceolatæ.

Cæteris fructificationis partibus omnino convenit cum *Salvia pratensi* Linnæi.

Ut supra diximus, perennat hæc species, & tota fere æstate floret, autumni tempore ramosior evadit, quo, præcipue foliorum figura, ab aliis omnibus differt, & facile distinguitur hæc planta.

An huc referri quit Sclarea italica, pratensis, foliis in profundas lacinias & crenas incisis, flore Coeruleo? Cat. Plant. Hort. Pisan. pag. 155. Sed cum ibi hæc planta nec figura illustrata sit, nec descripta, nihil certi statui potest.

Tota hæc planta suave olet, & musto ferventi immissa, ei odorem saporemque tribuit Vini, quod vulgo *Moscato* dicitur.

A. Calyx a latere visus, ad propriam magnitudinem delineatus.
B. idem cum corolla.
C. Corolla seorsim picta.

**Figure 3**. Iconography of *Salvia ceratophyllaides* and description of the species from the writings of Arduino (1764) "*Veronensis horti publici patavini custodis animadversiorum botanicarum specimen alterum*".

Arduino stored the type specimens used to describe the species in his herbarium in Vicenza, which unfortunately was destroyed during World War II. In 1763 he sent Linnaeus some herbarium specimens, which are still preserved in the Linnean Herbarium in London (LINN 42.55) (Figure 4), wich reports the name of the species and links to a list attached of some *exsiccata* sent by Arduino to Linneo.




**Figure 4.** The herbarium specimen of *Salvia ceratophylloides* Ard. sent by Arduino to Linnaeus in 1763 and stored in the Linnaean Herbarium at London (*LINN 42.55*).

As early as the 1800s, this species was known in the Reggio Calabria area in some localities [18, 19]. Successive reports date back to the first two decades of the 20$^{th}$ century [20], when the species was considered extremely rare [21].

Lacaita [20] organized the taxonomic framework of *S. ceratophylloides*, clarifying the real place of origin of the species. He evidenced that the species has never been found wild in Sicily and that the few specimens found in various herbaria all came from southern Calabria or from cultivations obtained from seeds collected always in these localities.

Lacaita [20] clarify that the samples named by Linneo as *Salvia ceratophylla* L. and by later authors such as *S. ceratophylloides* L. are, actually, to be attributed to *Salvia ceratophylloides* Ard.

The deep environmental transformations undergone by the suburban area of Reggio Calabria, due to intense urbanization and devastating fires affecting the territory, have resulted in profound landscape changes with the reduction,

degradation and disappearance of natural habitats. In fact, in the localities mentioned in the literature (Gallico Superiore, Terreti, Straorino, Ortì, Vito Superiore, Pietrastorta) [21] *S. ceratophylloides* was no longer found, despite research by various botanists [22, 23]. Thus, in 1997, it was declared extinct and listed in the "Red Book of Flora of Italy" as "Extinct in the Wild" (EW) [22]. Its extinction was confirmed by later authors who studied the genus *Salvia* in Italy [23, 24] and by Scoppola and Spampinato [25] In the "Atlas of Endangered Species" of Italian flora (Figure 5).

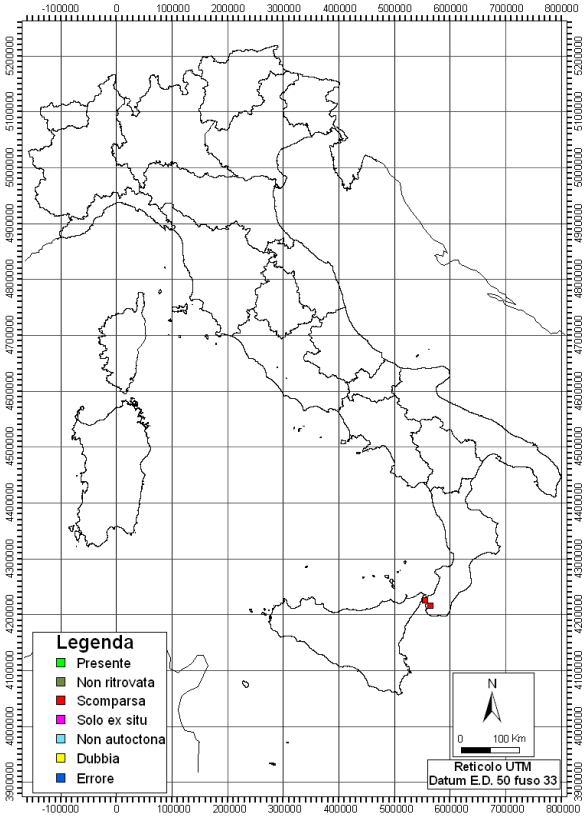



**Figure 5**: Italian distribution of *Salvia ceratophylloides* Ard. from Atlas of Endangered Species [25].

Field research conducted between 2008 and 2010 uncovered four small new populations of *S. ceratophylloides* nearby Reggio Calabria (Puzzi, Cataforio) at sites about 10 km away from those for which the species was known in the early 1900s literature [21]; each population consisted of a few dozen individuals, with a total of nearly 100 mature individuals [26, 27]. During 2016-2018, eight more small populations of *S. ceratophylloides* were found in hard-to-reach places, again around Reggio Calabria, with about 1100 individuals [28]. The distribution

of plants in the fragmented subpopulations was very irregular in relation to habitat quality. At some sites, the number of plants was more abundant, with about 250 individuals; at other sites, individuals did not exceed 3 units [28].

Despite the new populations discovered during the PhD research activity (see Chapter 3) *S. ceratophylloides* covers an "Extent of Occurrence" (EOO) of 4,2 $Km^2$ and an "Area of Occupancy" (AOO) di 7 $Km^2$, which allows to asses this species as "Critically Endangered" (CR) [28, 29] according to IUCN [30] criteria and categories. The entity, to date, is not protected: in fact, the population of the species does not fall within protected areas or Sites of Community Importance.

### 2.3. Species description

*Salvia ceratophylloides* (Figures 6) is a perennial herbaceous plant (scapose hemicryptophyte), densely pubescent for both glandular and simple patent hairs. The plant is 30–90 cm tall, has upright or ascending stems, normally lignified and much ramified at the base. The leaves are pinnate-partite, with toothed lobes, the basal of 10–12 × 4–6 cm, and the cauline of 3–4 × 1–2 cm. The leaf blade, wrinkled on both sides, is glandular and pubescent, more evident on the lower one. The inflorescences are very showy, 20–30 cm long, normally ramified at the base, and are made up of 5–6 verticillaster each with 4–6 flowers. The calyx, 8–10 × 3–5 mm, is zygomorphic, ferruginous, and covered with numerous sessile or pedicel glandular hairs. The bilabiate corolla, violet, 15–25 mm long (three times the calyx) has an upper lip strongly folded to the cap on the stamens pubescent-glandular on the outside. The two stamens are 10 mm long and the style 20–30 mm long, protrudes over 10 mm from the upper lip and has a deeply bifurcated purple colored stigma at the extremity. The fruit is a peculiar schizocarp: a microbasarium made up of four dark brown, spherical to ovoidal mericarps; each mericarp, 2–3 mm long, has a thickened margin. *Salvia ceratophylloides* has a main flowering period in spring from April to June and a second flowering period in autumn from October to November. Pollination is entomophilous, mediated mainly by hymenoptera (*Eucera* sp., *Bombus* sp., *Apis* sp.). The fruiting occurs after some flowering weeks. Seed dispersal is mainly carried out by ants (myrmecochory) [29, 31]. It is a strongly aromatic plant, rich in essential oils [32],

and of future potential economic interest. The composition of volatile substances produced by glandular hairs suggests that these substances are involved in chemical defense against insects [29]. The chromosome number 2n = 54 allow to considered this species as a hexaploid arrangement [33] in accordance with the basic number x = 9 which is reported for some its allied taxa (*S. pratensis*, *S. haematodes*) resulting diploid with 2n = 18 [12].




**Figures 6**: Detail of: inflorescence (a); tetrachenio (b); flower (c); seeds (d). Ph.V.L.A. Laface.

## 2.4. Habitat

*Salvia ceratophylloides* grows spontaneously in the habitat of the EEC Directive 92/43: "5330 thermo Mediterranean and predesert scrub" subtype "32.23 Diss dominated garrigues". This habitat includes Mediterranean steppes such as grasslands with *Ampelodesmos mauritanicus* (Poir.) Dur. & Schinz., sands vegetation with *Artemisia campestris* subsp. *variabilis* (Ten.) Greuter and more arely garrigues characterised by *Cistus creticus* L. subsp. *creticus*

and *Thymbra capitata* (L.) Cav. (Figure 7). The most frequently growing species with *S. ceratophylloides*, in addition to the aforementioned species, are some annual or perennial grasses (*Lagurus ovatus* L., *Avena barbata* Link, *Macrobriza maxima* (L.) Tzvelev, *Hyparrhenia hirta* (L.) Stapf., *Dasypyrum villosum* (L.) P. Candargy), several dwarf shrubs (*Micromeria graeca* (L.) Benth. ex Rchb., *Phlomis fruticosa* L.), and some shrubs (*Cytisus infestus* (C. Presl) Guss. subsp. *infestus*, *Spartium junceum* L.). Mostly, they are widespread species in the Mediterranean steppic grasslands and garrigues [28, 29]. The populations are located on hills at altitudes between 250 and 450 m a.s.l., characterised exclusively by layers of loose sands alternating with banks of soft Pliocene calcarenites [34]. The species grows in a territory with average annual temperatures of 18 °C and average annual rainfall of 600 mm, concentrated in the autumnal months of November and December, and a summer dry period of about 5 months [29]. According to Pesaresi [35], the bioclimate is classificate as "Oceanic Pluviseasonal Mediterranean", with upper thermo-Mediterranean thermotype and lower sub-humid ombrotype.

Ecophysiological studies carried out on *S. ceratophylloides*: shown that the species has a very strong adaptive capacity to future climate change, and develops resilient forms of defence [36, 37].




**Figure 7.** Natural habitat of *Salvia ceratophylloides* Ard. a.) Mediterranean steppe: grassland with *Ampelodesmos mauritanicus* (Poir.) Dur. & Schinz.; b.) sands vegetation with *Artemisia campestris* subsp. *variabilis* (Ten.) Greuter; c.) garrigue characterised by *Cistus creticus* L. subsp. *creticus* and *Thymbra capitata* (L.) Cav.

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# **CHAPTER 3.** Analysis of the Population Structure and Dynamic of Endemic *Salvia ceratophylloides* Ard. (Lamiaceae)

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# Analysis of the Population Structure and Dynamic of Endemic *Salvia ceratophylloides* Ard. (Lamiaceae)

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**Abstract:** Understanding how changes of any origin interact with the structure and survival of entire populations is very important for the protection and conservation of threatened, rare and/or endemic species. In this study, structure and population dynamics of *Salvia ceratophylloides* Ard., a precious endemic species, belonging to the subgenus *Sclarea* (Moench) Benth., section *Plethiosphace* Benth. (Lamiaceae) exclusive to the suburban environments of Reggio Calabria (Southern Italy), was analysed. Interactions between this species and its different growth habitats were examined. Moreover, the disturbance factors which directly affect the demographic viability of the species, influencing its growth, reproduction and distribution in its distribution area were identified. From 2019 to 2021, a census by counting individuals of all the known stations, recorded according to a specific protocol, was carried out. The recorded data were statistically analysed and compared with those of the phytosociological surveys carried out using the Braun-Blanquet method and summarised in phytosociological classes, in accordance with the hierarchical floristic classification system of vascular plant communities, accepted at national and European levels. The structure of the different populations was also related to the different threat factors that afflict *S. ceratophylloides*. It was observed that the most structured populations of *S. ceratophylloides* were found in natural and semi-natural environments where the anthropogenic disturbance was minor, while populations with an irregular structure were found in sites exposed to disturbances of various origins. The different phytosociological classes do not interact directly on population structure. The most important factors affecting structure and distribution are disturbances of various origins, in particular anthropogenic and phytosanitary disturbances. In order to keep populations balanced and stable over time, it would be useful to adopt conservation measures for the species and the habitat in which they live, with practical solutions for the following: (a) to limit infestations by insects that parasitize stems and seeds; (b) to prevent mowing, fires, grazing and the introduction of invasive alien species.

**Keywords:** endemism; demography; population structure; conservation; Calabria; Southern Italy

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## 1. Introduction

A useful tool for the conservation and management of rare and threatened plant species is knowledge of the relationships between population dynamics, vegetation and habitat [1]. Managing the conservation of these populations requires a detailed understanding of the life cycle of the species under study and the temporal variations of "life stages" [2,3].

Critical phases in the life cycle of rare plants can be detected through the study of population dynamics [4–6]. These studies can highlight what factors interfere with, and influence, population trends, and whether these are related to threats to the species, the structure and composition of the surrounding vegetation or different management, control and land-use practices [7]. Through this analysis, it is possible to use a forecasting approach as to what the effects of ecological changes on threatened populations might be [1,8,9]. However, the laboriousness and the timelines associated with this type of study prevent their widespread use in conservation biology [10].

A faster method of conducting population analyses of perennial (herbaceous) plants is to analyse their structure in a single census. The structure of a population can be described by classifying individual plants by age and size, or by considering the different phenological stages of the individuals that compose a population, generally referred to as "life stages" [6,11].

Population dynamics are also strongly influenced by climate change, which, in recent years, is having very serious impacts on flora and fauna [12–16]. As a consequence of climate change, a distributional shift of plant species to higher altitudes and latitudes is expected. This will be almost impossible for rare and/or endemic taxa, which are tightly bound to a narrow ecological niche and exclusive to a specific range, which is very often fragmented [14,17–20]. In addition, a further threat is posed by alien species, which, finding favourable temperatures, rapidly expand their range, competing with native species and causing the loss of habitats that preserve rare and/or endemic species [21–24].

The Lamiaceae family is one of the biggest group of plants which have several properties due to their rich composition in essential oils, and are considered, for this reason, an important group of Medicinal Aromatic Plants (MAPs) [25,26]. They are also valued as ornamental plants, and as culinary and medicinal herbs, making them a group of exceptional ecological, ethnobotanical and floristic importance [27]. The genus *Salvia*, spread from the Far East through Europe to the New World, represents a cosmopolitan group with nearly 1.000 species, resulting in one of the largest genera belonging to this family [28]. It is present in the pharmacopoeia of many countries around the world, where it assumes a very important economic role; numerous species are used for medicinal, food, and ornamental purposes [29,30]. The genus *Salvia* has a very wide range, occurring in Central and South America with 500 spp., 250 spp. in Central Asia/Mediterranean and 90 spp. in East Asia [28]. According to European flora [31], the genus Salvia occurs in Europe with 36 species, 3 subspecies, 3 hybrids and 2 aliens. In a more recent work, Nikolova & Aneva [32], counted 39 species and 1 subspecies for Europe.

The Italian flora, to date, includes 28 species and 6 subspecies of the genus *Salvia*, of which 11 taxa allochthonous, and 22 native, of which 4 are endemic [33], these include *Salvia ceratophylloides* Ard., a rare endemism exclusive to the suburbs of Reggio Calabria (Southern Italy) (Figure 1). Hedge [31] and Nikolova & Aneva [32] do not recognize *S. ceratophylloides* as a separate species, considering it a synonym of *S. pratensis*. On the contrary, Pignatti [34,35] recognizes it as an endemic species, exclusive to southern Calabria.

*Salvia ceratophylloides* belongs to the subgenus *Sclarea* (Moench) Benth., section *Plethiosphace* Benth., characterised by a campanulate calyx, above two grooves, concave, with three conniving teeth and corolla with a crescent-shaped, compressed upper lip [36]. It is part of the *S. pratensis* group present in Italy with some entities: *S. pratensis* L. subsp. *pratensis*, *S. pratensis* L. subsp. *saccardina* (Pamp.) Poldini, *S. haematodes* L., *S. virgata* Jacq. and *S. ceratophylloides* Ard. [35]. Del Carratore and Garbari [36], in their study on the section *Plethiosphace*, report the following for Italy: *Salvia clandestina* L., *S. haematodes* L., *S. pratensis* L., *S. saccardiana* (Pamp.) Del Carr. and Garbari, *S. verbenaca* L., *S. virgata* Jacq., and considered *S. ceratophylloides* extinct, as it has not been found in recent decades.

Already in 1800 [37,38] this species was known in the Reggio Calabria area in several localities. Subsequent reports date back to the first two decades of the 20th century [39], when the species was considered extremely rare [40]. The profound environmental transformations undergone by the suburban area of Reggio Calabria, due to intense urbanisation and the devastating fires that ravage the territory, has brought about profound changes in the landscape with the reduction, degradation and disappearance of natural habitats. As a result, in the localities mentioned in the letter (Gallico Superiore, Terreti, Straorino, Ortì, Vito Superiore, Pietrastorta) [40] *S. ceratophylloides* was no longer found, despite searches by various botanists. So, in 1997, it was declared extinct and listed in the 'Red Book of the Flora of Italy' as 'Extinct in the Wild' (EW) [41]. Its extinction was confirmed by later authors who studied the genus *Salvia* in Italy [42] and by Scoppola and Spampinato [43] in the "Atlas of Endangered Species" of the Italian flora. Field research, however, made it possible

to find four micro-populations of the species at different locations (Puzzi and Cataforio) in 2008. The populations consisted of a few dozen breeding individuals and were about 10 km away from the populations previously reported in the literature [44]. Subsequent studies over time have made it possible to verify the presence of the species in other localities and to define its conservation status and taxonomic and ecological characteristics in relation to related species [19].




**Figure 1.** *Salvia ceratophylloides* Ard. (**a**) breeding individual (LG = Large Generative); (**b**) flower detail; (**c**) detail of strongly incised leaves.

The objective of this study was a careful census of the existing population in order to define the actual distribution and composition and the correlations between population distribution, vegetation and threats to the species' habitats. Understanding the interactions between populations and habitats, and how these may affect population dynamics and survival over time, is of fundamental importance in understanding the strategy to safeguard endangered taxa, especially when they are endemic.

## 2. Materials and Methods

### *1.1. Study Area*

The distribution area of *S. ceratophylloides* falls in southern Italy (South Calabria) and is entirely within the municipality of Reggio Calabria. Field research carried out between 2017 and 2021, ascertained the presence of the species in various localities (Puzzi fraz. di Gallina (Serro dei Morti and Serro d'Angelo), Mosorrofa (Serro Ciugna) and Mosorrofa Vecchio, Aretina (Serro della Cattina, Prai), San Todaro, Armo (Spilingari and Grotta di Sant'Arsenio). A total of 17 micro-populations are known to date, all distributed in the suburban periphery of Reggio Calabria (Figure 2).

Table 1 shows the climatic parameters of humidity, temperature and precipitation in the time range 1991–2021 and in the years 2019, 2020, 2021.

These climatic parameters do not affect the population trend of *S. ceratophylloides* and they did not change significantly over the 3 years of the survey; in fact, they remained within the average calculated over the 30-year period 1991–2021.

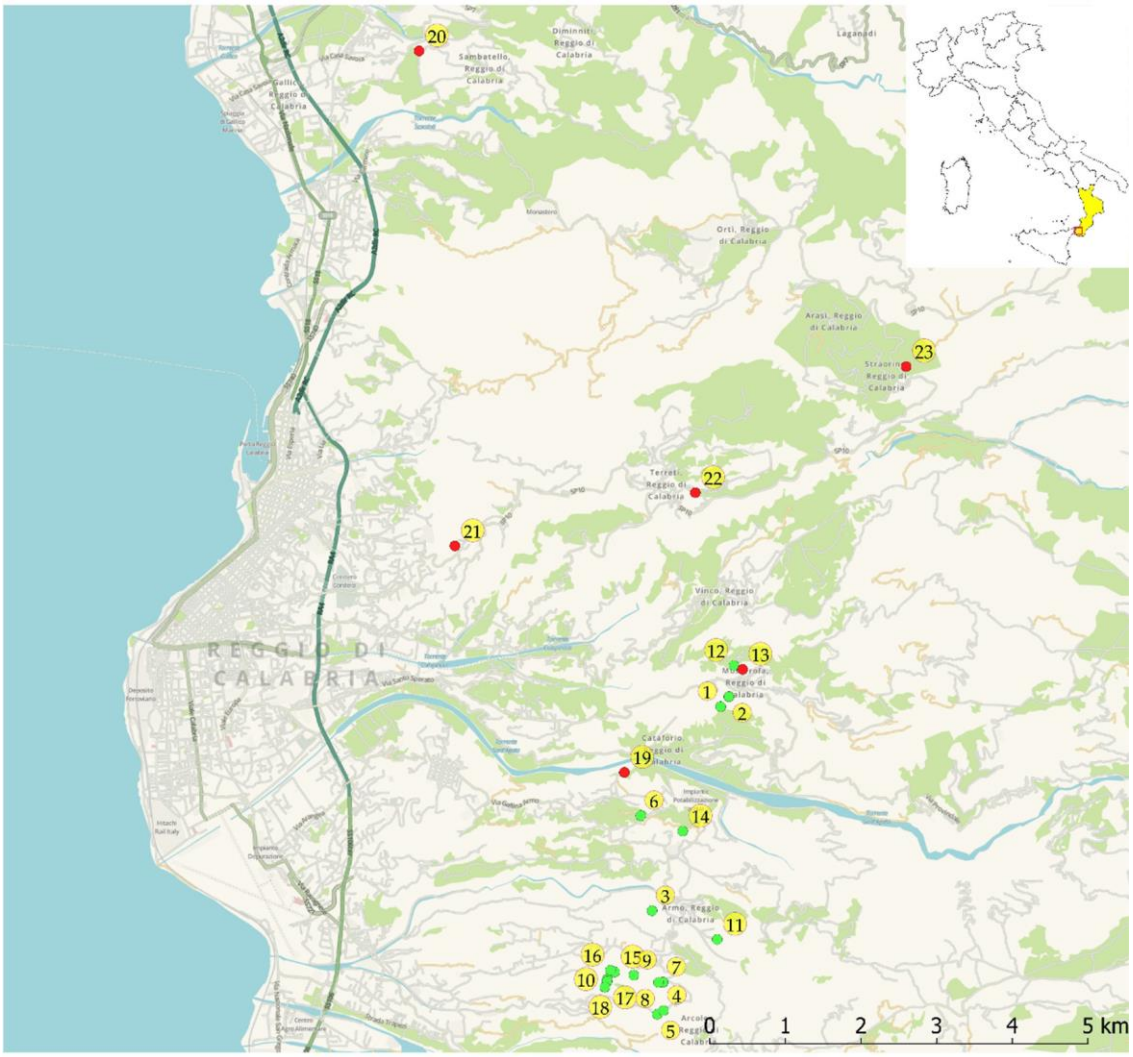



**Figure 2.** Distribution of *Salvia ceratophylloides* Ard. near Reggio Calabria (RC), Calabria region (S-Italy). In green are the micro-populations currently present, in red those that are extinct. 1—Serro Ciugna, Mosorrofa; 2—Serro Ciugna, Mosorrofa; 3—Spilingari, Armo; 4—Contrada S. Todaro, Aretina; 5—Contrada S. Todaro, Aretina; 6—Serro dei Morti, Puzzi fraz. di Gallina; 7—Prai, Aretina; 8—Prai, Aretina; 9—Aretina; 10—Aretina; 11—Grotta di S. Arsenio, Armo; 12—Mosorrofa vecchio; 13- Mosorrofa vecchio (exstinct in 2019); 14—Serro d'Angelo, Puzzi fraz. of Gallina; 15—Prai, Aretina; 16—Prai, Aretina; 17—Serro della Cattina, Aretina; 18—Serro della Cattina, Aretina; 19—Lutrà, Fiumara di Sant'Agata; 20—Galluzzi, Gallico Superiore; 21—Pietra Storta; 22—Croce Missionaria, Terreti; 23—Fontana Acqua Fresca, Straorino.

**Table 1.** Climatic parameters referred to Armo locality (Reggio Calabria) (these data were obtained from the NASA Langley Research Center (LaRC) POWER Project funded through the NASA Earth Science/Applied Science Program [45]).

| Parameter | 1991/2021 | 2019 | 2020 | 2021 |
|---|---|---|---|---|
| Specific Humidity at 2 Meters (g/kg) | 9.59 | 9.7 | 9.58 | 9.64 |
| Relative Humidity at 2 Meters (%) | 71.52 | 70.88 | 69.56 | 70.06 |
| Temperature at 2 Meters Maximum | 35.43 | 35.19 | 34.13 | 38.08 |
| Temperature at 2 Meters Minimum | 4.64 | 4.43 | 6.55 | 4.44 |
| Temperature at 2 Meters Range | 30.79 | 30.76 | 27.59 | 33.64 |
| Precipitation Corrected (mm/day) | 1.86 | 1.85 | 1.54 | 1.94 |
| Precipitation Corrected Sum (mm) | 609.68 | 606.45 | 511.52 | 706.65 |

The bioclimate of this area is typically Mediterranean Pluviseasonal [46] with average annual temperatures of 18 °C and average annual precipitations of about 600 mm, centralised in the autumn months of November and December. It is characterised by a summer dry period of about 5 months [19].

*Salvia ceratophylloides* grows at altitudes between 260 and 380 m a.s.l., on sandy substrates alternating with soft limestone beds of Pleistocene and Pliocene origin [47].

### *1.2. Population Analysis*

The population census was carried out for three consecutive years (2019–2020–2021), in June, using the protocol proposed by Hegland et al. [11], in a study on the population dynamics of *Salvia pratensis*, a species related to *S. ceratophylloides* in terms of biological and phenological characteristics. The census covered the entire current population of this endemic point species.

In order to facilitate the population census, the micro-populations of the species were subdivided into sub-areas with similar habitats, on which the count of individuals was carried out distinguishing the different "life stages" (Table S1). Micro-population 13, which had only one plant in 2018 [48], was omitted from the census because it became extinct in the following years.

In each sub-area, individuals were surveyed, distinguishing five "life stages" (Figure 3):

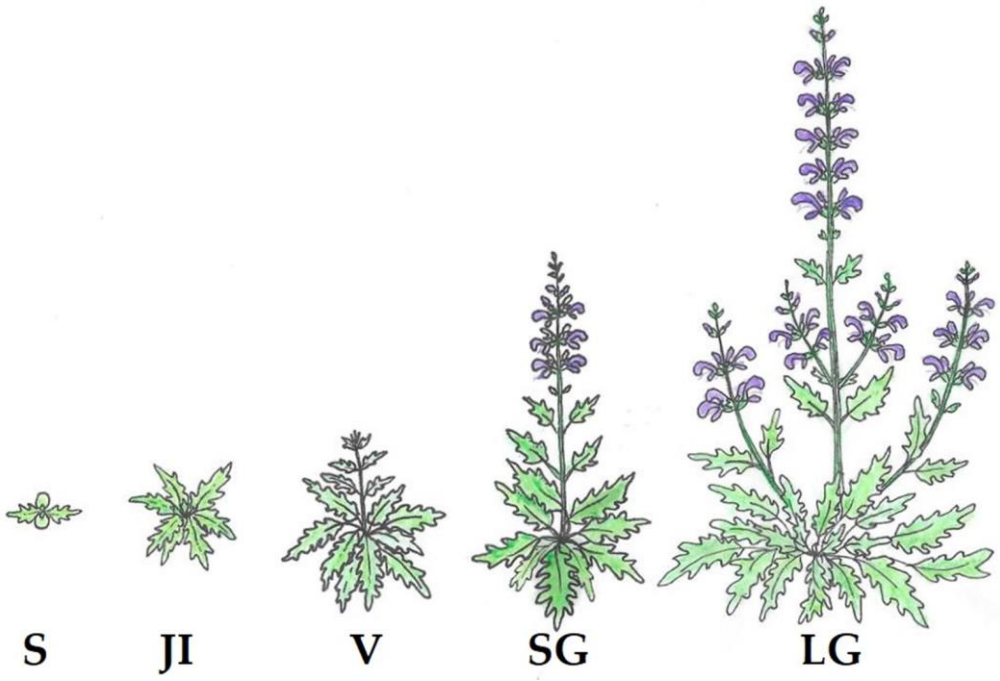



**Figure 3.** "Life stage" of *Salvia ceratophylloides* Ard. (S = seedling; JI = Juveniles/Immatures; V = Vegetative; SG = Small Generative; LG = Large Generative). Life stages are according to [11], the original pictures have been drawn by V.L.A. Laface.

S = Seedlings, with cotyledons and one/two main leaves.

JI = (J) Juveniles with two/three pairs of leaves and (I) Immature plants with three/four pairs of leaves. In Hegland et al. [11] these two "life stages" are considered distinct: in this work it was preferred to unify the data, since for *S. ceratophylloides* it is impossible to distinguish the two phenological stages as described for *S. pratensis.*

V = Vegetative adults with at least five pairs of leaves.

G = Generative adults having one to five flowering stems up to 50 cm high. Within the G category, two size sub-classes have been distinguished: SG = Small Generative adults with one or two flowering stems; LG = Large Generative adults with more than two flowering stems, usually the largest individuals are also the oldest (3–4 years old).

In each sub-area, the population density and the increase and decrease over the 3 years of the survey were estimated using the Malthusian exponential growth model [49].

$$N_t = N_0 e^{rt}$$

where:

$N_0$ is the number of individuals at time zero (No. of individuals in 2019);
$N_t$ is the number of individuals after a certain time interval (No. Individuals in 2021);
$e$ is the Euler number;
$r$ is the intrinsic population growth rate for each individual and for each unit of time considered (the difference between births and deaths in the unit of time);
$t$ is the time from $t_0$ to the year considered.

In particular:

$$r = \ln(R)$$

$R$ is the net fundamental growth rate per capita, and indicates the average contribution of each initial individual to the population after the time interval has elapsed. It integrates both the survival of individuals and the birth rate, referred to the time interval.

$$R = N_0/N_t$$

In order to assess future population trends, assuming constant ecological and environmental conditions, the variations (increase or decrease) of the different population types revealed by cluster analysis were estimated over a five-year period.

### *1.3. Habitat Characterisation and Georeferencing*

In order to characterise the habitat of *S. ceratophylloides* in each micro-population, ecologically and physiognomically homogenous sub-areas were identified, on which vegetation analysis was carried out using the phytosociological method [50–52].

Taxa nomenclature is according to Bartolucci et al. [53] and the relevant updates in the Portale della Flora d'Italia [33].

For each species, the relevant phytosociological class was considered in accordance with Mucina [54] and the Prodromo alla Vegetazione d'Italia [55].

All micro-populations of *S. ceratophylloides* were uniquely recorded, georeferenced and entered into a shapefile processed with QGIS 2.18.7® (OSGeo, Beaverton, OR, USA) (Figure 2).

### *1.4. Pressures and Threats*

For each sub-area, the pressures and threats acting on the habitat were analysed and coded according to the "Reference list Threats, Pressures and Activities" by Salafsky et al. [56], modified by the European Environment Information and Observation Network (EIONET) [57]. The different threats were estimated in relation to their importance: low (L), medium (M) or high (H). In order to quantify the pressures, the importance values were expressed numerically (1 = low L; 2 = medium M, 3 = high H) (Table S3).

### *1.5. Statistical Analysis*

Data on population structure, threats and vegetation were entered into matrices using Microsoft Excel© 2019 (Microsoft Corporation, Redmond, WA, USA). For statistical analyses, three-year averages of the data were calculated and transformed into percentages. The life stage data of each sub-area were used to analyse the degree of similarity by means of hierarchical cluster analysis with the group average method (UPGMA), chord distance for ratio scale data, and K-means clustering [58]. The Past 4.10© software (Hammer, Oslo, Norway) [59] was used for both statistical analyses. The population groups that the cluster highlighted in relation to the "life stage" ratios, in accordance with Hegland et al. [11] and Oostermeijer et al. [60], can be defined as "Dynamic", characterised

by high ratio [(S + JI + V)/G] between breeding and non-breeding individuals, "Normal", with a balanced ratio between breeding and non-breeding and "Regressive", with a low ratio between breeding/non breeding. Sub-areas with a very small number of individuals (>10) occupying areas of less than 10 $m^2$ were excluded from the statistical analysis as they were not significant.

To measure the strength of the relationships between the different "life stages" in relation to pressures and vegetation, the correlation coefficient was calculated using Microsoft Excel© 2019 software: this value is between +1 and−1, indicating a positive (+1) or negative (−1) correlation between the matrices. In the linear regression, the different "life stages" were used as dependent variables and the different pressures as independent variables.

The equation for calculating the correlation coefficient is:

$$Correl\ (X,Y) = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}}$$

where: $\bar{x}$, $\bar{y}$ are the mean values of the first matrix ("life stage") and mean values of the second matrix (threats; vegetation) of the sample mean.

For the correlation value, the linear regression test was carried out for all parameters considered previously, using the least squares method; this processing was also carried out using Microsoft Excel© 2019 software.

The equation defining the linear correlation is as below:

$$Y_i = \beta_0 + \beta_i X_i + \varepsilon$$

where: $i$ is the number of observations, $Y_i$ is the dependent variable (which in our case coincides with the different "life stages"), $X_i$ is the independent variable (which coincides with threats or vegetation),

$$\beta_0 + \beta_i X_i$$

is the regression function where: $\beta_0$ is the intercept of the regression line (it represents the value of $Y$ when $X$ is equal to 0), $\beta_i$ represents the gradient of the line (it is the angular coefficient of the regression line i.e., the rate of change of $Y$ when $X$ changes). $\varepsilon$ is the stochastic error and represents the difference between the actual value of a dependent variable and its predicted value.

The residuals obtained from the linear regression analysis were analysed graphically by constructing Q-Q plots (quantile-quantile graphs), which made it possible to verify their normally distributed trend in order to obtain confirmation of the validity of the linear regression model.

Co-occurring data on plant species cover (excluding *S. ceratophylloides* and those species found to be less frequent in the surveys) were analysed by Detrended Correspondence Analysis (DCA) [61] using R© software (Foundation for Statistical Computing, Vienna, Austria).

## 3. Results

### *1.6. Population Structure*

The census (Table S1) showed that the population of *S. ceratophylloides* is currently fragmented into 17 micro-populations (census 2021), subdivided into 40 sub-areas, each consisting of 1 individual up to a maximum of 401, for a grand total of 1555 plants.

The number of individuals present in each sub-area was not constant over time. As shown in Figure 4, there were more numerous micro-populations with >60 individuals (5B, 6A, 6B, 6C, 7B, 10) that showed an increasing trend. Conversely the less numerous micro-populations with >20 individuals (1A, 1B, 2A, 3A, 4, 5A, 11B, 11C, 11D, 11E, 11F, 11G, 11H, 11I, 12A, 14A, 15A, 16, 17) were more fluctuating, as were those with a small number of individuals >10 (2B, 2C, 3B, 6D,6E, 6F, 6G, 7A, 8, 9, 11A, 12B, 15B, 18). For the population 6G, the rate of increase/decrease was calculated with reference to the years 2020–2021 as

the sub-area did not exist before. Moreover, this sub-area maintained a constant number of individuals over the two years. Sub-area 2C, on the other hand, was extinct, as no individuals were recorded in 2021.

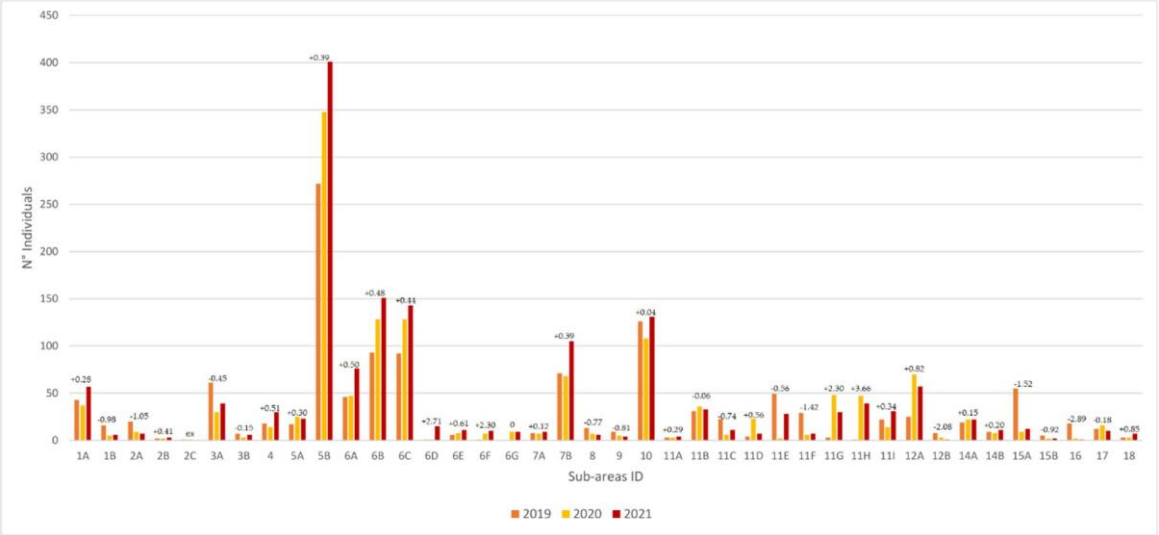



**Figure 4.** Development of the *Salvia ceratophylloides* Ard. population census in the 40 sub-areas from 2019 to 2021. The Malthus increase-decrease index (r) [49] is reported for each sub-area.

The total number of individuals for each sub-area in the three different years ranged from a minimum of 1 to a maximum of 272 in 2019, for a total of 1242 individuals, from 1 to 348 in 2020, for a total of 1317 individuals, and from a minimum of 1 to a maximum of 401 in 2021 (Table S1). The distribution of the different "life stages" also varied from year to year. "Life stage" S represented 1% of the population and remained constant in all three survey years. "Life stage" JI constituted 5% of the individuals surveyed in 2019 and 2020, while in 2021 it represented 10 % of the individuals with an increase of 5%. "Life stage" V increased gradually year on year, from 20% in 2019, to 25% in 2020, to 31% in 2021. The more generative "life stages" SG and LG tended to decrease over time: SG in 2019 represented 43% of the population, in 2020 39% and in 2021 37%, while LG was 31% in 2019, 30% in 2020, and 21% in 2021 (Figure 5).

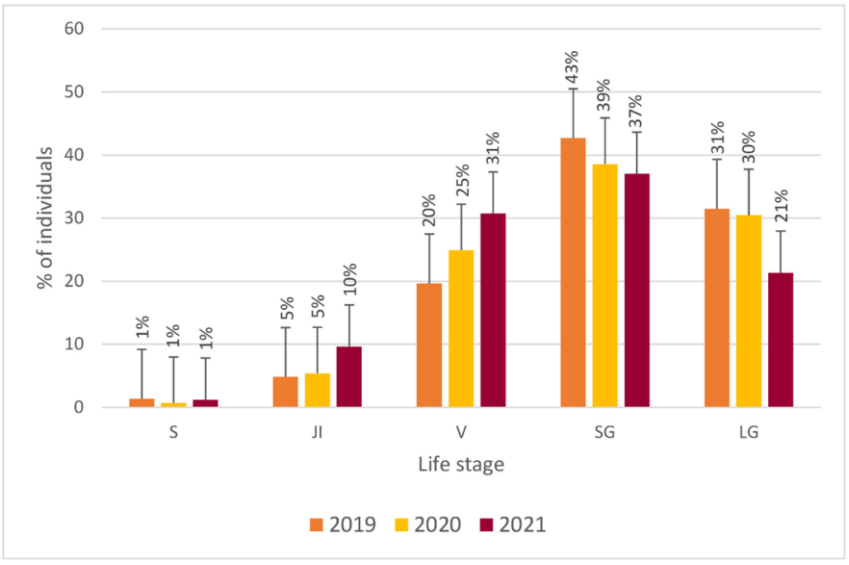



**Figure 5.** Distribution (%) of "life stages" of *Salvia ceratophylloides* Ard. between 2019, 2020 and 2021 (Error bars represent standard deviations).

To confirm the previous results, the population density was estimated in relation to total individuals, distinguishing them as non-breeding and breeding individuals in the 3 different years in relation to the areas considered for each sub-area (TableS1).

The graph (Figure 6) shows that the different sub-areas had different population densities in different years. Some of the sub-areas showed an increasing trend (1A, 2B, 4, 5A, 5B, 6A, 6B, 6C, 6E, 6F, 7A, 7B, 10, 11A, 11B, 11I, 12A, 14A, 14B, 18), others showed a decreasing trend (1B, 2A, 2C, 3A, 3B, 8, 9, 11C, 12B, 17) and some had strong fluctuations from year to year, being those most directly impacted by human activities (6D,11E, 11F, 11G,11H,15A, 15B, 16). Sub-area 6G (discovered in 2020) was constant over the years.

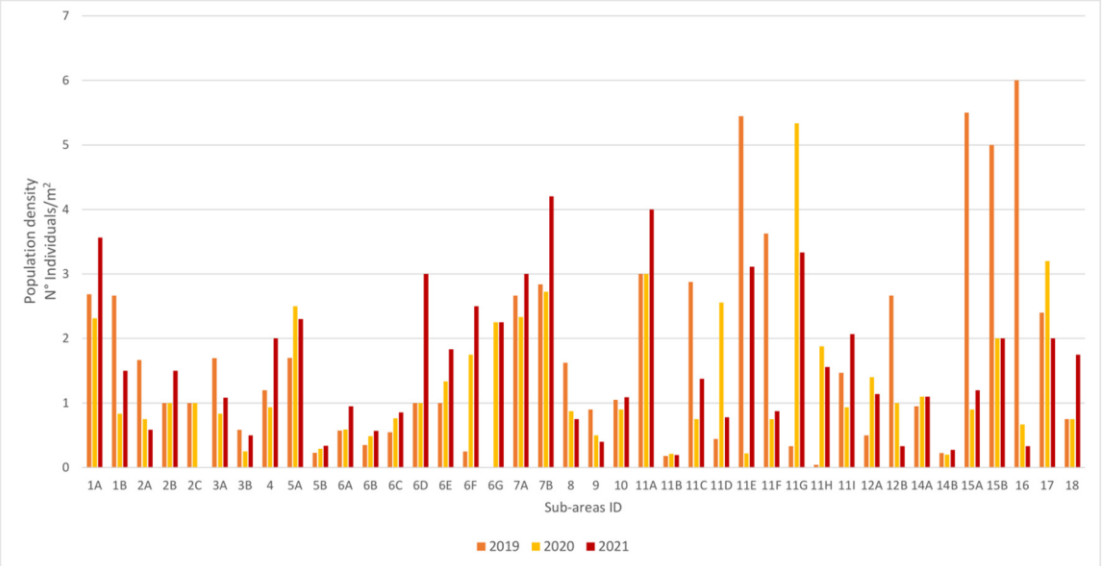



**Figure 6.** Population density of *Salvia ceratophylloides* Ard. in the 40 sub-areas analysed from 2019 to 2021.

The graph of average numbers of individuals/area of the sub-areas over the three years (Figure 7) shows that as the area increased, the number of individuals increased, with a maximum of 340 individuals over an area of 1200 $m^2$ in sub-area 5B.

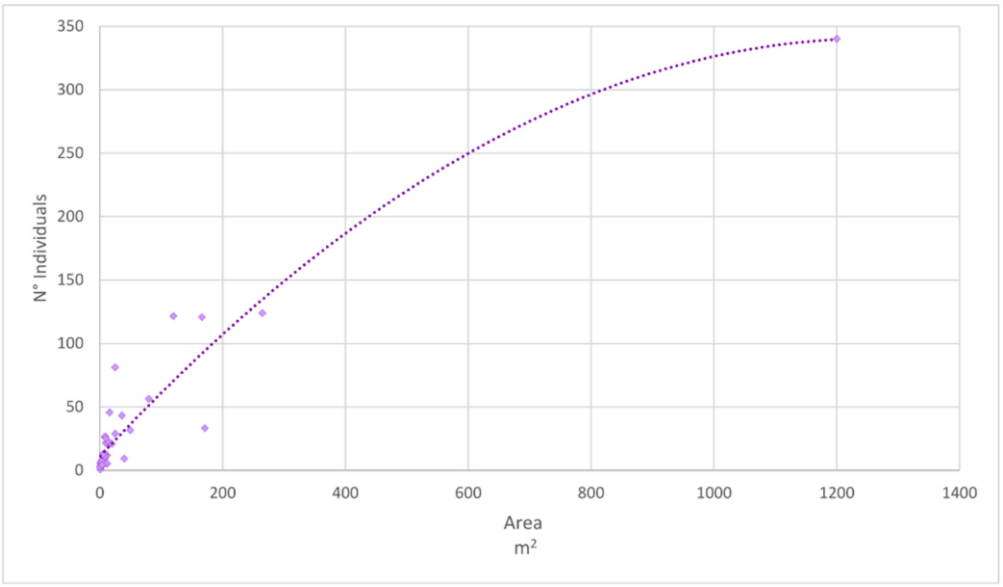



**Figure 7.** Average number of individuals of *Salvia ceratophylloides* Ard. per sub-area over the three years.

Analysing the variations in the density of non-breeding individuals over the three years (Figure 8) showed extreme variability. Only in a few micro-populations was a constant density observed (1A, 3A, 5A, 5B, 7B, 11D, 11F, 14A, 14B). In many sub-areas, years in which non-breeding individuals were not present alternated with years in which they suddenly appeared (1B, 2A, 2B, 3B, 4, 6A, 6D, 6E, 7A, 11C, 11E, 11G, 12B, 16, 17, 18). Non-breeding individuals were not present in sub-areas 2C, 11A AND 15B.

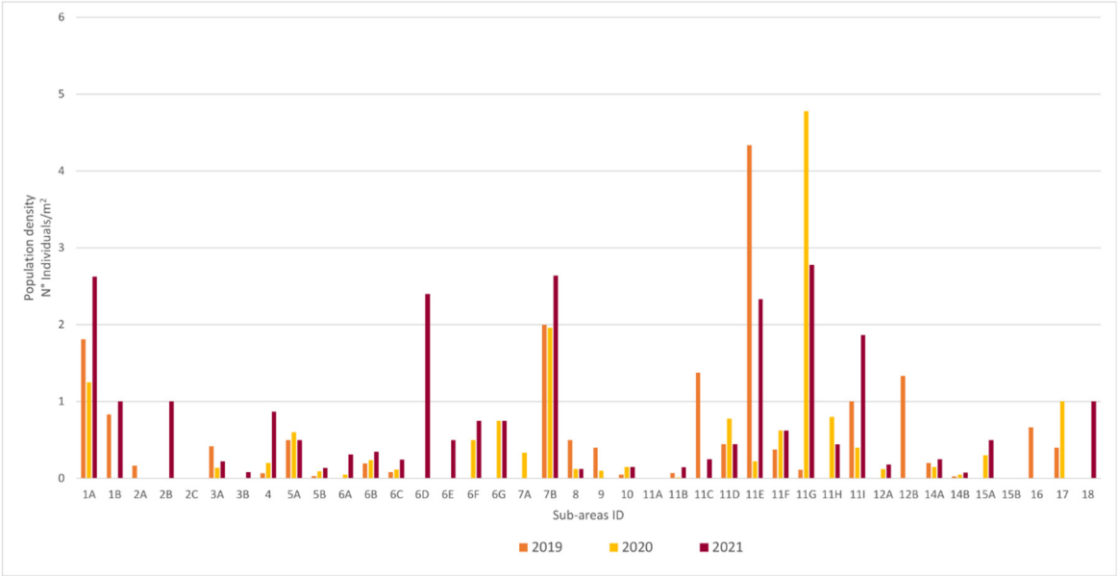



**Figure 8.** Variation in the density of non-breeding individuals of *Salvia ceratophylloides* Ard. in the sub-areas over the three years.

On the other hand, if we consider the variation in density of breeding individuals over the three years (Figure 9), we can observe that in many sub-areas there was a limited fluctuation in density (1A, 1B, 2A, 2B, 3A, 3B, 4, 5A, 5B, 6A, 6B, 6C, 6D, 6E, 6F, 7A, 7B, 8, 9, 10, 11A, 11B, 11C, 11G, 11I, 12A, 12B, 14A, 14B, 17, 18), while in some sub-areas (2C, 11D, 11E, 11F, 11H, 15A, 15B, 16) a strong fluctuation was observed, similar to what was observed for the total density.

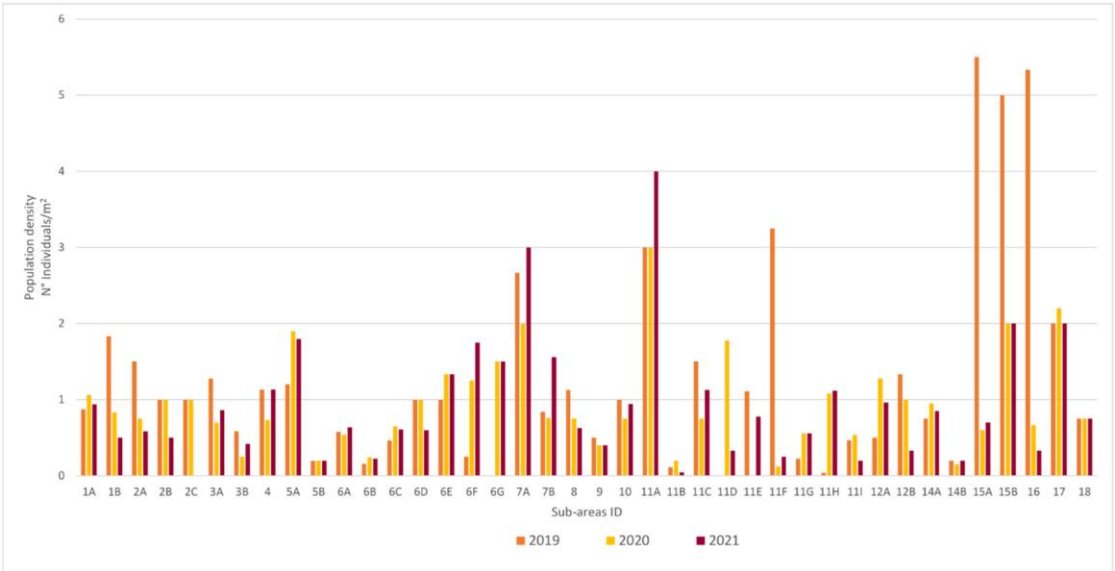



**Figure 9.** Variation in the density of breeding individuals of *Salvia ceratophylloides* Ard. in the sub-areas over the three years.

The cluster analysis of the "life stage"/number of individuals matrix highlighted the dissimilarity between different sub-areas. This aggregation revealed three groups of population types (Figures 10 and 11). To define the significance of the three different groups, the ratio of non-breeding juvenile stages to breeding adult stages was taken into account [(S + JI + V)/G], with G = (SG + LG).

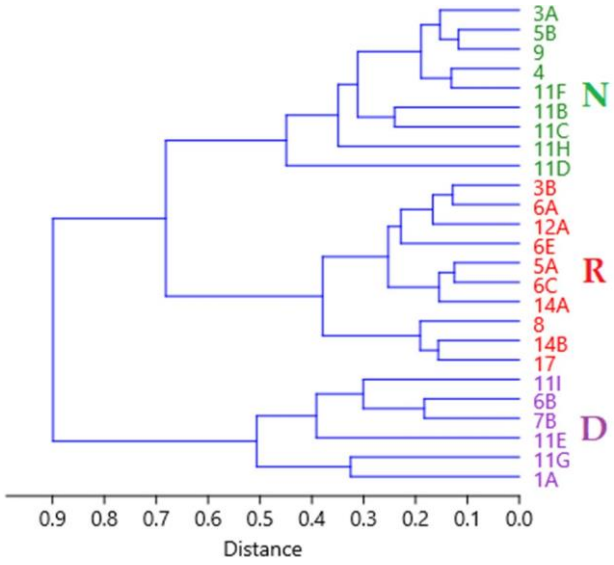



**Figure 10.** Dendrogram of population classification related to "life stage" of *Salvia ceratophylloides* Ard. The abbreviations refer to the sub-areas shown in Table S1. In green, populations classified as "Normal"—N; in red, "Regressive"—R; in purple, those classified as "Dynamic"—D.

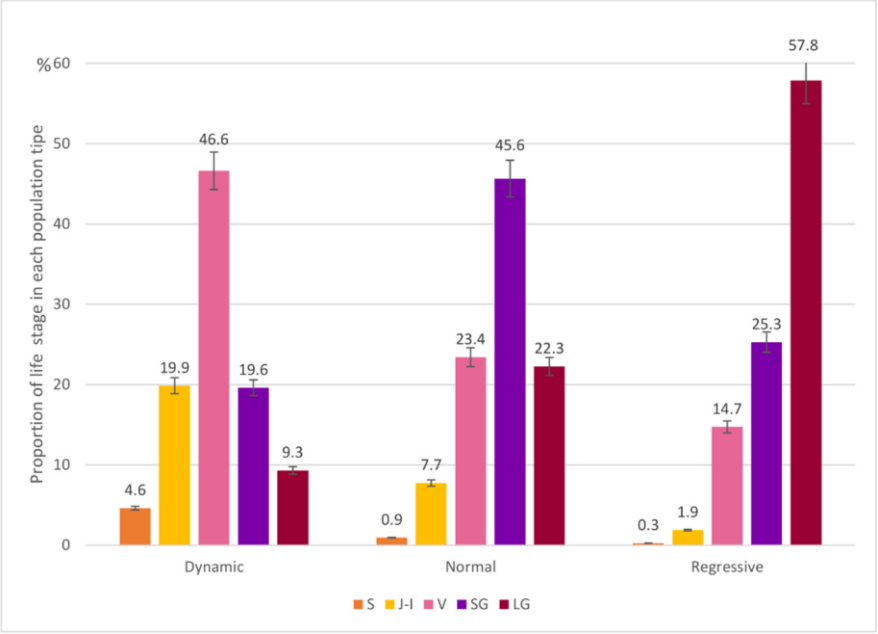



**Figure 11.** Population structure of *Salvia ceratophylloides* Ard. Three population types ("Dynamic", "Normal" and "Regressive") were distinguished in accordance with clustering analysis. The percentage of individuals in relation to the total population type is given for each "life stage". Error bars represent standard deviations.

The sub-areas of the first group were clearly distinct from the others and could be defined as "Dynamic", in accordance with [11], as they were characterised by a higher number of non-breeding juveniles than breeding ones. In fact, this group was characterised

by a relatively high [(S + JI + V)/G] ratio, with an average of 2.91 and a range of 1.25 to 5.75. The average of young individuals was 71.1%, of which 46.6% were represented by "life stage" V, 19.9% by JI and 4.6% by S (Figure 11).

The second group was characterised by sub-areas with fewer non-breeding juveniles than the previous group, and instead had a higher number of breeding individuals. The ratio [(S + JI + V)/G] averaged 0.49 and ranged from 0.27 to 0.79. "Life stages" were represented by 32.1% non-breeding individuals and 67.9% breeding individuals, of which 45.6% belonged to "life stage" SG. This group could be defined as "Normal" or "Stable" according to [60] (Figure 11).

The third group was represented by aged sub-areas, characterised by a higher presence of SG and LG breeding individuals, corresponding to 83.1% of the entire population, of which the majority belonged to the "life stage" LG (58%). Very few young non-breeding individuals were present in this group, making up 16.9% of all the sub-areas, of which 14.7% belonged to "life stage" V, 1.9% J-I and only 0.3% from S. The ratio [(S + JI + V)/G] had an average value of 0.21 and ranged from 0.07 to 0.30. In relation to the analysed factors, this group could be defined as "Regressive" in accordance with [60] (Figure 11).

Overall, "Regressive" populations accounted for 40% of the entire population, while "Normals" made up only 36% and "Dynamics" 24%.

### *3.2. Relationships between "Life Stages" and Pressures*

The field surveys made it possible to determine the pressure factors and the intensity with which they affected the different sub-areas of the *S. ceratophylloides* population (Table S4), detailed in Table 2.

**Table 2.** Pressures observed on the population of *Salvia ceratophylloides* Ard. The abbreviations of the sub-areas refer to Table S1. The intensity of the pressures is expressed in H = high; M = medium; L = low.

| **Sub Aree** | | **1A** | **6B** | **7B** | **11E** | **11G** | **11I** | **3A** | **4** | **5B** | **9** | **11B** | **11C** | **11D** | **11F** | **11H** | **3B** | **5A** | **6A** | **6C** | **6E** | **8** | **12A** | **14A** | **14B** | **17** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Population Tipe** | | **Dynamic** | | | | | | | | | | **Normal** | | | | | | | | | | | | | **Regressive** | |
| **Threats Code** | **Threats Name** | | | | | | | | | | | | | | | | | | | | | | | | | |
| A08 | Mowing or cutting of grasslands | | | | L | L | L | | | | | L | L | L | L | L | L | | | | | | | L | L | |
| A10 | Extensive grazing or undergrazing by livestock | | | | | | | | L | | L | | | | | | | | | L | L | | | | M | M |
| A11 | Burning for agriculture | H | | | | | | | | | | | | | | | | | | | | | | | L | L |
| A15 | Tillage practices in agriculture | | | H | | | | | | | | | | | | | | | | | L | | M | | L | L | M |
| F07 | Sports, tourism and leisure activities | | | | H | H | H | | | | | | H | H | H | H | H | | | | | | | | | | |
| I01-I02 | Invasive alien species of Union/not Union concern | M | M | | L | L | | | | | | | L | L | L | L | M | | | | | | L | | H | L | M | L |
| L06 | Interspecific faunal and floral relations (competition, predation, parasitism, pathogens) | H | H | H | M | | | | M | | | M | M | | | | | | | M | | H | H | | H | M | M | L |
| M05 | Collapse of terrain, landslide | | | | | | | | | | | | | | | | | | | L | | | | | | | | |

Linear regression analysis showed the effect of pressures acting in sub-areas in relation to different "life stages" (Table 3). The youngest "life stages" S-JI were positively correlated with mowing and recreational tourism activities (A08 $R^2 = 0.43$, $p = 0.03$; F07 $R^2 = 0.58$, $p = 0.003$) and negatively with grazing (A10 $R^2 = -0.40$, $p = 0.05$). Vegetative stages V were positively correlated with recreational tourism activities (F07 $R^2 = 0.352$, $p = 0.08$). Breeding

"life stages" SG-LG were positively correlated with grazing (A10 $R^2 = 0.395$, $p = 0.05$) and negatively with mowing (A08 $R^2 = 0.395$, $p = 0.05$).

**Table 3.** Linear regression analysis between "life stage" and pressure ($R^2$—correlation value; $p$—level of significance).

| Life Stage | Threats | $R^2$ | $p$ | Sign. |
|---|---|---|---|---|
| S-JI | A08 | 0.434 | 0.03 | ** |
| | F07 | 0.576 | 0.003 | ** |
| | A10 | −0.403 | 0.046 | ** |
| V | F07 | 0.352 | 0.08 | * |
| SG-LG | A08 | −0.343 | 0.09 | * |
| | F07 | −0.523 | 0.01 | ** |
| | A10 | 0.395 | 0.05 | * |

$p \leq 0.1$, * < 0.05, ** < 0.01.

The Q-Q plot (Quantiles-Quantiles graph) graphically demonstrated an effective normal distribution of the data, validating the hypotheses obtained from the linear regression analysis, as shown in Figure 12.

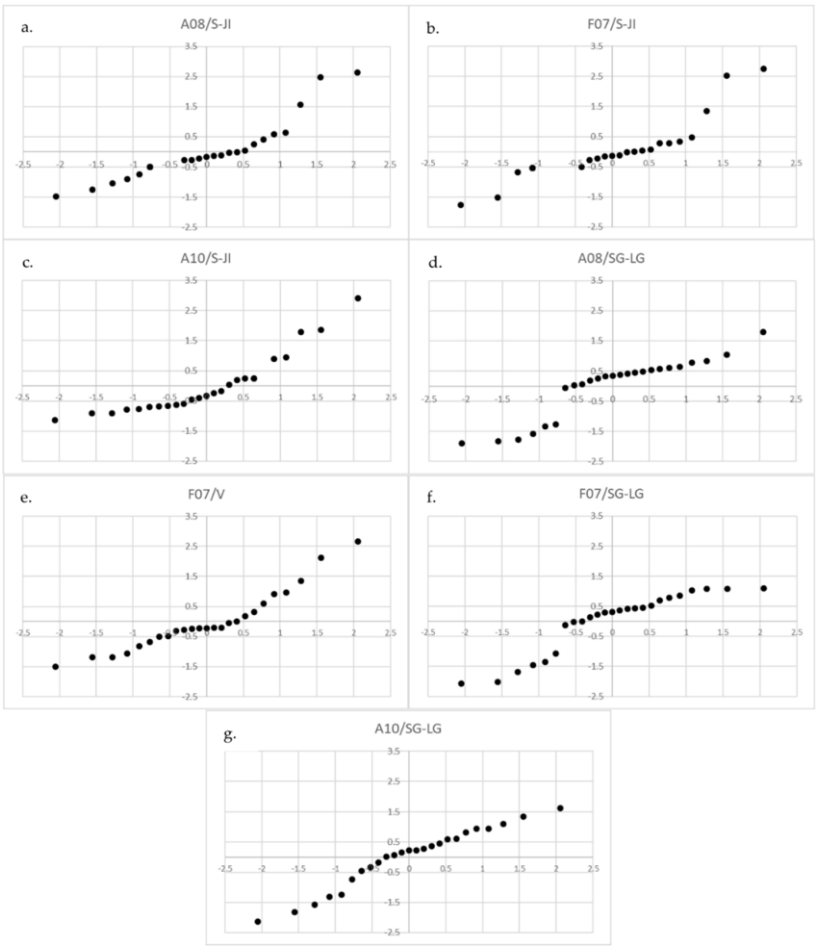



**Figure 12.** Q-Q plot, with graphic representation of the actual normal distribution of the data for the different "life stages" and pressures examined of *Salvia ceratophylloides* Ard. Only data found to be significant in the linear regression analysis were analysed (as in Table 3). (**a**) Q-Q plot pressure A8, "life stage" S-JI; (**b**) Q-Q plot pressure F07, "life stage" S-JI; (**c**) Q-Q plot pressure A10, "life stage" S-JI; (**d**) Q-Q plot pressure F07, "life stage" V; (**e**). Q-Q plot pressure A8, "life stage" SG-LG; (**f**) Q-Q plot pressure F07, "life stage" SG-LG; (**g**) Q-Q plot pressure A10, "life stage" SG-LG.

### 3.3. Relationships between "Life Stage" and Vegetation

The relationship between three different population types, resulting from the cluster analysis and the vegetation surveyed with the phytosociological methodology, was examined using DCA (Figure 13). The geometric distance on the diagram reflects the difference between the surveys. Examining the positions of the species on the diagram in relation to the 3 different population groups resulting from the previous analyses ("Dynamic", "Normal", "Regressive") we can see some significant differences. The Eigenvalues for the four axes of the DCA were 0.808, 0.604, 0.341 and 0.219, respectively. Since Jongman et al. [62] believe that axes with Eigenvalue values less than 0.5 should not be considered, as they do not express a relevant floristic gradient, only the first axis (DCA Axis1) and the second (DCA Axis2) can be considered representative of the main floristic gradient.

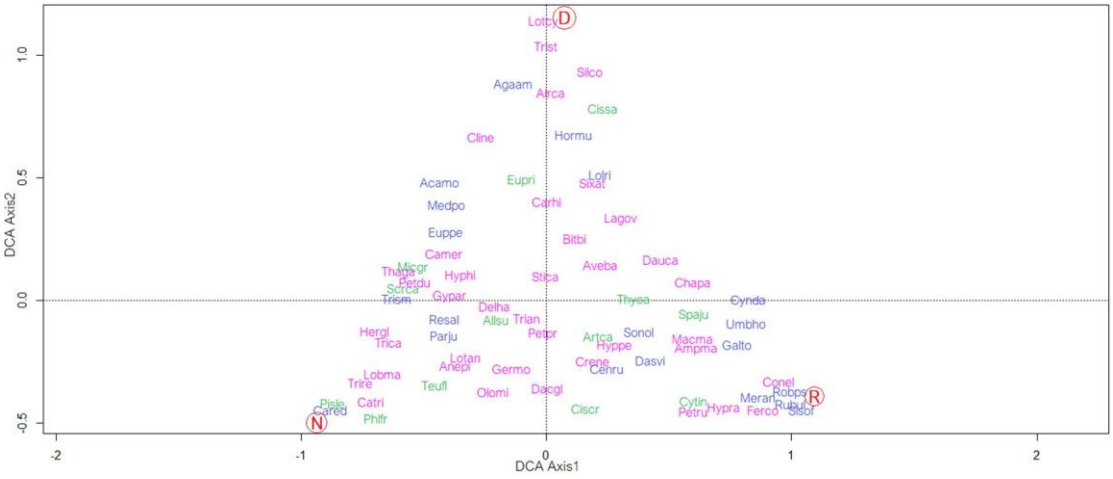



**Figure 13.** Detrended Correspondence Analysis (DCA), indicates the distribution of the different population types of *Salvia ceratophylloides* Ard. (N = Normal; R = Regressive; D = Dynamic) and the position of co-occurring plant species whose relative abbreviations refer to Table S2. The colours of the species correspond to: Blue = Synanthropic; Green = natural; Purple = semi-natural.

The number of species is higher in the "Normal" populations, ranging from a minimum of 17 to a maximum of 70, with an average of 43 species in all the sub-areas examined. The "Dynamic" populations presented a minimum of 15 and a maximum of 60 species, with an average value of 42.5. Species in the "Regressive" populations were scarcely numerous, with a minimum of 18 and a maximum of 34, the mean value being 28 species (Table4).

**Table 4.** Maximum and minimum number of species present in the surveys of the different types of populations of *Salvia ceratophylloides* Ard. ("Normal", "Dynamic", "Regressive").

| Population Typology | Min. Species | Max. Species | Mean |
|---|---|---|---|
| Normal | 17 | 70 | 43 |
| Dynamic | 15 | 60 | 42.5 |
| Regressive | 18 | 34 | 28 |

*Anemone hortensis* L. subsp. *hortensis*, *Arenaria leptoclados* (Rchb.) Guss. subsp. *leptoclados*, *Asparagus acutifolius* L., *Asparagus albus* L., *Eudianthe coeli-rosa* (L.) Fenzl ex Endl., *Euphorbia peplus* L., *Hippocrepis ciliata* Willd., *Lysimachia arvensis* (L.) U.Manns & Anderb. subsp. *arvensis*, *Orchis italica* Poir., *Petrosedum tenuifolium* (Sm.) Grulich, *Plantago albicans* L., *Poa trivialis* L., *Rumex bucephalophorus* L. subsp. *bucephalophorus*, *Senecio leucanthemifolius* Poir., *Trigonella italica* (L.) Coulot & Rabaute, *Verbena officinalis* L. are only present in "Dynamic" populations.

*Rumex pulcher* L., *Seseli tortuosum* L. subsp. *tortuosum*, *Andropogon distachyos* L., *Echium vulgare* L. subsp. *pustulatum* (Sm.) Em. Schmid & Gams, *Linaria purpurea* L., *Onopordum*

*illyricum* L. subsp. *illyricum*, *Pteridium aquilinum* (L.) Kuhn subsp. *aquilinum*, *Scolymus hispanicus* L., *Silene gallica* L., *Solanum nigrum* L., *Verbascum thapsus* L. subsp. *thapsus*, *Vinca major* L. subsp. *major*, *Viola odorata* L. are exclusive to "Natural" populations.

*Ailanthus altissima* (Mill.) Swingle, *Anredera cordifolia* (Ten.) Steenis, *Brassica fruticulosa* Cirillo subsp. *fruticulosa*, *Calendula arvensis* (Vaill.) L., *Convolvulus althaeoides* L., *Lolium perenne* L., *Oloptum thomasii* (Duby) Banfi & Galasso, *Plantago lanceolata* L., *Silene vulgaris* (Moench) Garcke subsp. *tenoreana* (Colla) Soldano & F.Conti, *Crupina crupinastrum* (Moris) Vis., *Jasione montana* L., *Papaver rhoeas* L., *Opuntia ficus-indica* (L.) Mill. are exclusive to "Regressive" populations.

The taxa present in the vegetation surveys belonged to 16 phytosociological classes. Of these, 4 brought together vegetation from natural habitats, 5 semi-natural, 7 synanthropic (Tables S2 and S3).

In relation to the phytosociological classes, the populations showed a different distribution (Figure 14). The class *Chenopodietea* was the most represented, with a coverage value of 25% in the "Dynamic", 18% in the "Normal" and 18% in the "Regressive" populations.

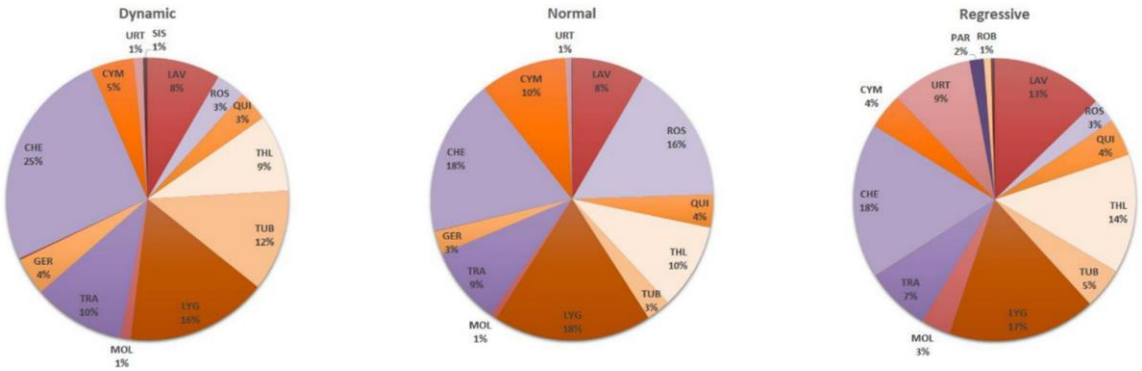



**Figure 14.** Coverage percentages of the different phytosociological classes in relation to population types: "Dynamic", "Normal", "Regressive". ART—*Artemisietea vulgaris*; CHE—*Chenopodietea*; LAV—*Cisto-Lavanduletea stoechadis*; CYM—*Cymbalario-Parietarietea diffusae*; URT—*Galio aparines-Urticetea maioris*; TUB—*Helianthemetea guttati*; LYG—*Lygeo sparti-Stipetea tenacissimae*; MOL—*Molinio-Arrhenatheretea*; ROS—*Ononido-Rosmarinetea*; PAR—*Papaveretea rhoeadis*; QUI—*Quercetea ilicis*; ROB—*Robinietea*; SIS—*Sisymbrietea*; TRA—*Stipo-Trachynietea distachyae*; THL—*Thlaspietea rotundifoliae*; GER—*Trifolio-Geranietea sanguinei* (for class descriptions see Table S3).

The other most represented classes were the following: *Lygeo sparti-Stipetea tenacissimae*, with a coverage value of 16% in the "Dynamic", 18% in the "Normal" and 17% in the "Regressive" populations; *Cisto-Lavanduletea stoechadis*, with a coverage value of 8% in the "Dynamic" and "Normal" populations and 13% in the "Regressive" populations; *Thlaspietea rotundifoliae*, with a coverage value of 8% in the "Dynamic" and "Normal" populations and 14% in the "Regressive" populations; *Galio aparines-Urticetea dioicae*, with a cover value of 6% in "Dynamic" populations, 10% in "Normal" populations and 13% in "Regressive" populations; *Stipo-Trachynietea distachyae*, with a cover value of 7% in" Dynamic" populations, 8% in "Normal" populations and 5% in "Regressive" populations. The other phytosociological classes had very low coverage values, and, in particular, the species of the class *Helianthemetea guttati* presented a coverage value of 12% for the "Dynamic" populations, while having very low values for the "Normal" (3%) and "Regressive" (5%) populations. Species of the class *Ononido-Rosmarinetea*, had higher cover values in "Normal" populations (16%) while they were sporadic in "Dynamic" and "Regressive" populations. Alien species of the class *Robinietea* were scarcely present (1%) only in the "Regressive" populations.

Taking into consideration the habitats (natural, semi-natural and synanthropic) to which the vegetation classes refer (Figure 15), it can be seen that the "Dynamic" populations presented a greater number of species linked to semi-natural habitats (44%) and synanthropic species (32%). The "Normal" populations predominantly presented species typical

of natural habitats (38%), with fewer species linked to semi-natural habitats (33%) and synanthropic species (29%). Regarding the "Regressive" populations, the species belonging to the three habitats were distributed almost equally.

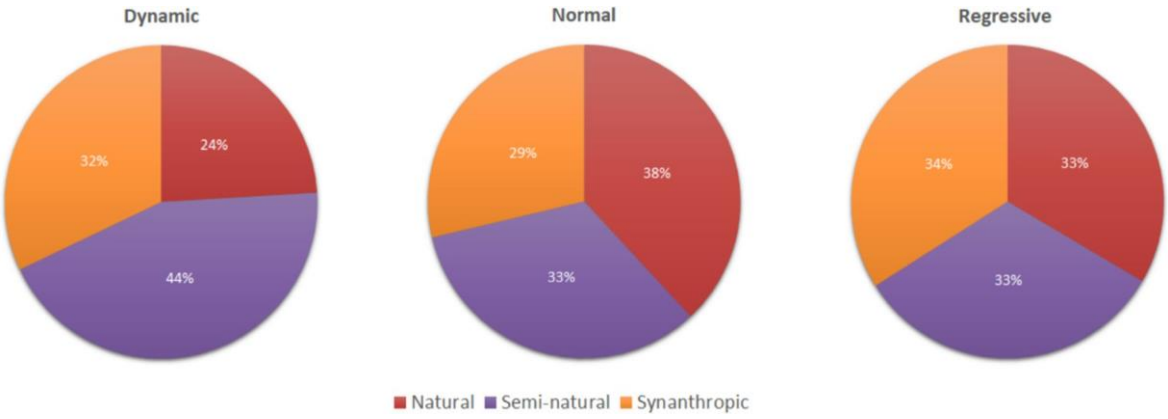



**Figure 15.** Percentage coverage of the different habitat types in relation to "Dynamic", "Normal", "Regressive" population types of *Salvia ceratophylloides* Ard.

## 4. Discussion

The census revealed that the population of *S. ceratophylloides* showed an inconstant trend over time, with significant differences in the number of individuals present in the different populations (Figure 4). The more structured populations, with a greater number of individuals, tended to grow over the years, as evidenced by the positive values of the Malthus index [49] (5B, 6B, 6C, 7B, 10). This increase was due to the better organised structure of the population itself, and its ability to resist external influences that may affect its dynamics. Populations with fewer individuals, on the other hand, tended to be more sensitive to external influences that caused their decrease: this was highlighted by the negative value of the Malthus index [49] (2A, 8, 9, 15, 17).

The trend of the census population in the 40 sub-areas from 2019 to 2021 (Figure 4), also showed considerable differences in the rate of increase–decrease: in fact, in some of the sub-areas there was a strong variation, due to the fact that some micro-populations had been subjected to very strong external pressures, such as fire or mowing.

The analysis of the "life stages" of the entire population (Figure 5) showed that non-breeding "life stages" (S, JI, V) represented the lowest percentage of the population, varying from 26% in 2019, to 31% in 2020, up to 42% in 2021, showing an overall increasing trend. In contrast, the reproductive "life stages" represented more than 50% of the population and underwent a significant decrease over the three years. The increase and decrease in "life stages" was directly related to the pressures the habitat underwent, with these pressures acting more violently on the more advanced "life stages" and being less influential in the juvenile stages (Table 3).

The cluster analysis of the matrix No. of individuals/"life stage"/sub-area, made it possible to distinguish, in accordance with Heglad [11] and Oostermeijer [60], three different types of populations in relation to the distribution of the different "life stages", defined as: "Dynamic", "Normal", "Regressive" (Figure 10). "Regressive" populations accounted for 40% of the entire population, while "Normal" constituted 36% and "Dynamic" 24%. Non-breeding "life stages" (S, JI, V) were more represented in the "Dynamic" populations, which were characterised by a high ratio of non-breeding individuals to breeding individuals (SG, LG) (Figure 11). In the "Normal" populations, a balance between breeding and non-breeding "life stages" was observed, while in the "Regressive" populations there was a greater representation of non-breeding "life stages", represented mainly by "life stage" LG, an indication of the ageing of the population.

The pressures affecting the population and the individual sub-areas in which it was distributed (Table S4) were, first and foremost, the fires that often affect this area [63,64],

mostly linked to grazing or agricultural activities, which, if repeated over time, can lead to the extinction of *S. ceratophylloides* populations, as observed for micro-population 13 [61]. Alien invasive species, both included and not included in EU Directive 1143/2014, were often introduced accidentally (micro-population 12) or deliberately (micro-population 11), with serious negative consequences for the invaded habitat [21–24]. *Salvia ceratophylloides* was severely damaged by various pests that affect fruits and stems. *Squamapion elongatum* (Germar, 1817) (*Coleoptera-Apionidae*) digs tunnels into the stems, inhibiting plant growth and subsequent flower formation. *Systole salvia* (Zerova 1970) (*Hymenoptera-Eurytomidae*) irreparably damages the fruits, as the larva of this species feeds on them, emptying them completely [65].

The pressures analysed affected the different "life stages" differently (Table 3) and, consequently, the different types of population. In particular, the non-breeding "life stages" (S, JI, V), that characterised the "Dynamic" populations, were positively correlated with anthropic activities, such as mowing and sporting, tourist and recreational activities. These pressures tended, on the other hand, to negatively influence the breeding "life stages" (SG, LG), thus affecting, above all, the "Regressive" populations. Mowing damages adult individuals, often represented by large branched plants 0.5–1 m high, while avoiding very young individuals (S, JI), which grow close to the ground (Figure 3). Although the species was not eaten by animals, due to the presence of essential oils [66], young individuals were negatively affected by the presence of grazing [67]. Trampling caused by ungulates [*Capra hircus* (L., 1758) and *Ovis aries* (L., 1758)], irreparably damages the seedlings. On the contrary, the latter was positively correlated with "life stage" SG, LG to which it did not cause damage, instead limiting competition with other pabular species eaten by grazing animals.

There are also many threats acting in the areas surrounding the population, which could affect the species' habitats. Urban expansion of cities, with the consequent construction of infrastructure (E01, F01) is one of the main threats as it is a factor in the fragmentation and change of natural and semi-natural habitats [68–70], as highlighted by Spampinato et al. [71,72]. Urbanisation has already, in the past, caused the extinction of several micro-populations (19, 20, 21) of the species known from the literature (Figure 2) [39]. Reforestations carried out mainly in the 1950s (B01) [73,74] contributed to the extinction of other populations (22, 23) reported in the literature (Figure 2) [40]. Studies on the eco-physiological characteristics of the species [66] show that climate change [16] may adversely affect the species' population. On the whole, all the sub-areas suffered mainly from anthropogenic pressures, which, as shown, acted by altering the relationships between the different life stages. Under conditions of less anthropic disturbance, the population structure was 'normal' with a more or less balanced ratio of breeding individuals to nonbreeding individuals. Under more natural conditions of less anthropogenic disturbance, the latter was probably the population structure of *S. ceratophylloides*. The DCA analysis of the species/population type matrix (Figure 13) showed that the different species detected in the vegetation analysis did not follow a defined trend: in fact synanthropic, natural and semi-natural species, in relation to the different types of populations obtained from the cluster analysis ("Normal", "Dynamic", "Regressive"), on the whole were distributed in a way that did not involve making groups. It was observed, however, that some of them were more closely linked to certain population types. In particular, the "Regressive" (R) populations were characterised by a greater presence of synanthropic and ruderal species (*Robinia pseudoacacia* L., *Rubus ulmifolius* Schott, *Sisymbrium officinale* (L.) Scop., *Mercurialis annua* L., *Galactites tomentosus* Moench, *Dasypyrum villosum* (L.) P.Candargy, *Centranthus ruber* (L.) DC. subsp. *ruber*, *Sonchus oleraceus* L., *Umbilicus horizontalis* (Guss.) DC., *Cynodon dactylon* (L.) Pers.), frequent in heavily disturbed habitats. The "Dynamic" (D) populations, on the other hand, presented numerous semi-natural species (*Lotus cytisoides* L., *Trifolium stellatum* L., *Silene colorata* Poir., *Aira caryophyllea* L., *Sixalix atropurpurea* (L.) Greuter & Burdet, *Lagurus ovatus* L. subsp. *ovatus*). The "Normal" (N) populations showed an equal

distribution of the different species types, with greater representation of natural habitat species (*Pistacia lentiscus* L., *Phlomis fruticosa* L., *Teucrium flavum* L. subsp. *flavum*).

Heglad et al. [11], in their analysis of the related *Salvia pratensis*, analysed the populations in relation to the different management methods (mowing or grazing) and showed how these significantly influence the vegetation of the different population types ("Regressive", "Dynamic" and "Normal"). They clearly distinguish groups of species related by ecological characteristics (nutrient-poor or nutrient-rich soil species) from the different population types.

Shomurodov et al. [6] stated that populations of *Salvia lilacinocoerulea* Nevski, endemic and punctiform species to the Western Pamir-Alay mountain range, are strongly conditioned by vegetation and soil type. These two factors, strongly affect the population dynamics, in some cases representing a real limitation for the species. In our study, these factors did not influence the population, essentially because the pedology was the same in all sub-areas. The analysis of the vegetation classes (Figure 14) showed that the species of the class *Chenopodietea* were widely distributed in all the population types, bearing witness to the anthropic disturbance affecting them. The class *Lygeo sparti-Stipetea tenacissimae* was also widespread in all population types, i.e., in arid environments of the Mediterranean belt, influenced by fires and characterised by herbaceous perennials, such as *Hyparrhenia hirta* (L.) Stapf subsp. *hirta* and *Ampelodesmos mauritanicus* (Poir.) T.Durand & Schinz. In the "Normal" populations, the species of the garrigues, typical of the classes *Cisto-Lavanduletea stoechadis* and *Ononido-Rosmarinetea*, were better represented, while in the "Regressive" populations the species of the latter classes were poorly represented, and the species linked to synanthropic environments, such as those characteristic of the classes *Galio aparines-Urticetea maioris*, *Papaveretea rhoeadis* and *Robinietea*, were better represented.

Overall, a certain relationship was observed between the characteristic species of the various vegetation classes (natural, semi-natural, synanthropic) and the population types ("Regressive"," Dynamic", "Normal") (Figure 15). In particular, species typical of the natural type classes were well represented in the "Normal" populations, while species typical of the semi-natural vegetation classes were better represented in the "Dynamic" type populations and, finally, albeit slightly, species typical of the synanthropic vegetation classes were better represented in the "Regressive" type populations.

Numerous studies have dealt with threatened and/or endangered species [4–6]. These studies focused on population dynamics, in order to establish safeguards and protection measures for these species. This can be achieved through specific in situ conservation measures, such as the establishment of micro-reserves [75], an approach successfully developed in recent decades in Spain and, subsequently, in other European and Mediterranean countries [76–78]. For *S. ceratophylloides*, the extension of the micro-reserve should cover about 7 $km^2$, around the hills of Reggio Calabria, encompassing the entire Area Of Occurrence (AOO) of the species [48].

## 5. Conclusions

This work lays the scientific basis for the planning of conservation and protection measures capable of reducing and eliminating, over time, the pressures that adversely affect the *Salvia ceratophylloides* population.

The work shows that *S. ceratophylloides* micro-populations have non-stable dynamics over time, and are deeply conditioned by the pressures exerted on the habitat and on individuals, acting with different intensity in relation to different "life stages". These stresses are mostly represented by anthropogenic disturbances, which affect habitat quality and are reflected in population dynamics over time. Important also are the pressures of natural origin that affect the reproductive and regenerative capacities of the species. The reiteration of such pressures over time could lead to slow and ineluctable decline and, thus, extinction of *S. ceratophylloides* in the wild. This would primarily affect micro-populations with a small number of individuals of the order of a dozen or less, which, as evidenced by the Malthus index, show a decrease. It is therefore on these micro-populations,

composed of a limited number of individuals, that action needs to be taken to reduce impacts and favour the renovation of the species, including through reintroduction. This can be achieved through specific in situ conservation measures, such as the establishment of micro-reserves. However, possible ex situ conservation measures at germplasm banks and botanical gardens should not be ruled out, nor the dissemination of this species in private gardens.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su141610295/s1, Table S1: Data from the population census of *Salvia ceratophylloides* Ard., the micro-populations of the species were divided into sub-areas with similar habitats, in each sub-area the count of individuals was carried out distinguishing the different "life stages"; Table S2: Complete list of the species present in the stations of *Salvia ceratophylloides* Ard. with the relative phytosociological class to which they belonged, in accordance with Mucina [50] and the "Prodromo della Vegetazione d'Italia" [51]: ART—*Artemisietea vulgaris*; CHE—*Chenopodietea*; LAV—*Cisto-Lavanduletea stoechadis*; CYM—*Cymbalario-Parietarietea diffusae*; URT—*Galio aparines-Urticetea maioris*; TUB—*Helianthemetea guttati*; LYG—*Lygeo sparti-Stipetea tenacissimae*; MOL—*Molinio-Arrhenatheretea*; ROS—*Ononido-Rosmarinetea*; PAR—*Papaveretea rhoeadis*; QUI—*Quercetea ilicis*; ROB—*Robinietea*; SIS —*Sisymbrietea*; TRA—*Stipo-Trachynietea distachyae*; THL—*Thlaspietea rotundifoliae*; GER—*Trifolio-Geranietea sanguinei*. Table S3: Phytosociological classes of the taxa present in the vegetation surveys. The class name, acronym, habitat type (S = synanthropic, SN = semi-natural, N = natural) and description are indicated; Table S4: Pressures observed in the sub-areas of *Salvia ceratophylloides* Ard. The codes and description of pressures/threats are in accordance to "Reference list Threats, Pressures and Activities" by [52], as modified by EIONET [53].

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# **CHAPTER 4.** Current and Potential Future Distribution of Endemic *Salvia ceratophylloides* Ard. (Lamiaceae)

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# Current and Potential Future Distribution of Endemic *Salvia ceratophylloides* Ard. (Lamiaceae)

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**Abstract:** Human activities and climate change are the main factors causing habitat loss, jeopardising the survival of many species, especially those with limited range, such as endemic species. Recently, species distribution models (SDMs) have been used in conservation biology to assess their extinction risk, environmental dynamics, and potential distribution. This study analyses the potential, current and future distribution range of *Salvia ceratophylloides* Ard., an endemic perennial species of the Lamiaceae family that occurs exclusively in a limited suburban area of the city of Reggio Calabria (southern Italy). The MaxEnt model was employed to configure the current potential range of the species using bioclimatic and edaphic variables, and to predict the potential suitability of the habitat in relation to two future scenarios (SSP245 and SSP585) for the periods 2021–2040 and 2041–2060. The field survey, which spanned 5 years (2017–2021), involved 17 occurrence points. According to the results of the MaxEnt model, the current potential distribution is 237.321 km$^2$, which considering the preferred substrates of the species and land-use constraints is re-estimated to 41.392 km$^2$. The model obtained from the SSP245 future scenario shows a decrease in the area suitable for the species of 35% in the 2021–2040 period and 28% in the 2041–2060 period. The SSP585 scenario shows an increase in the range suitable for hosting the species of 167% in the 2021–2040 period and 171% in the 2041–2060 period. Assessing variation in the species distribution related to the impacts of climate change makes it possible to define priority areas for reintroduction and in situ conservation. Identifying areas presumably at risk or, on the contrary, suitable for hosting the species is of paramount importance for management and conservation plans for *Salvia ceratophylloides*.

**Keywords:** conservation; Calabria; climate changes; endangered species; Italy; MaxEnt; SSP245; SSP585; vascular plants

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## 1. Introduction

Human activities and climate change are the main causes of habitat and biodiversity loss [1–6], seriously threatening the survival of many species, especially those with limited distribution and, especially, endemic species [7–14].

The 20th century saw the strongest warming trend of the last millennium, with an increase in average temperatures of approximately 0.6 °C, compared to pre-industrial times (1850–1900) [15–19]. Estimates suggest that future temperature increases could exceed this value, with an increase of between 0.1 and 0.2 °C expected per decade [19]. In addition, climate change, combined with economic globalisation, rapid infrastructure development, and human activities, has favoured the spread of invasive alien species, which, by rapidly expanding their range, affect natural habitats and lead to the extinction of species, especially those with limited ranges [20–26].

The Mediterranean region is characterised by high plant biodiversity and a remarkable richness of endemic species, which is due to several factors acting simultaneously [27–30].

Several authors assessed the impact that climate change could have on the distribution of species, particularly species with limited distributions, such as endemic species, which are more sensitive than others to environmental change and are at greater risk of extinction [10,31–36]. To this end, the ecological variables that influence the natural distribution of endemic species must be studied to identify the areas where they occur or could occur [10,32,37,38]. Currently, one of the most widely used systems for determining the environmental limits of species is the MaxEnt prediction model (Maximum Entropy Species Distribution Modeling) [39], which uses bioclimatic data and species occurrence to predict species distributions based on the maximum entropy theory, estimating a probabilistic distribution that is as uniform as possible but subject to environmental constraints [40–47].

The MaxEnt model has been used extensively in the field of conservation biology: it allows the prediction of the current and future potential range of a species [48,49]. Compared to other prediction models, it is more stable and reliable and works quickly and easily in modelling rare species with restricted ranges and limited occurrence data [43,47,50–53].

Lamiaceae, one of the largest families of angiosperms, includes more than 7000 species distributed throughout the world, with several species characterised by essential oils [54–58]. In the Italian flora, among the endemic species of this family with an extremely limited range [59,60], whose existence may be threatened in the near future by climate change, there is *Salvia ceratophylloides* Ard. (Figure 1), a species growing exclusively in southern Italy in the hill belt of the suburb of Reggio Calabria. It is clearly distinguished from the other perennial sage species of the *Salvia pratensis* L. group, to which it belongs [61,62], mainly by its wrinkled, pinnatifid leaves with toothed lobes [63,64]. Its chromosome number is 2n = 6x = 54 [65]. *Salvia ceratophylloides* (Figure 1) is a perennial herbaceous plant (scapose hemicryptophyte), densely pubescent with both glandular and simple patent hairs, has a main flowering period in spring from April to June, and has a second flowering period in autumn from October to November. Pollination is entomophilous, mediated mainly by hymenoptera (*Eucera* sp., *Bombus* sp., *Apis* sp.). The fruiting occurs after some flowering weeks. Seed dispersal is mainly carried out by ants (myrmecochory) [64]. Seed germination takes place mostly in spring, seedlings reach reproductive maturity (small generative) within 4–5 months, while they tiller (Large Generative) in the following year [13].



**Figure 1.** Details of the inflorescence, flowers, and habitat of *Salvia ceratophylloides* Ard. in its natural habitat (Ph. V.L.A. Laface).

The species was known only in a few nearby places, as can be seen from bibliographical references from 1800 [66,67] to the early 1900s [68,69], when, moreover, it was already very rare. Subsequently, despite the research of various botanists, the species was no longer found, having disappeared from the locations mentioned in the literature (Gallico Superiore, Terreti, Straorino, Ortì, Vito Superiore, Pietrastorta) [69]. For this reason, the species was considered extinct in 1997 and included in the "Libro rosso della flora d'Italia" (Red Book of the Flora of Italy) among the extinct species (EX) [70] and confirmed by Del Carratore and Garbari [71] and Scoppola and Spampinato [72].

Subsequent surveys in 2008 revealed four new occurrence points in the surroundings of Reggio Calabria at sites approximately 10 km from those for which the species was known in the literature of the early 1900s, each consisting of a few dozen individuals, totalling nearly 100 mature individuals [73–76].

Laface et al. [13] carried out field surveys between 2017 and 2021 and identified 17 occurrence points, always in the suburbs of Reggio Calabria, some of these with a small number of individuals. *Salvia ceratophylloides* covers an "Extent of Occurrence" (EOO) of 4.2 $km^2$ and an "Area of Occupancy" (AOO) of 7 $km^2$: this made it possible to assess the species as "Critically Endangered" (CR) [13,64,76] according to IUCN (International Union for Conservation of Nature) criteria and categories [77].

*Salvia ceratophylloides* grows spontaneously in the habitat of the EEC Directive 43/93: "5330 thermo Mediterranean and predesert scrub" subtype "32.23 Diss dominated garrigues". This habitat includes Mediterranean steppe, such as grasslands with *Ampelodesmos mauritanicus* (Poir.) Dur. & Schinz., sands vegetation with *Artemisia campestris* subsp. *variabilis* (Ten.) Greuter, and more rarely in garrigues, characterised by *Cistus creticus* L. subsp. *creticus* and *Thymbra capitata* (L.) Cav. The most frequently growing species with *S. ceratophylloides*, in addition to the aforementioned species, are some grasses (*Lagurus ovatus* L., *Avena barbata* Link, *Macrobriza maxima* (L.) Tzvelev, *Hyparrhenia hirta* (L.) Stapf., *Dasypyrum villosum* (L.) P. Candargy), several dwarf shrubs (*Micromeria graeca* (L.) Benth. ex Rchb., *Phlomis fruticosa* L.), and some shrubs (*Cytisus infestus* (C.Presl) Guss. subsp. *infestus*, *Spartium junceum* L.). Mostly, they are widespread species in the Mediterranean steppic grassland and garrigues [64,76]. The populations are located on hills at altitudes between 250 and 450 m a.s.l., characterised exclusively by layers of loose sands, alternating with banks of soft Pliocene calcarenites [78]. The species grows in a territory with average annual temperatures of 18 °C and an average annual rainfall of 600 mm, concentrated in the autumn, the months of November and December, and a summer dry period of approximately 5 months [13,64]. According to Pesaresi [79], the bioclimate is classified as oceanic pluviostagional Mediterranean, with upper thermo-Mediterranean thermotype and lower sub-humid ombrotype.

Numerous physiological studies have been carried out on *S. ceratophylloides*, and these have shown that the species has a very strong adaptive capacity to future climate change, and develops resilient forms of defence [80–82].

In order to safeguard the habitat of *S. ceratophylloides*, it is of fundamental importance, both theoretically and practically, to understand which areas are potentially suitable from a current and future climatic perspective. This, correlated with population dynamics [13], will make it possible to determine the most appropriate locations for effectively targeting conservation strategies aimed at protecting and reintroducing this critically endangered species. The aim of our study, therefore, is to analyse the species distribution patterns (SDM) of *S. ceratophylloides* by interpolating the occurrence points with environmental variables, and to model current and future scenarios to assess the current distribution and predict the habitat's conservation capacity in the context of climate change [19].

## 2. Materials and Methods

### *1.1. Species Occurrence Data*

Information concerning the current distribution of *S. ceratophylloides* was obtained during fieldwork carried out between 2017 and 2021 [13], and also considering historical

information reported in the literature by several authors [66–69,73–76] and verified in the field. For each point of occurrence, field coordinates were taken and the substrate and plant community recorded.

The collected data were analysed using QGIS 3.26.3® software (OSGeo, Beaverton, OR, USA) [83].

### *1.2. Environmental Variables*

In order to model the potential habitat of *S. ceratophylloides*, based on its current occurrence, a total of 22 ecological variables were considered (Table 1); specifically, 19 bioclimatic and 3 topographic. This information was obtained from the WorldClim database [84,85] at a spatial resolution (expressed as minutes of a degree of longitude and latitude) of 30 s (approx. 1 × 1 km). The topographic variables were extracted using QGIS 3.26.3® software [83].

**Table 1.** Description of variables used in the prediction of the MaxEnt model. The variables in bold were selected through Pearson's correlation analysis and were used in the modelling.

| Code | Description | Unit |
|---|---|---|
| **Bio 1** | **Annual Mean Temperature** | **°C** |
| Bio 2 | Mean Diurnal Range (Mean of monthly (max temp–min temp)) | °C |
| Bio 3 | Isothermality (BIO2/BIO7) (*100) | % |
| **Bio 4** | **Temperature Seasonality (standard deviation *100)** | **%** |
| Bio 5 | Max Temperature of Warmest Month | °C |
| Bio 6 | Min Temperature of Coldest Month | °C |
| Bio 7 | Temperature Annual Range (BIO5-BIO6) | °C |
| Bio 8 | Mean Temperature of Wettest Quarter | °C |
| Bio 9 | Mean Temperature of Driest Quarter | °C |
| Bio 10 | Mean Temperature of Warmest Quarter | °C |
| Bio 11 | Mean Temperature of Coldest Quarter | °C |
| Bio 12 | Annual Precipitation | mm |
| **Bio 13** | **Precipitation of Wettest Month** | **mm** |
| **Bio 14** | **Precipitation of Driest Month** | **mm** |
| Bio 15 | Precipitation Seasonality (Coefficient of Variation) | % |
| Bio 16 | Precipitation of Wettest Quarter | mm |
| Bio 17 | Precipitation of Driest Quarter | mm |
| Bio 18 | Precipitation of Warmest Quarter | mm |
| **Bio 19** | **Precipitation of Coldest Quarter** | **mm** |
| **Elev.** | **Elevation** | **meter** |
| Slope | Slope | degree |
| Aspe. | Aspect | degree |

Information on the environmental variables is an essential parameter for building a predictive model: however, overuse of the environmental variables may increase the spatial correlation between them, leading to overfitting and reducing the transferability of the model [86]. To avoid overfitting, it is necessary to calculate the correlation between all variables considered and exclude the highly correlated variables, which exponentially improves the predictive ability of the model [87]. For this purpose, Pearson's correlation analysis [88] was carried out using Past 4.1.4 © software (Hammer, Oslo, Norway) [89]. Environmental variables with correlation values falling in the following range were considered significant: $-0.8 \leq r \leq +0.8$. To assess the dominant environmental variables, i.e., those that defined the potential distribution of the species, the jackknife test [90] was performed. For the modelling of future scenarios, the Global Climate Model (GCM) BCC-CSM2-MR was used, with this model producing excellent results in many studies at the European and Mediterranean level [91,92]. For the scenarios reference for the IPCC's Sixth Assessment Report [19], where four Shared Socioeconomic Pathways (SSPs) are assumed:

- SSP585: with an additional radiative forcing of 8.5 W/m$^2$ by the year 2100;
- SSP370: with an additional radiative forcing of 7 W/m$^2$ by the year 2100;
- SSP245: with an additional radiative forcer of 4.5 W/m$^2$ by the year 2100;
- SSP126: with an additional radiative forcer of 2.6 W/m$^2$ by the year 2100.

To make the modelling more reliable and plausible, the scenarios SSP585 (most extreme) and SSP245 (intermediate) were chosen, for the periods 2021–2040 and 2041–2060.

Pearson's [88] correlation analysis made it possible to determine six ecological variables (out of 22) useful for modelling the distribution of the species. Five bioclimatic variables (Bio 1, Bio 4, Bio 13, Bio 14, Bio 19) and one topographic variable (Elev.) were found to be significant ($\leftarrow 0.8 \leq r \leq +0.8$) (Table 1, Figure 2). These variables were also used for modelling the future scenarios. Variables with values >0.8 and those <−0.8 were not considered in order to avoid overfitting.

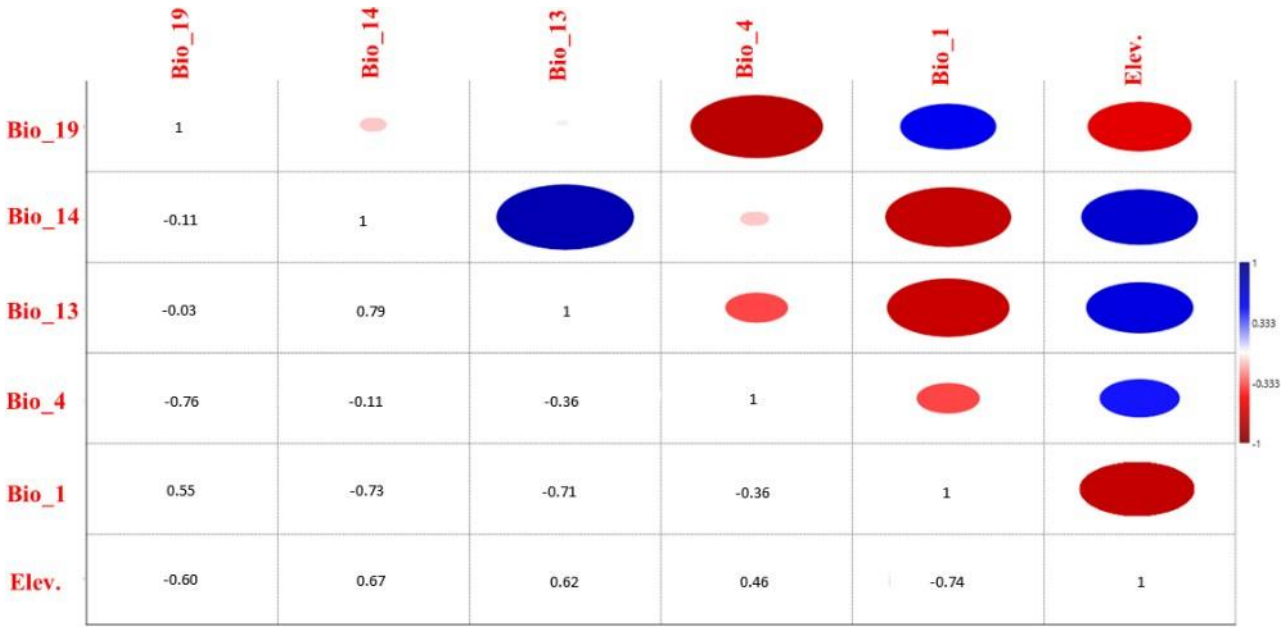



**Figure 2.** Pearson correlation analysis of significative environment variables for *Salvia ceratophylloides* Ard. ($-0.8 \leq r \leq +0.8$). Created with Past 4.1.4 © (Hammer, Oslo, Norway).

### *1.3. Model Construction*

The distribution point data (species and geographical coordinates, saved in .csv format) and the resulting bioclimatic variable data were imported into MaxEnt 3.4.4® (American Museum of Natural History, New York, NY, USA) [93,94].

In the analysed models, 75% of the data were selected for model training (calibration), using a maximum number of iterations of 1000, and 25% as test data, for model validation [93,94], keeping the other values as defaults. The Bootstrap method was used, implemented with 10 repetitions and the multiplier value at 0.5. The output format is complementary log-log (cloglog).

The accuracy of the generated model was verified using the Receiver Operating Characteristic (ROC) curve analysis method. The ROC curve has as the ordinate the percentage of true positive values (the ratio that exists and is expected to exist) and as the abscissa the percentage of false positive values (the ratio that does not exist but is expected to exist) [95]. The AUC (Area under the Curve) value is the area enclosed between the abscissa and the ROC curve, and has a range between 0.5 and 1. The higher the AUC value, the greater the distance from the random distribution, the more relevant the correlation between the environmental variables and the geographic distribution of the species, and the more reliable the predictive power of this model.

Conversely, the predictive power of the model is not very reliable. The model's performance is classified as: inadequate with AUC values ranging from 0.5 to 0.6; poor with values ranging from 0.6 to 0.7; reasonable with values ranging from 0.7 to 0.8; good with values ranging from 0.8 to 0.9; and excellent with values ranging from 0.9 to 1. The necessary means of measuring the model performance is the AUC score, as it has a strong independence from threshold choices. The smallest difference between the training and test AUC data (AUCDiff) was also observed; a lower difference indicates less overfitting in the model [96].

### *1.4. Distribution Maps: Visualisation and Analysis*

For the visualisation and investigation of the distribution areas of the species, the models created with the software MaxEnt (range 0–1) [39] were imported into the software QGIS 3.26.3 [83]. The areas found to be suitable for the species were grouped into 5 habitat potential classes (ranging from 0 to 1): highly unsuitable (≤0.20); unsuitable (0.21–0.40); moderately suitable (0.41–0.60); highly suitable (0.61–0.80); very highly suitable (≥0.80). For each model, the area for each selected class was calculated using QGIS [83].

To define the real distribution of the species, we interpolated the current and future models on the geological map of Calabria [78] and with the land use map of the Region of Calabria "Carta di Uso del Territorio" [97] using the software QGIS. In the first case, we considered the geological substrates on which the species grows, i.e., sands, calcarenites and conglomerates more or less cemented. In the land use map, which is divided into five macro-categories of land cover (1. Artificial surfaces; 2. Agricultural areas; 3. Forests and semi-natural areas; 4. Wetlands; 5. Water bodies), we considered land cover 2 and 3, because *S. ceratophylloides* grows in areas with a highly fragmented mosaic of agricultural and semi-natural habitats [13].

## 3. Results

### *1.5. Natural Distribution Data*

A total of 23 occurrence points of *S. ceratophylloides* are known (Figure 3), of which 17 currently occur in the area (albeit with a small number of individuals for occurrence points) while 6 are extinct: occurrence point 13 became extinct in 2019 and had only one individual in the previous year; occurrence point 19 was reported in 2008 [73] and was not found in subsequent years during field surveys; occurrence points 20, 21, 22, and 23 are historical reports dating back to the early 1900s [68,69] and were not found in the second half of the last century [71].

### *1.6. Analysis and Evaluation of Environmental Variables*

The calibration of the current potential distribution model for *S. ceratophylloides*, using the variables thus selected, was optimal (AUC mean = 0.986, ±0.001; AUCDiff (0.09 ± 0.006).

From the results obtained with the jackknife test, we know that the distribution of *S. ceratophylloides* is mainly influenced by the precipitation of wettest month (Bio 13), the annual mean temperature (Bio 1), and the precipitation of the coldest quarter (Bio 19); these contributed 69.3%, 7.8%, and 11.4%, respectively, to the MaxEnt model (Figure 4). In addition, two other environmental variables (Bio 4, Bio 14) contributed a total of 8.3% to the habitat distribution model and 3.2% to the topographic variable (Elev.) (Figure 4, Table 2).

In view of the importance of the permutation, the precipitation of wettest month (Bio 13) had the greatest impact on the model with 66.9%, the annual mean temperature (Bio 1) with 13.3%, while the other variables contributed a smaller percentage, totalling 19.8%.

Considering the six bioclimatic variables previously selected, the mean annual temperature range (Bio 1) of *S. ceratophylloides* is 15.7–19.7 °C, and the temperature seasonality (Bio 4) is 549–576%. In addition, the average precipitation in the wettest month (Bio 13) is 108–111 mm, in the driest month (Bio 14) it is 10–15 mm, and in the coldest quarter (Bio 19) it is 256–297 mm, on average. The altitude ranges from 11 to 689 m a.s.l.

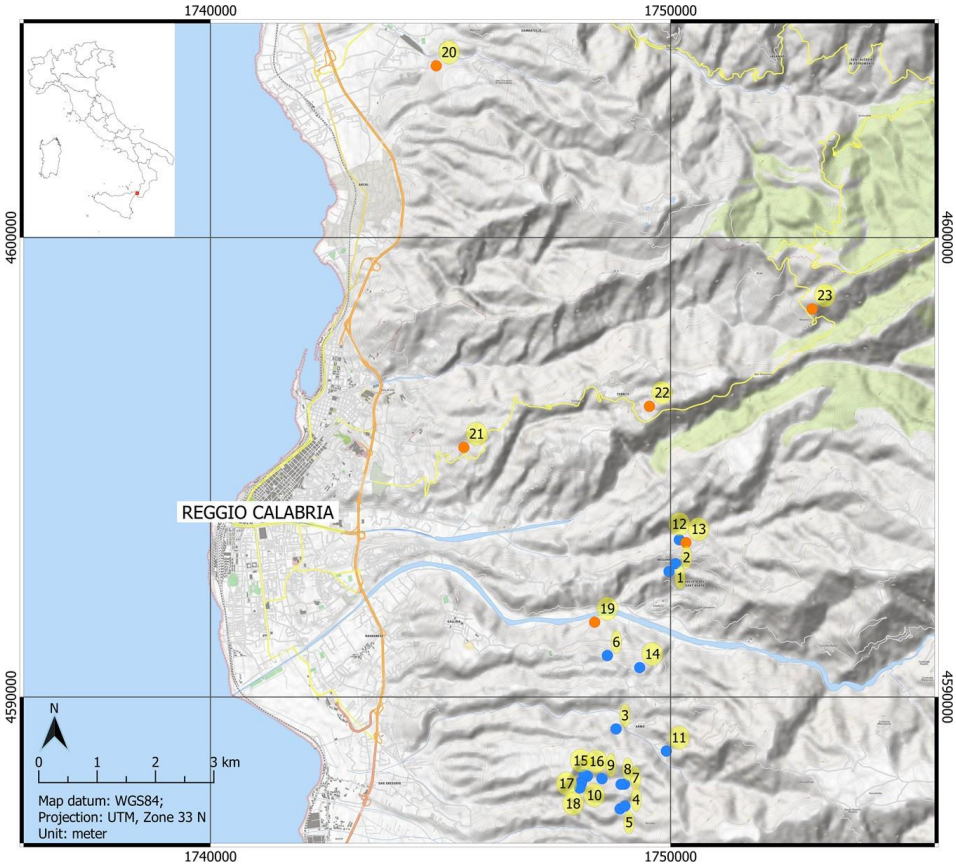



**Figure 3.** Occurrence points of *Salvia ceratophylloides* Ard. In blue are the micro-populations currently occurring, in orange the extinct ones. 1—Serro Ciugna, Mosorrofa; 2—Serro Ciugna, Mosorrofa; 3—Spilingari, Armo; 4—Contrada S. Todaro, Aretina; 5—Contrada S. Todaro, Aretina; 6—Serro dei Morti, Puzzi fraz. di Gallina; 7—Prai, Aretina; 8—Prai, Aretina; 9—Aretina; 10—Aretina; 11—Grotta di S. Arsenio, Armo; 12—Mosorrofa vecchio; 13—Mosorrofa vecchio; 14—Serro d'Angelo, Puzzi fraz. of Gallina; 15—Prai, Aretina; 16—Prai, Aretina; 17—Serro della Cattina, Aretina; 18—Serro della Cattina, Aretina; 19—Lutrà, Fiumara di Sant'Agata; 20—Galluzzi, Gallico Superiore; 21—Pietra Storta; 22—Croce Missionaria, Terreti; 23—Fontana Acqua Fresca, Straorino. In the top left-hand corner, the distribution area of the points of occurrence is highlighted in red.

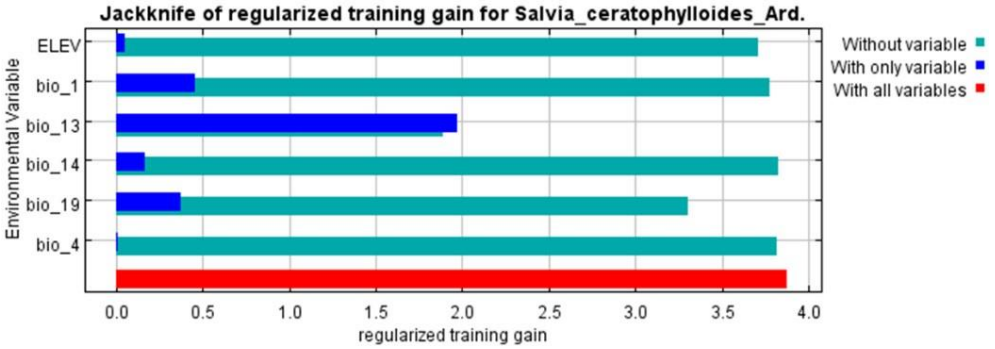



**Figure 4.** Relative predictive power of different environmental variables based on the jackknife of regularised training gain in MaxEnt models for *Salvia ceratophylloides* Ard.

**Table 2.** Percent contribution and permutation importance of environmental variables used to predict the MaxEnt model of *Salvia ceratophylloides* Ard. [SSPs- future scenarios (see text) Bio 1, Bio 4, Bio 13, Bio 14, and Bio 19. Elev (see Table 1)].

| Time | SSPs | Variable | Bio 1 | Bio 4 | Bio 13 | Bio 14 | Bio 19 | Elev. |
|---|---|---|---|---|---|---|---|---|
| Present time | | Percent contribution (%) | 7.8 | 7.3 | 69.3 | 1 | 11.4 | 3.2 |
| | | Permutation importance (%) | 13.3 | 1 | 66.9 | 0.8 | 9 | 9 |
| 2021/2040 | 245 | Percent contribution (%) | 7 | 5.5 | 86.3 | 0.1 | 0.9 | 0.2 |
| | | Permutation importance (%) | 0.1 | 1.1 | 97.8 | 0.2 | 0.6 | 0. |
| | 585 | Percent contribution (%) | 24.4 | 15.4 | 40.7 | 0 | 3 | 16.5 |
| | | Permutation importance (%) | 52.4 | 0 | 25 | 0.2 | 21.7 | 0.7 |
| 2041/2060 | 245 | Percent contribution (%) | 11.9 | 12.1 | 73.4 | 1 | 1.3 | 0.3 |
| | | Permutation importance (%) | 13.7 | 0.6 | 78.7 | 0.8 | 5.4 | 0.7 |
| | 585 | Percent contribution (%) | 16.5 | 14.2 | 25.6 | 0.1 | 42.6 | 1 |
| | | Permutation importance (%) | 15.4 | 1.5 | 76 | 0.1 | 0.8 | 6.2 |

### *1.7. Current Potential Distribution of Salvia ceratophylloides*

The current estimated potential habitat for *S. ceratophylloides* is located exclusively in the south/west of the Italian peninsula and Calabria (Figure 5): this corresponds to a total area of 237.321 km$^2$, equal to 1.58% of the entire regional territory and 0.08% of the Italian territory. In relation to the probability of occurrence of the species, the area is distributed as follows: very highly suitable (≥0.80) with an area of 30,440 km$^2$ (0.20%); highly suitable (0.61–0.80) with an area of 20,962 km$^2$ (0.14); moderately suitable (0 41–0.60) with a surface area of 59,434 km$^2$ (0.39%); and unsuitable (0.21–0.40) with a surface area of 126,485 km$^2$ (0.84%). The remaining territory (14,813,597 km$^2$, 98.42%) is unsuitable for the species (Table3).

**Table 3.** Classification of habitat suitability in relation to the probability values for the presence of *Salvia ceratophylloides* Ard. (highly unsuitable (≤0.20); unsuitable (0.21–0.40); moderately suitable (0.41–0.60); highly suitable (0.61–0.80); very highly suitable (≥0.80); area in km$^2$, relative percentage (%) in relation to the entire regional territory, % decrease (−) or increase (+) of the area suitable for the species.

| Time | SSP | Unit | Area tot. | ≥0.80 | 0.61–0.80 | 0.41–0.60 | 0.21–0.40 | ≤0.20 |
|---|---|---|---|---|---|---|---|---|
| Present time | | km$^2$ | 237.321 | 30.440 | 20.962 | 59.434 | 126.485 | 14,813.597 |
| | | % | 1.58 | 0.20 | 0.14 | 0.39 | 0.84 | 98.42 |
| 2021/2040 | 245 | km$^2$ | 153.986 | 25.020 | 18.258 | 26.326 | 84.382 | 14,896.932 |
| | | % | 1.02 | 0.17 | 0.12 | 0.17 | 0.56 | 98.98 |
| | | % inc./dec. | −35.11 | −17.81 | −12.90 | −55.71 | −33.29 | +0.56 |
| | 585 | km$^2$ | 633.513 | 129.708 | 94.667 | 171.816 | 237.322 | 14,417.405 |
| | | % | 4.21 | 0.86 | 0.63 | 1.14 | 1.58 | 95.79 |
| | | % inc./dec. | +166.94 | +326.11 | +351.61 | +189.09 | +87.63 | −2.67 |
| 2041/2060 | 245 | km$^2$ | 171.414 | 29.071 | 22.984 | 41.241 | 78.118 | 14,879.504 |
| | | % | 1.14 | 0.19 | 0.15 | 0.27 | 0.52 | 98.86 |
| | | % inc./dec. | −27.77 | −4.50 | +9.65 | −30.61 | −38.24 | +0.44 |
| | 585 | km$^2$ | 643.814 | 145.446 | 122.362 | 150.514 | 225.492 | 14,407.104 |
| | | % | 4.28 | 0.97 | 0.81 | 1.00 | 1.50 | 95.72 |
| | | % inc./dec. | +171.28 | +377.81 | +483.73 | +153.25 | +78.28 | −2.74 |

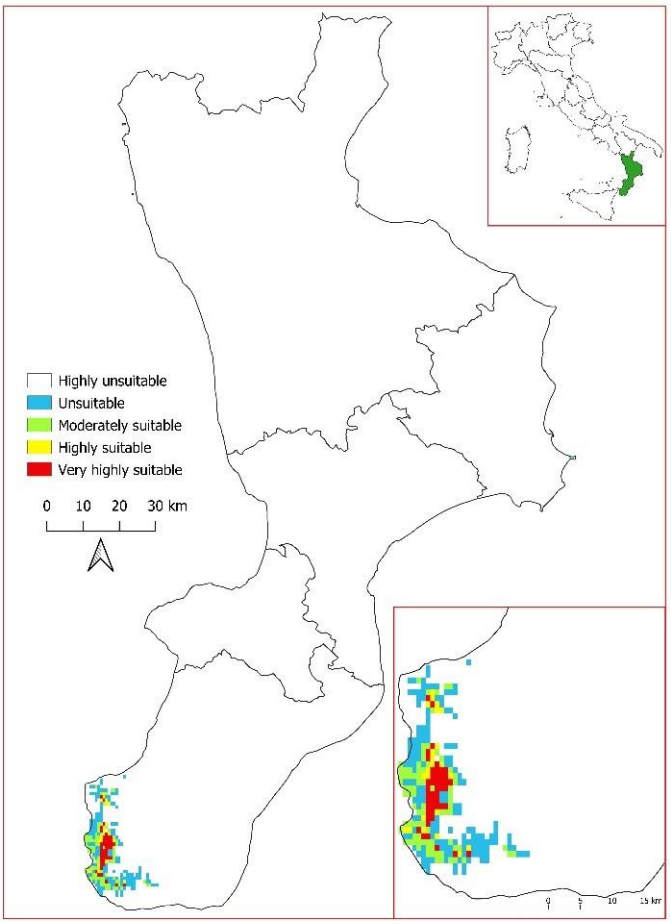



**Figure 5.** Prediction of the current potential distribution of *Salvia ceratophylloides* Ard. In white, highly unsuitable habitat (≤0.20); in blue, unsuitable (0.21–0.40); in green, moderately suitable (0.41–0.60); in yellow, highly suitable (0.61–0.80); in red, highly suitable (≥0.80). In the top left-hand corner, the Calabria region within the Italian territory is highlighted in green.

### *1.8. Future Potential Distribution of Salvia ceratophylloides*

The jackknife test (Figure 6) reveals that the distribution of *S. ceratophylloides* with SSP 245 over the 2021–2040 period is mainly influenced by the precipitation of the wettest month (Bio 13) with 86.3%, an annual mean temperature (Bio 1) with 7%, and a temperature seasonality (Bio 4) with 5.5%; the remaining variables contributing a total of 1.2%. Regarding the importance of permutation, the most influential variable is Bio 13 with 97.8%. With SSP 245 in the 20-year period between 2041–2060, the variables that contribute the most are the precipitation of the wettest month (Bio 13) with 73.4%, the temperature seasonality (Bio 4) with 12.1%, and the annual mean temperature (Bio 1) with 11.9%; the remaining variables contribute a total of 2.6%.

Regarding the SSP585 scenario in the 20-year period between 2021–2040, the variables contributing most to the model are Bio 13 with 40.7%, Bio 1 with 24.4%, Bio 4 with 15.4%, and Elev. with 16.5%; the remaining variables contribute 3% (Table 2). By permutation importance, there are Bio 1 with 52.4%, Bio 13 with 25%, and Bio 19 with 21.7%; the remaining variables with 0.8%. For the 20-year period between 2041–2060, the variables contributing most to the model are Bio 19 with 42.6%, Bio 13 with 25.6%, Bio 1 with 16.5%, and Bio 4 with 14.2%; the other variables contribute 1.1%. With regard to the importance of permutation, the most influential variables are Bio 4 with 76%, Bio 1 with 15.4%, and Elev. with 6.2%; the other variables account for 2.4% (Table 2).

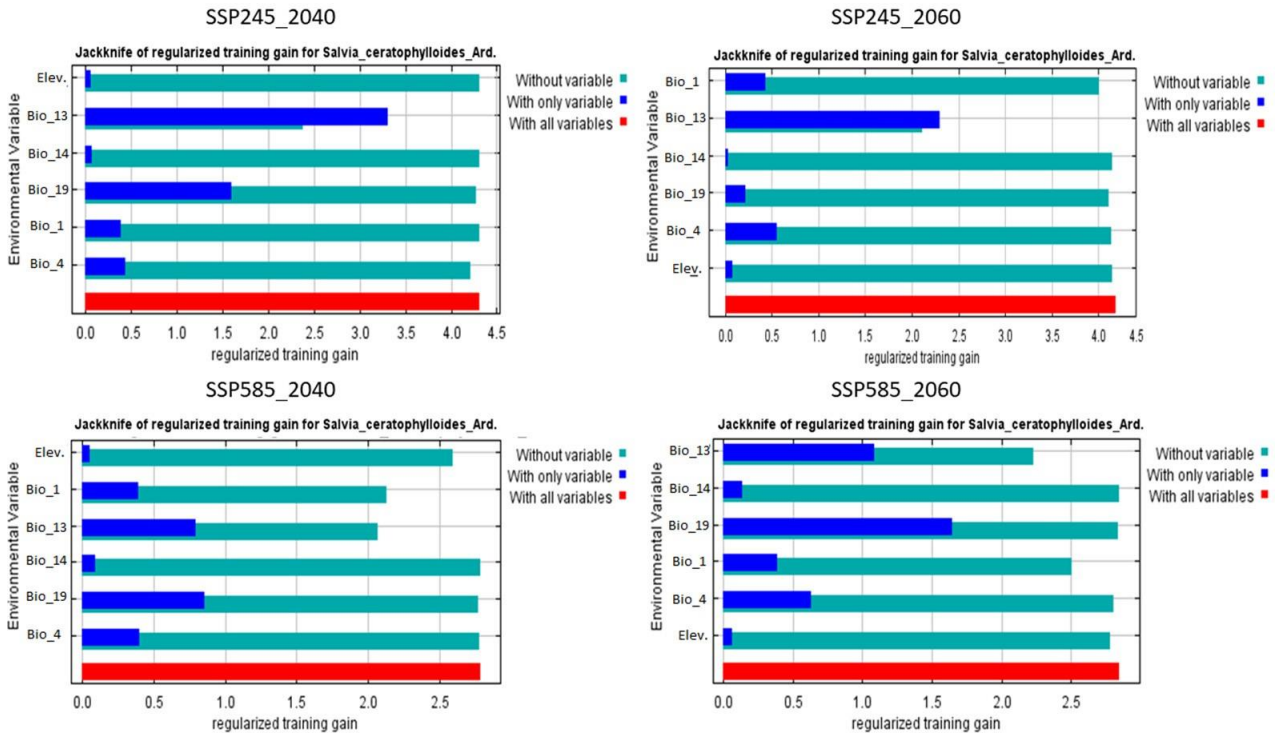



**Figure 6.** Relative predictive power of different environmental variables based on the jackknife of regularised training gain in MaxEnt models for *Salvia ceratophylloides* Ard.

The future potential distribution of *S. ceratophylloides*, estimated for two types of scenarios (SSP245 and SSP585), always occupies the south/west part of the Italian peninsula and Calabria (Figure 7), without expanding into other parts of the region. The habitat suitable for the species covers a total area of 153,321 km$^2$ (1.02%) in the SSP245 scenario, 2021–2040 and 171,414 km$^2$ (1.14%) in the SSP245 scenario of the following 20 years. It can be seen that, from the current distribution model, there is a decrease of 83,335 km$^2$ or 35% in the 20-year period between 2021–2040, and a decrease of 28% in the following 20-year period, with a loss of 65,907 km$^2$. In relation to the probability values for the presence of the species in the area of the SSP245 model, 2021–2040, is distributed as follows: very highly suitable (≥0.80) with an area of 25,020 km$^2$ (0.17%); and highly suitable (0.61–0.80) with an area of 18,258 km$^2$ (0.12%) (Table 3, Figure 7). The area of the SSP245 model, 2041–2060 is distributed as follows: very highly suitable (≥0.80) with an area of 29.071 km$^2$ (0.19%); and highly suitable (0.61–0.80) with an area of 22.984 km$^2$ (0.15%) (Table 3, Figure 7). It can be seen that the most significant decrease is in the optimal occurrence probability value of the species (≥0.80) with 17.81%, or 5420 km$^2$, less in the SSP245 scenario 2021–2040, compared to the current scenario; in the SSP245 2041–2060 scenario, it is 4.5%, or 1369 km$^2$, less.

The distribution model with the SSP585 scenario, shows a total area, suitable to host the species, of 633.513 km$^2$ (4.21%) in the 20-year period between 2021–2040 and 643.814 km$^2$ (4.28%) in the 20-year period between 2041–2061. Compared to the modelling of the current potential distribution, we can see an increase in area of 396.192 km$^2$ or 167%, in the 20-year period between 2021–2040, and an increase of 171% in the following 20-year period, with an increase of 65.907 km$^2$. In relation to the probability values for the presence of the species, the area of the SSP585 model, 2021–2040 is distributed as follows: very highly suitable (≥0.80) with an area of 129.708 km$^2$ (0.86%); and highly suitable (0.61–0.80) with an area of 94.667 km$^2$ (0. 63%) (Table 3, Figure 7). The potential area of the SSP585 model, 2041–2060 is distributed differently: very highly suitable ( ≥0.80) with an area of 145.446 km$^2$ (0.97%); and highly suitable (0.61–0.80) with an area of 122.362 km$^2$ (0.81%) (Table 3, Figure 7). It can be seen that the most significant increase is in the probability value of optimal occurrence of the species (≥0.80) in the SSP585 scenario 2021–2040 with

326.11%, or 99.268 km$^2$, more than the current scenario, in the SSP585, 2041–2060 scenario it is 377.81%, or 115.006 km$^2$, more.

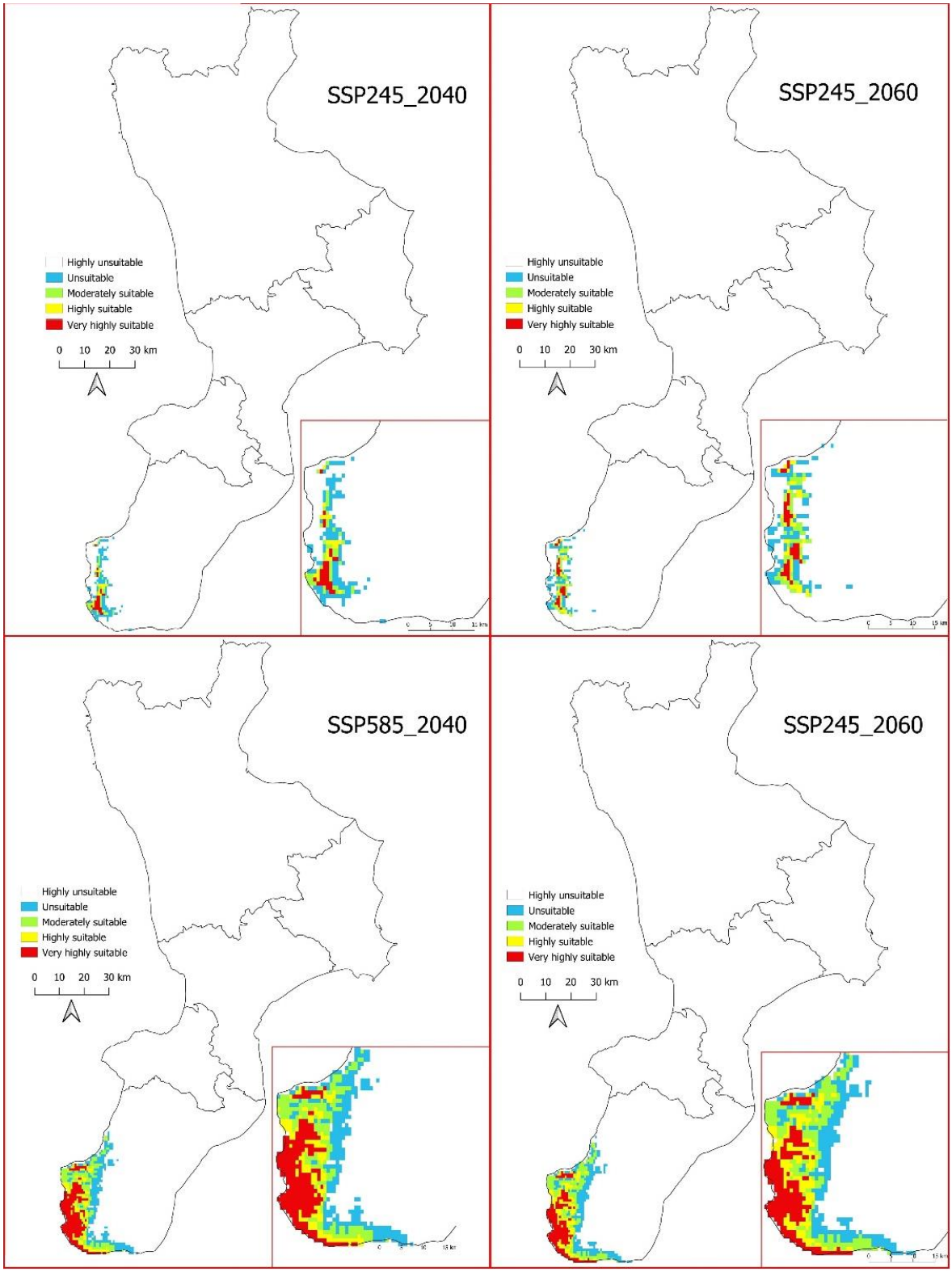



**Figure 7.** Prediction of the future potential distribution of *Salvia ceratophylloides* Ard. in two different scenarios SSP245 and SSP585 in two periods 2021–2040, 2041–2060. In white, highly unsuitable (≤0.20); in blue, unsuitable (0.21–0.40); in green, moderately suitable (0.41–0.60); in yellow, highly suitable (0.61–0.80); and in red, very highly suitable (≥0.80).

### *1.9. Real Distribution of Salvia ceratophylloides Analysed with Two Limiting Factors: Geology and Land Use*

Field studies and bibliographical references [13,64,68,69,74,75] show that *S. ceratophylloides* grows, in nature, exclusively on loose, sandy, and calcarenite substrates of Pliocene and Pleistocene origin; in particular, the analysis of the geological map [78] shows that there are three types of sandy substrates in Calabria: sands and conglomerates (Pleistocene); sands and conglomerates (Pleistocene–Pliocene); sands and conglomerates (Yellow Sands)–Pliocene, widespread throughout the region.

Although the geological substratum suitable for the species occupies 2066.204 km$^2$ (14.14% of the regional territory), from the superimposition of the current potential distribution models of the species we can observe that: the habitat suitable for the species covers a total area of 62.427 km$^2$, or 2.93% of the area occupied in the region by the geological substratum, and 0.41% of the entire regional territory. The suitable area is subdivided as follows in relation to the probability of occurrence of the species: very highly suitable (≥0.80) 16.285 km$^2$ (0.77% of the area occupied in the region by the substratum, 0.11% of the regional territory); and highly suitable (0.61–0.80) 4.071 km$^2$ (0.19% of the geological substratum, 0.03% of the regional territory (Table 4, Figure 8). This modelling shows a decrease of 74% compared to the current potential distribution model.

The model with SSP245 2021–2040 presents a total area of 31.892 km$^2$, equal to 1.50% of the geological substrate and 0.21% of the entire regional territory. In detail, the probability values for the presence of the species are distributed as follows: very highly suitable (≥0.80) with an area of 5.428 km$^2$ (0.25% of the geological substratum, 0.04% of the regional territory); and highly suitable (0.61–0.80) with an area of 9.500 km$^2$ (0.45% of the geological substratum, 0.06% of the regional territory) (Table 4, Figure 8).

**Table 4.** Classification of habitat suitability related to the probability values for the presence of the *Salvia ceratophylloides* Ard. in areas with sandy substrate and conglomerates in the Calabria Region. [highly unsuitable (≤0.20); unsuitable (0.21–0.40); moderately suitable (0.41–0.60); highly suitable (0.61–0.80); very highly suitable (≥0.80); area (km$^2$), and the relative percentage in relation to the geological substratum (% sub.) and percentage in relation to the entire regional territory (% reg. ter.)].

| Time | SSP | Unit | Area tot. | ≥0.80 | 0.61–0.80 | 0.41–0.60 | 0.21–0.40 | ≤0.20 |
|---|---|---|---|---|---|---|---|---|
| Present time | | km$^2$ | 62.427 | 16.285 | 4.071 | 19.000 | 23.071 | 2066.204 |
| | | % sub. | 2.93 | 0.77 | 0.19 | 0.89 | 1.08 | 97.07 |
| | | % reg. ter. | 0.41 | 0.11 | 0.03 | 0.13 | 0.15 | 13.73 |
| 2021/2040 | 245 | km$^2$ | 31.892 | 5.428 | 9.500 | 5.428 | 11.536 | 2096.739 |
| | | % sub. | 1.50 | 0.25 | 0.45 | 0.25 | 0.54 | 98.50 |
| | | % reg. ter. | 0.21 | 0.04 | 0.06 | 0.04 | 0.08 | 13.93 |
| | 585 | km$^2$ | 187.960 | 56.320 | 17.642 | 37.321 | 76.677 | 1940.671 |
| | | % sub. | 8.83 | 2.65 | 0.83 | 1.75 | 3.60 | 91.17 |
| | | % reg. ter. | 1.25 | 0.37 | 0.12 | 0.25 | 0.51 | 12.89 |
| 2041/2060 | 245 | km$^2$ | 50.213 | 4.750 | 6.107 | 10.857 | 28.499 | 2078.418 |
| | | % sub. | 2.36 | 0.22 | 0.29 | 0.51 | 1.34 | 97.64 |
| | | % reg. ter. | 0.33 | 0.03 | 0.04 | 0.07 | 0.19 | 13.81 |
| | 585 | km$^2$ | 192.031 | 50.892 | 19.678 | 48.856 | 72.605 | 1936.600 |
| | | % sub. | 9.02 | 2.39 | 0.92 | 2.30 | 3.41 | 90.98 |
| | | % reg. ter. | 1.28 | 0.34 | 0.13 | 0.32 | 0.48 | 12.87 |

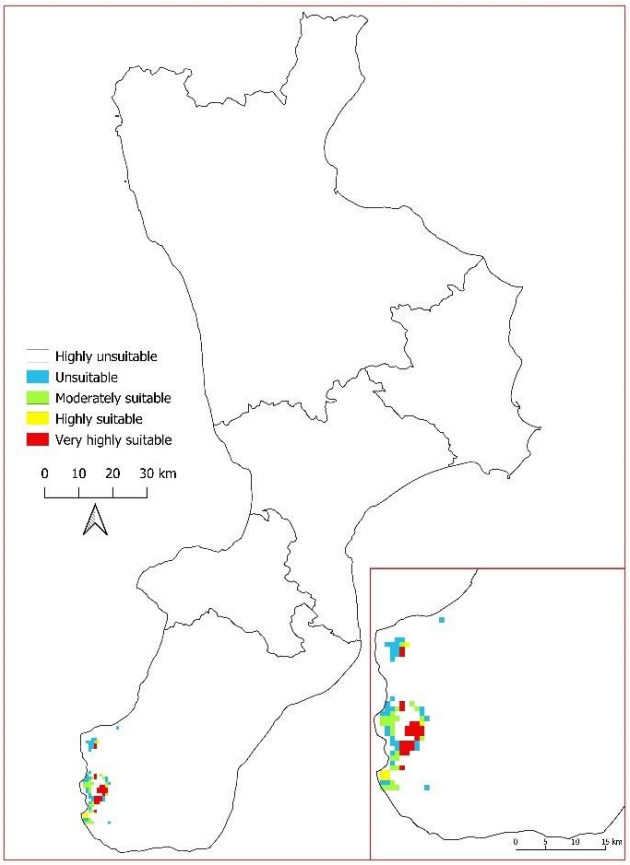



**Figure 8.** Prediction of the current potential distribution of *Salvia ceratophylloides* Ard. In relation to geological substrate. In white, highly unsuitable habitat (≤0.20); in blue, unsuitable (0.21–0.40); in green, moderately suitable (0.41–0.60); in yellow-low, highly suitable (0.61–0.80); and in red, highly suitable (≥0.80).

The SSP245 2041–2060 scenario presents a total area of 50.213 km$^2$, equal to 2.36% of the geological substratum and 0.33% of the regional territory. In relation to the probability values for the presence of the species, the area of model SSP245 2041–2060 is distributed as follows: very highly suitable (≥0.80) with an area of 4.750 km$^2$ (0.22% of the substratum, 0.03% of the regional territory); and highly suitable (0.61–0.80) with an area of 6.107 km$^2$ (0.29% of the substratum, 0.04% of the regional territory) (Table 4, Figure 9). Compared to the modelling of the current potential distribution interpolated with geological substrate data, we can see an increase in area of 18.164 km$^2$ or 132% in the 2021–2040 period, and an increase of 266% in the following 20 years with an increase of 36.485 km$^2$. Considering, on the other hand, the distribution area with the highest probability of hosting the species (≥0.80), overall, there is a decrease. In the 20-year period between 2021–2040, there is a decrease of 66.67% with a reduction in area of 10.857 km$^2$, and for the 20-year period between 2041–2060, there is a reduction of 70.83% and a loss of 11.535 km$^2$.

The distribution model with the SSP585 scenario shows a total area, suitable for hosting the species, of 187.960 km$^2$ in the 20-year period between 2021–2040, equal to 8.83% of the geological substratum considered and 1.25% of the entire Calabrian territory. In the following 20-year period (2041–2061), the area involved is 192.031 km$^2$, equal to 9.02% of the geological substratum and 1.28% of the regional territory. Considering the probability values for the presence of the species the area of the SSP585 model, in 2021–2040, is divided as follows: very highly suitable (≥0.80) 56.320 km$^2$ (2.65% of the geological substratum, 0.37% of the regional territory); and highly suitable (0.61–0.80) 17.642 km$^2$ (0.83% of the geological substratum, 0.12% of the regional territory) (Table 4, Figure 9). The next 20 years (2041–2060) show a distribution area of the species divided as follows: very highly suitable (≥0.80) 50.892 km$^2$ (2.39% of the geological substratum, 0.34% of the regional territory);

and highly suitable (0.61–0.80) 19.678 km$^2$ (0.92% of the geological substratum, 0.13% of the regional territory) (Table 4, Figure 9). Comparing the current potential distribution model interpolated with substrate data, with the SSP585 scenario, we find an increase of 174.232 km$^2$, or 1269%, for the 2021–2040 period, and an increase of 1299% in the following 20 years, with an increase of 178.303 km$^2$. Considering the distribution area with the highest probability of hosting the species, for the 20-year period between 2021–2040, we would have an increase of 245.84% with an increase of 40.035 km$^2$, for the 20-year period between 2041–2060, we would have an increase of 212.51% and a gain of 34.607 km$^2$. The future potential distribution models, interpolated with the geological substratum, show a decrease in area compared to the current potential distribution model. In the 20 years between 2021–2040, with scenario SSP245, there is a 79% decrease, while in the 20 years between 2041–2060 scenario SSP245, the decrease is 71%. The SSP585 scenario shows a decrease of 70% for both of the 20-year periods considered in the modelling.

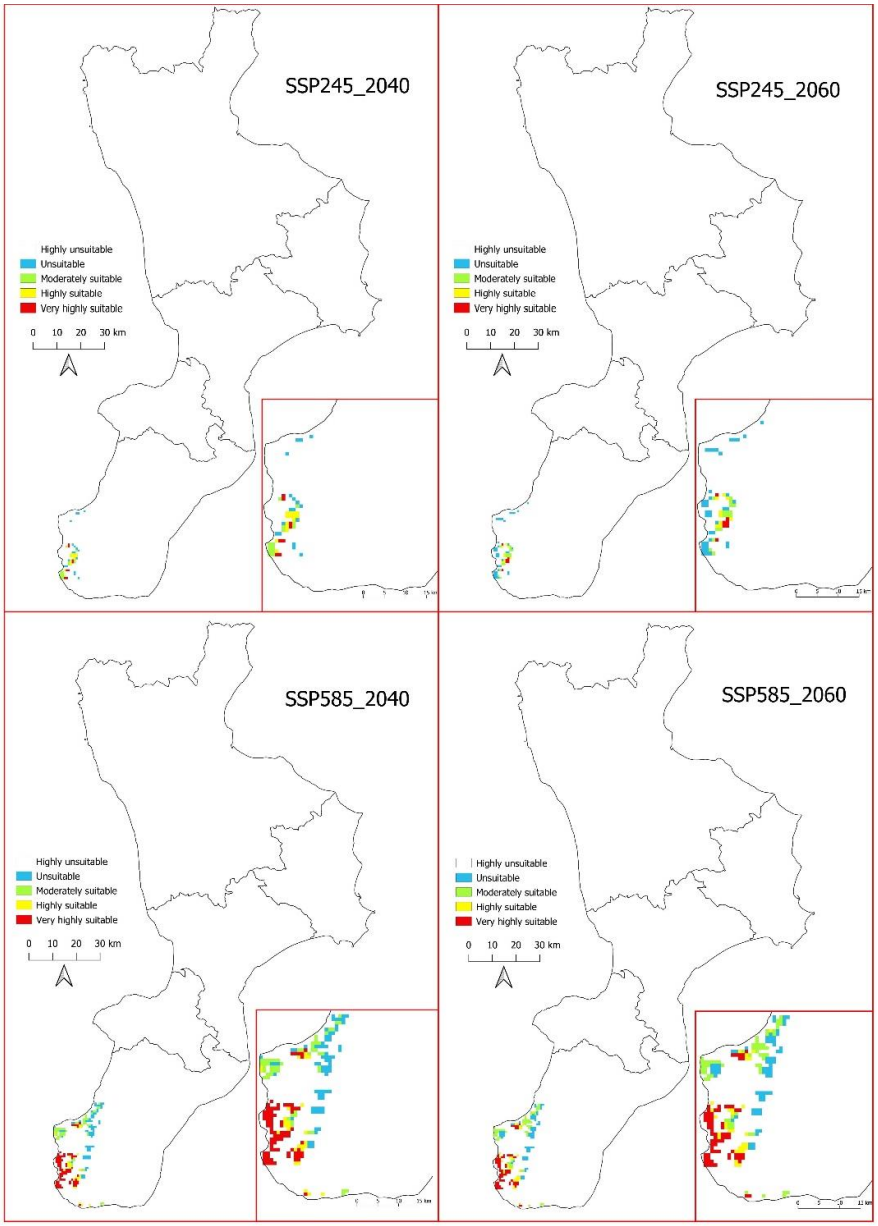



**Figure 9.** Prediction of the current potential distribution of *Salvia ceratophylloides* Ard. related to geological substrate, in two different scenarios SSP245 and SSP585 and two periods 2021–2040, 2041–2060. In white, highly unsuitable (≤0.20); in blue, unsuitable (0.21–0.40); in green, moderately suitable (0.41–0.60); in yellow, highly suitable (0.61–0.80); and in red, very highly suitable (≥0.80).

In accordance with the CORINE Land Cover system [98], class 2 (agricultural areas) and class 3 (forests and semi-natural areas) were considered in relation to the actual occurrence of the species; the second class was also considered because the Calabrian territory has fragmented agricultural areas that form a complex cultivation mosaic with the forests and semi-natural areas. All other land-use classes were omitted from the analyses.

Interpolating the current distribution model and the land use map shows that the area suitable for the species corresponds to 183.295 km$^2$, i.e., 1.22% of the entire regional territory; relating this to the current potential distribution model shows a decrease in the area suitable for the species of 54.026 km$^2$, i.e., 23% less (Table 5, Figure 10). The interpolation of the current distribution model with the exclusion of areas where there is no geological substrate suitable for the growth of the species, shows that the entire distribution area is 41.392 km$^2$, or 0.28%, of the entire regional territory, and in relation to the current potential distribution model, the area undergoes a decrease of 83%, or 195.929 km$^2$ (Figure 10). The table also shows the measures and percentages relating to the classification of habitat suitability in relation to the probability of occurrence values (Table 5).

**Table 5.** Ranking of habitat suitability of *Salvia ceratophylloides* Ard. Related to the values of probability of occurrence values in the different modelling obtained by interpolation with the current potential distribution. Very unsuitable (≤0.20); unsuitable (0.21–0.40); moderately suitable (0.41–0.60); very suitable (0.61–0.80); very suitable (≥0.80); and the area in km$^2$ and relative percentage (%) of decline compared to current potential modelling.

| Time | Unit | Area tot. | ≥0.80 | 0.61–0.80 | 0.41–0.60 | 0.21–0.40 |
|---|---|---|---|---|---|---|
| Present time | km$^2$ | 237.321 | 30.440 | 20.962 | 59.434 | 126.485 |
| Present time–land use | km$^2$ | 183.295 | 26.476 | 16.972 | 40.732 | 99.115 |
| | % | 23 | 13 | 19 | 31 | 22 |
| Present time–geological substrate | km$^2$ | 62.427 | 16.285 | 4.071 | 19.000 | 23.071 |
| | % | 74 | 47 | 81 | 68 | 82 |
| Present time–geological substrate–land use | km$^2$ | 41.392 | 14.928 | 2.714 | 10.857 | 12.893 |
| | % | 83 | 51 | 87 | 82 | 90 |

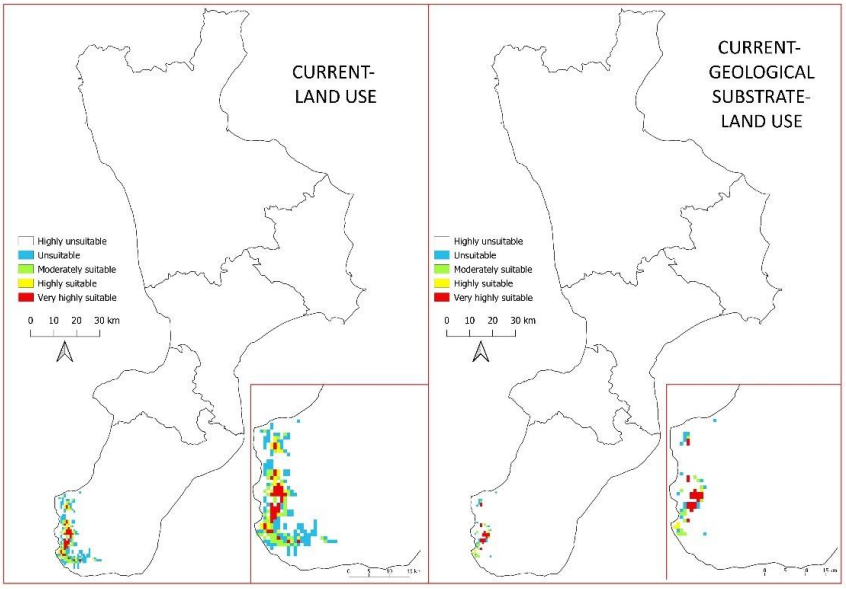



**Figure 10.** Prediction of the current potential distribution of *Salvia ceratophylloides* Ard. Only in relation to land use and land use with geological substrate. In white, highly unsuitable (≤0.20); in blue, unsuitable (0.21–0.40); in green, moderately suitable (0.41–0.60); in yellow, highly suitable (0.61–0.80); and in red, very highly suitable (≥0.80).

## 4. Discussion

The results of the current potential modelling show that the environmental suitability of *S. ceratophylloides* always falls within the same range as the observations made in the field in recent years, and are in accordance with the known distribution reported in the literature [13,64,66–69,73,74,76]. We can observe that the species does not extend its range; it is localised exclusively on the extreme southwestern side of the Italian Peninsula and the Calabria region, overlooking the Strait of Messina.

Further analyses of the current model suggest that the distribution of the species is strongly influenced by the same climatic conditions reported earlier in the literature [13,64]. The temperature and humidity variables that condition the reproductive biology of the species [13] proved important in defining the species' current potential distribution pattern. In particular, the average annual temperature parameters limit the distribution (7.8%) of this typically thermophilus species, as do the humidity parameters (precipitation of wettest month, precipitation of driest month, precipitation of coldest quarter) and temperature seasonality, which are closely linked to the species' ecological needs for germination and the release of young seedlings [13,64,80–82]. The elevation variable also has a range that does not differ from elevations measured at actual occurrence points [13,64]. The current potential distribution model includes (with a probability value of very highly suitable occurrence ≥80) areas where the species occurs as well as those where it is extinct [70,71]. Therefore, the extinction of the species in the latter areas is the result of severe environmental changes in the suburban area of Reggio Calabria, which is subject to extensive urbanisation and frequent devastating fires [99]. Future model projections for 2021–2040 and 2041–2060, obtained from the SSP245 and SSP585 scenarios, indicate that climate change will significantly influence the distribution of this species. The models with the SSP585 scenario show more significant impacts than the SSP245 scenario, which considers the same bioclimatic characteristics currently in place [19]. The SSP585 scenario shows that, the range suitable for the species will increase by 167% in the 2021–2040 period and 171% in the 2041–2060 period (Table 3, Figure 7). This trend can also be seen in other similar studies [100,101]. Furthermore, the SSP585 scenario predicts an extension of the optimal range to lower altitudes, down to sea level, and other authors also point to an altitudinal shift in the current potential distribution area of the examined species [43].

The SSP245 scenario shows a potential distribution of *S. ceratophylloides* similar to the current modelling, but with a decrease of 35% in the 2021–2040 period and 28% in the 2041–2060 period (Table 3, Figure 7). Similar decreases with the same scenario are also shown for other species [100].

*Salvia ceratophylloides* is a species with remarkable edaphic specialisation, as it grows exclusively on loose substrates characterised by Pliocene and/or Pleistocene sands and sandy conglomerates [13,64]; these substrates occupy 14% of the entire regional territory, but only 2.93% is occupied by the current potential distribution range of *S. ceratophylloides*. The geological substrate, in this case, becomes one of the limiting factors for the distribution of the species. Compared to the current distribution pattern, there is a decrease of 74%, with a loss of 174,894 km$^2$ of suitable area (Table 4, Figure 9), which considerably reduces the potential distribution range of the species. The model obtained by interpolating the SSP245 scenario with the geological substratum shows that the range suitable for the species will decrease by 79% in the period of 2021–2040 and by 71% in the period of 2041–2060 (Table 4, Figure 9), while the SSP585 scenario will show a decrease of 70% in both of the 20 years examined (2021–2040/2041–2060).

A further limiting factor is land use. The species' real range is entirely within a complex environmental mosaic, where agricultural areas (land use class 2) and natural and semi-natural habitats (land use class 3) are highly fragmented and interconnected. On the other hand, it is not present in urban areas (land use category 1), where it was probably present in the past before the expansion of the city, as bibliographic references attest [69]. Excluding the distribution of the species from urban areas, the potential distribution is

reduced by 23%, with a loss of 54,026 km$^2$, which mainly affects the lower elevation band (Table 5, Figure 10).

Considering the constraints imposed by the combination of geologic substrate and land use, the area suitable for *S. ceratophylloides* is reduced by 83% with a total area of 41,392 km$^2$ (Table 5, Figure 10) compared to 237,321 km$^2$ (Table 5, Figure 10) in the current distribution model that considers only bioclimatic variables and elevation.

Modelling obtained by subtracting the two limiting factors (geological substrate and land use) from the current range shows that the very highly suitable habitat (≥0.80), i.e., the one in which the probability of finding the species is very high, occupies 14.928 km$^2$; on the other hand, Laface et al. [13] show that the species has an Area of Occupancy (AOO) of 7 km$^2$. The modelled distribution is therefore greater than the observed AOO, and *S. ceratophylloides* could potentially be found in other areas where it has not yet been observed or where it is not present due to anthropogenic urbanisation [13] or other limitations, such as pests [102]. The current AOO and anthropogenic pressures justify the assessment of this species as Critically Endangered (CR) [13,64,75]. Without pressures and threats that currently limit the distribution of the species, the range will be 14.928 km$^2$ (very highly suitable ≥80), which would reassess the species as Endangered (EN).

Research on *S. ceratophylloides* confirms that the magnitude of change in the distribution of potential 2021–2040 and 2041–2060 niches is comparable. That is, the changes expected for the later period will occur approximately 20 years earlier than is commonly believed, as 2041–2060 is often overlooked in many studies, most of which are for 2061–2080. Hence, there is less time to develop strategies to mitigate the effects of climate change than is usually believed [103,104].

## 5. Conclusions

This study allowed us to develop very efficient models of the current and future potential distribution of *S. ceratophylloides*. These showed that habitat suitable for the species will decrease in 2021–2040 and 2041–2060 in the SSP245 scenario, and increase in the SSP585 scenario, but it should be noted that important constraints on the species' distribution are due to the geological substrate and land use, which significantly limit the current potential distribution.

The potential distribution model identifies areas of suitable habitat for the species occurrence to evaluate the presence of new occurrence points or to identify locations where there is a high probability of the species occurrence.

The assessment of changes in species distribution related to climate change impacts also made it possible to identify priority areas for reintroduction. Therefore, considering the results obtained, to reduce the risk of extinction of *S. ceratophylloides* in the wild, the reintroduction of the species in areas that are suitable according to modelling is an important in situ conservation measure

The model also gives us clear indications of where to focus conservation activities; for example, by establishing micro-reserves, small protected areas created to ensure the conservation, study, and monitoring of endemic endangered flora in the future, which can be entrusted to environmental associations or the landowner. Furthermore, this work may be useful for future actions to reintroduce and reinforce the existing *S. ceratophylloides* population in areas showed according to modelling. These activities should be accompanied by greater awareness raising among public opinion and political authorities to reduce the impact of human activities.

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# **CHAPTER 5.** Seed Priming in *Salvia Ceratophylloides* Ard.: Plant Development and Ecophysiology and Responses to Combined Abiotic Stress

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# SEED PRIMING IN *Salvia ceratophylloides* Ard.: PLANT DEVELOPMENT AND ECOPHYSIOLOGY AND RESPONSES TO COMBINED ABIOTIC STRESS

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## Abstract

The study on the phenological and ecophysiological responses of S. ceratophylloides to single and combined stresses showed that individuals whose seeds were exposed to priming treatments exhibited well-functioning, healthy plants that responded early and actively to simulated stresses of future climate change. The treatment positively influenced seedling emergence with a statistically significant increase [123% in the Osmopriming (OP) treatment and 108% in the Hydropriming (HP) treatment] compared to the non primed seed (control, CP). S. ceratophylloides plants treated with OP and HP showed a higher net photosynthetic rate [4.16 and 3.91 µmol (CO2) m-2 s-1, compared to 2.95 µmol (CO2) m-2 s-1 for CP. Heat (H) and combined stress (drought + DH heat) caused a significant reduction in PN by more than 50% compared to the control. Stomatal conductance measured at all three irradiations and in the presence of heat and combined stress was statistically reduced by 84% compared to the control (C), suggesting a stomatal-dependent reduction in photosynthesis. Overall, all the ecophysiological results pointed out a synergistic rather than additive effect of the two stresses.

## Introduction

*Salvia ceratophylloides* Ard. is an endemic and rare species, with very few individuals localised around the sandy hills of Reggio Calabria (southern Italy). Declared “extinct in the wild” [1,2], this plant species was rediscovered during field surveys conducted in the last decade [3-7], and is currently fragmented into 17 micropulations [8]. Fragmentation and loss of natural habitats by intense urbanization caused the and threats posed by insect attack [9], determined a strongly impact on survival of the few *S. ceratophylloides* individuals. Several studies have been conducted to understand the biology, ecophysiology, population structure and dynamic of *S. ceratophylloides* [8,10]. The micro-populations of this rare species pointed out non-stable dynamics over time as they are impacted by stressful factors that act on both habitat and individuals with different life-stage-dependent intensities [8]. Further, ecophysiological and metabolic analysis in a field study revealed that *S. ceratophylloides* showed sunny habitat preference and sharply “continuous” within-

plant variation of the morpho-ecophysiological traits and metabolic profiles especially in disturbed site only [11].

By previous studies is raised the the difficulty of surviving of the *S. ceratophylloides* individuals that as the other rare and threatened plants, require considerable research and knowledge on bio-technologies useful for promoting *ex-situ* conservation. Among the most interesting bio-technologies, the seed priming received more attention and interest from researchers for different reasons. It is ecofriendly and economical presowing techniques that speed and allow an uniform seed germination, increase the seed vigor and improve the seedling quality for the transplant operation [12, 13]. Technically, it is a pre-sowing seed treatment that allows controlled hydration of seeds that start the germination process but are stopped by re-hydration before the radicle/epicotyl emission [14,15]. The controlled hydration of the seeds can occur in water (hydropriming) or solution of salts, PEG or mannitol (osmopriming), germination promoters (hormopriming) or living microbial cells (biopriming) [14]. The seed priming is very interesting for the restoration ecology by native plant species, notably characterized by low, recalcitrant and non-uniform germination process. But above all, it is fundamental for the restoration ecology of fragile ecosystems such as those predominate by no-optimal environmental conditions with raising of drought, heat, nutritional, flooding, and salt stress [14,15]. This is due to the induction of plant tolerance to abiotic and biotic stress by molecular and biochemical changes that improve the "defence system" of the seedlings. For example, biopriming with cyanobacteria has been utilized for the dryland restoration by native plant species [16]; hydro- and osmo-priming improved the germination of pioneer species for the tropical region restoration [17] while osmopriming together with hormopriming pointed out a successful result for the restoration of European calcareous grasslands by native species [18].

Considering the effectiveness and improvements of the germination process, the seed priming could be more useful for the *ex-situ* and *in-situ* conservation of the rare and endangered plant species. In spite of this useful bio-technology, very few studies have been addressed to verify the seed priming in rare and endangered plant species. In this framework, this study focused on the effects of two seed priming, the hydropriming and osmopriming, on the phenology and ecophysiology of *Salvia ceratophylloides* Ard. Phenology is among the plant traits that most interesting because strongly influence the niche overlap [19, 20] and is under selection by climate [21, 22]. Further, the plant ecophysiology by 'gas exchange measurement' is a two tool used in conservation physiology for "*…understanding plant responses to environmental change…improving restoration success*…" as suggested by Madliger et al. [23]

The rare plant species could be also threat by the climate change whose predictions indicated a negatively impact on plant biodiversity [24]. As crucial for this endemic and rare plant species, this study evaluate the *Salvia ceratophylloides* responses to the

single and combined drought and heat stress, the main stressors of climate change, and how these responses are modulated by different seed priming.

## Material and Methods

### *Rationale and experimental design*

The present study has been conducted by two different experiments. The first experiment focused on the effects of different seed priming methods on the phenology and ecophysiology of *Salvia ceratophylloides* Ard. plants. For this aim, the experimental design involved three different priming methods [control priming (CP), hydropriming (HP) and osmopriming (OP): see below paragraphs] as pre-sowing *Salvia* seed treatments with 12 replicates for a total of 36 plants.

The second experiment related to the effects of the seed priming methods on the *Salvia* responses to the single and combined abiotic stress such as drought and heat, the main stressors of the climate changes. In this respect, three seed priming methods (CP, HP, and OP) and four stress treatments (drought (D), heat (H), drought+heat (DH) and control (C): see below paragraphs) have been included for a total of 36 plants (n= 3).

### *Plant material and Seed priming*

The seeds of *Salvia ceratophylloides* (Ard.), already described by Spampinato *et al.* [7], were collected from individuals of different populations located around the hills of Reggio Calabria (southern Italy).

One hundred and eighty healthy seeds have been used for the experiments. The seeds were sterilised by soaking in a 20% bleach solution for 10 minutes, after which they were washed thoroughly with deionised water. Then, 60 seeds were placed in a beaker in a 10% (w/v) PEG 8000 solution (Osmo-priming, OP) for 4 h at 25°C on a low-speed magnetic stirrer. Sixty seeds were immersed only in deionised water (Hydro-priming, HP) for 4 hours at 25°C, on a low-speed magnetic stirrer. After priming, the seeds were rinsed thoroughly with distilled water and dried in a thermostatic chamber at 20°C until they reached their original weight until the experimental use. Finally, 60 untreated seeds were used as controls (CP).

### *Seed Priming Effects on Salvia phenology and ecophysiology*

*Study system*

The *Salvia* seeds of each priming methods (CP, HP and OP) have been surface sterilized with 20% bleach solution for 20 minutes and rinsed with deionized water 5 times. Afterwards, five seeds of each priming methods have been sowed in pots filled with a mix of 1 part collected field soil [Terriccio professionale, Vigorplant Italia SRL: 21% baltic peat (0-10 mm), 37% Irish peat (0-20 mm), slow-release fertiliser (N, P, K), 13% volcanic pumic and 29% superfine peat (0-3 mm)] and 2 parts of autoclaved quartz sand (1-2 mm, Quarzo bianco - Amtra Pro Nature) (3 hours at 121°C, allowed to cool overnight and then other 3 hours at 121°C). Finally, the 36 pots (3 seed priming x 12 replicates) have been randomly distributed within a climatic chamber set at 25°C, 70% relative humidity (RH) and a 14:10 light: dark (L:D) photoperiod). During the experiment, each pot has been watered with 200 mL of tap water every four days, previously shown to guarantee a minimum of 80% soil field capacity.

*Phenological measurements.*

In this study, the life stages of *S. ceratophylloides* Ard. have been considered as well as of *S. pratensis* [25], a plant species related to *S. ceratophylloides* in terms of biological and phenological characteristics. Hence, the life stages of *S. ceratophylloides* were the followings:

S = Seedlings, with cotyledons and one/two main leaves;

JI = (J) Juveniles with two/three pairs of leaves and (I) Immature plants with three/four pairs of leaves;

V = Vegetative adults with at least five pairs of leaves;

G = Generative adults having one to five flowering stems up to 50 cm high. Within the G category, two size sub-classes have been further distinguished: SG = Small Generative adults with one or two flowering stems; LG = Large Generative adults with more than two flowering stems, usually the largest individuals are also the oldest (3–4 years old).

Every day from seeding (except Saturday and Sunday), the *Salvia* seedling emergence (% respect the total seeds) and the different life stages have been recorded and the time of appearance (days from seeding) and the duration of each life stages (days) have been calculated.

*Leaf Ecophysiological analysis*

At the same life stage (SG) and similar plant height, the ecophysiological and morphological analysis have been conducted on the *Salvia* plants.

The ecophysiological analysis involved the measurements of the net photosynthetic light response curves (NPLRC) that provide information on the photosynthetic performances in response to changing environmental conditions [26, 27]. Briefly, the curves were determined on health and well-developed leaf of *Salvia* plants using the LI-6400XT portable photosynthesis system (Li-Cor, Inc. Lincoln, Nebraska, USA) at the following irradiance levels: 2000, 1600, 800, 400, 200, 100, 50, 25, 12, 6 and 0 μmol $m^{-2}$ $s^{-1}$. The LICOR setting has been as the following: 500 cm3 $min^{-1}$ flow rate, 26 °C leaf temperature, $CO_2$ concentration 400 μmol($CO_2$) mol(air)$^{-1}$ (controlled by $CO_2$ cylinder). Each measurement have been made with a minimum and maximum wait time of 120 s and 200 s, respectively, and matching the infrared gas analyzers for 50 μmol($CO_2$) mol(air)$^{-1}$ difference in the $CO_2$ concentration between the sample and the reference before every change in I. The leaf to-air vapor pressure difference (VPD) was set to 1.5 kPa, and continuously monitored around the leaf during measurements and maintained at a constant level by manipulating the humidity of incoming air as needed. The measurements have been made in climate chamber during 8:30–11:30 am. Light curves were fitted by nonlinear regression using the Ye [28] model equation:

$$PN = \emptyset_{(I_0 - I_{comp})} \times \frac{1-\beta \times I}{1+\gamma \times I} \times (I - I_{comp}) \quad (1)$$

where: PN – the net photosynthetic rate [μmol($CO_2$) $m^{-2}$ $s^{-1}$]; I – the photosynthetic photon flux density [μmol(photon) $m^{-2}$ $s^{-1}$]; Icomp – the light compensation point [μmol(photon) $m^{-2}$ $s^{-1}$]; β – the adjusting factor (dimensionless); γ – the adjusting factor (dimensionless); ϕ (Icomp – I200) – the quantum yield obtained at the range between Icomp and I200 [μmol($CO_2$) μmol(photon)$^{-1}$]. The following leaf-level photosynthetic parameters have been calculated by these equations [28]:

$$P_{gmax} = \emptyset_{(I_0 - I_{comp})} \times \frac{1-\beta \times I}{1+\gamma \times I} \times \left(I - I_{comp}\right) + R_D \quad (2)$$

$$R_D = \emptyset_{(I_0 - I_{comp})} \times I_{comp} \quad (3)$$

Isat – the light saturation point [μmol(photon) $m^{-2}$ $s^{-1}$]; Pgmax – the asymptotic estimate of the maximum gross photosynthetic rate [μmol($CO_2$) $m^{-2}$ $s^{-1}$]; RD – the dark respiration rate [μmol($CO_2$) $m^{-2}$ $s^{-1}$]. Finally, the ϕ (Icomp – I200) was

calculated as the slope of the linear regression of PN for values of I between Icomp and 200 μmol (photon) $m^{-2}$ $s^{-1}$ representing the "maximum quantum yield". Finally, according to Lobo et al. [29], we reported the Imax (μmol(photon) $m^{-2}$ $s^{-1}$) (light saturation point beyond which there is no significant change in PN) and the PN(Imax) (μmol($CO_2$) $m^{-2}$ $s^{-1}$) (maximum value of PN obtained at I = Imax) instead of Isat and Pgmax as more realistically adequate. We used a simple routine to minimize the error sum of squares (SSE) for fitting the models allowing the determination of equation parameters using the Microsoft Excel spreadsheet and Solver function (Microsoft Excel 2010). Non-linear regressions were repeated several times in order to minimize the sum of square of deviation between predicted and experimental values to less than 0.01% between two consecutive fits [30].

*Statistical analysis*

A completely randomized design with 12 replicates for each priming method has been utilized. All data were tested for normality (Kolmogorov–Smirnoff test) and homogeneity of variance (Levene median test) and, where required, the data were transformed. By SPSS Inc., V. 10.0, 2002 (SPSS Inc., Evanston, IL, USA), all parameters were analyzed by one-way analysis of variance with the priming method (CP, HP and OP) as main factor. Subsequently, Tukey's test has been used to compare the means of all parameters of each priming method ($p$<0.05).

***Responses of different priming-treated plants to the single and combined abiotic stress***

*Study system*

The *Salvia* seeds of each priming methods (CP, HP and OP) have been sown on 36 pots as before described. The pots have been placed in a climatic chamber set at 25°C, 70% relative humidity (RH) and a 14:10 light: dark (L:D) photoperiod). During the experiment, each pot has been watered with 200 mL of tap water every four days, previously shown to guarantee a minimum of 80% soil field capacity. After the seedling emergence, one plant was left for each pot

*Stress treatments*

At the SG life stage, the *Salvia* plants have been subjected to stresses. In particular, 18 pots have been transferred to a second growth chamber with the same environmental conditions except for the temperature set at 29 °C (Heat condition, H), whereas the remaining 18 were left in the previous growth chamber at 25 °C. In 9

pots of both growth chambers have been imposed drought stress (D) by the water withholding until to reach the theoretical fraction of 30% of field capacity (FC) measured by the gravimetric method. To the remaining pots, conversely, have been ensured well-watered conditions in order to maintain the theoretical fraction of 80% FC. The desired percentage of FC has been maintained by daily surface addition of water. Hence, the following stress treatments have been imposed: drought (D) (25° and water at 30% FC), heat (H) (29°C and water at 80% FC), combined (DH) (29°C and water at 30% FC) and control (C) (25° and water at 80% FC).

Overall, considering the three seed priming, the entire experiment yielded a total of 3 seed priming (CP, HP and OP) x 4 stress treatments (D, H, DH and C) × 3 (replicates) = 36 plants grouped as the following:

Control priming and Control stress treatment (CP-C); Control priming and drought stress (CP-D), Control priming and heat stress (CP-H), Control priming and combined stress (CP-DH), Hydropriming and control stress treatment (HP-C), Hydropriming and drought stress (HP-D), Hydropriming and heat stress (HP-H), Hydropriming and combined stress (HP-DH), Osmopriming and control stress treatment (OP-C), Osmopriming and drought stress (OP-D), Osmopriming and heat stress (OP-H), and Osmopriming and combined stress (OP-DH).

*Leaf Ecophysiological analysis*

At 0, 1 and 14 days from stress treatments, the ecophysiological no-destructively analysis have been conducted on the *Salvia* plants as described in the previous paragraph. In addition, the stomatal conductance (gs, mol $H_2O$ $m^{-2}$ $s^{-1}$) and transpiration rate (T, mmol $H_2O$ $m^{-2}$ $s^{-1}$) at each 25, 50 and 100 µmol $m^{-2}$ $s^{-1}$ of light intensities have been measured by LICOR. Further, the intrinsic water use efficiency (WUEi) has been calculated as the rate of photosynthesis (A) divided by the rate of stomatal conductance to water (gs) [31].

*Leaf morphological and plant growth analysis*

At 0 and 14 days from stress treatments, after the physiological measurements, the same leaves were used for the morphological analysis that consisted in the evaluation of the relative water content (RWC) and the leaf mass per area (LMA). The RWC is an important indicator of water status in plants [32], while the LMA has been strongly related to photosynthetic rate [33], growth rate [34] and decomposition rate [35]. Briefly, the *Salvia* leaves have been collected and immediately weighed (LFW, g), for determination the leaf area (LA, $cm^2$) used ImageJ® software package (National Institutes of Health, 9000 Rockville Pike, Bethesda, Maryland 20892, USA) and afterwards dipped in deionised water and left in the dark for 48 h.

Afterwards, they have been again weighed to measure the leaf turgid weight (LTW, g) and then placed in an oven at 70 °C for 48 h to determine the dry weight (LDW).

The relative water content (RWC, %) of the leaf has been calculated according to [36]:

$$RWC = ((LFW - LDW)/(LTW - LDW))x100 \quad (4)$$

The leaf mass per area (LMA, g LDW cm-2 LA) has been calculated in according to de la Riva *et al.* [37] as:

$$LMA = LDW/LA \quad (5)$$

Furthemore, at 14 days from stress treatments, the fresh and dry weight of the rosette ($RL_{FW}$ and $RL_{DW}$, g) and flowering stalk leaves ($FSL_{FW}$ and $FSL_{DW}$, g), the flowering stalk ($FS_{FW}$ and $FS_{DW}$, g), and the root system ($R_{FW}$ and $R_{DW}$, g) have been evaluated. Finally, the plant height (PH, cm) has been measured.

*Statistical analysis*

By SPSS Inc., V. 10.0, 2002 (SPSS Inc., Evanston, IL, USA), all ecophysiological parameters have been analyzed by Repeated Measure two-way ANOVA as priming methods (P) and Stress Treatments (T) as main factors and Priming x Treatments (PxT) as the interaction. While all the leaf morphological and plant growth parameters have been analyzed by two-way ANOVA as priming methods (P) and Stress Treatments (T) as main factors and Priming x Treatments (PxT) as the interaction. Subsequently, Tukey's test ($p<0.05$) has been used to compare the means of all parameters of each priming method and stress treatments.

## Results and Discussions

### *Seed Priming Effects on Salvia phenology and ecophysiology*

Seeds of native plant species usually pointed out several difficult to germinate causing limitation for the ecological restoration of low-biodiversity ecosystems. For example, lesser than 10% of field-distributed seeds were able to successfully produce a well-developed plant [38]. *Salvia ceratophylloides* Ard. is an endemic and rare native plant species of south Italy whose low seed production and/or threats posed by insect attack [9] are causing serious problems on the survival of this plant species in its habitats. In this framework, priming technologies to enhance the *Salvia* seed germination and hence the seedling emergence and plant development are

fundamental for the restoration outcomes associated with direct seeding. In this study, we treated the *Salvia* seeds with two priming methods (hydropriming and osmopriming) that were compared with the standard procedure of seeding of this species. Hydropriming and osmopriming of the *Salvia ceratophylloides* Ard. seeds positively affected the seedling emergence as showed by Figure 1. In particular, both HP and OP produced a statistical significant increase of the emergence of *Salvia* seedlings by 123% and 108%, respectively, respect than CP (Figure 1). To note the low seedling emergence (26%) with the standard procedure of seeding (CP) (Figure 1) that is weakly higher than that observed in field study of grass species [39], rare arable plants (segetal species) [40], *Eucalyptus* species [41], also of two *Salvia* species, *Salvia nemorosa* and *S. pratensis* [42].

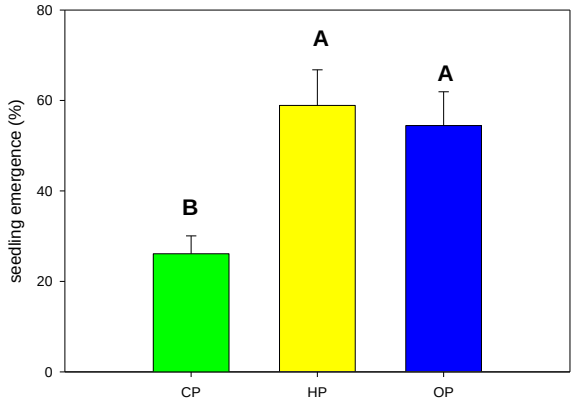



Figure 1 - Seedling emergence (%) of *Salvia ceratophylloides* plants treated with three different seed priming methods: control priming (CP), hydropriming (HP) and osmopriming (OP) (see Material and Method).
Different letters indicated statistically significant differences between the averages (n=12, $p<0.05$, test of Tukey).

Seed priming also determined a considerable influence on the life stage of *S. ceratophyloides* plants both by time of appearance and duration (Figure 2). Indeed, the hydropriming and, at lesser degree, osmorpiming significantly affected the early life stages of *S. ceratophylloides*, the seedling and juvenile/intermediate but not the V and SG life stages (Figure 2). Molecular study conducted on *Salvia miltiorrhiza* demonstrated that the most variation of an essential post-transcriptional process, the alternative splicing, occurred at the early life stages [43]. Figure 2 showed that, in particular, both seed priming extended the time of appearance (42 and 34 days for the HP and OP, respectively *vs* the 23 days for the CP) but reduced the duration of J/I (5.5 and 8.2 days for the HP and OP, respectively *vs* the 15 days for the CP) (Figure 2). The S life stage has been modified in the duration only and conversely to that of J/I life stage. In particular, both seed priming increased the duration of J/I: 32.5 and

24.4 days for the HP and OP, respectively *vs* the 13.6 days for the CP) (Figure 2). The seedling phase is the most critical phases during a plant's life history whose duration is dependent to the food reserves stored in the seed [44]. Probably, the seed priming, HP and OP, could impact more than CP on the seed metabolism of the germination process causing a more release of the seed metabolites and nutrients useful to sustain the seedling growth thus determining a longer duration of this stage without switch to external source. Because excess seed nutrients and metabolites such that observed in large-seeded species, determined a higher seedling fitness and resistance to the environmental hazards [45], we hypothesized that HP and OP could improve the *Salvia ceratophylloides* fitness and survival *via* seedling reinforcement.

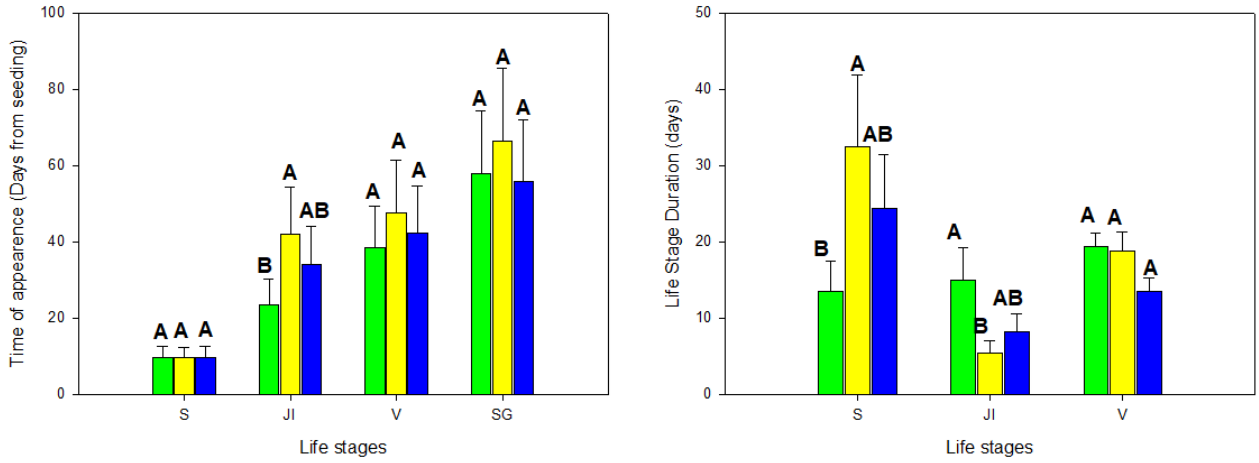



Figure 2 - Time of appearance (day from seeding) and duration of life stages of *Salvia ceratophylloides* plants treated with three different seed priming methods: control priming (CP) (green color), hydropriming (HP) (yellow color) and osmopriming (OP) (blu color) (see Material and Method).
Different letters within life stages indicate statistically significant differences between the means (n=12, $p<0.05$, test of Tukey)

To verify that the seed priming also results in a plant growth and defensive performances, we evaluated net photosynthetic light response curves that provide information on the plant performances in response to changing environmental conditions [26, 27]. In order to compare the different net photosynthetic light responses (NPLR) of *S. ceratophylloides* plants treated with diverse seed priming, the NPLR have been described by the iteratively solved Ye model [28](see equations 1, 2 and 3 in Material and Methods) whose curve represented the best fit of data ($p<0.001$ and $R^2>0.990$ for all the three curves, Figure 3). As observed in figure 3, the NPLR curves of OP and HP differed from those of CP. By non-linear regression, we estimated several parameters that permit to statistically compare the NPLR of *S. ceratophylloides* for each seed priming (Table 1).

Table 1. Leaf-level photosynthetic parameters for different *Salvia ceratophylloides* plants primed with different methods (CP: control priming; HP: hydropriming; OP: osmopriming; see Material and Methods). The leaf-level photosynthetic parameters were estimated by nonlinear regression using the Ye et al. model [28].

| | CP | HP | OP |
|---|---|---|---|
| **Icomp** [µmol (photons) m-2 s-1] | $35.19^{a}$ | $13.12^{b}$ | $18.15^{ab}$ |
| **Isat** [µmol (photons) m-2 s-1] | $720.89^{a}$ | $813.23^{a}$ | $791.34^{a}$ |
| **Imax** [µmol (photons) m-2 s-1] | $142.55^{b}$ | $204.33^{ab}$ | $212.82^{a}$ |
| **PN** [µmol (CO2) m-2 s-1] | $2.95^{b}$ | $3.91^{ab}$ | $4.16^{a}$ |
| **RD** [µmol (CO2) m-2 s-1] | $1.16^{a}$ | $0.69^{b}$ | $0.98^{ab}$ |

Different capital letters indicate statistically significant differences between averages within rows (one-way ANOVA with 10-12 replications; $p<0.05$, Tukey's test).

In particular, the *S. ceratophylloides* plants treated with OP and, at lesser degree, HP pointed out a higher net photosynthetic rate [4.16 and 3.91 µmol ($CO_2$) $m^{-2}$ $s^{-1}$ for the OP and HP, respectively vs the 2.95 µmol ($CO_2$) $m^{-2}$ $s^{-1}$ for the CP] (Table 1). Further, the seed priming of the *Salvia ceratophylloides* reduced the Icomp and increased the Imax, the light saturation point beyond which there is no significant change in PN (table 1), suggesting that *Salvia* plants treated with OP and HP efficiently photosynthesized in higher range of light irradiance. These results indicated that the *Salvia* individuals whose seeds have been exposed to priming treatments, exhibited well-performed and health plants. Previous studies also supported the present results which pointed out that the seed priming is a seed technology that promotes the germination process but also the photosynthetic conversion rate of seedlings [46, 47].

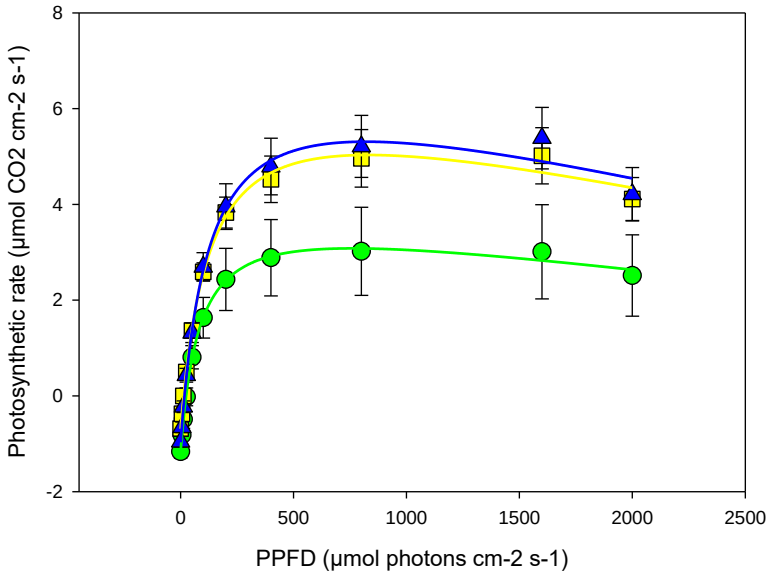


Figure 3 - Leaf photosynthetic light-response curves measured on *Salvia ceratophylloides* plants treated with three different seed priming methods: control priming (CP) (green color), hydropriming (HP) (yellow color) and osmopriming (OP) (blu color) (see Material and Method).
Data points represent means (n = 10–12). Light curves have been fitted by non-linear regression using the Ye et al. model [28].

### *Responses of different priming-treated Salvia plants to the single and combined abiotic stress*

Several studies revealed that the seed priming provided plant resistance to different abiotic and biotic stress permitting an increase of the plant fitness in fragile ecosystems with different environmental conditions such as drought, heat stress, salinity, and nutrient stress [15]. Considering that the long-term Climate Change predictions indicated a negatively impact on plant biodiversity [24], we evaluated the responses of *S. ceratophylloides* to the single and combined drought and heat stress, main stressors of climate change, and how these responses are modified by different seed priming. The *Salvia* plant growth has been weakly modified by stress treatments but dependent to the seed priming as indicated by the figures 4-8. In particular, the fresh weight of rosette leaves has been statistically increased in presence of drought stress respect than control in OP (+781%) but statistically reduced by the combined stress in CP seed priming (-96%), while any change has been observed in HP seed priming (Figure 4).

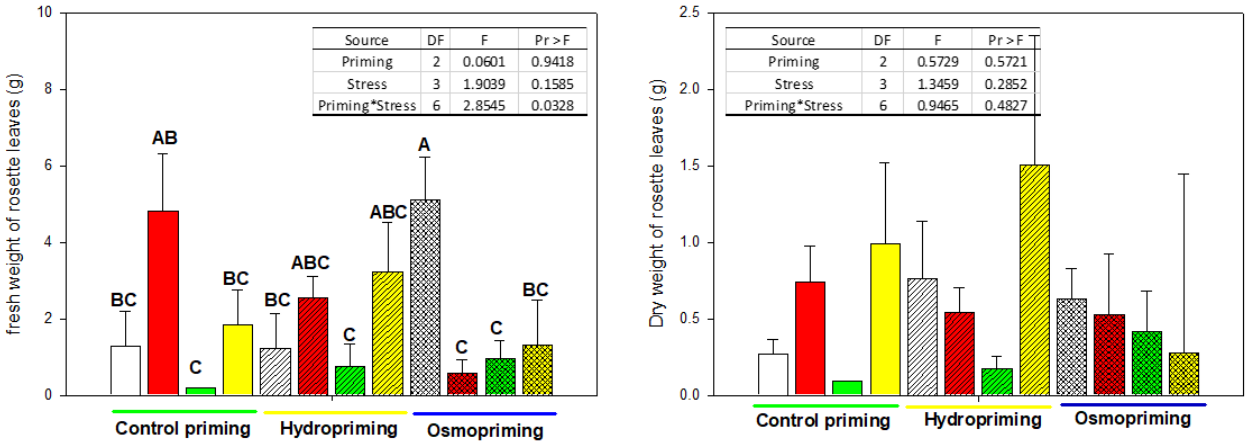



Figure 4. Fresh and dry weight of rosette leaf of *Salvia ceratophylloides* plants treated with three different seed priming methods [control priming, hydropriming and osmopriming (see Material and Method)] and exposed to different abiotic stressors [drought (white color), control (red color), drought+heat (green color) and heat (yellow color)] for 14 days from stress treatments.
Data points represent averages (n = 3). The insert shows the two-way ANOVA results. Different letters indicate statistically significant differences between the averages ($p$<0.05, test of Tukey). The letters are only reported whether either of the two independent variables or their interaction are statistically significant.

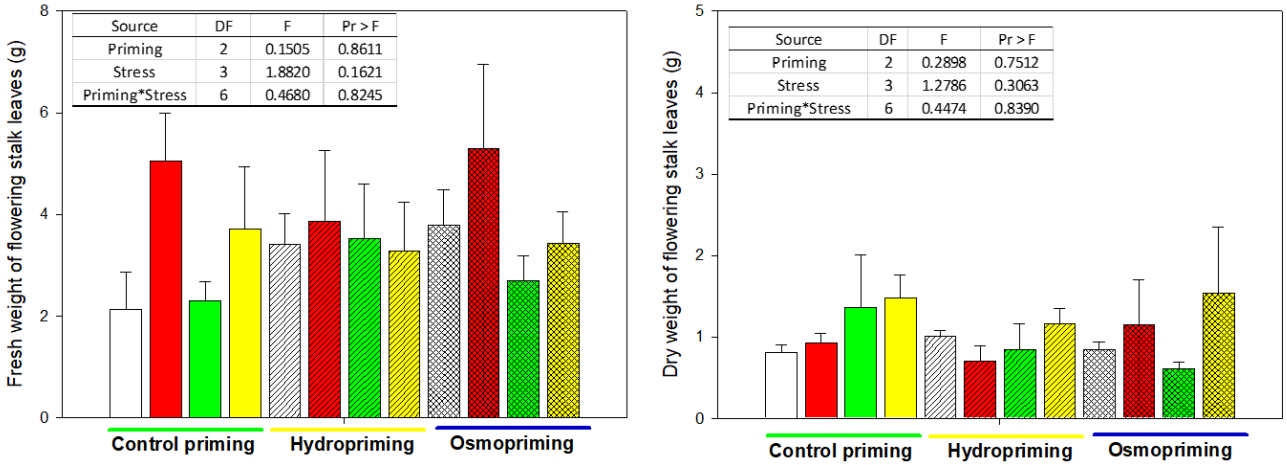



Figure 5. Fresh and dry weight of flowering stalk leaves of *Salvia ceratophylloides* plants treated with three different seed priming methods [control priming, hydropriming and osmopriming (see Material and Method)] and exposed to different abiotic stressors [drought (white color), control (red color), drought+heat (green color) and heat (yellow color)] for 14 days from stress treatments.
Data points represent means (n = 3). The insert shows the two-way ANOVA results. Different letters indicate statistically significant differences between the averages ($p$<0.05, test of Tukey). The letters are only reported whether either of the two independent variables or their interaction are statistically significant.

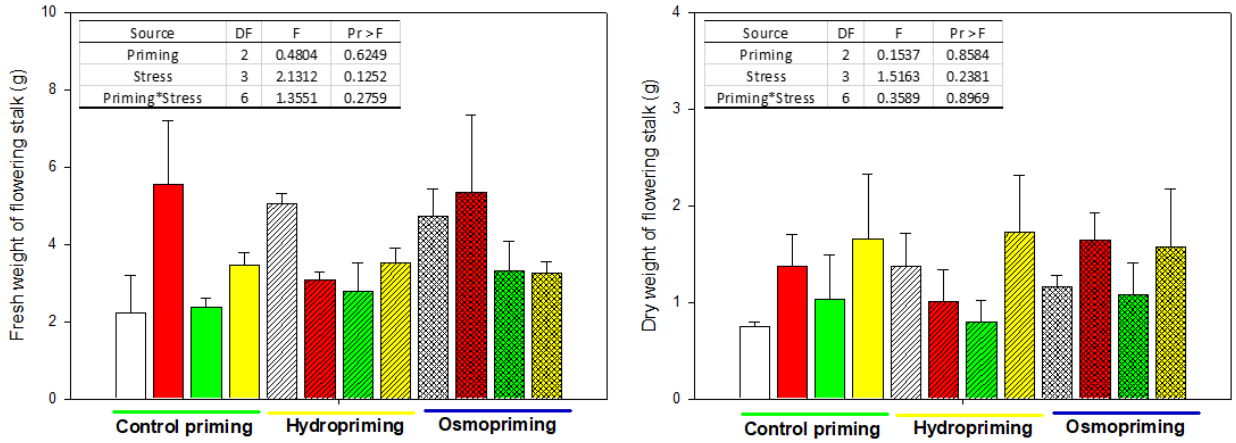



Figure 6 - Fresh and dry weight of flowering stalk of *Salvia ceratophylloides* plants treated with three different seed priming methods [control priming, hydropriming and osmopriming (see Material and Method)] and exposed to different abiotic stressors [drought (white color), control (red color), drought+heat (green color) and heat (yellow color)] for 14 days from stress treatments.
Data points represent means (n = 3). The insert shows the two-way ANOVA results. Different letters indicate statistically significant differences between the averages ($p$<0.05, test of Tukey). The letters are only reported whether either of the two independent variables or their interaction are statistically significant.

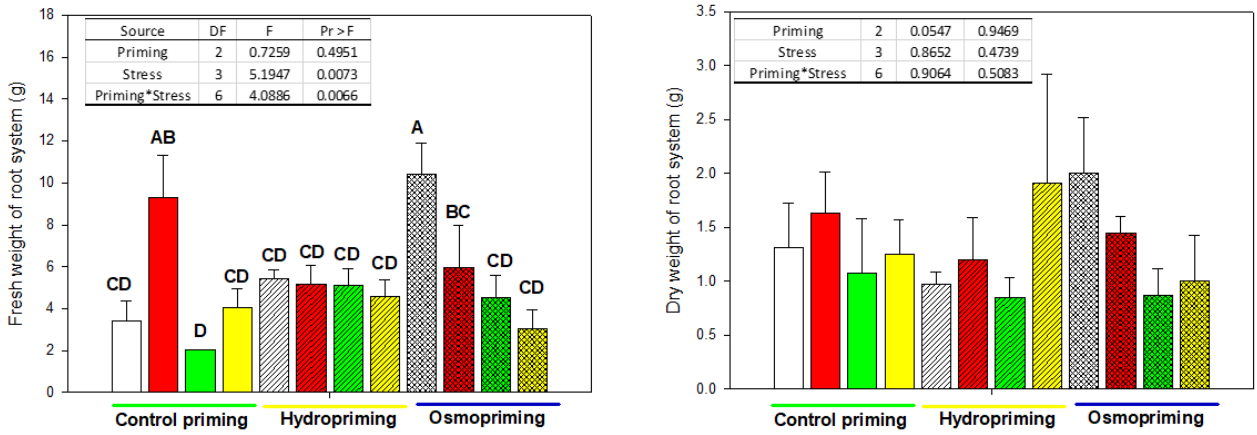



Figure 7 - Fresh and dry weight of root system of *Salvia ceratophylloides* plants treated with three different seed priming methods [control priming, hydropriming and osmopriming (see Material and Method)] and exposed to different abiotic stressors [drought (white color), control (red color), drought+heat (green color) and heat (yellow color)] for 14 days from stress treatments.
Data points represent means (n = 3). The insert shows the two-way ANOVA results. Different letters indicate statistically significant differences between the averages ($p$<0.05, test of Tukey). The letters are only reported whether either of the two independent variables or their interaction are statistically significant.

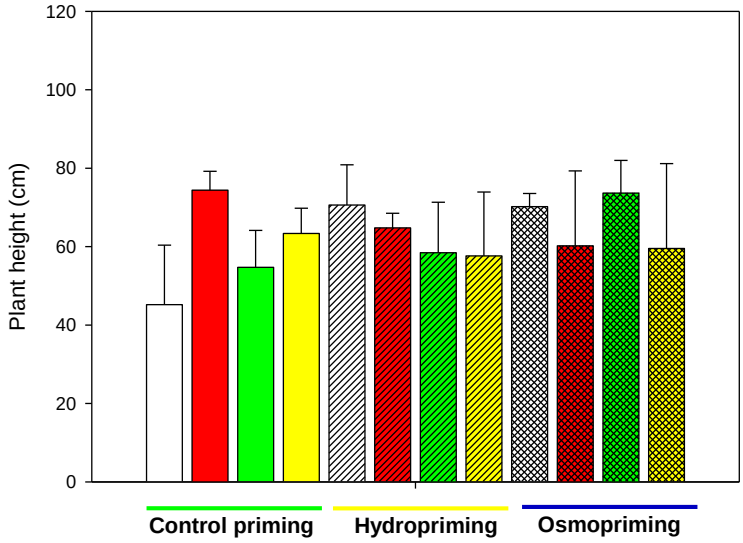



Figure 8. Height of *Salvia ceratophylloides* plants treated with three different seed priming methods [control priming, hydropriming and osmopriming (see Material and Method)] and exposed to different abiotic stressors [drought (white color), control (red color), drought+heat (green color) and heat (yellow color)] for 14 days from stress treatments.
Data points represent means (n = 3). The insert shows the two-way ANOVA results. Different letters indicate statistically significant differences between the averages ($p$<0.05, test of Tukey). The letters

are only reported whether either of the two independent variables or their interaction are statistically significant.

Similar pattern has been observed for the root fresh weight: respect than control treatment, the drought statistically increased this growth parameter in OP while it has been statistically reduced by both drought and combined stress in CP seed priming (Figure 7). The average of the leaf mass per area among the different groups (58.69 g m-2) is similar to that of *S. ceratophylloides* revealed in a field [11] and greenhouse studies [48, 49] and, however, it has been not modified by seed priming and stress treatments (Figure 9). Similar pattern was observed for the relative water content (Figure 10).

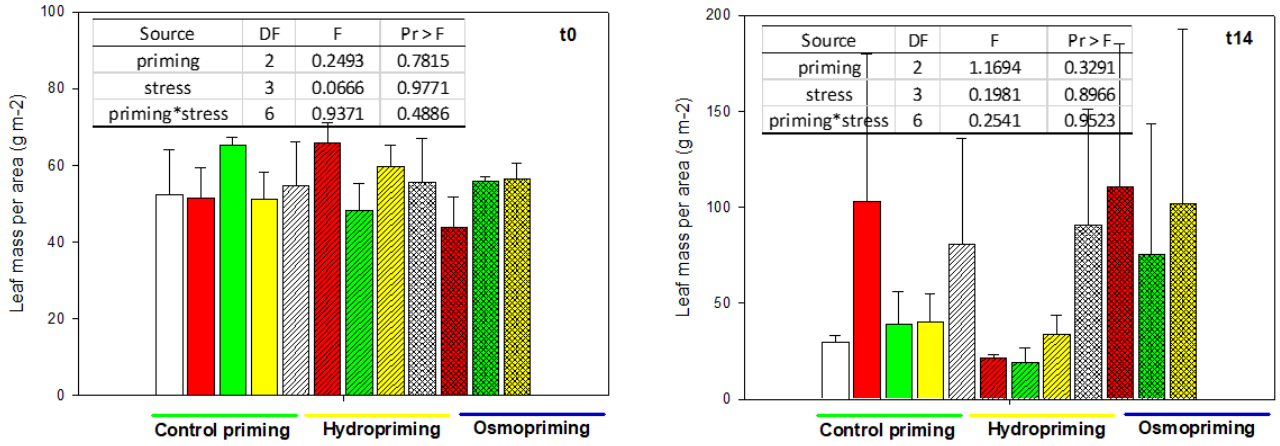



Figure 9. Leaf mass per area of *Salvia ceratophylloides* plants treated with three different seed priming methods [control priming, hydropriming and osmopriming (see Material and Method)] and exposed to different abiotic stressors [drought (white color), control (red color), drought+heat (green color) and heat (yellow color)] for 0 (t0) 14 days from stress treatments (t14).

Data points represent means (n = 3). The insert shows the Repeated Measure two-way ANOVA results. Different letters indicate statistically significant differences between the averages ($p$<0.05, test of Tukey). The letters are only reported whether either of the two independent variables or their interaction are statistically significant.

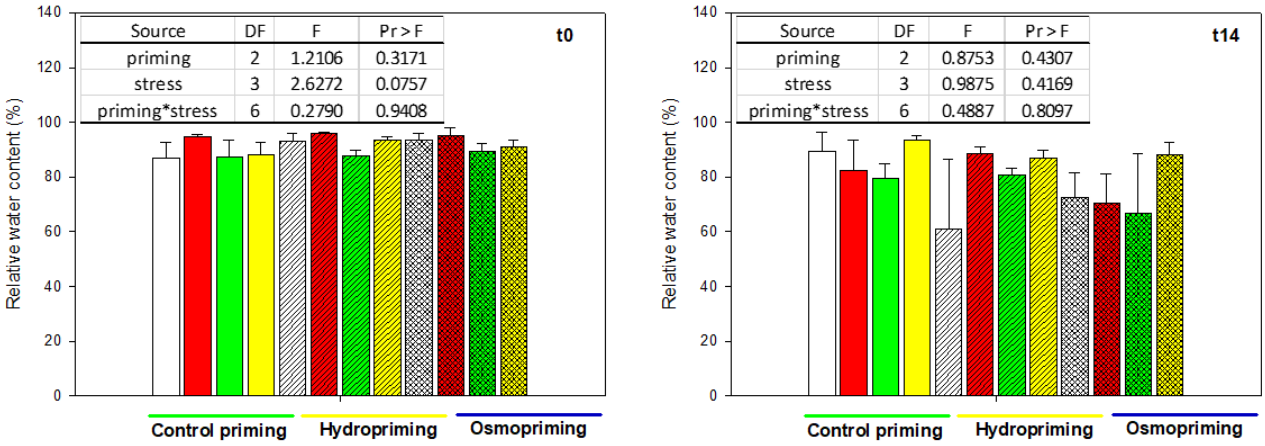



Figure 10 - Relative water content of *Salvia ceratophylloides* plants treated with three different seed priming methods [control priming, hydropriming and osmopriming (see Material and Method)] and exposed to different abiotic stressors [drought (white color), control (red color), drought+heat (green color) and heat (yellow color)] for 0 (t0) 14 days from stress treatments (t14).
Data points represent means (n = 3). The insert shows the Repeated Measure two-way ANOVA results. Different letters indicate statistically significant differences between the averages ($p$<0.05, test of Tukey). The letters are only reported whether either of the two independent variables or their interaction are statistically significant.

The ecophysiological analysis conducted on *S. ceratophylloides* plants pointed out very interesting results regarding the *Salvia* photosynthetic machinery responses to abiotic stress treatments and the modulation of these responses by seed priming (Figure 11, Tables 2-4).

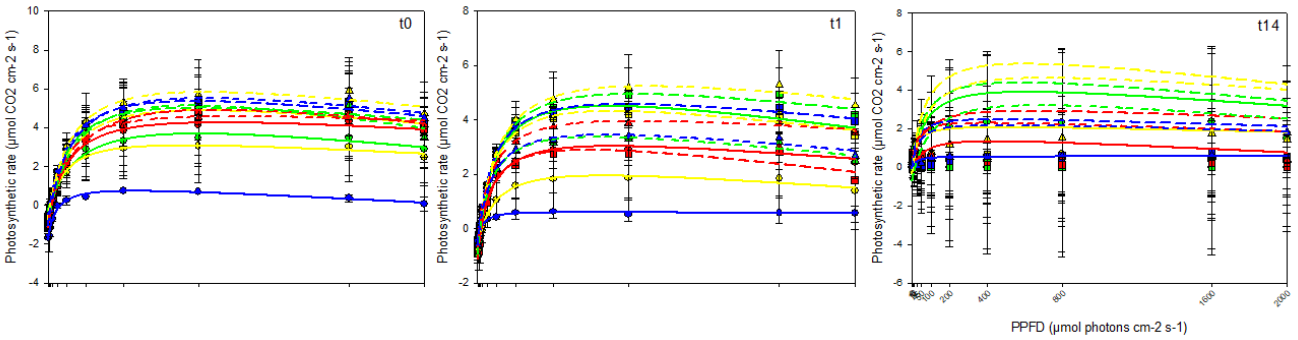



Figure 11 - Leaf photosynthetic light-response curves measured on *Salvia ceratophylloides* plants treated with three different seed priming methods [control priming (○, solid line), hydropriming (□, medium dash line) and osmopriming (△, short dash line)] and exposed to different abiotic stressors [control (green color), drought (yellow color), heat (red color), and drought+heat (blu color)] for 0 (t0), 1 (t1), and 14 days from stress treatments (t14). Data points represent means (n = 3). Light curves have been fitted by non-linear regression using the Ye et al. model (2007).

Table 2 – Leaf-level photosynthetic parameters of *Salvia ceratophylloides* plants primed with different seed priming methods (CP: control priming; HP: hydropriming; OP: osmopriming; see Material and Methods) and treated with different abiotic stressors [drought (D), heat (H), drought+heat (DH) and control (C)] for 0 days from stress treatments. [28]. The leaf-level photosynthetic parameters were estimated by nonlinear regression using the Ye et al. model [28].

| | Statistic# | | **Priming (P)** | **Treatments (T)** | | | | ***Seed priming average*** |
|---|---|---|---|---|---|---|---|---|
| | | | | Control (C) | Drought (D) | Heat (H) | Drought+Heat (DH) | |
| **Icomp** [µmol (photons) m-2 s-1] | P | 2.4900$^{ns}$ | CP | 20.39 | 17.55 | 47.26 | 49.70 | ***34.78*** |
| | T | 0.6926$^{ns}$ | HP | 11.58 | 12.78 | 17.23 | 10.91 | ***12.89*** |
| | PxT | 0.4547$^{ns}$ | OP | 19.39 | 12.71 | 20.88 | 20.51 | ***17.95*** |
| | | | ***Stress Treatment average*** | ***17.12*** | ***13.94*** | ***29.40*** | ***27.04*** | |
| **Isat** [µmol (photons) m-2 s-1] | P | 2.3550 $^{ns}$ | CP | 759.65 | 686.05 | 756.49 | 669.77 | ***718.60*** |
| | T | 0.9529$^{ns}$ | HP | 828.75 | 823.58 | 818.89 | 781.70 | ***816.05*** |
| | PxT | 0.7439$^{ns}$ | OP | 716.78 | 831.03 | 802.39 | 822.53 | ***789.27*** |
| | | | ***Stress Treatment average*** | ***768.39*** | ***791.99*** | ***789.79*** | ***758.00*** | |
| **Imax** [µmol (photons) m-2 s-1] | P | 2.3003$^{ns}$ | CP | 151.67 | 124.00 | 173.00 | 115.33 | ***140.63*** |
| | T | 0.2904$^{ns}$ | HP | 193.67 | 199.67 | 221.33 | 202.67 | ***201.29*** |
| | PxT | 0.4452$^{ns}$ | OP | 217.67 | 223.33 | 174.00 | 223.33 | ***210.74*** |
| | | | ***Stress Treatment average*** | ***187.67*** | ***189.63*** | ***180.44*** | ***191.38*** | |
| **PN** [µmol (CO2) m-2 s-1] | P | 0.6589$^{ns}$ | CP | 2.69 | 2.12 | 5.29 | 1.85 | ***2.78*** |
| | T | 0.5121$^{ns}$ | HP | 3.81 | 3.64 | 4.00 | 4.20 | ***3.88*** |
| | PxT | 0.5942$^{ns}$ | OP | 4.04 | 4.62 | 3.51 | 4.28 | ***4.20*** |
| | | | ***Stress Treatment average*** | ***3.51*** | ***3.63*** | ***3.64*** | ***4.23*** | |
| **RD** [µmol (CO2) m-2 s-1] | P | 3.3471$^{ns}$ | CP | 1.11 | 0.90 | 1.09 | 1.47 | ***1.12*** |
| | T | 0.6019$^{ns}$ | HP | 0.67 | 0.70 | 0.71 | 0.69 | ***0.73*** |
| | PxT | 0.3145$^{ns}$ | OP | 0.98 | 0.81 | 1.14 | 1.04 | ***0.95*** |
| | | | ***Stress Treatment average*** | ***0.92*** | ***0.79*** | ***1.07*** | ***0.96*** | |

Different capital letters indicate statistically significant differences between averages within rows. ($p$<0.05, Tukey's test).

The letters are only reported whether either of the two independent variables or their interaction are statistically significant ($p$<0.05).

#Statistical analysis: Repeated Measure two-way ANOVA with 3 replications (P: priming methods; T: Stress Treatments; PxT: Priming x Treatments interaction); * 0,05>P<0,01; ** 0,01>P<0,001; *** 0,001>P; NS not significant.

Table 3 – Leaf-level photosynthetic parameters of *Salvia ceratophylloides* plants primed with different seed priming methods (CP: control priming; HP: hydropriming; OP: osmopriming; see Material and Methods) and treated with different abiotic stressors [drought (D), heat (H), drought+heat (DH) and control (C)] for 1 days from stress treatments. The leaf-level photosynthetic parameters were estimated by nonlinear regression using the Ye et al. model [28].

| | Statistic# | | Priming (P) | Treatments (T) | | | | Seed priming average |
|---|---|---|---|---|---|---|---|---|
| | | | | Control (C) | Drought (D) | Heat (H) | Drought+Heat (DH) | |
| **Icomp** [µmol (photons) m-2 s-1] | P | 2.9790$^{ns}$ | CP | 11.22 | 27.79 | 29.71 | 20.95 | ***22.42*** |
| | T | 0.3769$^{ns}$ | HP | 10.59 | 12.84 | 43.64 | 8.66 | ***18.93*** |
| | PxT | 0.6678$^{ns}$ | OP | 17.30 | 10.88 | 10.45 | 10.73 | ***12.51*** |
| | | | ***Stress Treatment average*** | ***13.03*** | ***17.17*** | ***40.04*** | ***13.44*** | |
| **Isat** [µmol (photons) m-2 s-1] | P | 1.4977$^{ns}$ | CP | 687.53 | 643.91 | 670.16 | 546.45 | ***637.01*** |
| | T | 0.2308$^{ns}$ | HP | 825.38 | 736.78 | 648.21 | 778.63 | ***747.25*** |
| | PxT | 1.0241 $^{ns}$ | OP | 649.95 | 858.62 | 1562.27 | 655.26 | ***874.18*** |
| | | | ***Stress Treatment average*** | ***720.95*** | ***746.44*** | ***884.96*** | ***660.11*** | |
| **Imax** [µmol (photons) m-2 s-1] | P | 2.7053$^{ns}$ | CP | 165.67 | 109.33 | 119.00 | 31.33 | ***106.33*** |
| | T | 1.0161$^{ns}$ | HP | 190.67 | 163.33 | 122.00 | 164.33 | ***160.08*** |
| | PxT | 1.0289$^{ns}$ | OP | 130.33 | 200.00 | 140.50 | 131.00 | ***151.36*** |
| | | | ***Stress Treatment average*** | ***162.22*** | ***157.56*** | ***125.50*** | ***108.89*** | |
| **PN** [µmol (CO2) m-2 s-1] | P | 1.5406$^{ns}$ | CP | 3.26 | 2.15 | 3.39 | 0.16 | ***2.13*** |
| | T | 1.3745$^{ns}$ | HP | 3.84 | 3.25 | 3.20 | 3.45 | ***3.46*** |
| | PxT | 0.9432$^{ns}$ | OP | 2.45 | 4.05 | 2.84 | 2.52 | ***2.97*** |
| | | | ***Stress Treatment average*** | ***3.18*** | ***3.27*** | ***3.14*** | ***2.04*** | |
| **RD** [µmol (CO2) m-2 s-1] | P | 0.3805$^{ns}$ | CP | 0.65 | 0.61 | 0.84 | 0.83 | ***0.73*** |
| | T | 0.1453$^{ns}$ | HP | 0.68 | 0.76 | 1.11 | 0.56 | ***0.78*** |
| | PxT | 0.6137$^{ns}$ | OP | 0.92 | 0.69 | 0.65 | 0.59 | ***0.72*** |
| | | | ***Stress Treatment average*** | ***0.75*** | ***0.69*** | ***0.66*** | ***0.90*** | |

Different capital letters indicate statistically significant differences between averages within rows ($p$<0.05, Tukey's test).

The letters are only reported whether either of the two independent variables or their interaction are statistically significant ($p$<0.05).

#Statistical analysis: Repeated Measure two-way ANOVA with 3 replications (P: priming methods; T: Stress Treatments; PxT: Priming x Treatments interaction); * 0,05>P<0,01; ** 0,01>P<0,001; *** 0,001>P; NS not significant.

Table 4. Leaf-level photosynthetic parameters of *Salvia ceratophylloides* plants primed with different seed priming methods (CP: control priming; HP: hydropriming; OP: osmopriming; see Material and Methods) and treated with different abiotic stressors [drought (D), heat (H), drought+heat (DH) and control (C)] for 14 days from stress treatments. The leaf-level photosynthetic parameters were estimated by nonlinear regression using the Ye et al. model [28].

| | Statistic# | | Priming (P) | Treatments (T) | | | | Seed priming average |
|---|---|---|---|---|---|---|---|---|
| | | | | Control (C) | Drought (D) | Heat (H) | Drought+Heat (DH) | |
| **Icomp** [µmol (photons) m-2 s-1] | P | 0.8819$^{ns}$ | CP | 3.3 | 1.4 | 15.4 | 3.3 | ***5.88*** |
| | T | 0.4733$^{ns}$ | HP | 2.4 | 4.5 | 1.4 | 0.5 | ***2.46*** |
| | PxT | 1.0563$^{ns}$ | OP | 24.8 | 8.0 | 0.5 | 5.8 | ***10.61*** |
| | | | ***Stress Treatment average*** | ***10.16*** | ***4.65*** | ***7.17*** | ***3.55*** | |
| **Isat** [µmol (photons) m-2 s-1] | P | 0.1987$^{ns}$ | CP | 624.73 | 449.21 | 2040.73 | 199.75 | ***1010.50*** |
| | T | 0.3831$^{ns}$ | HP | 551.01 | 595.59 | 607.71 | 460.56 | ***557.63*** |
| | PxT | 0.5192 $^{ns}$ | OP | 610.06 | 768.47 | 467.42 | 461.47 | ***586.80*** |
| | | | ***Stress Treatment average*** | ***595.27*** | ***623.83*** | ***417.55*** | ***1181.77*** | |
| **Imax** [µmol (photons) m-2 s-1] | P | 4.6915* | CP | 123.33$^{ab}$ | 43.00$^{cd}$ | 48.33$^{cd}$ | 7.67$^{d}$ | ***55.58$^{Y}$*** |
| | T | 7.7095** | HP | 128.33$^{ab}$ | 164.33$^{a}$ | 92.50$^{abc}$ | 55.50$^{bcd}$ | ***117.40$^{X}$*** |
| | PxT | 1.1965$^{ns}$ | OP | 136.67$^{a}$ | 149.00$^{a}$ | 47.50$^{cd}$ | 58.33$^{bcd}$ | ***102.45$^{X}$*** |
| | | | ***Stress Treatment average*** | ***129.44$^{A}$*** | ***118.78$^{AB}$*** | ***60.71$^{BC}$*** | ***38.63$^{C}$*** | |
| **PN** [µmol (CO2) m-2 s-1] | P | 7.1514*** | CP | 3.01abcde | 1.52efg | 0.69fg | 0.15g | ***1.34$^{Y}$*** |
| | T | 11.6816*** | HP | 3.50abc | 4.48a | 2.08bcdef | 1.85cdefg | ***3.18$^{X}$*** |
| | PxT | 0.7539$^{ns}$ | OP | 3.46abcd | 3.57ab | 1.70defg | 1.58efg | ***2.58$^{X}$*** |
| | | | ***Stress Treatment average*** | ***3.30$^{A}$*** | ***3.19$^{A}$*** | ***1.37$^{B}$*** | ***1.11$^{B}$*** | |
| **RD** [µmol (CO2) m-2 s-1] | P | 0.5914$^{ns}$ | CP | 0.20 | 0.19 | 0.39 | 0.45 | ***0.31*** |
| | T | 0.3870$^{ns}$ | HP | 0.35 | 0.31 | 0.11 | 0.05 | ***0.23*** |
| | PxT | 0.6645$^{ns}$ | OP | 0.72 | 0.50 | 0.06 | 0.37 | ***0.44*** |
| | | | ***Stress Treatment average*** | ***0.42*** | ***0.33*** | ***0.32*** | ***0.22*** | |

Different capital letters indicate statistically significant differences between averages within rows ($p$<0.05, Tukey's test).

The letters are only reported whether either of the two independent variables or their interaction are statistically significant ($p$<0.05).

#Statistical analysis: Repeated Measure two-way ANOVA with 3 replications (P: priming methods; T: Stress Treatments; PxT: Priming x Treatments interaction); * 0,05>P<0,01; ** 0,01>P<0,001; *** 0,001>P; NS not significant.

At 14 days from stress treatment, the heat and combined stress caused a statistically reduction of PN of *Salvia* plants (Table 4) that, however, it has been also revealed at 1 days from stress treatments only for DH treatment, although not supported by statistic (table 3). A similar trend was evidenced for Imax (table 3 and 4). The stomatal conductance measured at all the three irradiances and in presence of heat and combined stress has been statistically reduced at 14 days from stress treatments (tables 5-7), suggesting a stomatal-dependent reduction of photosynthesis. The heat stress produced inhibition of the photosynthesis performance of other *Salvia* species [50, 51] although contrast results have been obtained in other studies [52]. However, to note that the combined stress determined a higher reduction of PN and Imax respect than heat stress (-66% and -58% for DH and H stress, respectively; Table 4) indicating a synergic (no-additive) effect of both single stress, the drought and heat stress. These results revealed the specific and unique physiological and molecular mechanisms underlying the *Salvia ceratophylloides* responses to the combined stress that cannot be predicted by results from single-stressor treatments. Different studies

have uncovered that plants evoke a "unique response" to the abiotic combined stresses for root morphology [53], root microbiota [54], root exudates [55], leaf proteome [56], and yield and nutrient uptake [57] but also for leaf proteome of *Salvia splendens* (Liu et al., 2013). Differently to the heat and combined stress, the drought did not modified the photosynthetic performance of *S. ceratophylloides* (Table 3 and 4). This result is in contrast to that observed by Abate's studies [48. 49] that revealed a drought-related inhibition of PN and stomatal conductance in *S. ceratophylloides* plants. Probably, the different potting soils (forest and commercial gardening substrate in this study and Abate experiment, respectively) and methods to indicate the drought stress (30% of soil field capacity and 50% of leaf water potential in this study and Abate experiment, respectively) could have provoked different levels of drought stress in *S. ceratophylloides* plants. Finally, the transpiration rate has been also reduced by heat and combined stress, while the intrinsic water use efficiency has been weakly modified by stress treatments (Tables 5-7).

It is interesting to evaluate how these *S. ceratophylloides* responses to the abiotic stress have been modulated by seed priming. Indeed, the figure 10 and the table 4 revealed that, at 14 days of stress treatments, these plant responses are different in relation to seed priming. Specifically, heat- and combined-stress-related inhibition of the PN and Imax was evidenced in seed priming PC, while it was strongly cancelled in HP and reduced in OP seed priming (Table 4). Similar results have been observed for the stomatal conductance and transpiration rate (Tables 5-7).

**Table 5 –** Leaf-level stomatal conductance, transpiration rate, and intrinsic water use efficiency (WUEi) of *Salvia ceratophylloides* plants primed with different seed priming methods (CP: control priming; HP: hydropriming; OP: osmopriming; see Material and Methods) and treated with different abiotic stressors [drought (D), heat (H), drought+heat (DH) and control (C)] for 14 days from stress treatments. The leaf-level photosynthetic parameters were estimated by nonlinear regression using the Ye et al. model [28] and extracted at 25 µmol $m^{-2}$ $s^{-1}$ of PPFD.

| | Statistic# | | Priming (P) | Treatments (T) | | | | Seed priming average |
|---|---|---|---|---|---|---|---|---|
| | | | | Control (C) | Drought (D) | Heat (H) | Drought+Heat (DH) | |
| **Stomatal conductance** (mol H2O m-2 s-1) | P | 2.5600$^{ns}$ | CP | 0.003 | 0.0006 | 0.0017 | 0.0001 | ***0.0019*** |
| | T | 3.7735* | HP | 0.0032 | 0.007 | -0.0005 | 0.0007 | ***0.0029*** |
| | PxT | 0.9650$^{ns}$ | OP | 0.0127 | 0.008 | 0.0023 | 0.0003 | ***0.0063*** |
| | | | ***Stress Treatment average*** | ***0.0063$^{A}$*** | ***0.0051$^{A}$*** | ***0.0011$^{B}$*** | ***0.0010$^{B}$*** | |
| **Transpiration rate** (mmol H2O m–2 s–1) | P | 2.2489$^{ns}$ | CP | 0.0815 | 0.0182 | 0.0492 | 0.0022 | ***0.0378*** |
| | T | 2.9967* | HP | 0.0914 | 0.1722 | -0.0136 | 0.0204 | ***0.0676*** |
| | PxT | 0.9209$^{ns}$ | OP | 0.3315 | 0.2158 | 0.0083 | 0.0645 | ***0.1550*** |
| | | | ***Stress Treatment average*** | ***0.1681$^{A}$*** | ***0.1354$^{A}$*** | ***0.0146$^{B}$*** | ***0.0291$^{B}$*** | |
| **WUEi** [µmol (CO2) mol-1 H2O m-2 s-1] | P | 1.4665$^{ns}$ | CP | 1521 | 1585 | 1701 | 6360 | ***2792*** |
| | T | 7.9431** | HP | 1051 | 1292 | 4651 | 2713 | ***2427*** |
| | PxT | 2.7238$^{ns}$ | OP | 31 | 299 | 4574 | 1031 | ***1484*** |
| | | | ***Stress Treatment average*** | ***868$^{B}$*** | ***1059$^{B}$*** | ***3642$^{A}$*** | ***3368$^{A}$*** | |

Different capital letters indicate statistically significant differences between averages within rows ($p$<0.05, Tukey's test).

The letters are only reported whether either of the two independent variables or their interaction are statistically significant ($p$<0.05).

#Statistical analysis: Repeated Measure two-way ANOVA with 3 replications (P: priming methods; T: Stress Treatments; PxT: Priming x Treatments interaction); * 0,05>P<0,01; ** 0,01>P<0,001; *** 0,001>P; NS not significant.

**Table 6 –** Leaf-level stomatal conductance, transpiration rate, and intrinsic water use efficiency (WUEi) of *Salvia ceratophylloides* plants primed with different seed priming methods (CP: control priming; HP: hydropriming; OP: osmopriming; see Material and Methods) and treated with different abiotic stressors [drought (D), heat (H), drought+heat (DH) and control (C)] for 14 days from stress treatments. The leaf-level photosynthetic parameters were estimated by nonlinear regression using the Ye et al. model [28] and extracted at 50 µmol $m^{-2}$ $s^{-1}$ of PPFD.

| | Statistic# | | Priming (P) | Treatments (T) | | | | Seed priming average |
|---|---|---|---|---|---|---|---|---|
| | | | | Control (C) | Drought (D) | Heat (H) | Drought+Heat (DH) | |
| **Stomatal conductance** (mol H2O m-2 s-1) | P | 2.5550$^{ns}$ | CP | 0.0031 | 0.0007 | 0.0017 | 0.0003 | ***0.0019*** |
| | T | 3.7624* | HP | 0.0033 | 0.0067 | -0.0001 | 0.0007 | ***0.0029*** |
| | PxT | 0.9663$^{ns}$ | OP | 0.0127 | 0.0081 | 0.0003 | 0.0023 | ***0.0063*** |
| | | | ***Stress Treatment average*** | ***0.0063$^{A}$*** | ***0.0052$^{A}$*** | ***0.0012$^{B}$*** | ***0.0011$^{B}$*** | |
| **Transpiration rate** (mmol H2O m–2 s–1) | P | 2.4782$^{ns}$ | CP | 0.0844 | 0.0213 | 0.0492 | 0.0077 | ***0.0406*** |
| | T | 5.2188** | HP | 0.0939 | 0.173 | -0.0031 | 0.0192 | ***0.0708*** |
| | PxT | 1.1329$^{ns}$ | OP | 0.3314 | 0.217 | 0.0099 | 0.0632 | ***0.1554*** |
| | | | ***Stress Treatment average*** | ***0.1699$^{A}$*** | ***0.1371$^{A}$*** | ***0.0187$^{B}$*** | ***0.0301$^{B}$*** | |
| **WUEi** [µmol (CO2) mol-1 H2O m-2 s-1] | P | 2.3385$^{ns}$ | CP | 2054 | 2181 | 1201 | 2001 | ***1860*** |
| | T | 5.7315* | HP | 1592 | 1595 | 2936 | 5963 | ***1420*** |
| | PxT | 0.9831$^{ns}$ | OP | 96 | 485 | 5831 | 1161 | ***3323*** |
| | | | ***Stress Treatment average*** | ***1247$^{B}$*** | ***1420$^{B}$*** | ***3323$^{A}$*** | ***3042$^{A}$*** | |

Different capital letters indicate statistically significant differences between averages within rows ($p$<0.05, Tukey's test).

The letters are only reported whether either of the two independent variables or their interaction are statistically significant ($p$<0.05).
#Statistical analysis: Repeated Measure two-way ANOVA with 3 replications (P: priming methods; T: Stress Treatments; PxT: Priming x Treatments interaction); * 0,05>P<0,01; ** 0,01>P<0,001; *** 0,001>P; NS not significant.

**Table 7 –** Leaf-level stomatal conductance, transpiration rate, and intrinsic water use efficiency (WUEi) of *Salvia ceratophylloides* plants primed with different seed priming methods (CP: control priming; HP: hydropriming; OP: osmopriming; see Material and Methods) and treated with different abiotic stressors [drought (D), heat (H), drought+heat (DH) and control (C)] for 14 days from stress treatments. The leaf-level photosynthetic parameters were estimated by nonlinear regression using the Ye et al. model [28] and extracted at 100 µmol $m^{-2}$ $s^{-1}$ of PPFD.

| | Statistic# | | **Priming (P)** | **Treatments (T)** Control (C) | Drought (D) | Heat (H) | Drought+Heat (DH) | ***Seed priming average*** |
|---|---|---|---|---|---|---|---|---|
| **Stomatal conductance** (mol H2O m-2 s-1) | P | 2.5374$^{ns}$ | CP | 0.0033 | 0.0009 | 0.0018 | 0.0002 | ***0.002*** |
| | T | 3.7608* | HP | 0.0035 | 0.007 | 0.0002 | 0.0008 | ***0.0031*** |
| | PxT | 0.9994$^{ns}$ | OP | 0.0129 | 0.0083 | 0.0005 | 0.0024 | ***0.0065*** |
| | | | ***Stress Treatment average*** | ***0.0066$^{A}$*** | ***0.0054$^{A}$*** | ***0.0013$^{B}$*** | ***0.0011$^{B}$*** | |
| **Transpiration rate** (mmol H2O m–2 s–1) | P | 2.3460$^{ns}$ | CP | 0.0916 | 0.0245 | 0.0819 | 0.0057 | ***0.0509*** |
| | T | 5.0742* | HP | 0.1 | 0.1784 | 0.0197 | 0.0225 | ***0.0801*** |
| | PxT | 1.1830$^{ns}$ | OP | 0.3376 | 0.0048 | 0.0145 | 0.066 | ***0.1607*** |
| | | | ***Stress Treatment average*** | ***0.1764$^{A}$*** | ***0.1426$^{A}$*** | ***0.0387$^{B}$*** | ***0.0314$^{B}$*** | |
| **WUEi** [µmol (CO2) mol-1 H2O m-2 s-1] | P | 0.7391$^{ns}$ | CP | 2210 | 2128 | 970 | 2204 | ***1878*** |
| | T | 2.2664$^{ns}$ | HP | 1881 | 1761 | 2909 | 3757 | ***2577*** |
| | PxT | 0.8143$^{ns}$ | OP | 135 | 649 | 4189 | 1195 | ***1542*** |
| | | | ***Stress Treatment average*** | ***1409*** | ***1513*** | ***2385*** | ***2690*** | |

Different capital letters indicate statistically significant differences between averages within rows ($p$<0.05, Tukey's test).
The letters are only reported whether either of the two independent variables or their interaction are statistically significant ($p$<0.05).
#Statistical analysis: Repeated Measure two-way ANOVA with 3 replications (P: priming methods; T: Stress Treatments; PxT: Priming x Treatments interaction); * 0,05>P<0,01; ** 0,01>P<0,001; *** 0,001>P; NS not significant.

These first results on *S. ceratophylloides* are fundamental for the conservation strategy of this endemic and rare plant species but also because there is very little information on the effects of seed priming on *Salvia spp*. responses to abiotic stresses. Indeed, only two study indicated that hormopriming improved the salt tolerance of *Salvia hispanica* [58] while seed priming with $CaCl_2$ determined chilling tolerance in *Salvia miltiorrhiza* [59]. However, a positive induction of resistance to environmental stress by seed priming has been observed in several plant species, mainly crops and for single stress but very few for the combined stress (see review of [60,61,15, 62].

## Conclusions

The present study was directed at answering questions related to seed priming of *Salvia ceratophylloides*, a rare, endemic, and threatened plant species.

Initial results suggested that osmopriming and hydropriming increased *Salvia* seedling emergence and, by prolonging the duration of the seedling stage, improved seedling establishment and transition to autotroph condition. In addition, the *Salvia* individuals treated with OP and HP pointed out a well performant and efficient photosynthetic machinery suggesting potentially enhanced plant growth, fitness and survival. The second result showed that *S. ceratophylloides* plants are negatively affected by climate change-related abiotic stressors. In particular, the synergistic (not additive) effects of the combined stress of drought and heat suggested that a "new stress state" characterized by specific signaling pathways and gene expression, probably orchestrated by hormonal interactions, might be induced with respect to the single stress. Third result indicated that the seed priming modulated the *Salvia* responses to the abiotic stress. Specifically, OP and HP mitigated the negative effects induced by heat and, especially, combined stress.
Overall, these results are crucial and fundamental for the predictions of *Salvia ceratophylloides* fitness and survival in the new Climate Change era, but above all, for the *ex-situ* conservation of this rare plant species.

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# **CHAPTER 6.** Threats Posed to the Rediscovered and Rare *Salvia ceratophylloides* Ard. (Lamiaceae) by Borer and Seed Feeder Insect Species.

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# Threats Posed to the Rediscovered and Rare *Salvia ceratophylloides* Ard. (Lamiaceae) by Borer and Seed Feeder Insect Species

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**Abstract:** The effects of herbivorous insects on a plant population are not always well tolerated. This is especially true if the herbivorous actions are directed toward rare plant species. *Salvia ceratophylloides* Ard. is a rare endemism of southern Italy. Observations of the plants in situ revealed that many of them were under severe stress and did not produce seeds. Therefore, to find out which factors affect the reproductive activity as a whole, an observational study was carried out. We found bottom-up and top-down effects on plant health and reproduction associated with herbivorous action. *Squamapion elongatum* (Coleoptera, Curculionoidea, Apionidae), in all monitored sites, infested plants non-uniformly but was able to threaten the health condition, flowering, and seed production of sage by digging tunnels into the sage branches (bottom-up action), and then secondarily by seed feeder *Systole salvia* Zerova (Hymenoptera, Eurytomidae) predating sage seeds (top-down action). Mainly, chalcid parasitoid wasps such as *Trichomalus* spp. (Hymenoptera, Pteromalidae), as well as *Eupelmus vesicularis* and *E. muellneri* (Hymenoptera, Eupelmidae), limited the herbivorous *S. elongatum* population and the seed herbivore *S. salviae* emerged with its parasitoid *Ormyrus diffinis* (Hymenoptera, Ormyridae). Overall, this study showed how ecological interactions among herbivores, their host, and their natural enemies act on this sage species in all sites investigated. Among the herbivores, mainly *S. elongatum* affected this rare sage species, which should be taken into consideration, especially in the formulation of biological control solutions and for improving operating practice aimed at reproducing the species. This study provides the molecular characterization of the herbivorous species involved, in order to support future projects to evaluate the intra- and interspecific genetic variability of insects, their evolutionary relationships, and phylogeny studies.

**Keywords:** sage; *Salvia ceratophylloides*; Apionidae; *Systole*; ecological function; herbivore; rare species; diversity; seed

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## 1. Introduction

The loss of both animal and plant biodiversity is basically related to several key factors, some of which are related to human activity (fragmentation and loss of habitat, pollution, etc.) and others related to climatic events and geological processes [1–3]. Often, the processes that determine the recovery of biodiversity are reversible and are linked to the reduction of pollutants and an increase in habitat favorable to the species [4]. To achieve this aim, it is often essential to know which factors at the local scale contribute to regulating the relationships among plants, the environment, and herbivores [5,6]. Among the biotic factors, the effects of both native and non-native herbivores must be carefully considered, particularly the herbivorous species capable of affecting the host plant's vitality and production of reproductive structures, even if these aspects are not always attentively evaluated [7,8]. In rare and endemic species, the reproductive aspects are very important,

as their populations are particularly restricted, as is their spread [9,10]. Reproductive strategies, therefore, are essential for determining the quantity and quality of offspring [11,12], which can be conditioned by the action of some herbivores or pathogens limiting the fitness of a species [13–15]. The detrimental action by herbivores, when occurring in rare species on a small number of individuals/populations, directly affects both suitability and genetic composition, influencing the population dynamics and long-term persistence [16]. *Salvia ceratophylloides* Ard. is strict endemic species that grows only in the lower belt of Aspromonte in the surroundings of Reggio Calabria [17,18]. Until 2008, *S. ceratophylloides* was considered a species "extinct in the wild" (EW) by authors who studied the genus *Salvia* in Italy, as well different floristic databases and checklists [19–22]. The intense urbanization of the areas surrounding the city of Reggio Calabria has led to profound changes in the landscape, with a decisive fragmentation and loss of natural habitats. This probably caused the extinction of the species from the sites in which researchers were attempting to collect it prior to 1900 [23]. However, Spampinato [24] did not exclude that some populations could still have survived on some sandy hills of Reggio Calabria. Further field surveys carried out in the last decade have allowed us to verify the presence of *S. ceratophylloides* in other areas and to discover some new populations in Reggio Calabria (Puzzi, Cataforio) [25–28] so as to better define its taxonomic and ecological characteristics, as well as its conservation status [18,28]. Since 2018, it has been observed that both sage plants and their seeds are infested by herbivores, thereby affecting their growth, inflorescence formation, and seed germination. Understanding which of the biotic causes can compromise the vitality and the reproductive capacity of this sage species and its performance in the area of diffusion has become essential. To accomplish this aim, we conducted non-manipulative experiments both in the field and laboratory. Specifically, in the field, we differentially evaluated the plant species' vitality according to the direct effects of the borer on the reproductive structures (inflorescence formation), while indirectly, in the laboratory, we investigated the sage's seed predator insect. Moreover, we evaluated the occurrence of natural enemies preventing herbivorous damage. The obtained results constitute the first contribution on the insect species related to the endemic *S. ceratophylloides*, generating new questions for future research on arthropod–plant interactions.

## 2. Materials and Methods

### *1.1. Study Species*

*S. ceratophylloides* is an herbaceous plant (scapose hemicryptophyte) (Figure 1a), densely pubescent for both glandular and simple patent hairs. The plant is 30–90 cm high, has upright or ascending stems, normally lignified and much ramified at the base. The inflorescences consist of several verticillasters (5–6), each with 4–6 flowers that are typically bilabiate (Figure 1b), and corolla violet (three times the calyx) with an upper lip strongly bent to cap the pubescent glandular stamens on the outside. The fruit is a peculiar schizocarp: a microbasarium made up of four dark brown, spherical–ovoidal one-seeded mericarps (nutlets) with a thickened margin. *S. ceratophylloides* has a main flowering period in spring, from April to June, and a second flowering period in autumn, from October to November. The fruiting occurs a few weeks after flowering; the species is a strongly aromatic plant, rich in essential oils [29].




**Figure 1.** *Salvia ceratophylloides* Ard: (**a**) Plant habitat; (**b**) inflorescence in detail, with the bud and open flowers displayed in verticillasters.

### *1.2. Sampling Sites*

*S. ceratophylloides* grows in Reggio Calabria (latitude 38°4′, longitude 15°41′), on the hills of the western side of the Aspromonte facing the Strait of Messina (southern Italy, Calabria, Reggio Calabria), at an elevation ranging from 250 to 400 m a.s.l., especially on the cooler slopes with north or northwest exposition [28,30] (Figure 2a). The geology of the area is characterized by layers of loose sand alternating with benches of soft calcarenites of Pliocene origin. The soils have a sandy texture with a basic pH and fall into the group of Calcaric Cambisols [31]. The average temperature in the study area (1971–2000) is approximately 18 °C, with an average annual rainfall of 500 mm concentrated in the autumn and a summer dry period of approximately 5 months [32]. *S. ceratophylloides* grows spontaneously in the habitat of the EEC directive 43/93: "5330 thermo Mediterranean and predesert scrub" subtype "32.23 diss-dominated garrigues." This habitat includes Mediterranean grasslands with *Ampelodesmos mauritanicus* (Poir.) Dur. & Schinz. (Figure 2a), vegetation of the sands with *Artemisia campestris* subsp. *variabilis* (Ten.) Greuter (Figure 2b), or more rarely garrigue with *Cistus creticus* L. (Figure 2c) [17]. The most frequent species growing with *S. ceratophylloides*, in addition to the aforementioned species, are some grasses (*Lagurus ovatus* L., *Avena barbata* Link, *Briza maxima* L., *Hyparrhenia hirta* (L.) Stapf., and *Dasypyrum villosum* (L.) P. Candargy), several dwarf shrubs (*Cistus creticus* L., *Cistus salviifolius* L., *Micromeria graeca* (L.) Benth. ex Rchb., *Thymbra capitata* (L.) Cav., and *Phlomis fruticosa* L.), and some shrubs (*Cytisus infestus* (C. Presl) Guss. subsp. *Infestus* and *Spartium junceum* L.) (Figure 2b). Mostly, they are widespread species in steppic grasslands and in Mediterranean garrigues.




**Figure 2.** Habitat of *S. ceratophylloides*: (**a**) Mediterranean grasslands with *Ampelodesmos mauritanicus* (Poir.) Dur. & Schinz.; (**b**) vegetation of the sands with *Artemisia campestris* subsp. *variabilis* (Ten.) Greuter; (**c**) garrigue with *Cistus creticus* L.

### *1.3. Data Collection*

#### 1.3.1. Study Methods and Field Observations

In 2018, in July, mature sage shoots from fully developed plants were collected ($N = 20$) from different sites in the study area. Each plant was observed and many of them (plants not producing inflorescence) displayed emerging holes along the principal axis. In the same year, approximately 200 seeds were collected and stored at laboratory room temperature. The seeds were observed weekly for emerging seed feeders. After these initial reports, we verified the threats posed by herbivores. A more detailed study was carried out in 2019, during which 18 sage sites were discovered and selected as study fields (Table 1). The study sites were within an area of approximately 7 $km^2$ and the minimum distance between the studied sage sites was 375 m. Starting from April until August, the sites were monitored every 15 days. Based on size, we also selected subsites (Table 1), for each of which the sage population structure was analyzed, and all sage plants were recorded and separated as plants in either the reproductive or the vegetative phase [33]. Moreover, we counted both healthy and infested plants; the latter were easily recognizable from June onward as they stopped the development and produced no inflorescence, also showing a yellow/green foliage (Figure 3a). In more advanced infections, it was possible to detect stems with clearly visible holes, particularly present in the basal and middle part of the plant (Figure 3b,c).

**Table 1.** Sampled sites with the presence of *S. ceratophylloides*. For all of the sites, the number of plants with different characteristics were counted.

| Station ID | Subsite | Date | Surface Subsite (m²) | Non-Breeding Plants | Breeding Plants | Total Number of Plants | Infested Plants |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 17.06.2019 | 16 | 29 | 14 | 43 | 5 |
| | 1B | | 6 | 5 | 11 | 16 | 3 |
| 2 | 2A | 17.06.2019 | 12 | 2 | 18 | 20 | 18 |
| | 2B | | 2 | 0 | 2 | 2 | 2 |
| | 2C | | 1 | 0 | 1 | 1 | 1 |
| 3 | 3A | 25.06.2019 | 36 | 15 | 46 | 61 | 35 |
| | 3B | | 12 | 0 | 7 | 7 | 4 |
| 4 | 4 | 22.06.2019 | 15 | 1 | 17 | 18 | 0 |
| 5 | 5A | 22.06.2019 | 10 | 5 | 12 | 17 | 0 |
| | 5B | | 1200 | 36 | 236 | 272 | 0 |
| 6 | 6A | 19.06.2019 | 80 | 0 | 46 | 46 | 15 |
| | 6B | | 265 | 52 | 41 | 93 | 8 |
| | 6C | | 168 | 14 | 78 | 92 | 30 |
| | 6D | | 1 | 0 | 1 | 1 | 0 |
| | 6E | | 6 | 0 | 6 | 6 | 2 |
| | 6F | | 1 | 0 | 1 | 1 | 0 |
| 7 | 7A | 22.06.2019 | 3 | 0 | 8 | 8 | 4 |
| | 7B | | 25 | 50 | 21 | 71 | 16 |
| 8 | 8 | 22.06.2019 | 8 | 4 | 9 | 13 | 1 |
| 9 | 9 | 22.06.2019 | 10 | 4 | 5 | 9 | 2 |
| 10 | 10 | 22.06.2019 | 120 | 6 | 120 | 126 | 20 |
| 11 | 11A | 19.06.2019 | 1 | 0 | 3 | 3 | 2 |
| | 11B | | 175 | 12 | 19 | 31 | 3 |
| | 11C | | 8 | 11 | 12 | 23 | 0 |
| | 11D | | 9 | 4 | 0 | 4 | 0 |
| | 11E | | 9 | 39 | 10 | 49 | 1 |
| | 11F | | 35 | 3 | 26 | 29 | 0 |
| | 11G | | 2 | 1 | 2 | 3 | 0 |
| | 11H | | 1 | 0 | 1 | 1 | 0 |
| | 11I | | 15 | 15 | 7 | 22 | 0 |
| 12 | 12A | 17.06.2019 | 50 | 0 | 25 | 25 | 6 |
| | 12B | | 3 | 4 | 4 | 8 | 2 |
| 13 | 13 | 17.06.2019 | Extinct | 0 | 0 | 0 | 0 |
| 14 | 14A | 23.06.2019 | 20 | 4 | 15 | 19 | 1 |
| | 14B | | 40 | 1 | 8 | 9 | 2 |
| 15 | 15A | 22.06.2019 | 10 | 0 | 55 | 55 | 2 |
| | 15B | | 1 | 0 | 5 | 5 | 0 |
| 16 | 16 | 22.06.2019 | 3 | 2 | 16 | 18 | 0 |
| 17 | 17 | 22.06.2019 | 25 | 2 | 10 | 12 | 2 |
| 18 | 18 | 22.06.2019 | 4 | 0 | 3 | 3 | 0 |

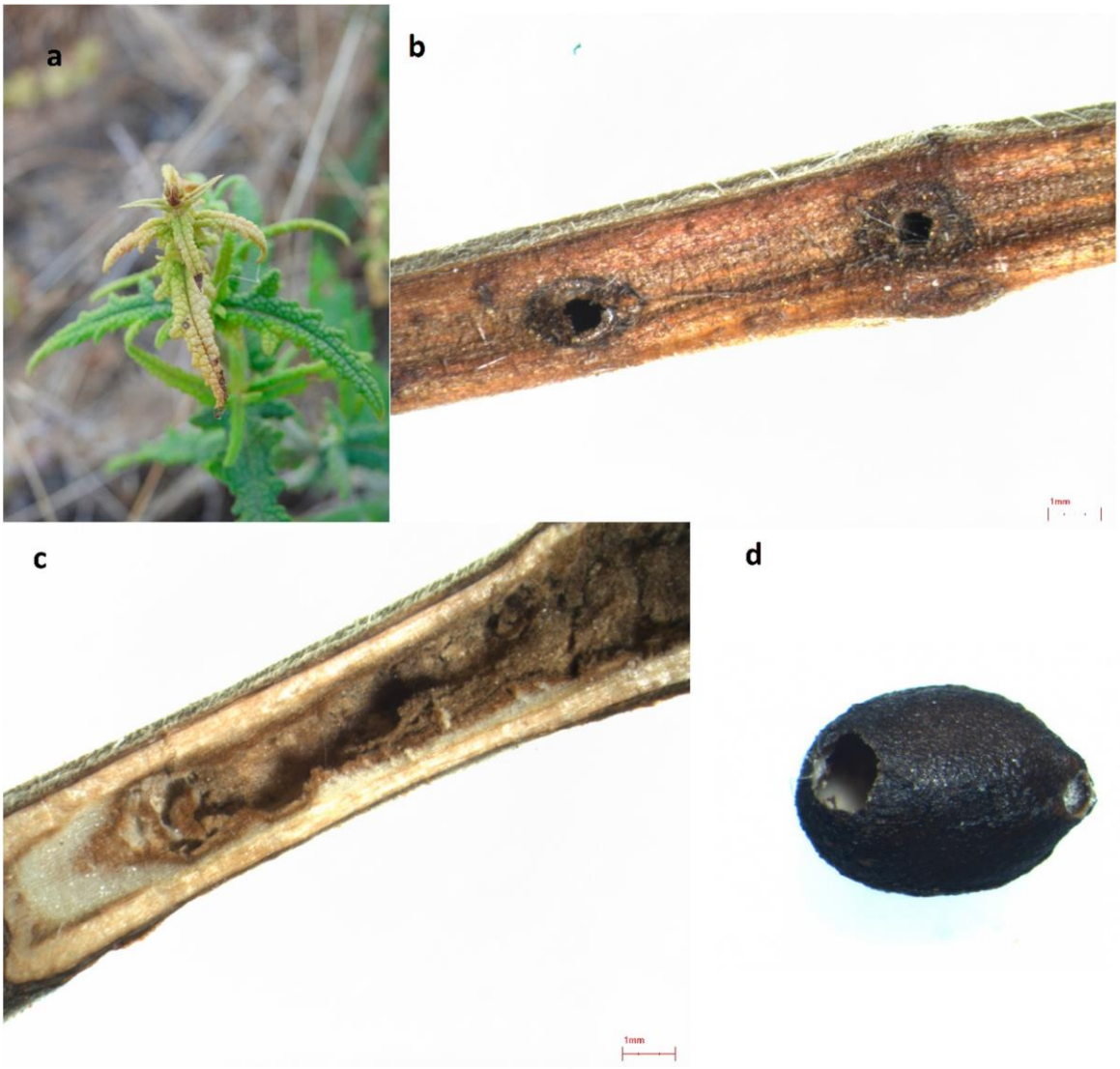



**Figure 3.** (**a**) *S. ceratophylloides* plants with a yellowed apex; (**b**) visible holes on the stem; (**c**) tunnels dug by *Squamapion elongatum;* (**d**) predated sage seed with an exit hole.

1.3.2. Borers and Their Natural Enemies

Considering the small number of plants present in all areas, the sampling involved the five sites where the number of sage plants was >40. In these sites, 10 individuals in the incipient flowering phase with some evidence of infestation (yellow/green color) were collected, cleaned of any external presences of insects, and transferred to the laboratory individually inside insect cages. To prevent or reduce evapotranspiration and plant drought stress, the roots were maintained directly in distilled water, both replaced and reviewed, on average, every three days. All of the emerging herbivorous specimens and their parasitoids were removed and preserved in absolute alcohol. The plants in the cage at the end of laboratory trial (November) were examined with a 20× magnification hand lens (Eschenbach® Germany) to search for emerging holes made by insects. For each plant's shoots, the orthogonal section of the branch and stems was measured and used to carry out the study of the herbivorous species.

1.3.3. Seed Feeders and Their Natural Enemies

In the last 10 days of June, inflorescences with mature seeds (with at least 80% of seeds formed) were collected in five sites (Table 1). These seeds were separated per site

and observed under a stereoscope; any damaged or shriveled seeds were excluded from further observation. The healthy seed were placed in seed sachets, which contained approximately 200 seeds each (production of one or two adjacent plants) or less, depending on the production per site in some cases ($N$ = 5932 seeds collected). All of the seeds were stored at laboratory temperature (approximately 20 °C) and checked for insect emergence (Figure 3d). Observations were carried out two times a week from the collection date to December. The insect specimens were recorded and separated by site and date. All emerged insects were preserved in absolute alcohol for storage.

#### 1.3.4. Herbivores and Natural Enemies' Identification

Each specimen that emerged from the plants and seeds was observed under a stereomicroscope (Olympus SZX9, Tokyo, Japan) at magnifications from 20X to 60X. Taxonomic identification was made using the dichotomous key for the Apionidae beetles [34–37], while for the seed calcidids and parasitoids, the dichotomous keys of Baur et al. [38–44] were used.

### *2.4. Data Analyses*

For the statistical analyses, we used the total number of sage plants detected. Differences among the populations of plants in the reproductive and vegetative phases were analyzed using Generalized Linear Model with the dependent variable (number of plants infested) adjusted to a binomial negative distribution with a log link function to model responses. The relationship among the plants infested, the total number of plants, and the reproductive phase at the date of monitoring were analyzed using Spearman's correlation coefficients. The proportion of infested plants at different sites was compared using a Kolmogorov–Smirnov (K-S) test of the equality of distributions. The relationships between the numbers of emerging holes and the mean diameter of each plant branch were interpreted using nonparametric analysis based on Spearman's correlation coefficients.

The parasitization of the seeds (number of seeds in which an herbivore or its parasitoid emerges) was evaluated at different sites. Fisher's exact test in a contingency table (two-tailed, $p < 0.05$) was used to assess the significance of any differences of the species that emerged at different sites. We used SPSS v. 23 [45] for all data analyses and Sigmaplot 13.0 [46] to produce graphs. All data are expressed as untransformed mean values ± standard errors (SEs).

### *2.5. Molecular Identification*

#### DNA Extraction, Amplification, and Sequencing

The species involved in this study were collected and stored individually in Eppendorf tubes with absolute ethanol at −20 °C. Rather than grinding the specimens, total genomic DNA was extracted from 10 samples of each species, following the protocol described in Vono et al. [47]. DNA extraction was performed on individual insects in 5 µL of proteinase K (20 mg/mL) and 80 µL of 5% Chelex 100 suspension, and then incubated at 55 °C for 1 h. Proteinase K was then inactivated at 100 °C for 8 min. The supernatant containing the DNA was removed after centrifugation and stored at −20 °C. Three genes were sequenced: the mitochondrial cytochrome c oxidase subunit I (COI), and ribosomal gene, and the expansion segment D2 of the 28S ribosomal subunit (28S-D2). The polymerase chain reaction (PCR) cycle (thermocycle conditions) and primers used to amplify a fragment of mitochondrial COI and a fragment of 28S-D2 ribosomal are reported in Table 2.

**Table 2.** Primer sequences with the relative amplification program of the mitochondrial cytochrome c oxidase subunit I (COI) and the expansion segment D2 of the 28S ribosomal subunit (28S-D2) genetic regions for molecular characterization of insect species.

| Name | Sequence 5′–3′ | Fragment | Source | PCR Cycle | | |
|---|---|---|---|---|---|---|
| | | | | T (°C) | Time | *N* of Cycle |
| LCO-1490 | GGTCAACAAATCATAAAGATATTGG | COI | [48] | 95 | 1′ | 40 |
| | | | | 94 | 30″ | |
| | | | | 48 | 1′30″ | |
| | | | | 72 | 1′ | |
| HCO-2198 | GTAAATATATGRTGDGCTC | | | 72 | 7″ | |
| D2F | CGTGTTGCTTGATAGTGCAGC | 28S-D2 | [49] | 95 | 3′ | 35 |
| | | | | 94 | 45″ | |
| | | | | 55 | 45″ | |
| | | | | 72 | 1′ | |
| D2R | TTGGTCCGTGTTTCAAGACGGG | | | 72 | 7″ | |

PCR = polymerase chain reaction.

For gene amplifications, PCR was performed on a BioRad thermocycler using 20 µL of the reaction volumes, consisting of 1×Promega PCR buffer (containing $MgCl_2$), 0.2 mM each of dNTP, 0.25 µM of each primer, 10 mg/mL of bovine serum albumin, 1.5 units of Go*Taq G2* DNA polymerase (Promega Italia, Milan, Italy), and 2 µL of the DNA template. The PCR products were checked on a 1.2% agarose gel stained with GelRED® (Biotium, Fremont, CA, USA), and then visualized and photographed under ultra-violet (UV) light. Sequences were trimmed and aligned manually in MEGA v. 7 and were virtually translated into the corresponding amino acid chain to detect frame-shift mutations and stop codons, using EMBOSS Transeq (https://www.ebi.ac.uk/Tools/st/emboss_transeq/) (accessed 21 April 2020) [50]. Edited sequences were checked against the GenBank database, and then submitted to the GenBank database under the accession numbers reported in Supplementary Table S1.

## 3. Results

### *1.4. Field Observations*

The average surface area of the sage of each site was 60.2± 30.54 $m^2$, with a maximum surface area in one site reaching 1200 $m^2$. Overall, the total area covered by the sage was 2408 $m^2$. The proportion of breeding plants in all sites at the time of sampling was 0.7716.

The infested plants were positively related to the reproductive phase (i.e., reproductive plants (RPs)) ($r_s$ = 0.517, $n$ = 39, $p$ < 0.001) and not to the vegetative phase (i.e., growing plants (GPs)) or sites (Table 3).

There was no relationship between the infested and total plants in each site ($r_s$ = 0.224, $n$ = 40, $p$ = 0.164). In all sites, the average proportion of infested plants not producing inflorescence was 0.2142. The distribution of the proportions of the infested plants was not uniform in the different sites (K-S tests = 3.082; $n$ = 39; $p$ < 0.001) with vast differences.

The number of plants in the laboratory that showed emergence holes was 8/10 collected. The number of holes varied from a minimum of two up to a maximum of 23 holes per plant. The average diameter of the shoot at the exit point was 4.55 mm ($n$ = 68), while the average diameter of the shoots without holes was 2.31 mm ($n$ = 14). For the plants examined, the association between the number of holes and the average diameter of the shoot showed a positive relationship ($r_s$ = 0.81, $n$ = 13, $p$ < 0.001). A principle axis or secondary stem with a diameter less than 2.30 mm was not infested.

**Table 3.** Generalized linear model with negative binomial distribution results evaluating the effect of different variables on the plants infested [a].

| Response Variable | Source | *Df* | Wald Chi-Square | *p* |
|---|---|---|---|---|
| Plants infested | Intercept | 1 | 0.91 | 0.340 |
| | Site | 12 | 19.34 | 0.081 |
| | Reproductive plants (RPs) | 1 | 12.04 | 0.001 |
| | Growing plants (GPs) | 1 | 0.50 | 0.468 |
| | RP * GP | 1 | 0.392 | 0.081 |

[a] The AIC (Akaike's information criterion) value was −500.74. The likelihood ratio (chi-square) was 71.02 (df = 20; $p < 0.001$).

### 1.5. Complex of Herbivores and Their Natural Enemies on Salvia ceratophylloides Plants

The complex of herbivores and their natural enemies is depicted in Figure 4.

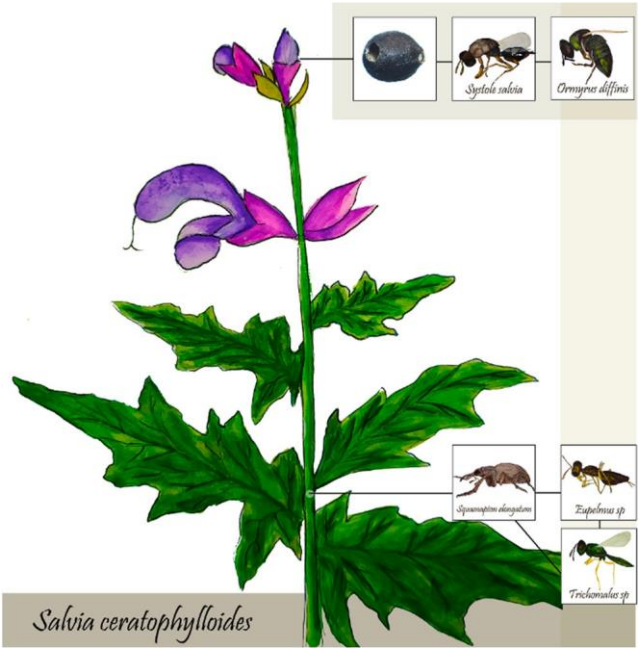



**Figure 4.** Complex of herbivores and their parasitoids present on *S. ceratophylloides*. Plants attacked by *S. elongatum* do not produce inflorescences and become visibly chlorotic. Top: Seed with hole and seed feeder species *Systole salviae* and its parasitoid *Ormyrus diffinis*. Bottom: *S. elongatum* and its parasitoids *Trichomalus* sp., *Eupelmus* sp.

The relationships among the species were well defined, with different species that emerged from the sage plant. They were *S. elongatum* (Germar, 1817) (Coleoptera Apionidae) (Supplementary Figure S1) (emerged $n = 15$) and its parasitoids *Trichomalus* spp. Thomson sp. 1878 (Hymenoptera, Chalcidoidea, Pteromalidae) (emerged $n = 20$), *Eupelmus vesicularis* (Retzius, 1783), and *E. muellneri* Ruschka, 1921 (Hymenoptera, Chalcidoidea, Eupelmidae) (emerged $n = 4$).

### 1.6. Salvia ceratophylloides Seed Herbivores and Their Natural Enemies

The number of seeds harvested was different in relation to the sites (3B = 70; 6A = 3726; 11E = 177; 14A = 1937). In total, 113 adult insect specimens (3.41% of seeds) emerged during summer–autumn (Figure 5).

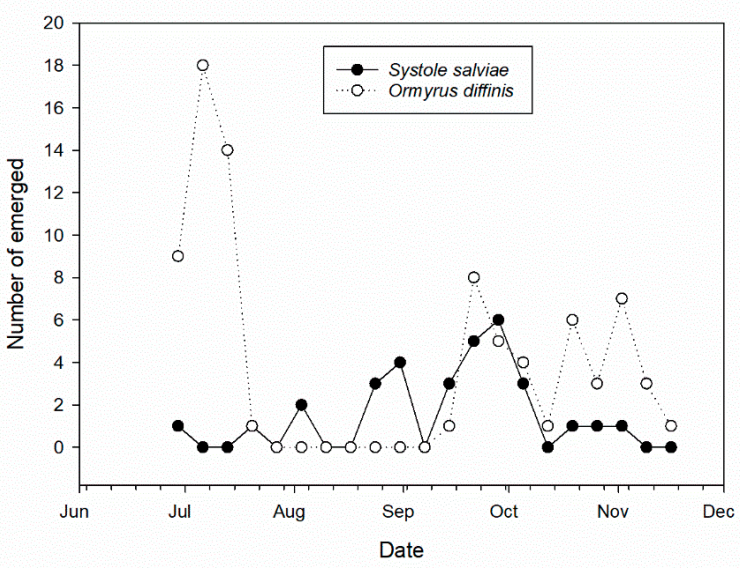



**Figure 5.** Emergence of *S. salvia* and *O. diffinis* during the summer and autumn seasons.

The percentage of seeds attacked by the seed feeders was different in relation to the site, with the minimum in site 6 (0.86%) and the maximum in site 3 (5.71%). Two insect species emerged from the sage seeds: *Systole salviae* (Zerova, 1968) (Hymenoptera, Chalcidoidea, Eurytomidae) and *Ormyrus diffinis* (Fonscolombe, 1832) (Hymenoptera, Chalcidoidea, Ormyridae). The species that emerged were different among the sites, with a preponderance of *O. diffinis* in site 14 and the absence of *S. salviae* emergence in site 11 (Figure 6).

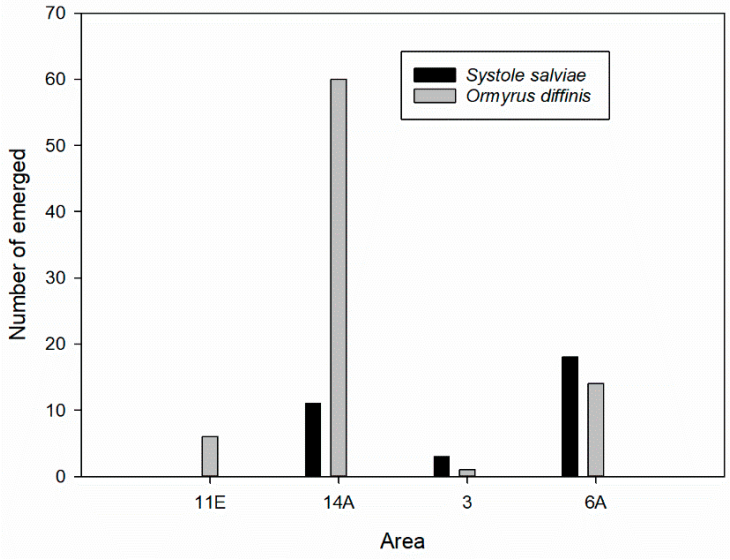



**Figure 6.** Species emerged from *S. ceratophylloides* seeds from the four different sites. There were significant differences in the proportion of the two emerged species (Fisher's exact test = 20.75; $N = 113$; $p < 0.001$).

### *1.7. Molecular Identification of the Species*

Molecular analysis was performed in order to confirm the identity of *S. elongatum*, *S. salviae, O. diffinis*, and *Tricomalus* spp. Our DNA extraction method proved effective for all species belonging to different orders, and a useful amount of genetic material was extracted to be used in the PCR. For each sample, two genomic regions were amplified. The polymerase chain reaction of *mt*-COI produced fragments between 422 and 622 bp.

The nucleotide composition of the *S. elongatum* sequences was T(U) = 29.6%, C = 15.6%, A = 38.4%, and G = 16.4%. For *S. salviae,* the nucleotide composition was T(U) = 29.7%, C = 14%, A = 44.8%, and G = 11.5%; for *O. diffinis*, it was T(U) = 28.9%, C = 13.6%, A = 45.4%, and G = 12.1%; and for *Trichomalus* spp., it was T(U) = 32.7%, C = 12.8%, A = 41.7%, and G = 12.8%. In all species, the average A + T content was high (mean value = 72.8%), which is in agreement with values for insects in general [48,51]. There were no molecular intraspecific differences in the samples analyzed. For fragment 28S-D2, a highly conserved region, with sequences of 371–555 bp in length, was obtained.

## 4. Discussion

Despite its endemicity and conservation importance in the Italian territory, not much is known about the performance of *S. ceratophylloides* in the area of occupancy. *S. ceratophylloides* populations are threatened by the anthropic activities related to their occurrence near cities, and these novel results highlight a new serious threat to the species primarily linked to *S. elongatum* distributed across all sites. The genus *Squamapion* Bokor, 1923 is distributed in the Palearctic and Afrotropical regions and includes 33 species [52]. These are mono- or oligophagous herbivores feeding on species of the family Lamiaceae, mainly of the genera *Salvia*, *Thymus*, *Thymbra*, *Mentha*, *Origanum*, *Prunella*, and *Saccocalyx*. Their larvae burrow tunnels inside roots or stems, occasionally causing galls [37]. *S. elongatum* is a species inhabiting the southern and central part of Europe, as well as East Asia and Algeria, and it colonizes lowland and sub-montane areas [53]. This species is characteristic of xerothermic grasslands, where it feeds on plants of the genus *Salvia*—*S. pratensis* and *S. nemorosa* [54]. Other studies prior to this have displayed an overall picture of herbivorous species that affect sage inflorescence (e.g., *S. sclareoides* Brot. [9,55]), but no such striking effect of herbivores has been highlighted in *Salvia* species. Despite the notable spread of the herbivorous beetle, the species is not reported for the most widespread and cultivated sage (*Salvia officinalis*) [56]. Hendrich et al. [57] reported the molecular characterization of the COI gene region performed on samples of *S. elongatum* collected in Germany. The nucleotide sequence of the *mt*-COI gene obtained in this study in order to confirm the identity of the species was compared with the sequences found in GenBank (https://blast.ncbi.nlm.nih.gov/Blast.cgi) (accessed 25 April 2020) [58]). The comparison showed that the percentage of identity between the samples used in this study and those in Germany amounted to 92.75%. This value must be considered valid because the records relating to *S. elongatum* in the database were limited to a few accessions. To date, most published DNA barcoding studies dealing with insects have focused on Hymenoptera and Lepidoptera, while few recent studies have examined the hyperdiverse Coleoptera [59,60]. Apparently, the genetic differentiation among populations has a complex background and may involve factors such as local adaptation and founder effects [61].

Hairston et al. [62] argued that observations of herbivores severely depleting green plants are rare. Wetzel et al. [63] highlighted that plants can contribute to the suppression of herbivorous populations via variable nutrient levels, whereas Koussoroplis et al. [64] considered the fundamental role of plant trait variability on herbivorous populations in natural important settings; however, the real threat of insect herbivores for different plant species is unsolved. Solving the numerous challenges pertaining to this threat can help us understand how herbivores interact with host plants and how changes in abiotic factors influence and constrain the effects of herbivores on their host [6]. For several circumstances and in many cases, the threat for plants species is associated with the introduction of invasive herbivorous species capable of conditioning, for example, reproduction or vitality [65,66]. Although *S. ceratophylloides* is a strong producer of essential oils, *S. elongatum* seems to affect the vitality and reproduction of species. We do not know the effects of this herbivore on, or its relationships with, the second autumn flowering. A secondary flowering is recorded for many species as a display of initially continuous flowering or because of damage [67]. Determining the cause of this second flowering in *S. ceratophylloides* is necessary in order to exclude a flowering related to the herbivores'

damage. The number of emerging holes for *S. elongatum* in each plant was related to the average diameter of plant stems with increased digging of tunnels according to the diameter size. According to the available literature, the period of occurrence of adults of *S. elongatum* is April [54], but in our study areas, the species emerged in June and on the first day of July. Chalcid wasps such as *Trichomalus* and secondary *E. vesicularis and E. muellneri* parasitized larvae of this apionid. To the genus *Trichomalus* belong widely diffused species, some of which have good potential for the biological control of other species of beetles such as the cabbage seedpod weevil (CSW), *Ceutorhynchus obstrictus* Marsham (Coleoptera: Curculionidae) [67]. *E. vesicularis* and *E. muellneri* have been detected as parasitoids of *Ruguloscolytus mediterraneus* (Eggers, 1922) (Coleoptera: Scolytidae) and *Sphenoptera davatchii* Descarpentries, 1960 (Coleoptera: Buprestidae) [68]. European species of *Eupelmus* (Macroneura Walker) are cosmopolitan and extremely polyphagous species [69–71].

In general, the amount of insect-feeding seed damage is low [72]. Occurrences of Eurytomid wasps (Hymenoptera: Eurytomidae) in seeds are amply documented for different species [73], and on sage seeds, we confirmed and highlighted the seed feeder *S. salviae* for this sage species. Previously, other finds on *S. pratensis*, *S. glutinosa* L., *S. scabiosifolia* Lam., and probably *S. grandiflora* Etlin. [41–44] have highlighted the emergence of *S. salviae*, while no *O. diffinis* has been reported; our case is the first report regarding a *Systole–Ormyrus* interaction. Based on available literature, *O. diffinis* plays the role of parasitoid for other species of *Ormyrus* sp. [74–77]. This species is also reared from the galls of *Neaylax alvia* and *N. nemorosae* (Hymenoptera Cynipidae) on different species of sage and from those of *Rhodus cyprius* (Hymenoptera Cynipidae) on *Salvia triloba* (Lamiaceae) [74]. *O. diffinis* is widespread and has only recently been reported in Iran [68]. In any case, for *O. diffinis*, the possible role in regulating the *S. salviae* population, as well as other better-known pest species [78], remains unknown.

In this study, considering the obtained data, we did not explore if this sage species exhibits a masting behavior and if environmental factors drive masting and the emergence of herbivores [79]. Espelta et al. [80], in two mid-term studies, showed, for example, that acorn production and predation are highly variable across years, while the abundance of adult weevils is positively related to autumn rainfall and to the number of infested acorns the previous years. Further investigations in our area are in progress in order to understand if the production of seeds in *S. ceratophylloides* follows the reproductive economy through seed predation for selecting the synchronous production of massive and null seed crops in this species.

## 4. Conclusions

Investigations will be carried out in order to evaluate and quantify in more detail the quantitative relationships between the abundance of *S. elongatum* larvae and inflorescence and seed production in *S. ceratophylloides*. We suppose that in reproductive plants, a low presence of herbivorous larvae could also influence the production of pollen or the abundance of seeds. Notwithstanding that the attack of apionids affects the internal tissues of the stem, damage to inflorescence formation was detected. The data acquired indicate that the density of the herbivore in the sage diffusion area does not represent a factor for quantitative regulation of flowering, but it is rather able to condition species survival. This interaction between host and established herbivores promotes a behavioral model of the pest populations affecting the reproduction of this sage species, which helps to explain their ecological relationship with the host plant, defining the real harmfulness, and to better undertake any phytoiatric decision and any plant species conservation activity. Conversely, the role of seed feeders appears to be very different, which seems more limited, and the relationship with sage is to be considered tolerable under natural conditions. Generally, seed predators should have little influence on many host plant populations, and further investigations are necessary to verify whether conjunct attack of both herbivores the same year causes a sharp reduction in sage in the area indicated.

**Supplementary Materials:** The following are available online at https://www.mdpi.com/1424-2818/13/1/33/s1, Table S1: Information about *Squamapion elongatum* and accession numbers related to the gene sequences of samples analysed. Figure S1: Dorsal and lateral view of *Squamapion elongatum*.

**Author Contributions:** C.P.B. conceived and designed the experiments; C.P.B. and G.V. performed the experiments, analyzed the data, wrote the paper, and contributed reagents/materials/analysis tools; V.L.A.L. collected the plants and materials, took the photos, and wrote and reviewed the paper; R.M., G.S. and C.M.M. collected the plants and materials and reviewed drafts of the paper. All authors have read and agreed to the published version of the manuscript.

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# CHAPTER 7. *Pimpinella anisoides* V. Brig

## 7.1. Introduction

*Pimpinella anisoides* V.Brig. (Figure 1) [Synonyms: *Apium anisoides* (Brign.) Caruel, *Apium gussonei* (C. Presl.) Calest., *Pimpinella bubonoides* DC., *Tobion bubonoides* Raf.; Italian name "Tragoselino meridionale"; Calabrian vernacular name "aranzu"] is an endemic species found in some administrative regions of central-southern Italy, such as Latium, Basilicata [1-3], Calabria [4, 5], Campania [6] and Sicily [7]. It belongs to the Apiaceae family, the third largest family in terms of number of native genera (85 in total). The genus *Pimpinella* L. (subfamily *Apioideae*, tribe *Pimpinelleae*) comprises about 150-180 annual or perennial species distributed in the temperate and subtropical regions of Eurasia and Africa, but also in South America and the western part of North America [8-10].



**Figure 1.** *Pimpinella anisoides* V. Brig. pollinated by lepidoptera *Lycaena dispar* (Haworth, 1803). Ph. V. L.A. Laface.

There are numerous studies on this genus, but its taxonomy has not yet been completely clarified: it is, in fact, one of the most complex genera in the Apiaceae family [11-15]. Fernandez Prieto *et al.* [16] point out that *Pimpinella* is

a non-monophyletic group and that the taxa of *Pimpinella* growing in Western Europe are part of phylogenetically independent groups that correspond to three different tribes of the subfamily *Apioideae: Pimpinelleae* (main group), *Pyramidoptereae* and *Smyrnieae*. In the genus *Pimpinella*, the base chromosome number is x = 8 to 11 [17].

In Italy, seven native species of the genus *Pimpinella* are reported [18] and one alien [19]. Following subsequent updates, it is now possible to recognise a total of 10 taxa, of which nine are native, including three subspecies and one alien [20]. However, the interpretation of the Italian taxa belonging to the genus *Pimpinella* L. is controversial. Indeed, Stinca and Ricciardi [21, 22] report 12 Italian taxa of *Pimpinella*, including nine species (eight native and one alien) and three subspecies.

### 7.2. Historical vicissitudes

*Pimpinella anisoides* was described in 1802 by Vincenzo Briganti in his work "*De nova pimpinellae specie cui nomen anisoides dissertatio cum tabula aenea*" [23] (Figure 2).




« XI »

PIMPINELLA ANISOIDES.

PIMPINELLA *Anisoides* foliis radicalibus bipinnatis, foliolis cuneiformibus apice dentatis incisisque.

*Habitat in montibus collibusque apricis*

*Floret Quintili mense. Perennis.*

DESCRIPTIO.

*Radix* perennis, ramosa, albicans, acris, hircum redolens.

*Caulis bi-pedalis, erectus, levitor striatus, ramosus. Rami patentes, alterni.*

*Folia* radicalia bipinnata, foliolis cuneiformibus, apice dentatis, incisisque: impari majore 3-lobo, pinnis auriculatis. Floralia nulla; basis tamen ramorum, ac pedunculorum squama acuminata, vaginantie arcte cincta.

*Petioli* communes canaliculati, vaginantes.

*Umbellae* numerosae, planiusculae: universales radiis 5 vel 7; partiales vero pluribus: in nubilibus radii ad unum latus inflexi. Involucrum universale, et partiale nullum. Flosculi omnes fertiles. Petala inflexo-cordata, subaequalia, alba uti stamina et pistilla.

*Semina* parva, fusca, ovato-oblonga; hinc gibba striata, illinc plana, *Anisi* odore, unde nomen.

*Observ.* Inter plantas spontaneas exemplaria deprehendi caule simplici praedita, et pedunculis squamis vaginantibus repletis; foliis porro radicalibus, quae folia PIMPINELLAE *Saxifragae* imitantur. Si culturae eadem planta destinetur, folia prima, quae a perennibus radicibus emittuntur, foliolis majoribus et fere crenatis sunt instructa; caulis in

**Figure 2.** Iconography of *Pimpinella anisoides* V.Brig. and description of the species from Briganti [23] "*De nova pimpinellae specie cui nomen anisoides dissertatio cum tabula aenea*".

### 7.3. Species description

*Pimpinella anisoides* (Figure 3) is a perennial herbaceous plant (scapose hemicryptophyte), with enlarged woody roots, the stem is erect, striate, zig-zagging in the inflorescence, has numerous (10-20) umbels. Basal leaves ovate-lanceolate (10-15 cm), 2-3-pinnate, with third-order ovate-lanceolate segments (1.5 × 3-4 mm), entire or with 1-2 teeth; upper leaves reduced to sheathing petiole. Umbrellas with 2-6 rays; involucre and involucret null; petals white, with apex curved towards the centre of the flower (inflected) and apparently bilobed; fruit dark, ovoid (2-4 mm long), glabrous [24]. Blooms from June to July. The dry fruit is a bilocular schizocarp, consisting of two (homomorphic) mericarps, with five ribs each, dorsally compressed (hemispherical), flanked in the ventral part and joined with the carpophore bifid to the middle, which usually split at maturity [14, 25]. The fruit is rich in various essential oils, making these species aromatically valuable [5, 26]. Pollination is entomophilous mediated mainly by hymenoptera, lepidoptera (Figure 1), diptera and coleoptera and seed dispersal occurs by barochory and myrmecochory. P. anisoides is a diploid species with chromosome number 2n = 20 [27]

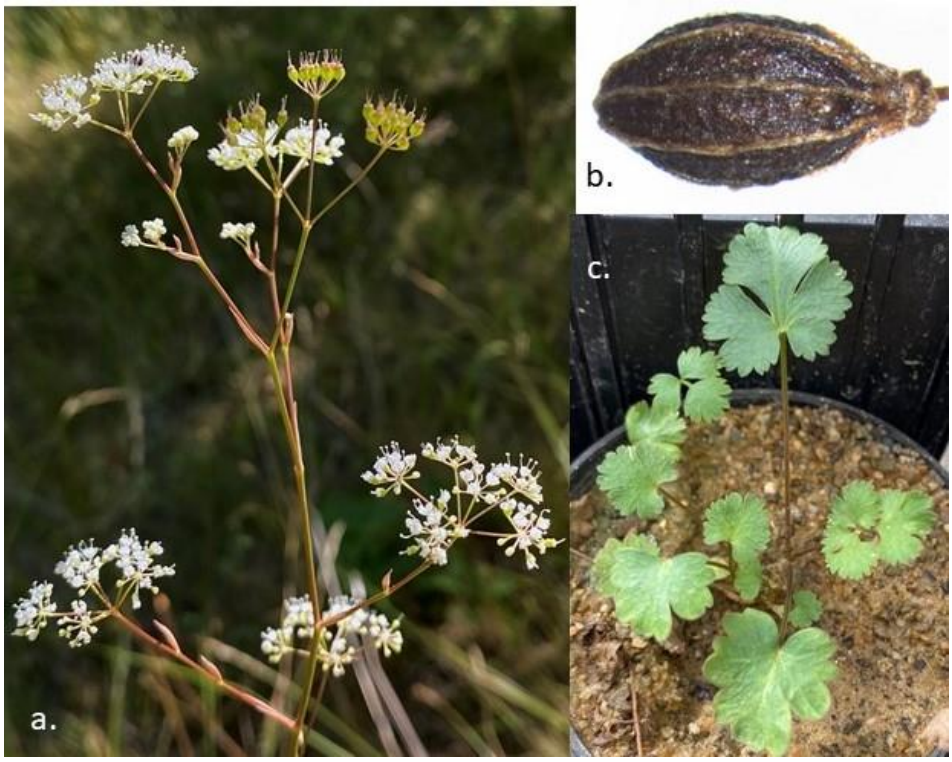



Figure 3. Detail of: inflorescences and fruits (a); fruit (b); young seedlings (c) of *Pimpinella anisoides* V. Brig. Ph. V.L.A. Laface.

### 7.4. Habitat

*Pimpinella anisoides* grows spontaneously in the habitat of the EEC Directive 92/43: "9260 *Castanea sativa* woods" and "91M0 Pannonian-Balkanic turkey oak-sessile oak forests" (Figure 4). The most frequently growing species with *Pimpinella anisoides* are: *Castanea sativa* Mill., *Quercus cerris* L., *Quercus pubescens* Willd. subsp. *pubescens*, *Q. frainetto* Ten., *Quercus petraea* (Matt.) Liebl. subsp. *petraea*, *Crataegus monogyna* Jacq., *Cytisus villosus* Pourr., *Sorbus domestica* L., *Brachypodium sylvaticum* (Huds.) P. Beauv. subsp. *sylvaticum*, *Teucrium siculum* (Raf.) Guss. subsp. *siculum*, *Drymochloa drymeja* (Mert. & W.D.J. Koch) Holub subsp. *exaltata* (C. Presl) Foggi & Signorini, *Vinca minor* L., *Fragaria vesca* L. subsp. *vesca*, *Luzula sylvatica* (Huds.) Gaudin subsp. *sicula* (Parl.) K. Richt., *Dactylis glomerata* L. subsp. *glomerata*, *Hedera helix* L. subsp. *helix*, *Sanicula europaea* L., *Geranium versicolor* L., *Aremonia agrimonoides* (L.) DC. subsp. *agrimonoides*

The species grows in the clearings of mesophilic and acidophilic formations of *Quercus cerris* L. or *Castanea sativa* Mill., located in the mountain belt at altitudes between 700 and 1300 m a.s.l. [5], on substrates characterised by phylladic schists or granites [28]. According to Pesaresi [29], the bioclimate are classificate as "Mediterranean Pluviseasonal Oceanic", with upper supra-Mediterranean thermotype and upper sub-humid ombrotype.




Figure 4. Natural habitat of *Pimpinella anisoides* V. Brig. a.) 9260 - *Castanea sativa* woods; b.) 91M0 - Pannonian-Balkanic turkey oak-sessile oak forests.

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# **CHAPTER 8.** Carpological analysis of two endemic Italian species: *Pimpinella anisoides* and *Pimpinella gussonei* (Apiaceae)

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# Carpological Analysis of Two Endemic Italian Species: *Pimpinella anisoides* and *Pimpinella gussonei* (Apiaceae)

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**Abstract:** This study aims to clarify the taxonomic doubts, which have varied over the centuries, on the only two endemic species of the genus *Pimpinella* growing in Italy: *P. anisoides* and *P. gussonei*. For this purpose, the main carpological characters of the two species were examined, analyzing the external morphological traits and their cross-sections. Fourteen morphological traits were identified, obtaining datasets for the two groups using 40 mericarps (20 per species). The obtained measurements were subjected to statistical analysis (MANOVA and PCA). Our results highlight that at least 10 of the 14 morphological traits analyzed support the distinction between *P. anisoides* and *P. gussonei*. In particular, the following carpological characters are very significant ways to distinguish between the two species: monocarp width and length (Mw, Ml), monocarp length from base to maximum width (Mm), stylopodium width and length (Sw, Sl), length/width ratio (l/w) and cross-section area (CSa). In particular, the fruit of *P. anisoides* is larger (Mw 1.61 ± 0.10 mm) than that of *P. gussonei* (Mw 1.27 ± 0.13 mm), the mericarps of the first species are longer (Ml 3.14 ± 0.32 vs. 2.26 ± 0.18 mm) and the cross-section area (CSa) of *P. gussonei* is larger (0.92 ± 0.19 mm) than that of *P. anisoides* (0.69 ± 0.12 mm). The results also highlight the importance of the morphological traits of the carpological structures for the specific discrimination of similar species. The findings of this study contribute to an evaluation of the taxonomic significance of this species within the genus *Pimpinella*, and also provide valuable information for the conservation of these two endemic species.

**Keywords:** endemism; fruit; morphometry; Sicily; Southern Italy; Umbelliferae

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## 1. Introduction

The genus *Pimpinella* L. is one of the most complex and species-rich of the family Apiaceae Lindl. Despite studies by numerous authors, its taxonomy is still not fully resolved [1–5]. Fernández Prieto et al. [6], in their study of the *Pimpinella* species from Western Europe, pointed out that it is a polyphyletic group. The genus includes about 150–180 taxa distributed in temperate and subtropical regions of Eurasia and Africa, South America, and western North America [6–9].

In the taxonomic studies on this genus, various morphological characters were considered [5,7,9,10], focusing on the micromorphological and anatomical characteristics of the fruit [11–18]. Carpological characters have traditionally been used for a long time in the systematics of Apiaceae, being among the most accessible to researchers [1,3]. The fruit anatomy and morphology have considerable taxonomic and evolutionary importance and, together with the molecular phylogenetic analyses, allow defining a

stable taxonomy and an evolutionary history of species and genera [17]. Molecular phylogenetic analyses have raised new questions and, in many cases, have initiated a review of generic boundaries [5,6]. Kljuykov et al. [18] highlighted the requirements of morphological analyses for the characterization of taxa, re-evaluating the value of single character states and refining the terminology.

*Pimpinella* fruit is a bilocular schizocarp, consisting of two (homomorphic) mericarps, each with five ribs, dorsally compressed (hemispherical), flanked in the ventral part and joined with the carpophore bifid to the middle, which usually splits at maturity [3,4,19]. The fruit is rich in various essential oils, making these species aromatically valuable [20].

In Italy, Bartolucci et al. [21] reported seven native species and Galasso et al. [22] one casual alien; subsequent updates recognize 10 taxa, of which 9 are native (including 3 subspecies) and 1 casual alien [23]. Stinca and Ricciardi [24,25], on the other hand, recognise 12 Italian taxa in the genus *Pimpinella*, including 11 native species and subspecies and 1 alien. Among the taxa occurring in Italy, only two species are endemic, namely *Pimpinella anisoides* V.Brig. and *Pimpinella gussonei* (C.Presl) Bertol.

*Pimpinella anisoides*, described by Vincenzo Briganti in 1802 [26], grows in Southern Italy (Campania, Basilicata, Latium, Apulia, Calabria, and Sicily) [21,23–25] in the mesophylous woodland belts of *Quercus* spp. and *Castanea sativa* Mill. In Calabria, this species has an important economic value in the niche goods market: in fact, it is used to flavor several bakery products and some typical liqueurs [26–28], while in Basilicata, the fruits called "ciminielli" are used for the preparation of traditional sweets [29].

*Pimpinella gussonei* is a species exclusive to Sicily [21,23–25], an island that is well-known as a hotspot for endemic species [30–32]. The species grows from the sea level up to 1500 m asl in uncultivated farmlands, clearings and coppices [33]. The taxonomic history of this species is rather controversial. The earliest information can be found in Cupani [34], who in his pre-Linnean work *Hortus Catholicus* reports the species in Enna (Sicily, Italy) as "*Pimpinella hircina, faxifraga*", and later [35] in "*Panphyton Siculum"* reports a detailed iconography and describes the species as *"Tragoselinum procerior et ramosior, Dauci alsatici foliis imis*", i.e., as "a taller, ramose tragoselinum with basal leaves of *Daucus alsaziano*" (Figure 1). Several authors of Sicilian or Italian floras quote Cupani as Presl [36] who describe the species in the Linnean system, Gussone [37,38] in "*Plantae rariores*" and Bertoloni in "*Flora italica*" [39].

Presl, in "*Deliciae Pragenses, Historiam Naturalem Spegtantes*", described the species as *Tragium gussonii* [36], dedicating it to Giovanni Gussone. Subsequently, Gussone [37] reported it in Calabria, near Reggio, highlighting how this species is strongly akin to *Pimpinella anisoides* as described by Briganti, so much so that it misled him on the identification of some specimens sent to him by foreign botanists. He also highlights the differential characteristics of the two species: "*…T. Gussonii, caulis semper dichotomus; umbellae radii 4–5; fructus griseo-villosi; styli divaricato-reflexi, stigmatibus capitatis: dum in P. anisoide, caulis dichotomus vel ramis aliquando ternis (semiverticillatis); umbellae radii 5–7*; *fructus glaberrimi, virentes; styli erecto-patentes, stigmatibus vix incrassatis*." That is: "*T. Gussonii*, stem always dichotomous; umbels with 4–5 rays; fruit grey-haired; styles divaricate-reflexed, with capitate stigmas: whereas in *P. anisoide* the stem is dichotomous or the branches are sometimes triple (semi-verticillate); umbels with 5–7 rays; fruits are very glabrous, green; styles erect-patent, the stigmas barely enlarged."

Bertoloni [39] considers *Tragium gussonei* a synonym of *Pimpinella gussonii*, and reports the species being in the Sicilian localities of Palermo, San Martino, Carini, Ficuzza and Alcamo, as already mentioned by Gussone [38], who also reported the species in Castellammare, Mazzara, Marsala, Termini, Polizzi, Caltavuturo, Castrogiovanni, Catania, Nicolisi and Randazzo.




**Figure 1.** Iconography of Cupani's *Panphyton Siculum* of 1713 [35], attributed to *Tragium gussonei* (on the right) by Presl [36], Gussone [37], Bertoloni [39].

Caruel [40] considers both *P. gussonei* and *P. anisoides* to be synonyms of *Apium anisoides*. Fiori [41] considers *P. gussonei* to be a variety of *P. anisoides*, pointing out that the distinctive characters of the varieties are attributable to carpological differences.

Tutin [42] does not recognise *P. gussonei* either as a species or as a subspecies or variety, believing that the carpological character of the pubescence of the fruit is part of the variability of *P. anisoides*. Pignatti [29] and Stinca and Ricciardi [24,25] include *P. gussonii* Bertol. in the variability of *P. anisoides*, pointing out that the taxonomic value of those populations with fruits provided with appressed hairs should be further investigated. Conti et al. [43] only recognized *P. anisoides*. Peruzzi et al. [44] distinguish the two species and according to Art. 60.7 of ICN specify that the spelling of the specific epithet originally published as "*gussonii*" is to be corrected to "*gussonei*". Bartolucci et al. [21] and their updates [23] consider *P. anisoides* V.Brig. and *P. gussonei* (C.Presl) Bertol. as two distinct species. Govaerts et al. [45], POWO [46] and Fernández Prieto et al. [6] consider *P. gussonei* (C.Presl) Bertol. a synonym of *P. anisoides* V.Brig. Furthermore, again according to Govaerts et al. [45] and POWO [46], *Tragium gussonei* C.Presl is a synonym of *Pimpinella villosa* Schousb., a species with a range including Morocco, the Azores Islands, Portugal and Spain. Presl [36] himself, in describing the species, emphasizes the profound affinity with *P. villosa* while highlighting its differences "*Affinis forte T. villoso (Pimpinellae villosae Schousb.) sed differre videtur: pinnulis ovatis profunde dentatis, petalis glabris...*" that is "... strongly akin to *T. villoso* (*Pimpinellae villosae* Schousb.), but appears to differ: deeply toothed ovate fins, glabrous petals…". Differences also highlighted by Gussone, who considers *P. gussonei* (sub *Tragium gussonii*) glabrous throughout [37]. Moreover, several authors, including Presl [36], point out that *Pimpinella gussonei* also has numerous affinities with *Pimpinella bubonoides* DC. Gussone [47] considers *P. bubonoides* as a synonym of *Pimpinella anisoides*, while Gussone [37] again highlights the distinguishing characteristics of *Pimpinella gussonei* (sub. *T. gussonii*) with respect to *P. bubonoides*, indicating that the species does not have large basal leaves, nor alternate and

composite cauline leaves. Bertoloni [39] considers *P. bubonoides* as a synonym of *P. gussonii*.

The historical excursus shows that the taxonomic events related to *Pimpinella gussonei* and *Pimpinella anisoides* are very complex and still unresolved.

This study provides a first characterization and differentiation between these two endemic species with the analysis of the carpological traits. This distinction is also helpful for economic purposes to identify commonly marketed fruits and counteract adulteration

## 2. Results and Discussion

### *2.1. Carpological Analysis*

In agreement with Cano et al. [48], fruit morphometry is a good tool for distinguishing similar species that differ in a few characters that are not always unique.

In the case of *P. anisoides* and *P. gussonei*, the schizocarp of both species is similar, oblong-ovoid in shape, with five grooves between five prominent, and more or less prominent dorsal ribs; it consists of two homomorphic mericarps, having a flat ventral surface, and is joined by a carpophore bifid to the middle, usually splitting when ripe [19].

In *P. anisoides*, the fruit is glabrous throughout, dark brown–black in color, having an average length of 3.14 (±0.59) mm and a width of 1.61 (±0.16) mm; the average length/width ratio is 1.94, and the distance between the base and the maximum width is 1.25 (±0.20) mm. The stylopodium has a length of 0.38 (±0.13) mm and a width of 0.47 (±0.14) mm. In *P. gussonei*, the fruit is pubescent due to numerous single hairs appressed to the dorsal part, the ventral part is glabrous or with a few scattered hairs and grey–black in color; on average it is 2.26 (±0.33) mm long and 1.27 (±0.27) mm wide, the average length/width ratio is 1.70, and the distance between the base and the maximum width is 0.91 (±0.19) mm. The stylopodium has a length of 0.30 (±0.07) mm and a width of 0.25 (±0.42) mm (Figure 2; Table 1).

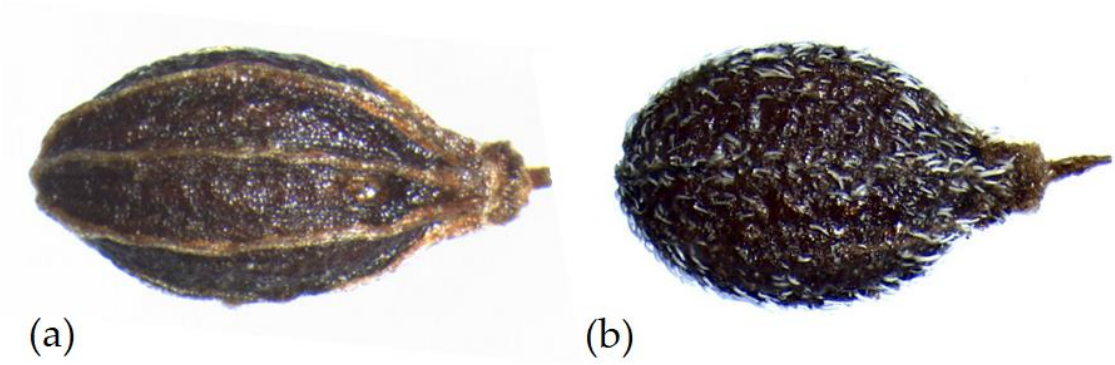



**Figure 2.** Mericarps of: (**a**) *Pimpinella anisoides* V.Brig. and (**b**) *Pimpinella gussonei* (C.Presl) Bertol.

**Table 1.** Comparison of the monocarp characters of *Pimpinella anisoides* V.Brig. and *Pimpinella gussonei* (C.Presl) Bertol. used in morphometric analyses. Quantitative numerical values (mm) are expressed as mean ± SD. Significant data (*p*) are indicated in bold. Fisher's F highlights the ratio of the variance between the two samples.

| Code | Description | *P. anisoides* | *P. gussonei* | | |
|---|---|---|---|---|---|
| | | **Mean ± SD** | **Mean ± SD** | **F** | ***p*** **(Statistical Significance)** |
| **Mw** | **Monocarp width (mm)** | **1.61 ± 0.10** | **1.27 ± 0.13** | **90.902** | *** |
| **Ml** | **Monocarp length (mm)** | **3.14 ± 0.32** | **2.26 ± 0.18** | **112.899** | *** |
| **Mm** | **Monocarp length from base to maximum width (mm)** | **1.25 ± 0.14** | **0.91 ± 0.10** | **76.237** | *** |
| **Sw** | **Stylopodium width (mm)** | **0.47 ± 0.06** | **0.25 ± 0.19** | **21.356** | *** |
| **Sl** | **Stylopodium length (mm)** | **0.38 ± 0.08** | **0.30 ± 0.04** | **18.878** | *** |
| **l/w** | **Length/width ratio** | **1.94 ± 0.19** | **1.70 ± 0.07** | **27.166** | *** |
| **CSw** | **Width of cross-section (mm)** | **1.50 ± 0.17** | **1.64 ± 0.21** | **5.154** | * |
| CSt | Thickness of cross-section (mm) | 0.74 ± 0.09 | 0.85 ± 0.12 | 2.857 | n.s. |
| **CSa** | **Cross-section area (mm²)** | **0.69 ± 0.12** | **0.92 ± 0.19** | **17.867** | *** |
| **CVw** | **Width of commissural vittae (mm)** | **0.17 ± 0.03** | **0.15 ± 0.02** | **5.636** | * |
| CVt | Thickness of commissural vittae (mm) | 0.53 ± 0.10 | 0.55 ± 0.06 | 0.389 | n.s. |
| CCSl | Commissure width (mm) | 1.18 ± 0.17 | 1.23 ± 0.13 | 0.937 | n.s. |
| CS w/t | Cross-section width/thickness ratio | 2.05 ± 0.31 | 1.94 ± 0.23 | 1.651 | n.s. |
| **CV w/t** | **Commissural vittae width/thickness ratio** | **3.25 ± 0.84** | **2.73 ± 0.45** | **5.086** | * |

* = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$; n.s. = $p > 0.05$.

The cross-section of the mericarps in both species is similar and shows morphological characteristics according to Laface et al. [20]; the dimensions of the different characters examined differ.

In *P. anisoides*, the cross-section area is 0.69 mm², with a thickness 0.74 (±0.17) mm long and 1.50 (±0.33) mm wide, and the average width/thickness ratio is 2.05. The commissural vittae are 0.53 (±0.18) mm long and 0.17 (±0.04) mm wide with a width/thickness ratio of 3.25. The commissure width is 1.18 (±0.31) mm. In *P. gussonei*, the cross-section area is 0.92 (±0.33) mm², the thickness is 0.85 (±0.21) mm long and 1.64 (±0.41) mm wide, and the average width/thickness ratio is 1.94. The commissural vittae are 0.55 (±0.12) mm long and 0.15 (±0.05) mm thick with a width/thickness ratio of 3.73. The commissure width is 1.23 (±0.28) mm (Figure 3, Table 1).

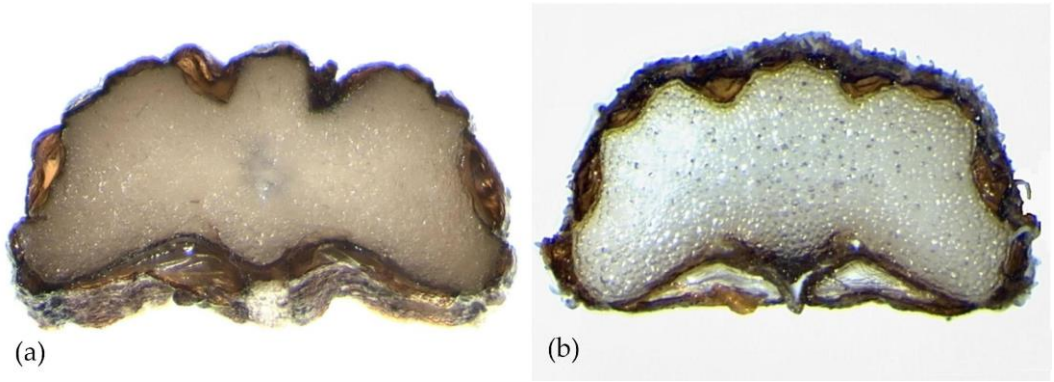



**Figure 3.** Mericarps cross-section of: (**a**) *Pimpinella anisoides* V.Brig. and (**b**) *Pimpinella gussonei* (C.Presl) Bertol.

*2.2. Statistical Analysis*

The results of the multivariate analysis of the characters are summarized in Table 1 and shown in the boxplots in Figure 4. The MANOVA multivariate analysis used to define the significance of the analyzed characters, shows that Mw, Ml, Mm, Sw, Sl, l/w and CSa, are highly significant ($p < 0.001$), while CSw, CVw and CV w/t are not very significant ($p < 0.05$), and the characters CVt, CCSl and CS w/t are not significant. The F

values also show that the two examined species display different morphological traits, some of which are more evident: Mw (F = 90.902), Ml (F = 112.899), Mm (F = 76.237), Sw (F = 21.360), Sl (F = 18.878), l/w (27.166) and CSa (F = 17.867) are more differentiated and CSw (F = 5.154), CVw (F = 5.636) and CV w/t (F = 5.086) are not very differentiated. The characters found to be non-significant, CSt, CVt, CCSl and CS w/t, have values of F < 1. The boxplots (Figure 4) allow us to visualize the centre and distribution of the data, and highlight some outliers for the characters Sw, CVw and CV w/t.




**Figure 4.** Boxplots of statistically significant fruit morphological characters of *Pimpinella anisoides* V. Brig. and *Pimpinella gussonei* (C.Presl) Bertol. Character abbreviations: fruit width (Mw); fruit length (Ml); length from the lower end to the point of maximum width (Mm); stylopodium width and length (Sw, Sl); length/width ratio (l/w); area per section (CSa); commissural vittae width (CVw); section width (CSw); commissural vittae width/thickness ratio (CVw/t). The terminology of fruit parts and section is in accordance with Kljuykov et al. [19], Akalın et al. [9], Yeşil et al. [18]

The PCA (Figure 5) clearly separates the fruits of *P. gussonei* and *P. anisoides*, showing a strong distinction between the carpological characters of the two species. In addition, the PCA shows that the first five characters with highest significance (Mw 76% variance, Ml 12% variance, Mm 4% variance, Sw 4% variance), explain 96% of the total variance. The biplot (Figure 5) also shows that some characters (Ml, Mm, Sw, Mw, l/w) contribute better to the characterization of *P. anisoides* than *P. gussonei*. On the whole, the characters concerning the external morphology of the fruit allow better distinction between the two species than the characters concerning the section of the fruit.

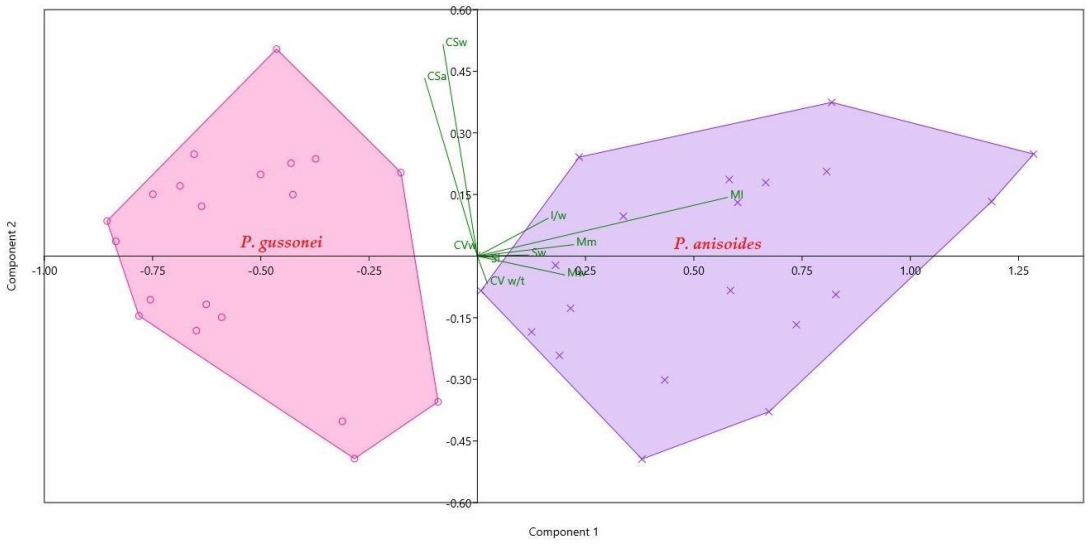



**Figure 5.** PCA based on 10 continuous quantitative traits' significant results for *Pimpinella anisoides* V.Brig. and *Pimpinella gussonei* (C.Presl) Bertol. fruits (see Table 1). The relative contribution of each variable is shown in green.

The obtained results highlight that the two species have similar carpological characteristics but have different size characters (Figure 4). The fruit of *P. anisoides* is larger (Mw 1.61 ± 0.10 mm) than that of *P. gussonei* (Mw 1.27 ± 0.13 mm); in addition, the mericarps of the first species are longer (Ml 3.14 ± 0.32 vs. 2.26 ± 0.18 mm). The stylopodium of *P. anisoides* is wider (Sw 0.47 ± 0.06 mm) than that of *P. gussonei* (0.25 ± 0.19 mm). The cross-section area (CSa) of *P. gussonei* is larger (0.92 ± 0.19 mm) than that of *P. anisoides* (0.69 ± 0.12 mm). The commissural vittae width/thickness ratio (CV w/t) is 3.25 ± 0.84 in *P. anisoides* and 2.73 ± 0.45 in *P. gussonei*, showing a more compressed shape in the mericarp of the first species. Overall, the mericarps of *P. anisoides* appear slightly more oblong (l/w-length/width ratio =1.94) than those of *P. gussonei* (l/w-length/width ratio = 1.70). In agreement with Gussone [37], all the samples of *P. gussonei* fruit are grey tomentose, whereas those of *P. anisoides* are glabrous throughout.

In addition, the carpological characters of *P. anisoides* and *P. gussonei* were compared with those of other species of the genus *Pimpinella* growing in Italy (Table 2).

**Table 2.** Comparison of the monocarp characters of *Pimpinella* species present in Italy.

| Taxon | Fruit Length (mm) | Indumentum | Shape of Fruit | Aromatic |
|---|---|---|---|---|
| *Pimpinella anisoides* V.Brig. | 2.5–3.7 | glabrous | oblong-ovoid | yes |
| *Pimpinella anisum* L. | 3.9–4 | strigose | ovoid | yes |
| *Pimpinella gussonei* (C.Presl) Bertol. | 1.9–2.6 | pubescens | oblong-ovoid | yes |
| *Pimpinella lutea* Desf. | 3.5–4 | glabrous | eliptic | no |
| *Pimpinella major* (L.) Huds. | 2.5–3.5 | glabrous | ovoid | no |
| *Pimpinella peregrina* L. | 1.9–2 | hispid | eliptic | no |
| *Pimpinella saxifraga* L. | 2.1–2.2 | glabrous | oblong-ovoid | no |
| *Pimpinella tragium* Vill. | 2 | strigose | ovoid | no |

The comparison in Table 2 shows that *P. gussonei* and *P. anisoides* are the only two natives to be of aromatic interest, apart from *P. anisum* of the species introduced for cultivation. Both species have oblong-ovoid fruits, similar to those of *P. saxifraga*, but this is not aromatic. The fruit size of *P. anisoides* is similar to that of *P. major*, which, however,

has ovoid fruits. *P. gussonei* is similar in size to *P. peregrina*, which, however, has elliptic and hispid fruits.

Traditionally, the *Pimpinella* genus differs from related genera of the Apiaceae family due to a series of characteristics that are mainly of carpological type. The fruits, no longer than 5 mm, are slightly longer than wide, ovoid-oblong to subglobose, laterally compressed, with inconspicuous filiform primary ridges [29,42]. The phylogenetic analysis conducted by Fernández Prieto et al. [6] shows that in the *Pimpinella* genus, it is not possible to identify sections as proposed by de Candolle [49] and Wolff [1]. On the other hand, Fernández Prieto et al. [6] separate some species formerly included in the *Pimpinella* genus, attributing them to related genera: *Spiroceratium* H.Wolff and *Parapimpinella* Fern. Prieto et al.

## 3. Materials and Methods

### *3.1. Fruit Collection and Morphometric Data*

The analysed fruits were collected from different localities: *P. anisoides* in Calabria in the Presila Catanzarese near Decollatura (CZ) and *P. gussonei* in Sicily near Gibilmanna (PA) (Figure 6).

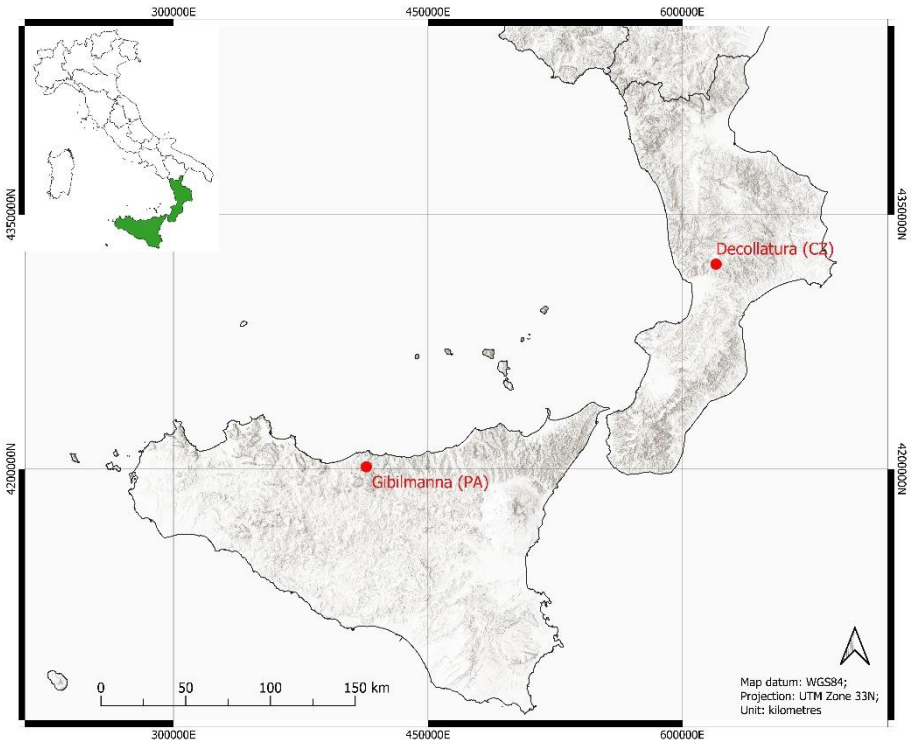



**Figure 6.** Map localities where fruit collections were carried out: Decollatura (Catanzaro—CZ) in Calabria for *Pimpinella anisoides* V.Brig. and Gibilmanna (Palermo—PA) in Sicily for *Pimpinella gussonei* (C. Presl) Bertol.

The samples were collected in August 2022 during the period of maximum fruit filling, the collection was randomized within the sampled population for both species. At the same time, herbarium samples of the two species were collected and stored at the herbarium of the Mediterranean University of Reggio Calabria (REGGIO) for those of *P. anisoides* and at the herbarium of the University of Catania (CAT) for those of *P. gussonei* (acronyms follow Thiers [50]). The two species are very similar, in fact they are scapose hemicryptophytes, with enlarged woody root, erect stems, up to 80 cm tall, tripinnatifid leaves with lanceolate final segments, usually provided with 1–2 teeth, umbel-shaped inflorescence without involucre and involucel with 5–6 rays, flowers with white petals. The fruits were measured, in all their parts, by means of a stereomicroscope equipped

with an Invenio 5SII HD camera connected to a computer where, by means of the DeltaPix inSight© software, it was possible to reconstruct the image using a multifocal system, and to determine the character measurements of the fruit. Morphometric analyses were carried out on a sample of 20 fruits and 20 cross-sections. The fruits measured were those that were found on a first macroscopic analysis to be perfectly ripe, well-formed and free of defects, caused by mechanical damage or insects. The following were measured in detail: fruit width (Mw), fruit length (Ml), length from the lower end to the point of maximum width (Mm), stylopodium width and length (Sw, Sl) and the length/width ratio (l/w). Fruit cross-sections were also observed to define their micromorphology, and the following were measured in detail: section width and thickness (CSw, CSt) and their ratio (CSw/t), commissural vittae width and thickness (CVw, CVt) and their ratio (CVw/t), commissure width (CCSl). The area per section (CSa) was also measured. The terminology of fruit parts and section is in accordance with Kljuykov et al. [19], Akalın et al. [9], Yeşil et al. [18]. Information of the carpological characters of the other species of the *Pimpinella* genus occurring in Italy is taken from Pignatti et al. 2018, Yeşil et al. [18] and Tutin et al. [42].

### *3.2. Statistical Analysis*

The data from the measurements were collected and analysed in a matrix in Excel©2019, the mean and standard deviation of the 14 characters examined were also calculated. To define the significance of the data, statistical differences were obtained by MANOVA multivariate analysis of the 14 characters (dependent variable) measured in both species (independent variable). SPSS® 23.0 software (SPSS Inc., Chicago, IL, USA) was used for this purpose. Quantitative raw data were subjected to Principal Component Analysis (PCA) with a covariance matrix based on morphological features found significant by the multivariate MANOVA analysis. The statistical significance of the Principal Components (PCs) was analysed by the Broken Stick method, using Past 4.3® software. [51,52]. Boxplots were carried out with Excel© 2023 using only those characters found significant by the multivariate MANOVA analysis. In each boxplot, the centre and distribution of the data are highlighted.

## 4. Conclusions

This study contributes to the initial characterization of and differentiation between *P. anisoides* and *P. gussonei*, two often confused species that locally have a certain economic importance for the fruits used to flavor foods and drinks. The carpological analysis of the two species endemic to Italy revealed differences in size and morphological and anatomical fruit characteristics. Overall, the results allow a simple distinction of the two species in agreement with Presl [36], Gussone [37,38] and Bertoloni [39], and highlight the importance of carpological characters for the taxonomy of the *Pimpinella* genus. However, in order to determine the relationship between the two endemic Italian *Pimpinella* species more precisely, extensive studies are still needed, including the analysis of the morphological characteristics of the vegetative and reproductive organisms as well as DNA sequences.

**Author Contributions:** Conceptualization, V.L.A.L. and G.S.; data curation, V.L.A.L., C.M.M. and G.S.; formal analysis, V.L.A.L. and G.S.; investigation, V.L.A.L., C.M.M., S.C., G.M. and G.G.d.G.; methodology, V.L.A.L., C.M.M. and G.S.; project administration, G.S.; supervision, C.M.M. and G.S.; validation, C.M.M., G.T. and G.S.; visualization, C.M.M. and G.S.; writing—original draft, V.L.A.L., C.M.M. and G.S.; writing—review and editing, V.L.A.L., C.M.M., G.T., S.C., G.M., G.G.d.G. and G.S. All authors have read and agreed to the published version of the manuscript.

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# **CHAPTER 9.** Morphological and phytochemical features in fruits of *Pimpinella anisoides* V.Brig. (Apiaceae)

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# Morphological and phytochemical features in fruits of *Pimpinella anisoides* V.Brig. (Apiaceae)

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**ABSTRACT**

The morphological characteristics, phytochemical composition of *Pimpinella anisoides* fruits was investigated. The morphological analysis of the monocarps contributed to distinguish *P. anisoides* from other related *Pimpinella* species used for commercial purposes, in particular *P. anisetum* and *P. anisum*. Our study showed that these fruits are different for their surface and shape: in particular, *P. anisoides* monocarps are glabrous, whereas the other two species are strigose. Two main compounds were identified in the essential oil of the five studied accessions: limonene (46.78-50.74%) and anethole (38.50-42.77%) whose sum ranged between 85.28 and 93.51%. estragole and $\beta$-phellandrene were other two representative compounds. All other volatiles accounted for less than 1% of the total volatile composition. One-way ANOVA analysis showed significant differences in almost all volatiles, whereas non-significant differences were found in the compounds detected in very low quantity. Hierarchical cluster analysis allowed to group the five accessions in three main clusters. Principal Component Analysis (PCA) showed that the first two principal components explained 71.80% of total variance. Results show that morphological and phytochemical features of the ripe fruits of *P. anisoides* can be used to distinguish this species from others, to avoid commercial sophistications and for a better conservation.

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## 1. Introduction

The conservation of threatened taxa is a global priority today, in both protected and unexplored areas (Capotorti et al. 2012; Sciandrello et al. 2017; Singh et al. 2021). Knowledge, study and field research are important tools for preserving biodiversity, avoiding favoring the spread of alien species (Cano Ortíz et al. 2022a, 2022b; Caruso 2022; Jiménez et al. 2022). Therefore, it is very important to keep botanical knowledge up to date so that we can always have the right information at the right time (Barthlott et al. 1996; Myers et al. 2000; Govaerts et al. 2021): this will help also to predict new scenarios and actions for plant conservation (Pelletier et al. 2018; Humphreys et al. 2019). One important tool to achieve these objectives are checklists and for Italy several studies generating different types of checklists were carried out (Peruzzi 2010, 2018; Bartolucci et al. 2018; Galasso et al. 2018; Musarella et al. 2018b; Spampinato et al. 2022). In particular, according to Peruzzi (2010), in Italy there are 173 botanical families, among which Apiaceae is the third family by number of native genera (85 in total). The genus *Pimpinella* L. belongs to this family (Apiaceae Lindl., subfamily Apioideae, tribe Pimpinelleae) and includes about 150-180 annual or perennial herbs distributed in the temperate and subtropical regions of Eurasia and Africa, but also in South America and in the western part of North America (Abebe 1992; Pimenov and Leonov 1993, Akalın et al. 2016).

There have been numerous studies on this genus, but its taxonomy has not yet been fully clarified, representing one of the most complex genera of the Apiaceae family (Wolff 1927, Matthews 1972, Engstrand 1987, Pu and Watson 2005, Magee et al. 2009). Fernández Prieto et al. (2018) points out that the *Pimpinella* is a non-monophyletic group and that the *Pimpinella* taxa growing in western Europe are part of phylogenetically independent groups that correspond to three different tribes of the Apioideae subfamily: Pimpinelleae (main group), Pyramidoptereae and Smyrnieae. Fruit morphology is essential for the taxonomy of the genus *Pimpinella*, and in general for the family Apiaceae; variations in shape, pubescence and anatomy are used to distinguish different species. (Morison 1672, Engler 1927, Özcan 2004, Akalin Uruşak and Kizilarslan 2013, Lyskov et al. 2015, Bani et al. 2016a, 2016b, Liu and Downie 2017). The anatomy of many species of this genus was studied (Khajepiri et al. 2010,

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Aksenov and Tikhomirov 1972, Magee et al. 2010, Akalın et al. 2016). Another important character regarding this genus is its phytochemical composition. Essential oils are important discriminating factor between different taxa (Perrino et al. 2021). They can have several applications in preventing some diseases (Benelli et al. 2017), but they are also a constituent of fragrances and flavours which are fundamental in a food or a beverage with regard to the approach of a consumer which: see, smell and taste a product before to eat or drink. Little is known about the essential oil of the *Pimpinella* genus with very scarce findings for the *P. anisoides* and *P. anisetum* species and some information more for the *P. ani- sum* species (Baser et al. 1999, Kiralan et al. 2012, Mahdavi et al. 2018, Samojlik et al. 2012, Tavallali et al. 2017).

Tabanca et al. (2005) studied the content of essential oils of 19 Turkish species of *Pimpinella* and established the phylogeny of *Pimpinella* species using gene sequence data and of essential oil analysis as a framework to ascertain whether there is a connection between the chemical and genetic profiles. Magee et al. (2010) studied the phylogeny of 16 African and Malagasy species, including also 26 species from Eurasia. Fereidounfar et al. (2016) analyzed 52 Southwest Asian species of *Pimpinella*. In the genus *Pimpinella*, the basic chromosome number is $x = 8$ to 11 (Fereidounfar et al. 2016). Bartolucci et al. (2018) reported seven native species of *Pimpinella* and Galasso et al. (2018) one alien. Following subsequent updates, it is now possible to recognize 10 taxa in total, including three subspecies, of which nine are native (N) and one alien (A) (Portal to the Flora of Italy 2021). However, the interpretation of the Italian taxa belonging to the genus *Pimpinella* L. is controversial. Indeed, Stinca and Ricciardi (2018, 2019) report 12 italian taxa of *Pimpinella*, including 9 species and 3 subspecies.

*Pimpinella anisoides* V.Brig. [Synonims: *Apium anisoides* (Brign.) Caruel, *Apium gussonei* (C.Presl) Calest., *Pimpinella bubonoides* DC., *Tobion bubonoides* Raf.; Italian name "Tragoselino meridionale"; vernacular Calabrian name "aranzu")] is an endemic species growing in some central-southern administrative regions of Italy, such as Lazio, Basilicata (Gavioli 1948; Laghetti et al. 1993; Hammer et al. 2000), Calabria (Laghetti et al. 2012; Maruca et al. 2019), Campania (Rosati et al. 2012), Sicily (Giardina et al. 2007; De Leonardis et al. 2007), and Puglia (Conti et al. 2005; Bartolucci et al. 2018; Pignatti 1982, Stinca and Ricciardi 2018, 2019), especially in the mountainous belt (Hammer et al. 2000; Maruca et al. 2019) occupied by mesophilic oak and chestnut woods. In Calabria, *P. anisoides* is reported for several loca- tions (Brullo et al. 2001). However, the practice of harvesting its fruits to flavor various traditional baked goods and liqueurs and as seasoning is known only for the Reventino Massif and Sila Catanzarese area (Maruca et al. 2019).

Although the species is currently considered LC (Least Concern) (Orsenigo et al. 2018), it is collected for commercial purposes in several regions: this is compromising the reproductive potential of the species with negative effects on the size of populations (Hammer et al. 2000; Maruca et al. 2019). Some studies on the chemical composition of *P. anisoides* were carried out in the past. Menichini et al. (2009) studied acetylcholinesterase and butyrylcholinesterase inhibition of the ethanolic extract and monoterpenes from *P. anisoides*, whereas Conforti et al. (2010) described its chemical profile and *in vitro* properties, finding 23 major components in the ethanolic extract of its fruits.

Distinguishing one *Pimpinella* species from another is not an easy task (yeşil et al. 2018).Morphometric studies are very important in discriminating botanical taxa (Cano et al. 2017, Musarella et al. 2018a, yu et al. 2019a, 2019b). In particular, in the genus *Pimpinella*, as well as in most of the Apiaceae, the fruits take on considerable diagnostic significance and are considered essential in taxonomic analysis (yeşil et al. 2018). According to Spjut (1994), Apiaceae fruits are classified as polachenarium, i.e. a schizocarpic fruit, originating from an inferior ovary separating in single fruits (monocarps) from a longitudinal central axis (columella, or carpophore) often remaining attached to the axis at maturity.

In order to provide scientific support to protect the small natural Calabrian populations of *P. anisoides* from the indiscriminate harvesting that threatens their existence, phytochemical and morphological investigations were carried out to assess their characteristics also for the purpose of proper valorisation and protection. In addition, the characterisation of *P. anisoides* fruits makes it possible to avoid the adulteration of the marketed product, thus enhancing its peculiarities.

## 2. Material and methods

The fruits (monocarps) were collected in five locations in the Sila Catanzarese, province of Catanzaro (central Calabria, S-Italy) (Figure 1), at altitudes between 700 and 900 m above




**Figure 1.** map of *Pimpinella anisoides* V. Brig. fruits collection locations in the province of catanzaro (cZ), calabria (s-italy): 1. monticelli, 2. cutura, 3. Pietra di fota, 4. cutura, 5. marignano.

**Table 1.** sources of *Pimpinella anisoides* V. Brig. fruits and their collection data in the province of catanzaro (calabria, s-italy).

| accession id | location | municipality | month and year of collection | collector farm | altitude (m a.s.l.m.) |
|---|---|---|---|---|---|
| Pa_1 | monticelli | cicala | august 2018 | azienda muraca | 900 m |
| Pa_2 | cutura | sorbo san Basile | august 2018 | azienda muraca | 780 m |
| Pa_3 | Pietra di fota | san Bernardo di Decollatura | July 2018 | azienda talarico | 840 m |
| Pa_4 | cutura | cicala | July2017 | azienda talarico | 700 m |
| Pa_5 | marignano | Decollatura | august 2017 | azienda talarico | 900 m |

sea level, in mountain forests of chestnut or deciduous oaks, mainly *Quercus cerris* forests of the series "Southern Appeninic neutral-subacidophilous turkey oak - *Physospermo vertivillati - Querco cerridis sigmetum"* (Bernardo et al. 2010) which represent their habitats (Table 1). The fruits were harvested at the time of ripening between July 2017 and August 2018 by local farmers who also deal with their marketing.

The fresh fruits were cleaned in the Geobotany laboratory of the Mediterranean University of Reggio Calabria (Italy), counted and analyzed for quality. To this purpose, 300 fruits were randomly sorted into six groups of 50. In each group, the fruits were observed and distinguished by an optical stereomicroscope Optech® into: "normal" (intact fruits, ripe, without evident macroscopic damages); "damaged" (for mechanical damages, malformations or with holes or injuries caused by insects); "aborted" (fruits that have not completed the ripening process correctly). Only "normal" fruits were used in the morphological and phytochemical analyses. Specimens of *P. anisoides* collected in the study area, are stored in the Herbarium of the Mediterranean University of Reggio Calabria (REGGIO), acronym in agreement with Thiers (2021).

### 2.1 Morphological analysis

Fruits were analyzed and measured using a stereomicroscope equipped with an HD camera Invenio 5SII connected to a computer where its DeltaPix inSight© software is installed. This software allowed to reconstruct the image using a multifocal system, to determine the exact dimension of the fruits at different magnifications and to apply these measurements directly on the image of the examined objects (Figure 1).

The observations were carried out on a sample of 20 fruits for each of the five locations examined. The following dimensions were measured: monocarp width and length, length from base to maximum width of monocarp and stylopodium width and length (Figure 2 and Table 1). Fruit terminology is in agreement with Akalın et al. (2016) and yeşil et al. (2018).

### 2.2 Essential oil extraction

Fruits were harvested and air dried at room temperature until constant weight. For each sample, a 30 g aliquot was randomly taken out of 100 g. Fruits were powdered by a home grinder and blended with 300 mL water. At this point, fruits were hydro-distilled in an all glass Clevenger-type apparatus for 3 h. The essential oil was separated from the water, placed in a glass vial and stored in the dark at 4 °C before GC-MS analysis that was conducted within 48 h after extraction.

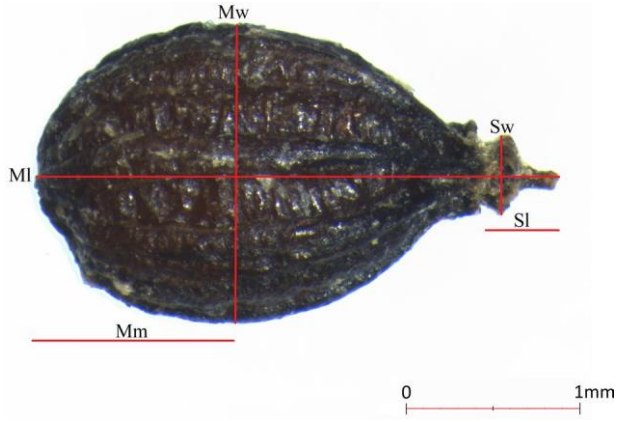



**Figure 2.** monocarp of *Pimpinella anisoides* V. Brig. photographed and measured under a stereomicroscope using the DeltaPix insight© software. mw: monocarp width; ml: monocarp length; mm: monocarp length from base to maximum width; sw: stylopodium width; sl: stylopodium length.

### 2.3 GC-MS analysis

The samples were analysed by gas chromatography with mass spectrometry (GC-MS) using a GCMS-QP2010 Ultra (Shimadzu, MI, Italy) operated by Lab solution software. The chromatographic separation was conducted using a fused capillary column (Mega SE52, 0.25 µm, 0.25 mm, 30 m). MS source temperature: 280 °C; interface temperature: 280 °C; ionization energy: 70 eV; ionization current: 60 A. The oil components were identified by computer matching against the Nist library.

### 2.4 GC-FID analysis

GC analysis was performed to quantify compounds using a GC2010 Plus Tracera operated with GC solution (Shimadzu, MI, Italy) equipped with flame ionization detectors (FID), and fused capillary column (Mega SE52, 0.25 µm, 0.25 mm, 30 m). The oven temperature was programmed as follows: isothermal 40 °C for 3 min, from 40 to 220 °C (6 °C/min), from 220 °C to 250 °C (15 °C/min), and isothermal for 5 min; injector temperature: 270 °C (injection mode: split 1/100); detector temperature: 270 °C; carrier gas: helium.

One µl of essential oil was directly injected. The relative proportions of the essential oil constituents were expressed as percentages obtained by peak-area normalization.

### 2.5 Statistical analysis

Means and standard deviations was calculated by Excel© 2010 software. Statistical differences were calculated by one-way ANOVA and Tukey test for post hoc analysis at

**Table 2.** main characteristics of *Pimpinella anisoides* V.Brig. monocarps in the five locations reported with their iD accession.

| | Pa_1 mean ± Ds | Pa_2 mean ± Ds | Pa_3 mean ± Ds | Pa_4 mean ± Ds | Pa_5 mean ± Ds | sig. |
|---|---|---|---|---|---|---|
| monocarp width | 1.58 ± 0.12ab | 1.64 ± 0.17a | 1.51 ± 0.11b | 0.84 ± 0.14d | 1.10 ± 0.15c | *** |
| monocarp length | 3.10 ± 0.35a | 3.10 ± 0.34a | 2.90 ± 0.32a | 2.25 ± 0.30b | 2.51 ± 0.21b | *** |
| monocarp length from base to maximum width | 1.23 ± 0.14a | 1.23 ± 0.16a | 1.22 ± 0.16a | 0.88 ± 0.13c | 1.05 ± 0.12b | *** |
| stylopodium width | 0.46 ± 0.07ab | 0.48 ± 0.07a | 0.46 ± 0.06ab | 0.41 ± 0.05b | 0.43 ± 0.05b | ** |
| stylopodium length | 0.39 ± 0.09a | 0.38 ± 0.15ab | 0.30 ± 0.05c | 0.31 ± 0.08bc | 0.28 ± 0.06c | *** |
| length/width ratio | 1.96 ± 0.20c | 1.90 ± 0.22c | 1.93 ± 0.22c | 2.72 ± 0.35a | 2.32 ± 0.30b | *** |

***significance at $p < 0.001$; **significance at $p < 0.01$.

$p < 0.05$ using the SPSS® 23.0 software (SPSS Inc., Chicago, IL, USA). Principal Component Analysis (PCA) was applied using SPSS® software for Windows©, version 17.0 (Chicago, IL, USA). Then, a cluster analysis was performed and a classification obtained through the mean link on the Euclidean distance squared similarity function.

## 3. Results and discussion

### 3.1 Morphology

A preliminary morphological analysis shows that 50% of the fruits were “normal”, 30% “aborted” and 20% “damaged”.The "normal" fruits are oblong-ovoid (length/width ratio 1.09) to oblong-cylindrical (length/width ratio 2.05), on average 2.77 (± 0.30) mm long and 1.33 (± 0.14) mm wide; the monocarp length from base to maximum width is 1.12 (± 0.14) mm. The stylopodium is on average 0.45 (± 0.06) mm long and 0.33 (± 0.09) mm wide (Table 2).

The fruits are always glabrous in all their parts with five well evident dorsal ribs more or less prominent (Figure 3a). The monocarp is compressed dorsally. The ventral surface is flat, longitudinally is well visible the columella that joins the two monocarps (Figure 3 b).

Examination of the fruit cross-section showed that *P. anisoides* monocarps are characterised by a smooth, thin cuticle (Figure 4). Five small vascular bundles (vb) are present in the lower half of the dorsal and lateral ribs.

The vittae present in the mesocarp containing the essential oils in which the species is rich, are divided into:

- vallecular vittae (vv): three between the central groove and the median groove and four in the median grooves closest to the commissural side. They are larger than the vascular bundles (vb);
- commissural vittae (cv): located on the commissural side are four, two larger and more obvious as typical feature of fruits of the genus *Pimpinella* (Akalın et al. 2016; Magee et al. 2010), the other two smaller located near the lateral vascular bundles (vb).

The endosperm (e) occupies the largest part of the section (Figure 4).

The analysis of variance of results (Anova test) (Table 2) shows a high significance value of the data (*** = $p < 0.001$).

The morphological analysis of the monocarps, allows to distinguish the fruits of *P. anisoides* from related *Pimpinella* species used for commercial purposes. In particular, the monocarps of *P. anisetum* Boiss. & Balansa are strigose with sharp, stiff, slanting hairs, hair-like scales or bristles which are appressed to the surface and ovoid in shape, whereas *P. anisum* L. has strigose, ovoid-subglobose fruits (yeşil et al. 2018). In *P. anisoides* the monocarps are completely glabrous and vary in form from oblong-ovoid to oblong-cylindrical (Table 3A). The cross-section of *P. anisoides* shows similarities to other commercial *Pimpinella* species (Table 3B), 1 median rib and 4 lateral rib, as were as vascular bundle, the number of vallecular vittae is 14 in *P. anisoides*, 17-18 in *P. anisetum* and 11 in *P.anisum*, while there are 4 commissural vittae in all three species. The cross-section thickness/width ratio is 2,02 in *P.anisoides,* 1.58 in *P.anisetum* and 1.59 in *P. anisum*; the commissural vittae of *P. anisoides* are 0.53 × 0.17 mm in width and thickness, in *P.anisetum* are 0.27 × 0.11mm, and in *P. anisum* are 0.22 × 0.11 mm. The commissure width is 1.01 – 1.35 mm in *P. anisoides*, 0.43–0.51 mm in *P. anisetum*, and 0.64–0.82 mm in *P.anisum.*

### 3.2 Phytochemical features

Thirty-two components were identified in the *P. anisoides* essential oil studied in this work (Table 4). The four preponderant compounds of the five studied accessions were: limonene, anethole, estragole and *β*-phellandrene, here listed in decreasing order of concentration detected.

The most representative was limonene ranging between 50-74% (Pa_3) and 46.78% (Pa_5) ($p < 0.001$ (Table 4). Limonene is a hydrocarbon monoterpene used to prepare flavourings, perfumes and in local medicine for its anaesthetic, antiseptic, expectorant, antiviral, antilithic and antimicrobial properties (Boulos 1993; Burt 2004; Duke and Beckstrom-Sternberg 2001; Reichling et al. 2009) even if Boughendjioua and Boughendjioua (2017) have found a lower antimicrobial activity of limonene than alcohols and phenols. Studies in aromatherapy have shown an anti-migraine activity (de Groot and Schmidt 2016; Rafieian-Kopaei et al. 2019). Menichini et al. (2009) found a 13.5% limonene content in *P. anisoides* essential oil from Calabria region after fruits maceration in ethanol. This allows us to speculate that water used as a solvent facilitates the limonene extraction from fruits if compared with ethanol. *P. anisoides* was found to have a higher limonene content than *P. anisum*, in fact in the latter, the limonene content was: 2.06% in Iranian fruits (Mahdavi et al. 2018); 0.63 g/kg, 0.51 g/kg and 2.11 g/kg in Iranian fruits obtained from plants grown in a soil without Zn addition and with 0.1% and 0.2% Zn addition (w/v), respectively (Tavallali et al. 2017); 0.06% in Serbian seeds

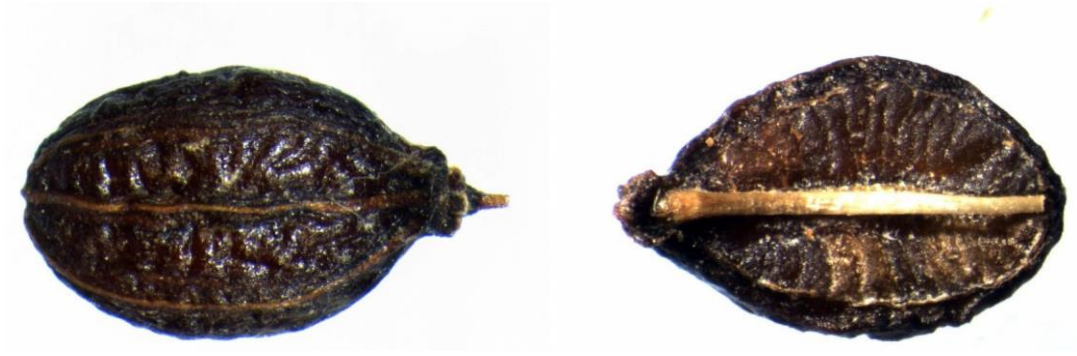


**Figure 3.** monocarp of *Pimpinella anisoides* V.Brig. obvserved in dorsal (a) and ventral (b) view, with a stereomicroscope using the DeltaPix insight© software.

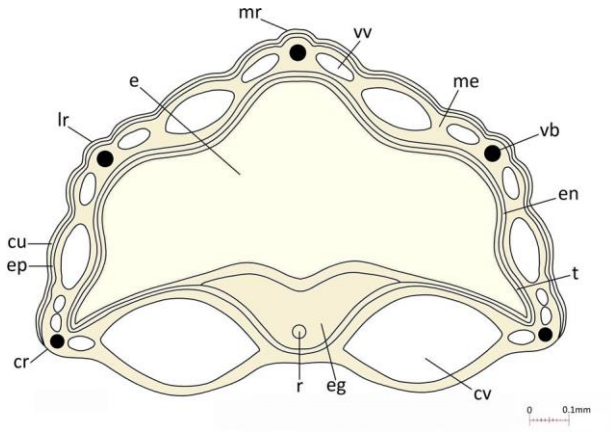



**Figure 4.** monocarp transverse section of *Pimpinella anisoides* V.Brig. cr: commissural rib; cu: cuticula; cv: commissural vittae; e.g.: endosperm groove; en: endocarp; e: endosperm; ep: epiderm; lr: lateral rib; me: mesocarp; mr: median rib; r: raphe; vb: vascular bundle; vv: vallecular vittae; t: testa.

(Samojlik et al. 2012); 0.2% in Turkish seeds from Fadliya region, Mosul Province (Kiralan et al. 2012).

Limonene is characteristic of the essential oil of *Citrus* species and has been quantified: 84.73% in lemon peel (Al-Jabri and Hossain 2018); 39.74% in lemon flower [*Citrus* × *limon* (L.) Osbeck] (Ben Hsouna et al. 2017); 60.8% in *Citrus medica* cv. "Diamante" peel (Poiana et al. 1998), 31.10% to 44.48% in bergamot (*Citrus bergamia* Risso) peel (Giuffré and Nobile 2020; Gioffrè et al. 2020). Limonene is also contained in the essential oil of other genera and spe- cies but in lower quantity: 6.05% 5.67% and 5.54% in the essential oil extracted by a Clevenger-type apparatus with steam distillation respectively from flowers, fruits and leaves of wild fennel [*Foeniculum vulgare* Mill. subsp. *piperitum* (Ucria) Bég.] (Marrelli et al. 2020), 3.80% to 10.11% in essen- tial oil of needles of Calabrian pines (*Pinus nigra* J.F. Arnold subsp. *laricio* Palib. ex Maire) (Foti et al. 2020).

Anethole was the second major volatile in *P. anisoides* fruit essential oil and ranged between 42.77% (Pa_5) and 38.50% (Pa_3) ($p < 0.001$ (Table 2). Anethole is a phenylpropanoid. It is sweet (13 times sweeter than sugar) and it is used in alcoholic beverages and in aromatised foods (Marinov and Valcheva-Kuzmanova 2015). It is recognised to have the following properties: antioxidant (Oktay et al. 2003), anti-fungal and anti-microbial (Astani et al. 2011; Hammer et al. 1999; Maruzzella and Freundlich 1959), spasmolytic (Cambar and Aviado 1970), gastro-protective (Coelho-De-Souza et al. 2013; Ibrahim et al. 2013), sedative (Mileni Versuti Ritter et al. 2014) and in reducing the risk of Parkinson's disease (Drukarch et al. 2006). Studies in aromatherapy have shown that anethole might produce anti-migraine effects *via* the inhibition of neurogenic inflammation through the MAPK and NF- κB pathways (Chainy et al. 2000). In the literature it is reported as characteristic for *Pimpinella* genus. In a previous study conducted on *P. anisoides* fruits collected in the region of Calabria, anethole was found to be 54.5% of the total volatiles, from essential oil extracted by maceration with ethanol (Menichini et al. 2009). Anethole was found to be the predominant volatile in *P. anisetum* oil from Turkey obtained by a Clevenger apparatus (77.1% in fruit oil and 55.2% in herb oil respectively) (Baser et al. 1999). Anethole also predominated in *P. anisum*: 93.5% in seed essential oil from Turkey obtained by hydrodistillation (Kiralan et al. 2012); 74.40% in seed essential oil obtained by a Sohlet extractor and distilled water as a solvent (Mahdavi et al. 2018); 88.49% in seed essential oil from Serbia obtained by hydrodistillation and *n*-hexane as collecting solvent (Samojlik et al. 2012). Anethole is also contained (even if in lower quantity) in seed essential oil of fennel (*Foeniculum vulgare* Mill.) (49.76-81.21%) (Ben Abdesslem et al. 2021) and guarana [*Paullinia cupana* H.B.K. var. *sorbilis* (Mart.) Ducke] (Benoni et al. 1996).

Estragole (methyl chavicol) ranged between 5.76% (Pa_5) and 6.67% (Pa_2) ($p < 0.001$) (Table 4). Estragole is a phenylpropanoid, more specifically an alkenylbenzene for which, if consumed in high quantity, a carcinogenic and genotoxic activity was found (Scientific Committee on Food (SCF) 2001a, 2001b, 2001c) even if estragole orally administered to mice for 10 mg/kg/day for 14 days showed no toxicity (Ponte et al. 2012).

In a study on *P. anisetum*, Baser et al. (1999) found higher amounts of estragole compared with the *P. anisoides* of et al. of the present work: 22.4% in fruit oil and 41.9% in herb oil. In studies conducted on the essential oil of *P. anisum*, estragole was found to be: 2.4% in seeds submitted to hydrodistillation with double-distilled water (Bluma and Etcheverry 2008); 1.39% and 0.63% from Algerian seeds respectively submitted to hydrodistillation and to microwave assisted hydrodistillation (Boumahdi et al. 2021); 1.73% from

**Table 3.** comparison of the monocarp characteristics of three commercial *Pimpinella* L. species.

**3A.** measurements and features of monocarps.

| species | fruit length and width (mm) | length/width ratio | indumentum | shape of fruit |
|---|---|---|---|---|
| *P. anisoides* | 2.53-3.84 × 1.44-2.07 | (1.90) 2.2 (2.72) | glabrous | oblong-ovoid/ oblong-cylindrical |
| *P. anisetum* | 1.5–1.57 × 1–1.08 | 1.5 | strigose | ovoid |
| *P. anisum* | 3.9–4 × 1.5–1.53 | 2.6 | strigose | ovoid-subglobose |

**3B.** measurements and features of monocarps cross-section.

| species | no of vallecular vittae | no of commissural vittae | cross-section thickness/width ratio | commissural vittae width and thickness (mm) | commissure width (mm) |
|---|---|---|---|---|---|
| *P. anisoides* | 14 | 4 | 2.05 | 0.53 × 0.17 | 1.01–1.35 |
| *P. anisetum* | 17–18 | 4 | 1.58 | 0.27 × 0.11 | 0.43–0.51 |
| *P. anisum* | 11 | 4 | 1.59 | 0.22 × 0.11 | 0.64–0.82 |

the characteristics of *Pimpinella anisoides* V.Brig. come from this study, those of *Pimpinella anisetum* Boiss. & Balansa and *Pimpinella anisum* L. from yeşil et al. (2018) and akalın et al. (2016).

**Table 4.** fruit essential oil composition of the five accessions of *Pimpinella anisoides* V.Brig. collected in calabria (southern italy).

| compound | Pa_1 mean ± sD | Pa_2 mean ± sD | Pa_3 mean ± sD | Pa_4 mean ± sD | Pa_5 mean ± sD | significance level |
|---|---|---|---|---|---|---|
| α-Pinene | 0.03 ± 0.01ab | 0.02 ± 0.01b | 0.03 ± 0.01ab | 0.05 ± 0.01a | 0.03 ± 0.01ab | * |
| β-Phellandrene | 1.55 ± 0.03c | 1.59 ± 0.03c | 1.77 ± 0.07b | 1.83 ± 0.03b | 1.99 ± 0.01a | *** |
| β-myrcene | 0.23 ± 0.02c | 0.22 ± 0.02c | 0.25 ± 0.03c | 0.34 ± 0.02b | 0.44 ± 0.04a | *** |
| limonene | 49.10 ± 0.11b | 49.11 ± 0.07b | 50.74 ± 0.10a | 48.00 ± 0.05c | 46.78 ± 0.08d | *** |
| *p*-cresol | 0.05 ± 0.01ab | 0.04 ± 0.01ab | 0.05 ± 0.02ab | 0.03 ± 0.01b | 0.06 ± 0.01a | * |
| *trans*-*p*-mentha-2,8 dienol | 0.04 ± 0.01c | 0.05 ± 0.01c | 0.10 ± 0.02b | 0.14 ± 0.01a | 0.09 ± 0.02b | *** |
| cis-limonene-oxide | 0.07 ± 0.01a | 0.07 ± 0.02a | 0.07 ± 0.02a | 0.05 ± 0.01a | 0.07 ± 0.01a | n.s. |
| *cis*-*p*-mentha-2,8 dienol | 0.03 ± 0.01b | 0.04 ± 0.02b | 0.09 ± 0.03a | 0.05 ± 0.01ab | 0.06 ± 0.01ab | * |
| *trans*-limonene-oxide | 0.03 ± 0.01b | 0.04 ± 0.01b | 0.09 ± 0.02a | 0.05 ± 0.01b | 0.05 ± 0.01b | ** |
| cyclohexene | 0.10 ± 0.02a | 0.10 ± 0.02a | 0.09 ± 0.03a | 0.09 ± 0.01a | 0.08 ± 0.01a | n.s. |
| geraniol | 0.01 ± 0.01b | 0.02 ± 0.01b | 0.05 ± 0.01a | 0.02 ± 0.01b | 0.02 ± 0.01b | *** |
| estragole | 6.49 ± 0.05b | 6.67 ± 0.04a | 6.40 ± 0.06b | 6.19 ± 0.03c | 5.76 ± 0.04d | *** |
| *cis*-carveol | 0.04 ± 0.01b | 0.06 ± 0.01b | 0.13 ± 0.03a | 0.08 ± 0.01b | 0.07 ± 0.01b | *** |
| *trans*-carveol | 0.04 ± 0.01a | 0.03 ± 0.01a | 0.05 ± 0.02a | 0.05 ± 0.01a | 0.04 ± 0.01a | n.s. |
| carvone D | 0.03 ± 0.01c | 0.05 ± 0.02bc | 0.13 ± 0.03a | 0.07 ± 0.00bc | 0.09 ± 0.01ab | *** |
| *p*-anisaldehyde | 0.39 ± 0.02 cd | 0.45 ± 0.02bc | 0.49 ± 0.05b | 0.37 ± 0.02d | 0.66 ± 0.02a | *** |
| anethole | 40.98 ± 0.05c | 40.57 ± 0.09d | 38.50 ± 0.07e | 41.36 ± 0.03b | 42.77 ± 0.09a | *** |
| 4-terpinyl acetate | 0.02 ± 0.01ab | 0.02 ± 0.01ab | 0.03 ± 0.01a | 0.01 ± 0.01b | 0.02 ± 0.01ab | n.s. |
| *p*-acetonyl anisole | 0.03 ± 0.01a | 0.06 ± 0.02a | 0.04 ± 0.01a | 0.04 ± 0.01a | 0.03 ± 0.01a | n.s. |
| methyl eugenol | 0.04 ± 0.01a | 0.04 ± 0.01a | 0.05 ± 0.01a | 0.04 ± 0.01a | 0.03 ± 0.01a | n.s. |
| β-caryophyllene | 0.38 ± 0.03bc | 0.38 ± 0.03c | 0.47 ± 0.05b | 0.64 ± 0.03a | 0.45 ± 0.02bc | *** |
| humulene | 0.03 ± 0.01ab | 0.03 ± 0.01a | 0.03 ± 0.01a | 0.03 ± 0.01ab | 0.01 ± 0.01b | ** |
| farnesol | 0.02 ± 0.01a | 0.02 ± 0.01a | 0.02 ± 0.01a | 0.03 ± 0.01a | 0.02 ± 0.01a | n.s. |
| limonene 1,2-epoxide | 0.01 ± 0.01a | 0.01 ± 0.01a | 0.02 ± 0.02a | 0.03 ± 0.01a | 0.02 ± 0.01a | n.s. |
| β-copaene | 0.06 ± 0.01ab | 0.05 ± 0.02b | 0.10 ± 0.03a | 0.09 ± 0.01a | 0.07 ± 0.01ab | ** |
| β-santalol | 0.02 ± 0.01ab | 0.02 ± 0.01b | 0.01 ± 0.01b | 0.04 ± 0.01a | 0.03 ± 0.01a | ** |
| isohomogenol | 0.04 ± 0.01a | 0.03 ± 0.01ab | 0.03 ± 0.01ab | 0.02 ± 0.01b | 0.03 ± 0.01ab | * |
| nerolidol | 0.01 ± 0.01a | 0.01 ± 0.01a | 0.01 ± 0.01a | 0.03 ± 0.01a | 0.02 ± 0.01a | n.s. |
| α-Bisabolene | 0.02 ± 0.01a | 0.01 ± 0.01a | 0.01 ± 0.01a | 0.02 ± 0.01a | 0.01 ± 0.01a | n.s. |
| cariophyllene oxide | 0.08 ± 0.02a | 0.10 ± 0.02a | 0.08 ± 0.02a | 0.10 ± 0.01a | 0.07 ± 0.01a | n.s. |
| spatulenol | 0.04 ± 0.01a | 0.03 ± 0.01a | 0.05 ± 0.01a | 0.03 ± 0.01a | 0.03 ± 0.01a | n.s. |
| α-Bisabolol | 0.05 ± 0.01bc | 0.05 ± 0.01bc | 0.04 ± 0.01c | 0.07 ± 0.01ab | 0.09 ± 0.01a | *** |

Values are expressed as percentage content± standard Deviation (sD). * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$; n.s. = $p > 0.05$.

seeds produced in Turkey and subjected to hydrodistillation (Kiralan et al. 2012); 1.87% from Iranian seeds and distilled water as a solvent (Mahdavi et al. 2018).

β-Phellandrene was detected in a range between 1.99% (Pa_5) and 1.55% (Pa_1) ($p < 0.001$). It is a cyclic monotepene that was not listed as the major constituents of the *P. anisoides* essential oil in the only existing study conducted from fruits collected in the region of Calabria (Menichini et al. 2009). β-Phellandrene is one of the minor volatiles found in the peel essential oil some *Citrus* species: 0.40% in *Citrus reticulata* Blanco grown in Algeria (Boughendjioua and Boughendjioua 2017); 0.19% and 0.07% respectively in *Citrus x aurantium* L. (sub *Citrus sinensis*) and *Citrus x limon* (L.) Osbeck (sub *Citrus lemon*) taxa grown in Spain (Espina et al. 2011). Higher quantity of β-phellandrene were found in the essential oil of wild populations of *Echinophora cinerea* (Boiss.) Hedge & Lamond from Iran (13.11% − 10.29%) (Ghasemi Pirbalouti and Gholipour 2016) and in *Artemisia dracunculus* L. growing in Tajikistan (3.2%) (Sharopov et al. 2020).

Each ofthe other volatiles of the five studied accessions of *P. anisoides* was detected at concentrations below 0.50% (Table 4). No significant differences ($p > 0.05$) were found for cis-limonene-oxide (0.05%-0.07%), cyclohexene, trans-carveol (0.03%-0.05%), 4-terpenyl acetate (0.01%-0.03%), *p*-acetonyl anisole (0.03%-0.06%), methyl eugenol (0.03%-0.05%), farneseol (0.02%-0.03%), limonene 1,2-epoxide (0.01%-0.03%), nerolidol (0.01%-0.03%), α-bisabolene (0.01%-0.02%), cariophyllene oxide (0.07%-0.10%), and spatulenol (0.03%-0.05%) (Table 4).

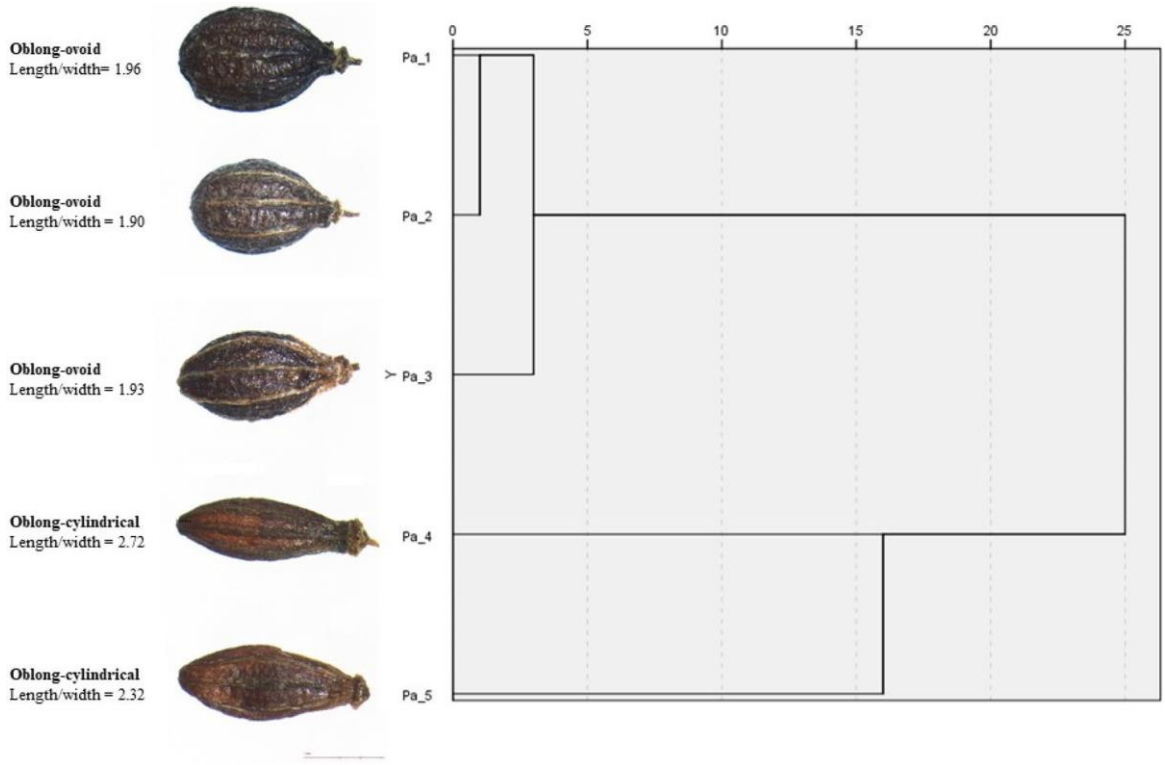



**Figure 5.** cluster analysis and corresponding monocarp shape of the different accessions of *Pimpinella anisoides* V.Brig.

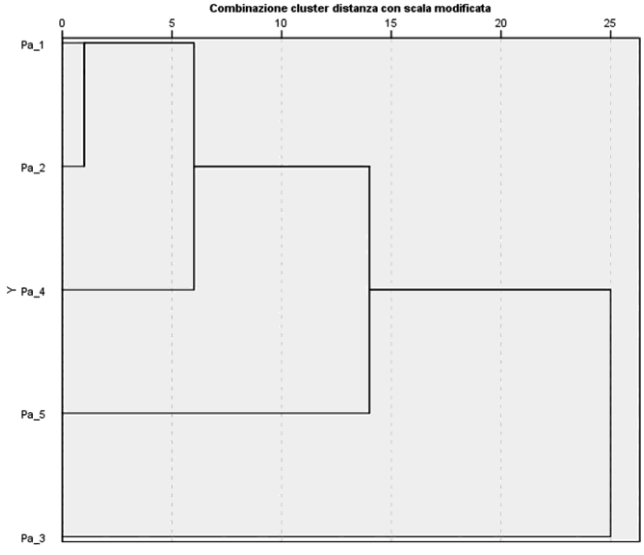



**Figure 6.** cluster analysis and corresponding essential oil of the different accessions of *Pimpinella anisoides* V.Brig.

### 3.3 Cluster analysis

The cluster analysis was conducted both on the basis of morphometric data and of the volatile composition. The results obtained on the basis of the morphometric data distinguished two main clades. Pa_1 and Pa_2 are at a distance of 1 and are closely related to Pa_3 at a distance of 3, whereas Pa_4 and Pa_5 are grouped in the second clade at a distance of 16. This was due to fruit shape, which is oblong-ovoid in the Pa_1, Pa_2 and Pa_3 accessions, whereas it is oblong-cylindrical in the Pa_4 and Pa-5 accessions. In particular, Pa_1, Pa_2 and Pa_3 show a fruit having a smaller length/width ratio than Pa_4 and Pa_5 (Figure 5).

The analysis based on volatile composition produced three main clusters (Figure 6). The first cluster grouped Pa_1, Pa_2 and Pa_4 at a distance of 6. Pa_1 and Pa_2 were at a distance of 1, this was due to the lowest *β*-Phellandrene content and a high limonene content. The second cluster distinguished Pa_4 on the basis of a significantly higher limonene percentage and lower anethole percentage. Finally, the third cluster distinguished the Pa_3 essential oil which showed the lowest limonene and estragole contents and the highest anethole content (Figure 6). In brief, for three out of five accessions (Pa_3, Pa_4 and Pa_5) there was no relationship between morphometric data and volatile composition in contrast to Pa_1 and Pa_2, which were in both cases grouped together at a distance of 1.

### 3.4 Principal components analysis (PCA)

The analysis of chemical data by the technique of PCA permitted to group chemically the samples in three groups, so as to reveal their similarities and differences. The significant factor loadings from the PCA of chemical constituent variables were obtained as suggested by D'Agostino et al. (2014), after Varimax rotation. (Figure 7). PCA results revealed that the first two principal components explained 71.80% of total variance. The loadings of first and second principal components (PC1 and PC2) accounted for 44.08 and 27.72% of the variance, respectively. The first component (PC1) is highly positively correlated with *α*-pinene, *β*-phellandrene, *β*-myrcene, farnesol, *β*-cariophyllene, limonene 1,2 epoxide, nerolidol. The

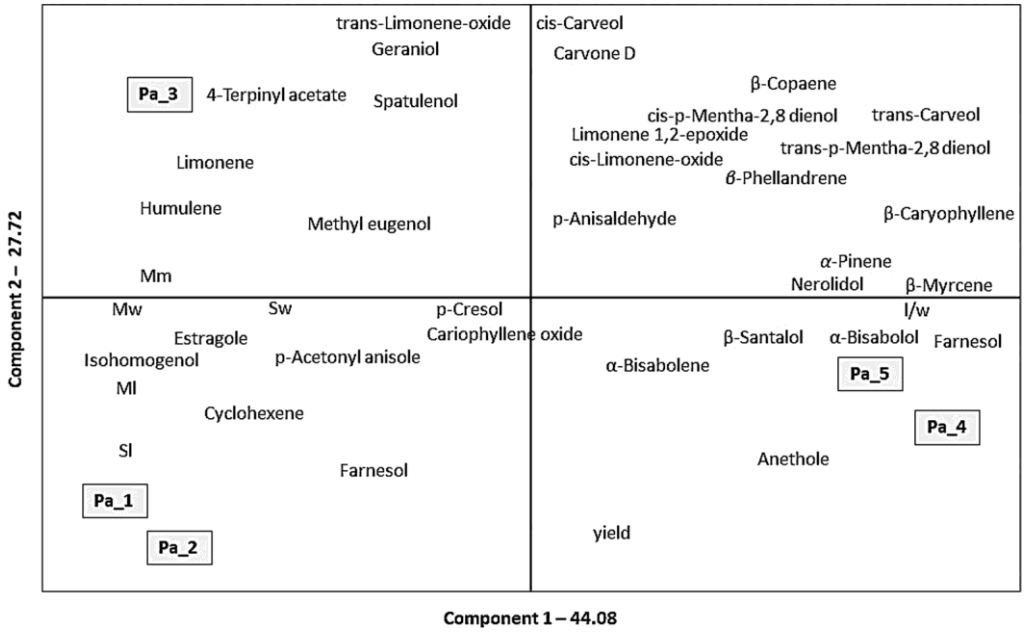



**Figure 7.** Biplot graph, Pc1 versus Pc2, using loadings and scores for essential oils of *Pimpinella anisoides* V.Brig. growing in different locations. mm: mericarp length from base to maximum width; mw: mericarp width; ml: mericarp legth; sw: stylopodium width; sl: stylopodium length; l/w: length/width ratio.

second component (PC2) is characterized by the positive correlation with cis-p-mentha-2,8 dienol, *trans-p*-mentha-2,8 dienol, limonene-oxide, geraniol, cis carveol, trans carveol, carvone D and spatulenol. The biplot graph PC1 x PC2 of the loadings and scores relates the data, of chemical constituents of the essential oils and the morphological data of the fruits in relation to the five accessions, in order to correlate them. Thus, anethole, *α*-bisabolene, nerolidol, *α*-bisabolol, *β*-myrcene, *β*-santalol and farnesol were the prin- cipal components that contributed to the clustering of the samples obtained of accessions Pa_4 and Pa_5 accessions. PCA statistical analyses indicate the existence of three groups. The first group of clustered accessions is formed by Pa_4 and Pa_5, the second by only Pa_3 and the third by Pa_1 and Pa_2.

Hierarchical cluster analysis was mainly influenced by limonene, anethole and estragole, in fact, it grouped accessions Pa_1 and Pa_2 with the highest estragole content and a limonene and anethole content higher than in accessions Pa_4 and Pa_5. Pa_5 was the most distant clade, showing the lowest limonene and estragole content concentrations. This is also useful for countering the sophistication with the use of fruits of other related species as well as the illegal harvesting of immature fruits.

Finally, this new knowledge will allow to plan future *in situ* and *ex situ* for conservation actions of *P. anisoides*, allowing to preserve its natural populations and to start experimental cultivations of this species to increase its avail- ability on the local and international market, thereby avoid- ing the indiscriminate harvesting that is threatening its existence.

## 4. Conclusions

*Pimpinella anisodes* is widely used in the study area for flavoring some typical bakery products, such as “taralli” and “scaldatelli” (Hammer et al. 2000), and a typical liqueur (Maruca et al. 2019). This traditional use threatens the survival of the species locally, in order to favour the availability of *Pimpinella* fruits, local people collect the immature plants and grow them in their homes. This practice reduces the natural dispersal of seeds and population renewal in the wild. According to Perrino and Wagensommer (2021), avoiding genetic erosion is very important to increase the conservation of several taxa. The study of carpological characters from a morphological and phytochemical point of view provides information to characterize and recognize the ripe fruits of *P. anisoides*. These distinctive characters are very important and necessary to know in order to prevent the sold material from being sophisticated with other types of fruits of inferior quality, which are often mixed with those of *P. anisoides*.

## 5. Disclosure statement

No potential conflict of interest was reported by the authors.

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## Conclusions and Future Perspectives

Conservation biology study of endangered species is today the most widely tool for protecting biodiversity at local and global levels. The scientific basis of this discipline can be translated into concrete actions to preserve species and ecosystems. The study undertaken in this PhD has allowed us to understand the issues concerning the conservation of two precious endemisms: *Salvia ceratophylloides* Ard. and *Pimpinella anisoides* V. Brig. in order to propose concrete strategies aimed at safeguarding these species.

Studies carried out on *Salvia ceratophylloides* have shown that the species has population dynamics that are not stable over time and are profoundly affected by pressures and threats on the habitat and individuals. The stress is mainly represented by anthropogenic disturbances, which compromise habitat quality and affects the population dynamics over time. Pressures and threats of natural origin, such as parasite attacks due to insects obligate parasites of genus *Salvia*, that affect the reproductive and regenerative capacities of the species, also play a decisive role. Models of the current and future potential distribution of *S. ceratophylloides*, generated by MaxEnt, show that it is greater than the actual distribution. The MaxEnt model analysed changes in distribution in relation to climate change and showed that suitable habitat for the species will decrease in 2021-2040 and 2041-2060 in the SSP245 scenario, the less drastic of the two analysed, while it will increase in the SSP585 scenario. It should be noted, however, that important constraints on the distribution of the species are also due to geological substrate and land use, which significantly limit the current potential distribution. The study of the ecophysiological and phenological responses of the species shows that priming treatments increase the emergence of *Salvia* seedlings and prolong the duration of the early phenological stages, allowing better establishment and an easy transition to the autotrophy condition. Furthermore, the treated plants show an efficient and well-functioning photosynthetic machinery, showing a reduction in the negative effects induced by heat and, above all, by combined stress (drought and heat).

Overall, the results obtained lay the scientific basis for the planning of conservation and protection measures capable of reducing, over time, the

pressures and threats that affect the population of *Salvia ceratophylloides*. This can be achieved through specific *in situ* conservation measures, such as the creation of micro-reserves or small protected areas, as well as providing specific guidelines for *ex situ* conservation of this rare plant species, at germplasm banks, botanical gardens and private gardens. Furthermore, the assessment of changes in the distribution of the species in relation to the impacts of climate change has made possible to identify priority areas on which *in situ* implemented conservation measures, including the reintroduction of the species.

Studies carried out on *Pimpinella anisoides* have shown that the traditional use of the species threatens its survival at the local level, since, in order to obtain a greater quantity of fruit, stakeholders harvest immature plants by placing them in pots with water and harvesting the fruit later; this practice reduces the natural dispersal of the seeds and the renewal of the population in the wild. The study of carpological characters from a morphological and phytochemical point of view provides information to characterise and recognise the mature fruits of *P. anisoides*. Know these distinctive characters are very important and necessary in order to prevent the sold material from being adulterated with immature fruits or fruits of other species of inferior quality, which are often mixed with those of *P. anisoides*. In addition, the carpological analysis clarified taxonomic doubts concerning the only two Italian endemic species of the genus *Pimpinella*, which allowed easy differentiation between *P. anisoides* and the related *P. gussonei*, highlighting the importance of carpological characters for the taxonomy of the genus *Pimpinella*. In view of the economic importance of this species, it is desirable to start cultivation in order to guarantee the supply of ripe fruit to the market.

The dissemination of this research, together with an increase of public and political awareness, can help reduce the risk of extinction of these species. Scientific knowledge is the cornerstone on which the protection and conservation of these species and the management of their habitat must rest. The biodiversity protection makes it possible to maintain and preserve the precious balance that governs nature, on which our survival depends.

# APPENDIX I: Additional papers

## Alien Flora

1. Three New Alien Taxa for Europe and a Chorological Update on the Alien Vascular Flora of Calabria (Southern Italy).
   Valentina Lucia Astrid Laface, Carmelo Maria Musarella, Ana Cano Ortiz, Ricardo Quinto Canas, Serafino Cannavò and Giovanni Spampinato. 2020. https://doi.org/10.3390/plants9091181
2. Alien flora in Calabria (Southern Italy): an updated checklist.
   Giovanni Spampinato, Valentina Lucia Astrid Laface, Giandomenico Posillipo, Ana Cano Ortiz, Ricardo Quinto Canas, Carmelo Maria Musarella. 2022. https://doi.org/10.1007/s10530-022-02800-y
3. Notulae to the Italian alien vascular flora: 8
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8. Notulae to the Italian alien vascular flora: 13
   Galasso *et al*. 2022. https://doi.org/10.3897/italianbotanist.13.85863
9. Notulae to the Italian alien vascular flora: 14
   Galasso *et al*. 2022. https://doi.org/10.3897/italianbotanist.14.97758
10. Italian Vascular Flora: New Findings, Updates and Exploration of Floristic Similarities between Regions
    Adriano Stinca, Carmelo Maria Musarella, Leonardo Rosati, Valentina Lucia Astrid Laface, Wolfgang Licht, Emanuele Fanfarillo, Robert Philipp Wagensommer, Gabriele Galasso, Simonetta Fascetti, Assunta Esposito, Tiberio Fiaschi, Gianluca Nicolella, Giuseppina Chianese, Giampiero Ciaschetti, Giovanni Salerno, Paola Fortini, Romeo Di Pietro, Enrico Vito Perrino, Claudia Angiolini, Leopoldo De Simone and Giacomo Mei. 2020. https://doi.org/10.3390/d13110600
11. New Chorological Data for the Italian Vascular Flora
    Leonardo Rosati, Simonetta Fascetti, Vito Antonio Romano, Giovanna Potenza, Maria Rita Lapenna, Antonio Capano, Pietro Nicoletti, Emmanuele Farris, Peter James de Lange, Eva Del Vico, Laura Facioni, Emanuele Fanfarillo, Edda Lattanzi, Ana Cano-Ortiz, Michela Marignani, Maria Caterina Fogu, Erika Bazzato, Erik Lallai, Valentina Lucia Astrid Laface, Carmelo Maria Musarella, Giovanni Spampinato, Giacomo Mei, Giuseppe Misano, Giovanni Salerno, Assunta Esposito and Adriano Stinca. 2020. https://doi.org/10.3390/d12010022
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## Habitat

1. New national and regional Annex I Habitat records: from #45 to #59

Giovanni Rivieccio, Claudia Angiolini, Mattia Martin Azzella, Simonetta Bagella, Gianmaria Bonari, Federica Bonini, Silvia Cannucci, Maria Carmela Caria, Alessandro Crisafulli, Romeo Di Pietro, Assunta Esposito, Emanuele Fanfarillo, Emmanuele Farris, Valentina Ferri, Tiberio Fiaschi, Luigi Forte, Paola Fortini, Lorenzo Gianguzzi, Daniela Gigante, Valentina Lucia Astrid Laface, Giovanni Maiorca, Francesca Mantino, Giacomo Mei, Francesco Minutillo, Antonio Morabito, Carmelo Maria Musarella, Glauco Patera, Enrico Vito Perrino, Giovanni Spampinato, Adriano Stinca, Gianmarco Tavilla, Valeria Tomaselli, Giancarlo Tondi, Robert Philipp Wagensommer, Giuseppe Bazan. 2022. https://doi.org/10.3897/pls2022592/06

# Etnobotany

1. Contribution to the Ethnobotanical Knowledge of Serre Calabre (Southern Italy)
   Chiara Gentile, Giovanni Spampinato, Miriam Patti, Valentina Lucia Astrid Laface, Carmelo Maria Musarella, 2022 https://doi.org/10.31586/rjees.2022.389

# Physiology

1. The Assessment and the Within-Plant Variation of the Morpho-Physiological Traits and VOCs Profile in Endemic and Rare *Salvia ceratophylloides* Ard. (Lamiaceae)
   Rosa Vescio, Maria Rosa Abenavoli, Fabrizio Araniti, Carmelo Maria Musarella, Adriano Sofo, Valentina Lucia Astrid Laface, Giovanni Spampinato and Agostino Sorgonà. 2021. https://doi.org/10.3390/plants10030474

*plants*

MDPI

*Article*

# Three New Alien Taxa for Europe and a Chorological Update on the Alien Vascular Flora of Calabria (Southern Italy)

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**Abstract:** Knowledge on alien species is needed nowadays to protect natural habitats and prevent ecological damage. The presence of new alien plant species in Italy is increasing every day. Calabria, its southernmost region, is not yet well known with regard to this aspect. Thanks to fieldwork, sampling, and observing many exotic plants in Calabria, here, we report new data on 34 alien taxa. In particular, we found three new taxa for Europe (*Cascabela thevetia*, *Ipomoea setosa* subsp. *pavonii*, and *Tecoma stans*), three new for Italy (*Brugmansia aurea*, *Narcissus* 'Cotinga', and *Narcissus* 'Erlicheer'), one new one for the Italian Peninsula (*Luffa aegyptiaca*), and 21 new taxa for Calabria (*Allium cepa*, *Asparagus setaceus*, *Bassia scoparia*, *Beta vulgaris* subsp. *vulgaris*, *Bidens formosa*, *Casuarina equisetifolia*, *Cedrus atlantica*, *Chlorophytum comosum*, *Cucurbita maxima* subsp. *maxima*, *Dolichandra unguis-cati*, *Fagopyrum esculentum*, *Freesia alba*, *Juglans regia*, *Kalanchoë delagoënsis*, *Passiflora caerulea*, *Portulaca grandiflora*, *Prunus armeniaca*, *Prunus dulcis*, *Solanum tuberosum*, *Tradescantia sillamontana*, and *Washingtonia filifera*). Furthermore, we provide the first geolocalized record of *Araujia sericifera*, the confirmation of *Oxalis stricta*, and propose a change of status for four taxa (*Cenchrus setaceus*, *Salpichroa origanifolia*, *Sesbania punicea*, and *Nothoscordum gracile*) for Calabria. The updated knowledge on the presence of new alien species in Calabria, in Italy and in Europe could allow for the prevention of other new entries and to eliminate this potential ecological threat to natural habitats.

**Keywords:** biodiversity; check-list; exotic plant; herbarium specimens; invasiveness; new floristic records; plant diversity

## 1. Introduction

The increase in alien plant invasion represents a very significant ecological problem for native flora [1]. This produces several impacts around the world such as the reduction of native and endemic species and habitats, but also damage to socio-economic and human health [2–6]. For example, *R. pseudocacia* L. has several effects on the endangered lichen species *Lobaria pulmonaria* (L.) Hoffm. (loss of diversity, among others) that are also due to climate change [7–9]. Thanks to a recent work, several invasive alien species were assessed in Italian regions [10]: in Toscana, *Carpobrotus acinaciformis* (L.)

L. Bolus produces a reduction in native biodiversity and habitat degradation in the habitat of 1240, whereas in Lombardia, *Lagarosiphon major* (Ridl.) Moss produces primary production alteration and modification of natural benthic communities in the habitats of 3140 and 3150, respectively.

Although Calabria has been the object of interest by numerous scholars since 1800 [11–15], only in recent decades has there been a significant increase in botanical studies that have affected its territory in various investigation fields: such as floristic [16–22], phytosociological [23–28], ethnobotanical [29–35], and many others [36–42]. However, these works only in part provided data on the alien flora present in the Calabrian territory.

According to Bartolucci et al. [43], Calabrian vascular flora amounts to 2799 taxa including native, cryptogenic, and alien taxa. As for these latter, Galasso et al. [1] recorded, for this region, "only" 267 alien taxa; therefore, Calabria seems to be one of the Italian regions with the fewest exotic taxa in a spontaneous state! According to Musarella et al. [44], this is probably due to a lack of knowledge of vascular flora in the most anthropized areas. However, many contributions were later added to [1] and have increased the knowledge on the invasive alien flora in Calabria [44–52]. A recent work estimates that Calabrian alien vascular flora amounts to 336 taxa [53]. Subsequently, another eight taxa have been reported as new to Calabria by Galasso et al. [54].

This paper aims to document new records (collected specimens and observations) of alien plant taxa for Calabria (Figure 1). For each taxon, relevant information about the ecology and distribution and a careful assessment of the naturalization status is also provided.

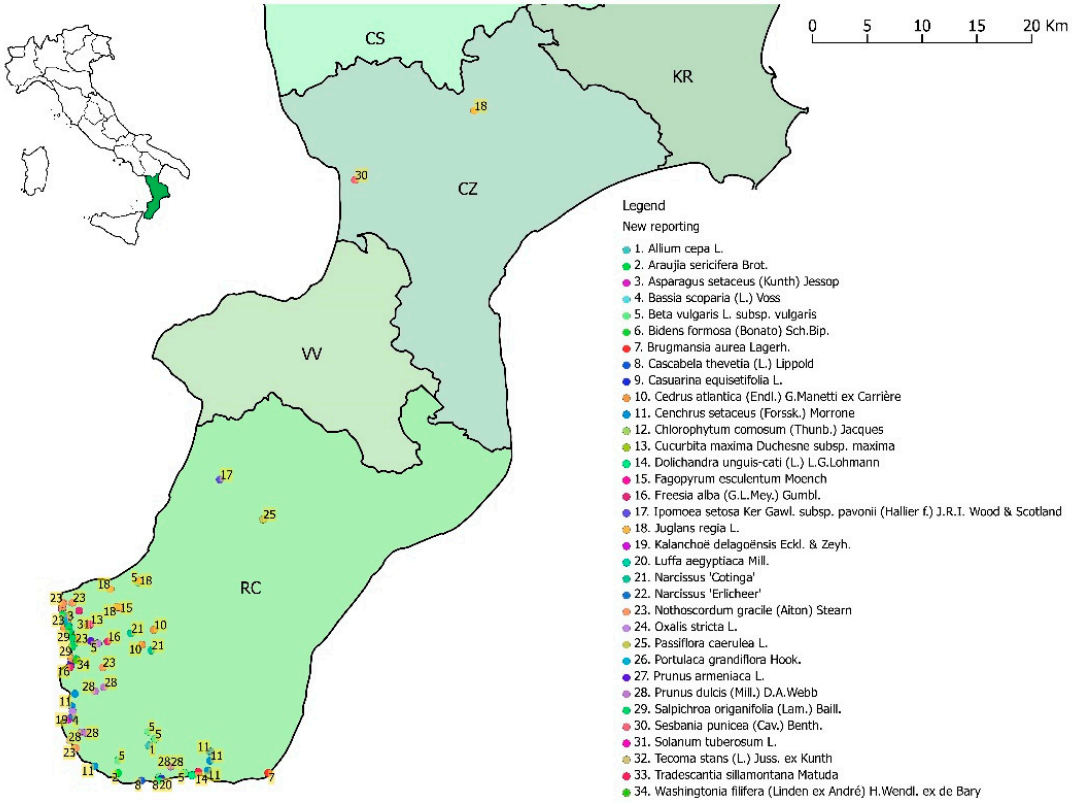



**Figure 1.** Distribution of the 34 alien taxa recorded for the flora of Calabria (Southern Italy, Europe). Calabrian provinces: CS = Cosenza, CZ = Catanzaro, KR = Crotone, RC = Reggio Calabria, VV = Vibo Valentia.

## 2. Results

In this research work, we report 34 alien taxa recorded in several places of Calabria with different status of invasiveness (Figure 2; Table 1; Appendix A). Among these, three taxa are new for Europe

(*Cascabela thevetia*, *Ipomoea setosa* subsp. *pavonii*, and *Tecoma stans*), three are new for Italy (*Brugmansia aurea, Narcissus* '*Cotinga*', and *Narcissus* '*Erlicheer*'), one is new for the Italian Peninsula (*Luffa aegyptiaca*), and 21 are new for Calabria (*Allium cepa*, *Asparagus setaceus*, *Bassia scoparia*, *Beta vulgaris* subsp. *vulgaris*, *Bidens formosa*, *Casuarina equisetifolia*, *Cedrus atlantica*, *Chlorophytum comosum*, *Cucurbita maxima* subsp. *maxima*, *Dolichandra unguis-cati*, *Fagopyrum esculentum*, *Freesia alba*, *Juglans regia*, *Kalanchoë delagoënsis*, *Passiflora caerulea*, *Portulaca grandiflora*, *Prunus armeniaca*, *Prunus dulcis*, *Solanum tuberosum*, *Tradescantia sillamontana*, and *Washingtonia filifera*). Furthermore, we provide, for Calabria, the first geolocalized record of *Araujia sericifera*, the confirmation of *Oxalis stricta*, and propose a change of status for *Cenchrus setaceus*, *Salpichroa origanifolia*, and *Sesbania punicea* from naturalized to invasive, and for *Nothoscordum gracile* from casual to invasive. Some taxa were found in only one place, while others in several places, for a total of 118 records (Table S1).

In particular, as below discussed and already confirmed by Spampinato et al. [50], *Cenchrus setaceus*, among others, showed a high degree of invasion in natural habitats. Other taxa have also been found in protected sites falling within the Natura 2000 network: *Beta vulgaris* subsp. *vulgaris*, *Cedrus atlantica*, *Fagopyrum esculentum*, *Freesia alba*, *Juglans regia*, and *Nothoscordum gracile*.

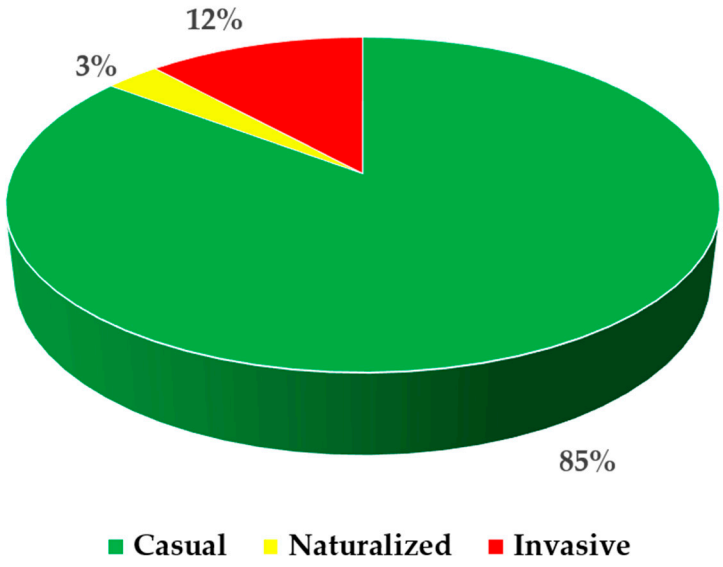



**Figure 2.** Current status of invasiveness of the 34 alien taxa recorded for the flora of Calabria (Southern Italy, Europe).

**Table 1.** List of the 34 alien taxa recorded for the flora of Calabria (Southern Italy, Europe), with their eventual first record for Europe, first record for Italy, or confirmation for Calabria, and finally, the current status of invasiveness in the region and the previous one if changed.

| ID | Taxon | First Record for Europe | First Record for Italy | First Record for Calabria | Confirmation for Calabria | Current Status | Previous Status |
|---|---|---|---|---|---|---|---|
| 1 | *Allium cepa* L. | | | X | | C | |
| 2 | *Araujia sericifera* Brot. | | | G | | C | |
| 3 | *Asparagus setaceus* (Kunth) Jessop | | | X | | C | |
| 4 | *Bassia scoparia* (L.) Voss | | | X | | C | |
| 5 | *Beta vulgaris* L. subsp. *vulgaris* | | | X | | N | |
| 6 | *Bidens formosa* (Bonato) Sch. Bip. | | | X | | C | |
| 7 | *Brugmansia aurea* Lagerh. | | X | | | C | |
| 8 | *Cascabela thevetia* (L.) Lippold | X | | | | C | |
| 9 | *Casuarina equisetifolia* L. | | | X | | C | |
| 10 | *Cedrus atlantica* (Endl.) G. Manetti ex Carrière | | | X | | C | |
| 11 | *Cenchrus setaceus* (Forssk.) Morrone | | | | | I | N |
| 12 | *Chlorophytum comosum* (Thunb.) Jacques | | | X | | C | |
| 13 | *Cucurbita maxima* Duchesne subsp. *maxima* | | | X | | C | |
| 14 | *Dolichandra unguis-cati* (L.) L.G. Lohmann | | | X | | C | |
| 15 | *Fagopyrum esculentum* Moench | | | X | | C | |
| 16 | *Freesia alba* (G.L. Mey.) Gumbl. | | | X | | C | |
| 17 | *Ipomoea setosa* Ker Gawl. subsp. *pavonii* (Hallier f.) J.R.I. Wood & Scotland | X | | | | C | |
| 18 | *Juglans regia* L. | | | X | | C | |
| 19 | *Kalanchoë delagoënsis* Eckl. & Zeyh. | | | X | | C | |
| 20 | *Luffa aegyptiaca* Mill. | | IP | X | | C | |
| 21 | *Narcissus 'Cotinga'* | | X | | | N | |
| 22 | *Narcissus 'Erlicheer'* | | X | | | C | |
| 23 | *Nothoscordum gracile* (Aiton) Stearn | | | | | I | C |
| 24 | *Oxalis stricta* L. | | | | X | C | |
| 25 | *Passiflora caerulea* L. | | | X | | C | |
| 26 | *Portulaca grandiflora* Hook. | | | X | | C | |
| 27 | *Prunus armeniaca* L. | | | X | | C | |
| 28 | *Prunus dulcis* (Mill.) D.A. Webb | | | X | | C | |
| 29 | *Salpichroa origanifolia* (Lam.) Baill. | | | | | I | N |
| 30 | *Sesbania punicea* (Cav.) Benth. | | | | | I | N |
| 31 | *Solanum tuberosum* L. | | | X | | C | |
| 32 | *Tecoma stans* (L.) Juss. ex Kunth | X | | | | C | |
| 33 | *Tradescantia sillamontana* Matuda | | | X | | C | |
| 34 | *Washingtonia filifera* (Linden ex André) H. Wendl. ex de Bary | | | X | | C | |

Notes: X = New or confirmed record; G = first Geolocalized record; IP = new record only for Italian Peninsula. Current and previous status of invasiveness: C = Casual; N = Naturalized; I = Invasive.

## 3. Discussion

The continuous and constant increase in a short time of new records of alien taxa in the Calabrian territory, and generally in Italy and Europe, represents a worrying threat for the autochthonous biodiversity and a clear sign of the ongoing climate change [55].

As shown in Figure 1, most of the new reports of alien taxa occurred within inhabited areas; these have a high risk of future invasion of natural habitats [56]. A total of 85% of recorded taxa is "casual", 3% "naturalized", and 12% is "invasive". This last percentage of invasive taxa comes from a change of status that we propose in the present work, which means that several taxa continue to expand their range of distribution, representing a constant threat for native species and habitats.

Several records have been found along roadsides (Figure 3). Indeed, roadsides are places where alien taxa can establish [57,58] and are a considerable way to invade other areas [59]. Obviously, roads were also the places traveled by us during our research as it is more common to find new alien taxa along them. This does not mean that other habitats are not good places for alien taxa: in fact, numerous taxa have been encountered in other habitats but not considered here because they have already been reported previously for Calabria. In this study, we found that, out of 118 records, 60% were found along roadsides (Figure 3)! Only 8% were found in sidewalks and in temporary water bodies such as drainage channels and *fiumare* (typical rivers of southern Italy with torrential and irregular regime.), 7% in uncultivated fields, 5% in crop habitats, and 12% in other habitats (outcropping rocks, walls, shrublands and ruins). More details are reported in Table 2.

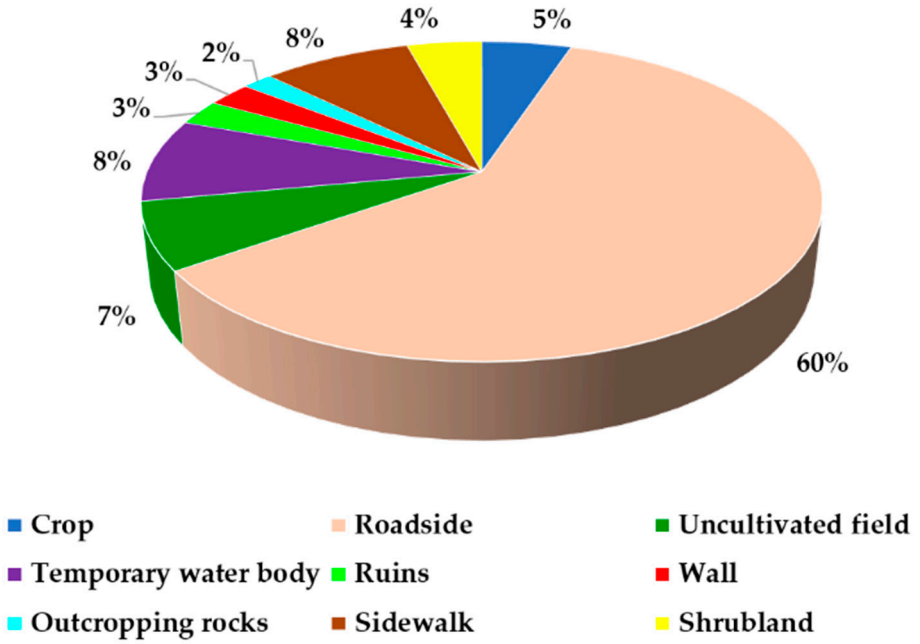



**Figure 3.** Habitats of the 34 alien taxa recorded for the flora of Calabria (Southern Italy, Europe).

**Table 2.** Detailed list of the 34 alien taxa recorded to Calabria (Southern Italy, Europe) including family, period of introduction, native range, life form, habitat, and number (No.) of records for each taxon.

| ID | Taxon | Family | Period of Introduction | Native Range | Life Form | Habitat | No. of Records |
|---|---|---|---|---|---|---|---|
| 1 | *Allium cepa* L. | Amaryllidaceae | Archeophyte | Culton | G bulb | Crop | 1 |
| 2 | *Araujia sericifera* Brot. | Apocynaceae | Neophyte | Southern America | P lian | Roadside | 2 |
| 3 | *Asparagus setaceus* (Kunth) Jessop | Asparagaceae | Neophyte | Southern Africa | P lian | Uncultivated field | 5 |
| 4 | *Bassia scoparia* (L.) Voss | Chenopodiaceae | Neophyte | Central Asia | T scap | Roadside | 1 |
| 5 | *Beta vulgaris* L. subsp. *vulgaris* | Chenopodiaceae | Archeophyte | Culton | H scap | Crop/Uncultivated field/Roadside | 7 |
| 6 | *Bidens formosa* (Bonato) Sch. Bip. | Asteraceae | Neophyte | Northern and Central America | T scap | Roadside | 2 |
| 7 | *Brugmansia aurea* Lagerh. | Solanaceae | Neophyte | Ecuador | NP | Roadside | 1 |
| 8 | *Cascabela thevetia* (L.) Lippold | Apocynaceae | Neophyte | Central and Southern America | Ch frut | Temporary water body | 2 |
| 9 | *Casuarina equisetifolia* L. | Casuarinaceae | Neophyte | Australia | P scap | Wall | 2 |
| 10 | *Cedrus atlantica* (Endl.) G. Manetti ex Carrière | Pinaceae | Neophyte | Northern Africa | P scap | Shrubland | 2 |
| 11 | *Cenchrus setaceus* (Forssk.) Morrone | Poaceae | Neophyte | Northern and Eastern Africa and Arabian Peninsula | H caesp | Roadside | 6 |
| 12 | *Chlorophytum comosum* (Thunb.) Jacques | Asparagaceae | Neophyte | Southern Africa | H scap | Temporary water body | 2 |
| 13 | *Cucurbita maxima* Duchesne subsp. *maxima* | Cucurbitaceae | Neophyte | Culton | T scap | Temporary water body/Roadside | 2 |
| 14 | *Dolichandra unguis-cati* (L.) L.G. Lohmann | Bignoniaceae | Neophyte | Southern America | P lian | Temporary water body/Ruins | 3 |
| 15 | *Fagopyrum esculentum* Moench | Polygonaceae | Neophyte | Asia | T scap | Roadside | 1 |
| 16 | *Freesia alba* (G.L. Mey.) Gumbl. | Iridaceae | Neophyte | Southern Africa | G bulb | Roadside/Ruins/Wall | 3 |
| 17 | *Ipomoea setosa* Ker Gawl. subsp. *pavonii* (Hallier f.) J.R.I. Wood & Scotland | Convolvulaceae | Neophyte | Southern America | G bulb | Roadside | 1 |
| 18 | *Juglans regia* L. | Juglandaceae | Cryptogenic | Western Asia | P scap | Temporary water body/Roadside | 5 |
| 19 | *Kalanchoë delagoënsis* Eckl. & Zeyh. | Crassulaceae | Neophyte | Southern Africa | Ch succ | Roadside | 1 |
| 20 | *Luffa aegyptiaca* Mill. | Cucurbitaceae | Neophyte | Southern Africa | T scap | Temporary water body | 1 |
| 21 | *Narcissus 'Cotinga'* | Amaryllidaceae | Neophyte | Culton | G bulb | Crop/Shrubland | 2 |
| 22 | *Narcissus 'Erlicheer'* | Amaryllidaceae | Neophyte | Culton | G bulb | Roadside | 1 |

**Table 2.** *Cont.*

| ID | Taxon | Family | Period of Introduction | Native Range | Life Form | Habitat | No. of Records |
|---|---|---|---|---|---|---|---|
| 23 | *Nothoscordum gracile* (Aiton) Stearn | Amaryllidaceae | Neophyte | Southern America | G bulb | Roadside/Sidewalk | 36 |
| 24 | *Oxalis stricta* L. | Oxalidaceae | Neophyte | Northern America | H scap | Sidewalk | 3 |
| 25 | *Passiflora caerulea* L. | Passifloraceae | Neophyte | Southern America | P lian | Roadside | 1 |
| 26 | *Portulaca grandiflora* Hook. | Portulacaceae | Neophyte | Southern America | T scap | Roadside/Sidewalk | 2 |
| 27 | *Prunus armeniaca* L. | Rosaceae | Archeophyte | Culton | P scap | Crop | 1 |
| 28 | *Prunus dulcis* (Mill.) D.A. Webb | Rosaceae | Archeophyte | Feral | P scap | Outcropping rocks/Roadside/Shrubland | 7 |
| 29 | *Salpichroa origanifolia* (Lam.) Baill. | Solanaceae | Neophyte | Southern America | Ch frut | Roadside | 10 |
| 30 | *Sesbania punicea* (Cav.) Benth. | Fabaceae | Neophyte | Southern America | P scap | Temporary water body | 1 |
| 31 | *Solanum tuberosum* L. | Solanaceae | Neophyte | Culton | T scap | Temporary water body | 1 |
| 32 | *Tecoma stans* (L.) Juss. ex Kunth | Bignoniaceae | Neophyte | Northern America | P lian | Sidewalk | 1 |
| 33 | *Tradescantia sillamontana* Matuda | Commelinaceae | Neophyte | Southern America | G rhiz | Uncultivated field | 1 |
| 34 | *Washingtonia filifera* (Linden ex André) H. Wendl. ex de Bary | Arecaceae | Neophyte | Northern America | P scap | Sidewalk | 1 |
| | | | | | | Total | **118** |

Note. Plant life forms (according to the Raunkiaer system) Ch frut, Frutescent chamaephyte; Ch succ, Succulent chamaephyte; G bulb, Bulbous geophyte; G rhiz, Rhizome geophyte; H caesp, Cespitose hemicryptophyte; H scap, Scapose hemicryptophyte; NP, Nanophanerophyte; P lian, Climbing phanerophyte; P scap, Scapose phanerophyte; T scap, Scapose therophyte.

We verified the distribution of taxa within the Natura 2000 network. Some taxa grew in network sites: *Beta vulgaris* subsp. *vulgaris*, *Cedrus atlantica*, *Fagopyrum esculentum*, *Freesia alba*, *Juglans regia*, and *Nothoscordum gracile* (Table 3). *B. vulgaris* subsp. *vulgaris* was found in SAC IT9350145 "Fiumara Amendolea (including Roghudi, Chorio, and Rota Greco)" and in SPA IT9350300 "Costa Viola", while *C. atlantica*, *F. esculentum*, *F. alba*, *J. regia*, and *N. gracile* were only found in the SPA IT9350300 "Costa Viola". If *C. atlantica*, *F. esculentum*, *F. alba*, and *J. regia* are considered as "casual", *B. vulgaris* subsp. *vulgaris* tends to naturalize, and *N. gracile* becomes invasive in other sites where it has been found, also representing a potential threat for protected areas such as SPA "Costa Viola".

**Table 3.** Alien taxa found in two sites of the Natura 2000 network in Calabria (Southern Italy, Europe).

| ID | Taxon | SAC/SPA | SAC/SPA Code | SAC/SPA Name |
|---|---|---|---|---|
| 5 | *Beta vulgaris* L. subsp. *vulgaris* | SAC | IT9350145 | Fiumara Amendolea (incluso Roghudi, Chorio e Rota Greco) |
| 5 | *Beta vulgaris* L. subsp. *vulgaris* | SPA | IT9350300 | Costa Viola |
| 10 | *Cedrus atlantica* (Endl.) G.Manetti ex Carrière | SPA | IT9350300 | Costa Viola |
| 15 | *Fagopyrum esculentum* Moench | SPA | IT9350300 | Costa Viola |
| 16 | *Freesia alba* (G.L. Mey.) Gumbl. | SPA | IT9350300 | Costa Viola |
| 18 | *Juglans regia* L. | SPA | IT9350300 | Costa Viola |
| 22 | *Nothoscordum gracile* (Aiton) Stearn | SPA | IT9350300 | Costa Viola |

Notes. SAC: Special Area of Conservation [60]; SPA: Special Protection Area [61].

Two species (*Araujia sericifera* and *Washingtonia filifera*) are recently included in a list of candidate species to be submitted to the national prioritization procedure for their inclusion in a national list according to Regulation (EU) No. 1143/2014 [62]. Therefore, knowledge of new sites of *A. sericifera* and the new record of *W. filifera* for Calabria are very important for their control because they have a detrimental impact on plant communities [63].

Among others, *Cenchrus setaceus* is rapidly spreading in the regional territory after its first report in 2007 [64]. Indeed, these authors reported *C. setaceus* (sub *Pennisetum setaceum*) for Calabria in two locations, both along communication routes, but at a high distance from each other: one along the A2 motorway between Rosarno and Gioia Tauro in the province of Reggio Calabria on the Thyerrenian side, and another along highway SS 106 Jonica near Cropani Marina in the province of Catanzaro on the Ionian side of the region. After several new records of this alien species for Calabria by Musarella et al. [44,50], new individuals have been recorded near the previously observed in Reggio Calabria where they have generated new tufts in the same point ["lungo Raccordo Autostradale 4 di Reggio Calabria prima della galleria Spirito Santo in direzione Sud (Reggio Calabria), roadside, 93 m s.l.m., 21.11.2018, 557933–4218164, obs. et det. V.L.A. Laface et C.M. Musarella"] and a few tens of meters from them ["lungo la SS 106 Jonica presso località Ravagnese (Reggio Calabria), roadside, 38 m s.l.m., 19.11.2018, 558138–4213357, leg. et det. C.M. Musarella (REGGIO)] [44]. According to Brundu [65], only an early detection and rapid eradication (EDRE) of *C. setaceus* can prevent its rapid spread, for this reason, its continuous monitoring is really important to prevent ecological damage.

Two cultivars of *Narcissus* used as ornamentals were observed by the authors (Figure A1). Report no. 21 was recorded for two locations where it has multiplied over the years after the first observation in 2013 by Laface and report no. 22 was recorded for the first time at the beginning of 2020 by Musarella. It is likely that they escaped cultivation or were thrown among the waste material from nearby gardens. As to which cultivars they were, there are more than 27,000 daffodils of garden origin registered in the International Daffodil Register and Classified List in 2008 [66]. According to [66], the report no. 21, which has single flowers with solitary flowers, white reflexed perianth segments and an apricot-pink corona, belongs in Division 6 (Cyclamineus) and was recognized as *Narcissus 'Cotinga'*. Report no. 22,

which has double flowers with white perianth segments with a trace of yellow at the base, belongs to Division 4 (Double flowered) and is referred to as *Narcissus 'Erlicheer'*. Regarding their invasiveness, it is important to consider that daffodils rarely spread rapidly and certainly the Division 4 cultivars are sterile, so cannot spread by seed. For this reason, we consider it to not have a detrimental impact on the environment. These are both first records for Italy.

## 4. Materials and Methods

This research was based on fieldwork carried out randomly and during a well-designed research field for the coordination of monitoring activities of natural and semi-natural habitats of the flora and fauna species of the Natura 2000 Network present in Calabria (see Funding section) from 2018 to 2020 as well as on herbaria and literature surveys. As part of this project, in fact, it was necessary to verify the conservation status of the habitats in accordance with the European Directive [60] as well as in relation to the possible threat or pressure exerted by an alien species on them. Fieldwork consisted of collecting samples of alien plants and identifying them in the laboratory. The collected specimens was stored dried in the herbarium of the Mediterranean University of Reggio Calabria (Italy) (REGGIO, acronym according to Thiers [67]). The investigated area was the whole of Calabria, but the new records concern only the central-southern part.

The taxa in the floristic list are arranged in alphabetical order (Appendix A). Nomenclature, taxa delimitation, and regional distribution are in accordance with Galasso et al. [1] and the following update [45–49,53]. The specimens were identified using Flora Europaea [68–72], Flora d'Italia [73–77], Flora of North America [78], Flora of China [79], and some monographic works [66,80–82]. The update distribution of the considered taxa was verified also using [83,84]. Life forms and native range were according to [73–77,85] and by on-field observation. Period of introduction of the taxa recorded were verified on "Portale della Flora d'Italia" [85].

For each taxa, we provide the following information: (1) accepted name; (2) basionym and most relevant synonyms; (3) plant family; (4) period of introduction (archeophyte, neophyte, or cryptogenic); (5) native range; (6) life form; (7) data record in Calabria, Italy, or Europe; (8) current invasiveness status for the region (according to Pyšek et al. [86]); (9) date of observation; (10) discovery localities (municipality, administrative province) (*exsiccata* and *observata*) with details on the location (in Italian, according to the information on the specimen labeldata); (11) terminology of Pyšek et al. [86]; (12) decimal degrees geographic coordinates (datum WGS84); (13) growth environment; (14) altitude (meters above sea level–m a.s.l.); (15) *legit* (or *observavit*) and *determinavit*; (16) herbarium where the specimen is stored; and (17) distribution and/or ecological notes when available. For some taxa not documented with a herbarium specimen, we report some pictures where available (Appendix B). All other plants pictures are reported in Appendix B.

## 5. Conclusions

Although there is adequate knowledge of the alien flora in Italy, not much is known about those in Calabria thus far. As before indicated, Calabrian alien vascular flora amounts to 344 taxa [53,54]. Thanks to this study, it was possible to increase this knowledge by reporting new data on 34 taxa: one (1) confirmation for Calabria, some new for Calabria (21), other new for the Italian Peninsula (1), three (3) for the whole of Italy, and three (3) new for the whole of Europe. Furthermore, a georeferenced location for *Araujia sericifera* (1) and the invasiveness status for four (4) species already known for the region are reported here for the first time. In total, 28 taxa are new to Calabria. Therefore, we can currently count 373 alien plant taxa for the whole of Calabria. This was possible thanks to the increasing attention to the exotic taxa introduced because, compared to the past, these taxa are invading more and more indigenous habitats, compromising their ecological balance and threatening the survival of native taxa. Works like these are very important because they provide the possibility of identifying a large number of new alien plant species that are spreading worldwide, allowing us to fill in the many gaps at the regional, national and global level.

Nonetheless, it is now clear that knowledge of native species is not enough for the protection of a specific territory. Of additional importance is the knowledge of alien species, their invasive potential, prevention in their introduction (both intentional and accidental), and their immediate eradication (i.e., *Cenchrus setaceus*, *Nothoscordum gracile*, *Salpichroa origanifolia*, and *Sesbania punicea*, which are spreading very rapidly as invasives). All these actions must be carried out by both the public and private institutions responsible for this, and most notably by citizens that can responsibly act autonomously in this sense. However, the ever-increasing diffusion of taxonomic, biological and ecological knowledge must form the basis for carrying out sustainable policies for the environment.

**Supplementary Materials:** The following are available online at http://www.mdpi.com/2223-7747/9/9/1181/s1, Table S1: Details of all 118 new records.

**Author Contributions:** Conceptualization, C.M.M.; Methodology, C.M.M.; Validation, C.M.M. and G.S.; Formal analysis, C.M.M., V.L.A.L. and G.S.; Investigation, S.C., V.L.A.L., C.M.M. and G.S.; Resources, S.C., V.L.A.L., C.M.M. and G.S.; Data curation, V.L.A.L. and C.M.M.; Writing—original draft preparation, C.M.M., V.L.A.L. and G.S.; Writing—review and editing, A.C.O., V.L.A.L., C.M.M., R.Q.C. and G.S.; Visualization, C.M.M.; Supervision, C.M.M. and G.S.; Project administration, C.M.M. and G.S.; Funding acquisition, G.S. All authors have read and agreed to the published version of the manuscript.

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**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

(1) ***Allium cepa* L.** [≡*Allium ascalonicum* auct., non L., *Allium esculentum* Salisb.]

Amaryllidaceae Archeophyte Culton Bulbous geophyte

First record for Calabria (casual)

*Observatum*: 6 June 2019, Strada Comunale Amendolara (Reggio Calabria province), wheat field, 37.978678°N–15.818553°E, 348 m a.s.l., *obs. et det.* V.L.A. Laface.

Note. Some flowering plants have been observed in a wheat field, which probably escaped cultivation from the vegetable gardens nearby. Casual alien in Abruzzo, Basilicata, Campania, Emilia-Romagna, Friuli Venezia Giulia, Lazio, Lombardia, Marche, Molise, Piemonte, Sardegna, Toscana, Umbria and Veneto, according to Galasso et al. [1].

(2) ***Araujia sericifera* Brot.** [≡*Araujia albens* (Mart.) G. Don, *Araujia hortorum* E. Fourn.]

Apocynaceae Neophyte Southern America Climbing phanerophyte

First geolocalized reports in Calabria (casual)

*Specimina*: 4 July 2019, Catona (Reggio Calabria province), roadside climbed to a wire mesh, 38.174222°N–15.649700°E, 25 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 29 July 2019, Località Zonzoloso, Borgata Musa (Reggio Calabria province), roadside climbed to a wire mesh, 37.933149°N–15.753858°E, 57 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. *A. sericifera* is present in Italy as naturalized in Abruzzo and Sicilia, as casual in Lazio, Lombardia, Marche, Molise, Puglia, Sardegna, and Toscana, and as invasive in Campania [1]. In

Calabria, this species was indicated as "recently not confirmed" by Celesti-Grapow et al. [87] and Galasso et al. [1], whereas was recently reported by Musarella et al. [44] for the same locality of Catona as casual, but in an unspecified uncultivated field. Recently, Lazzaro et al. [62] proposed this species for its inclusion in a national list of invasive species according to EU Regulation 1143/2014 [88].

(3) ***Asparagus setaceus* (Kunth) Jessop** [≡*Asparagopsis setacea* Kunth]

Asparagaceae Neophyte Southern Africa Climbing phanerophyte

First record for Calabria (casual)

*Specimina*: 2 March 2020, Località Bolano, tra Catona e Villa San Giovanni (Reggio Calabria province), citrus grove abandoned for many years, 38.203382°N–15.635614°E, 7 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 4 March 2020, Catona (Via Feudo) (Reggio Calabria province), climbed to a wire mesh, 38.185416°N–15.646368°E, 16 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 3 March 2020, Gallico Marina (Reggio Calabria province), abandoned citrus grove, 38.164632°N–15.649939°E, 9 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 11 May 2020, Catona (Reggio Calabria province), climbed to a wire mesh, 38.188973°N–15.642679°E, 37 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

*Observata*: 3 March 2020, Gallico Inferiore (Reggio Calabria province), uncultivated garden, 38.166028°N–15.653223°E, 16 m a.s.l., *obs. et det.* V.L.A. Laface.

Note. Used as an ornamental plant, probably escaped from the surrounding gardens. In the above localities, it was found in an old citrus grove and in abandoned lands where it also climbs over the existing trees. It is distributed in different regions of the Italian Peninsula as naturalized in Campania and Sicilia, whereas it is casual in Lazio, Puglia, Sardegna, Trentino-Alto Adige, and Toscana [1].

(4) ***Bassia scoparia* (L.) Voss** [≡*Chenopodium scoparia* L.]

Chenopodiaceae Neophyte Central Asia Scapose therophyte

First record for Calabria (casual)

*Specimen*: 21 October 2019, Via Torrente Carrò e Quattrone, Pellaro (Reggio Calabria province), roadside, 38.026944°N–15.656278°E, 16 m a.s.l., *leg. et det.* C.M. Musarella (REGGIO).

Note. Widely used as an ornamental plant, particularly appreciated for the creation of low hedges, it is probably escaped from plants grown in pots or from nearby flowerbeds (observed by Musarella). *B. scoparia* is present throughout Italy as invasive, naturalized, or casual alien and not reported only for Molise and Basilicata [1].

(5) ***Beta vulgaris* L. subsp. *vulgaris*** [≡*Beta cicla* L.; *Beta esculenta* Salisb.; *Beta hortensis* Mill.; *Beta rapa* Dumort.]

Chenopodiaceae Archeophyte Culton Scapose hemicryptophyte

First record for Calabria (naturalized)

*Specimen*: 28 February 2020, Ortì Inferiore (Reggio Calabria province), orchard, 38.147958°N–15.709523°E, 604 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

*Observata*: 26 January 2020, Via Provinciale Sant'Elia-Montebello Jonico (Reggio Calabria province), roadside, 37.954042°N–15.754001°E, 230 m a.s.l., *obs. et det.* V.L.A. Laface; 9 February 2020, C.da Pellegrino, Fiumara Acrifa (Reggio Calabria province), bergamot grove, 37.926021°N–15.839961°E, 17 m a.s.l., *obs. et det.* V.L.A. Laface; 9 February 2020, Bova Marina, vicino la Fiumara Amendolea (Reggio Calabria province), bergamot grove, 37.933048°N–15.893546°E, 17 m a.s.l., *obs. et det.*

V.L.A. Laface; 19 January 2020, San Fantino (Reggio Calabria province), uncultivated field, 38.001735°N–15.817078°E, 329 m a.s.l., *obs. et det.* V.L.A. Laface; 22 January 2020, San Pantaleone Località Varada (Reggio Calabria province), uncultivated field, 37.989366°N–15.831174°E, 544 m a.s.l., *obs. et det.* V.L.A. Laface; 10 June 2019, Solano Superiore, Bagnara (Reggio Calabria province), roadside, 38.248756°N–15.794914°E, 653 m a.s.l., *obs. et det.* V.L.A. Laface.

Note. *B. vulgaris* subsp. *vulgaris* is cultivated throughout Italy for food purposes. It grows abundantly in uncultivated and cultivated fields, in abandoned lands and on the edges of country roads. The subspecies is considered as a casual alien throughout Italy [1]. Several records above reported are known by Laface since about twenty years for their own domestic food uses.

(6) ***Bidens formosa* (Bonato) Sch. Bip.** [≡*Coreopsis formosa* Bonato; *Cosmos bipinnatus* Cav., non *Bidens bipinnata* L.; *Cosmos bipinnatus* Cav.]

Asteraceae Neophyte Northern and Central America Scapose therophyte

First record for Calabria (casual)

*Specimina*: 29 February 2020 Località Cazzeria, Catona (Reggio Calabria province), roadside, 38.191548°N–15.646137°E, 25 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 29 February 2020, Località Cazzeria, Catona (nei pressi del ponte dell'autostrada A3) (Reggio Calabria province), roadside, 38.192187°N–15.647553°E, 28 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. *B. formosa* is reported as a casual alien in regions of northern and central Italy [1].

(7) ***Brugmansia aurea* Lagerh.** [≡*Brugmansia pittieri* (Saff.) Moldenke; *Brugmansia affinis* (Soff.) Moldenke]

Solanaceae Neophyte Ecuador Nanophanerophyte

First record for Italy (casual)

*Specimen*: 11 January 2020, S.S. Jonica 106, Galati, Brancaleone (Reggio Calabria province), roadside, 37.932976°N–16.069568°E, 8 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. Cultivated for ornamental purposes, very fragrant trumpet-shaped flowers, this plant is very attractive to bees, butterflies, and birds. Two plants were recorded along the road, mixed with *Opuntia ficus-indica* (L.) Mill. and *Oxalis pes-caprae* L. (Appendix B, Figure A2). In Europe, *B. aurea* was recorded only in Spain [89], therefore, this is the second report for Europe and the first for Italy.

(8) ***Cascabela thevetia* (L.) Lippold** [≡*Cascabela peruviana* (Pers.) Raf.; *Thevetia peruviana* (Pers.) K. Schum.]

Apocynaceae Neophyte Central and Southern America Frutescent chamaephyte

First record for Europe (casual)

*Specimina*: 5 October 2019, Melito di Porto Salvo (Reggio Calabria province), water drainage channel, 37.920423°N–15.802782°E, 9 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 19 October 2019, Fiumara Acrifa (Reggio Calabria province), near a fiumara, 37.920494°N-15.839534°E, 9 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. *C. thevetia* is an evergreen shrub native to tropical America (Mexico, Central America (Guatemala, Belize, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama), South America (Colombia, Venezuela, British Guiana, Brazil, Ecuador, Peru, and Bolivia) and cultivated in the Antilles (Bahamas, Cuba, Haiti, Jamaica, Puerto Rico, and Dominican Republic), but it is widespread in the tropics around the world [90]. It is commonly cultivated as an ornamental plant and its flowering occurs throughout the year. Numerous seedlings have been found, born from

seeds, in a water drainage channel and some adult plants along a wall, on the side of a typical little river ("fiumara"), mixed with *Phyllostcahys aurea* Carrière ex Rivière and C. Rivière (Appendix B, Figure A3). In Europe, it is reported as doubtful for Cyprus [91] and a preserved specimen is recorded for Portugal, but without a certain locality [92]. However, according to [83,84], *C. thevetia* is not given as present in Cyprus. Therefore, our finding represents the first European record.

(9) ***Casuarina equisetifolia* L.**

Casuarinaceae Neophyte Australia Scapose phanerophyte

First record for Calabria (casual)

*Observata*: 29 December 2019, Reggio Calabria (incrocio Via Aschenez-Via Willermin) (Reggio Calabria province), wall, 38.115494°N–15.654883°E, 35 m a.s.l., *obs. et det.* V.L.A. Laface; 18 January 2019, Straci, Marina di San Lorenzo (Reggio Calabria province), wall of a traditional water collection tank ("gebbia"), 37.923677°N–15.844383°E, 19 m a.s.l., *obs. et det.* V.L.A. Laface.

Note. The plants observed were certainly generated by the seeds of some trees nearby planted, accidentally blown into the cracks in the walls (Appendix B, Figure A4). According to Galasso et al. [1], in Italy, this species is a casual alien in Lazio, Sicilia, Campania, and naturalized in Puglia and Toscana.

(10) ***Cedrus atlantica* (Endl.) G. Manetti ex Carrière** [≡*Pinus atlantica* Endl.]

Pinaceae Neophyte Northern Africa Scapose phanerophyte

First record for Calabria (casual)

*Specimen*: 9 May 2020, Piani di Reggio, Reggio Calabria (Reggio Calabria province), slope, 38.145513°N–15.803511°E, 1163m a.s.l., *leg. et det.* V.L.A. Laface.

*Observata*: 6 May 2019, S.S. 184, Santo Stefano in Aspromonte (Reggio Calabria province), roadside and beech wood, 38.170283°N–15.828692°E, 1211m a.s.l., *obs. et det.* V.L.A. Laface.

Note. According to Galasso et al. [1], in Italy, this species is a casual alien only in Sicilia and Basilicata.

(11) ***Cenchrus setaceus* (Forssk.) Morrone** [≡*Phalaris setacea* Forssk.; *Pennisetum setaceum* (Forssk.) Chiov.]

Poaceae Neophyte Northern and Eastern Africa and Arabian Peninsula Cespitose hemicryptophyte

Change of status for Calabria: from naturalized to invasive (invasive)

*Specimina*: 15 February 2020, Occhio di Pellaro (Reggio Calabria province), roadside, 38.043684°N–15.656055°E, 6 m a.s.l., *leg. et det.* C.M. Musarella (REGGIO); 8 May 2020, S.S. 106 (Reggio Calabria province), roadside, 38.064363°N–15.662721°E, 40 m a.s.l., *leg. et det.* C.M. Musarella (REGGIO); 17 May 2020, Saline Joniche (Reggio Calabria province), roadside, 37.944089°N–15.703504°E, 11 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 2 June 2020, C.da Venturi, Bova (Reggio Calabria province), roadside and uncultivated field, 37.937291°N–15.942257°E, 144 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 02-06-2020, Località Scilindermeno, Bova (Reggio Calabria province), roadside and wall, 37.953626°N–15.947259°E, 230 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 02-06-2020, Coddurena, Bova (Reggio Calabria province), roadside, 37.968476°N–15.947824°E, 398 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. *C. setaceus* is one of the "black" species present in the "Union list" of the European Union [86]. In Italy, this species is a casual alien in Calabria, Lazio, and Toscana, naturalized in Puglia, and invasive in Sardegna and Sicilia [1]. Subsequently, Musarella et al. [44] reported it as

naturalized in Calabria. The specimens collected (S.S. 106 Occhio di Pellaro and Saline Joniche) along some city streets (Appendix B, Figure A5) probably come from some nearby villas or other spontaneous individuals geographically close. The new records reported here previously had not been observed by the authors, which means that they were born less than a year after previous reports by Musarella et al. [44].

Reported for the first time in Calabria in 2007 [64], the species shows (as in other Italian regions) a strongly invasive character. *C. setaceus* was initially reported for this region by Celesti-Grapow et al. [87] and then confirmed by Musarella et al. [49] as casual. Recently, it was recorded as naturalized, according to Musarella et al. [44], but this species continues its uncontrollable expansion in Calabria and can therefore be considered as invasive.

(12) ***Chlorophytum comosum* (Thunb.) Jacques** [≡*Anthericum comosum* Thunb.]

Asparagaceae Neophyte Southern Africa Scapose hemicryptophyte

First record for Calabria (casual)

*Specimina*: 22 February 2020, Località Santa Maria, Ortì Inferiore (Reggio Calabria province), water drainage channel, 38.147425°N–15.711690°E, 608 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 22 February 2020, Località Santa Maria, Ortì Inferiore (Reggio Calabria province), rushes in an abandoned field, 38.147170°N–15.711247°E, 598 m a.s.l., *leg. et det.* V.L.A. Laface.

Note. Several plants have been observed, most likely escaped from some pots nearby. The species has always been observed near wetlands. In Italy, this species is recorded as a casual alien in Abruzzo, Lombardia and Sardegna, and as naturalized in Campania [1].

(13) ***Cucurbita maxima* Duchesne subsp. *maxima***

Cucurbitaceae Neophyte Culton Scapose therophyte

First record for Calabria (casual)

*Observata*: 23 July 2019, Sambatello (Reggio Calabria province), roadside, 38.179022°N–15.694885°E, 297 m a.s.l., *obs. et det.* V.L.A. Laface; 06.06.2019, Ortì Inferiore (Reggio Calabria province), water drainage channel, 38.147552°N–15.710772°E, 604 m a.s.l., *obs. et det.* V.L.A. Laface.

Note. *C. maxima* is locally cultivated for food purposes. Some flowering plants have been observed near water sources, likely to have escaped cultivation from nearby vegetable gardens. According to Galasso et al. [1], this subspecies is considered as a casual alien in northern Italy, in some regions of central Italy, and on the islands.

(14) ***Dolichandra unguis-cati* (L.) L.G. Lohmann** [≡*Bignonia unguis-cati* L.; *Macfadyena unguis-cati* (L.) A.H. Gentry]

Bignoniaceae Neophyte Southern America Climbing phanerophyte

First record for Calabria (Casual)

*Specimina*: 4 July 2019, Gallico (Reggio Calabria province), ruins, 38.146874°N–15.660094°E, 28 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 26 January 2020, Bova Marina (Reggio Calabria province), climbed to a wire mesh and ruins, 37.930419°N–15.915407°E, 9 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 26 January 2020, Località Vena, Bova Marina (Reggio Calabria province), climbing among the bricks of a bridge and in a water drainage channel, 37.929289°N–15.908896°E, 9 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. *D. unguis-cati* is present in Italy as a casual alien only in Campania, Lazio, Liguria, Sicilia, and Toscana [1].

(15) ***Fagopyrum esculentum* Moench** [≡*Fagopyrum sagittatum* Gilib.; *Fagopyrum vulgare* Hill; *Polygonum fagopyrum* L.]

Polygonaceae Neophyte Asia Scapose therophyte

First record for Calabria (casual)

*Specimen*: 5 May 2019, Lucia, Laganadi (Reggio Calabria province), roadside, 38.206843°N–15.756740°E, 388 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. Few plants were recorded along a road, mixed with *Amaranthus* sp. and *Setaria* sp., probably escaped from the cultivation of nearby gardens or vegetable gardens. In Italy, it is present in many regions as a casual alien (Abruzzo, Campania, Emilia-Romagna, Friuli Venezia Giulia, Lazio, Lombardia, Piemonte, Puglia, Trentino-Alto Adige, Umbria, and Veneto), whereas in Toscana it is naturalized [1].

(16) ***Freesia alba* (G.L. Mey.) Gumbl.** [≡*Freesia refracta* var. *alba* G.L. Mey.; *Freesia leichtlinii* subsp. *alba* (G.L. Mey.) J.C. Manning & Goldblatt]

Iridaceae Neophyte Southern Africa Bulbous geophyte

First record for Calabria (casual)

*Specimina*: 2 March 2020, Località San Cono, Rosalì (Reggio Calabria province), drywall limiting a "fiumara", 38.202119°N–15.671522°E, 94 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 4 March 2020, Ortì Superiore (Reggio Calabria province), roadside, 38.151084°N–15.731452°E, 668 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

*Observata*: 9 February 2020, Località Trabocchetto, Reggio Calabria (Reggio Calabria province), in a gutter, 38.108561°N–15.652622°E, 82 m a.s.l., *obs. et det.* V.L.A. Laface.

Note. A South African species [80], present in Italy as casual alien in Abruzzo, Basilicata, Lazio, Liguria, Molise, Puglia, Sardegna, Sicilia, Toscana and as naturalized in Campania [1].

(17) ***Ipomoea setosa* Ker-Gawl. subsp. *pavonii* (Hallier f.) J.R.I. Wood & Scotland** [≡*Calonyction pavonii* Hallier f.; *Merremia pavonii* (Hallier f.) D.F. Austin & Staples; *Ipomoea setosa* var. *pavonii* (Hallier f.) House]

Convolvulaceae Neophyte Southern America Bulbous geophyte

First record for Europe (casual)

*Specimen*: 18 October2019, C.da La Monaca, Rizziconi (Reggio Calabria province), roadside, 38.418530°N–15.967880°E, 81 m a.s.l., *leg.* S. Cannavò, *det.* S. Cannavò, V.L.A. Laface, C.M. Musarella *et* G. Spampinato (REGGIO).

Note. Recently, Wood et al. [81] published a monograph on *Ipomoea* genus in the New World. In it, the authors describe 425 taxa of *Ipomoea* and provide an identification key. According to these authors, the collected specimen from Rizziconi belong to *I. setosa* subsp. *pavonii*, a new recognized subspecies (*comb. et stat. nov.*). This subspecies is native to South America and it has fleshy trichomes on peduncles and pedicels, and these last are strongly swollen below the calyx. Its flowers have a short corolla of 5–6.5 cm [81]. Some details of the plants collected in Calabria are presented in Figure A6 of Appendix B. Until this record, *Ipomoea setosa* subsp. *pavonii* had not been recorded in Europe. Thus, our finding represents the first European record, according to Euro+Med PlantBase [83] and DAISIE (Inventory of alien invasive species in Europe) [sub *Merremia pavonii* (Hallier f.) D.F. Austin & Staples] [91].

(18) ***Juglans regia* L.**

Juglandaceae Cryptogenic Western Asia Scapose phanerophyte

First record for Calabria (casual)

*Specimina*: 16 February 2020, Cicala (Catanzaro province), escarpment, 39.024162°N–16.503332°E, 885 m a.s.l., *leg.* D. Grande, *det.* C.M. Musarella (REGGIO); 14 March 2020, Fiumara Catona, San Roberto (Reggio Calabria province), riverbed, 38.208153°N–15.754430°E, 374 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 09.05.2020, San Roberto (Reggio Calabria province), roadside, 38.208000°N–15.749657°E, 349 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 25 May 2020, Villaggio del Pino, Melia di Scilla, (Reggio Calabria province), roadside, 38.237782°N–15.737439°E, 600 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 25 May 2020, Solano (Reggio Calabria province), roadside, 38.251673°N–15.797604°E, 601 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note: Some adult plants have been observed in both localities of Cicala and San Roberto, whereas juveniles were found in Solano and Melia di Scilla (Appendix B, Figure A7). In Italy, based on Galasso et al. [1], *J. regia* is present as naturalized in almost all regions of the Italian Peninsula or as cryptogenic in Sardegna, Lombardia, and Veneto, whereas it is absent only in Puglia. In Calabria, its use is known not only for their fruits as food but also for their leaves as an emollient for excessive feet perspiration [33,35] or to treat warts [34].

(19) ***Kalanchoë delagoënsis* Eckl. & Zeyh.** [≡*Bryophyllum delagoense* (Eckl. & Zeyh.) Druce; *Kalanchoë delagoensis* Eckl. & Zeyh.]

Crassulaceae Neophyte Southern Africa Succulent chamaephyte

First record for Calabria (casual)

*Specimen*: 15 February 2020, Via Sottolume, Pellaro (Reggio Calabria province), roadside, 38.021766°N–15.648545°E, 15 m a.s.l., *leg. et det.* C.M. Musarella (REGGIO).

Note. Some plants have been observed on roadsides, probably originating from some nearby pots where the plant is grown. According to Galasso et al. [1], this species is present as a casual alien in Sicilia, Sardegna, Lazio, and Puglia.

(20) ***Luffa aegyptiaca* Mill.** [≡*Luffa cylindrica* M. Roem., non-*Momordica cylindrica* L.; *Momordica luffa* L.]

Cucurbitaceae Neophyte Southern Africa Scapose therophyte

First record for Calabria and Italian Peninsula (casual)

*Specimen*: 19 October 2019, Fiumara Acrifa (Reggio Calabria province), riverbed, 37.920592°N–15.839740°E, 9 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. Several plants have been found occupying a large part of the river ("fiumara") and almost completely covered the vegetation below, characterized mainly by shrubs of *Tamarix africana* Poir (Appendix B, Figure A8). Based on Galasso et al. [1], *L. aegyptiaca* is present exclusively in Sicilia as a casual alien, therefore, this is the first report for Calabria and the Italian Peninsula.

(21) ***Narcissus 'Cotinga'***

Amaryllidaceae Neophyte Culton Bulbous geophyte

First record for Italy (naturalized)

*Specimina*: 27 April 2019, Piani di Reggio (Reggio Calabria province), grazing-meadow covered with broom, 38.136339°N–15.823482°E, 1313 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 14 March

2020, Podargoni (Reggio Calabria province), abandoned walnut grove, 38.164593°N–15.780524°E, 543 m a.s.l., *leg.* V.L.A. Laface, *det.* C.M. Musarella (REGGIO).

(22) ***Narcissus 'Erlicheer'***

Amaryllidaceae Neophyte Culton Bulbous geophyte

First record for Italy (casual)

*Specimen*: 24 January 2020, Via Torrente Carrò e Quattrone, Pellaro (Reggio Calabria province), roadside, 38.027402°N–15.657049°E, 18 m a.s.l. *leg. et det.* C.M. Musarella (REGGIO).

(23) ***Nothoscordum gracile* (Aiton) Stearn** [≡*Allium gracile* Aiton; *Nothoscordum inodorum* (Aiton) G. Nicholson; *Nothoscordum borbonicum sensu Auct. Fl. Ital.*, non Kunth]

Amaryllidaceae Neophyte Southern America Bulbous geophyte

Change of status for Calabria: from casual to invasive (invasive)

*Specimina*: 5 March 2020, Archi Carmine (Reggio Calabria province), roadside, 38.155941°N–15.662968°E, 34 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 9 May 2020, Catona (Reggio Calabria province), roadside, 38.187991°N–15.640659°E, 9 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 9 May 2020, Catona (Reggio Calabria province), roadside, 38.186554°N–15.639327°E, 5 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 09 May 2020, Catona (Reggio Calabria province), roadside, 38.185641°N–15.638498°E, 3 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 9 May 2020, Catona (Reggio Calabria province), roadside, 38.182539°N–15.640183°E, 1 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 9 May 2020, Catona (Reggio Calabria province), roadside, 38.173234°N–15.640023°E, 1 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Località San Francesco, Catona (Reggio Calabria province), roadside, 38.181355°N–15.647343°E, 23 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Gallico Inferiore (Reggio Calabria province), roadside, 38.172231°N–15.651144°E, 34 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Gallico Inferiore (Reggio Calabria province), roadside, 38.172078°N–15.651199°E, 23 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Località S. Antonino, Gallico Inferiore (Reggio Calabria province), roadside, 38.169784°N–15.651662°E, 18 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Gallico Inferiore (Reggio Calabria province), roadside and wall, 38.167760°N–15.652999°E, 19 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10-05-2020, Ponte Itria, Gallico Inferiore (Reggio Calabria province), roadside, 38.164272°N–15.654143°E, 15 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Gallico Inferiore (Reggio Calabria province), roadside, 38.158512°N–15.656363°E, 15 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Scaccioti, Archi (Reggio Calabria province), roadside, 38.156560°N–15.660512°E, 26 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Campo Calabro (Reggio Calabria province), roadside, 38.215613°N–15.658041°E,139 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Campo Calabro (Reggio Calabria province), roadside, 38.215233°N–15.656918°E, 142 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Concessa (Reggio Calabria province), roadside, 38.193435°N–15.641554°E, 30 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Concessa (Reggio Calabria province), roadside, 38.192726°N–15.641197°E, 33 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Concessa (Reggio Calabria province), roadside, 38.192295°N–15.640988°E, 24 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Concessa (Reggio Calabria province), roadside, 38.192072°N-15.640936°E, 22 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 10 May 2020, Villa San Giovanni (Reggio Calabria province), roadside, 38.215063°N–15.638823°E, 27 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 8 May 2020, Lazzaro (Reggio Calabria province), roadside, 37.974493°N–15.664018°E, 17 m a.s.l., *leg. et det.* C.M. Musarella (REGGIO); 08 May 2020, Lazzaro (Reggio Calabria province), roadside, 37.974547°N–15.664240°E, 18 m a.s.l., *leg. et det.* C.M. Musarella (REGGIO); 8 May 2020, Lazzaro (Reggio Calabria province), roadside, 37.974068°N–15.664895°E, 17 m a.s.l., *leg. et det.* C.M. Musarella (REGGIO); 8 May 2020, Lazzaro

(Reggio Calabria province), roadside, 37.974218°N–15.665000°E, 18 m a.s.l., *leg. et det.* C.M. Musarella (REGGIO); 13 May 2019, Viale Umberto Zanotti Bianco, Villa San Giovanni (Reggio Calabria province), sidewalk, 38.214597°N–15.637022°E, 8 m a.s.l., *obs. et det.* V.L.A. Laface (REGGIO); 13 May 2020, Viale Umberto Zanotti Bianco, Villa San Giovanni (Reggio Calabria province), roadside, 38.213352°N–15.636946°E, 10 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 13 May 2020, Viale Umberto Zanotti Bianco, Villa San Giovanni (Reggio Calabria province), roadside, 38.212765°N–15.637123°E, 9 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 13 May 2020, Acciarello, Villa San Giovanni (Reggio Calabria province), roadside, 38.208752°N–15.635923°E, 9 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 13 May 2020, Bolano, tra Catona e Villa S. Giovanni (Reggio Calabria province), roadside, 38.205922°N–15.635899°E, 5 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 13 May 2020, Spontone, Catona (Reggio Calabria province), roadside, 38.192740°N–15.636915°E, 11 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 13 May 2020, Sambatello (Reggio Calabria province), roadside, 38.177942°N–15.690210°E, 270 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. *N. gracile* has been observed growing in the crevices of sidewalks, probably escaped from nearby pots or flower beds. In Italy, it is present as naturalized in Campania, Toscana, and Puglia and as a casual alien in Liguria, Piemonte, and Sardegna [1]. *N. gracile* was recently reported in Calabria by Rosati et al. [52] as casual in Lazzaro (Reggio Calabria province). In several locations reported here in *Specimina* (and in particular in Lazzaro), this species has spread everywhere, especially along the edges of the streets. Therefore, due to its rapid spread, we propose here the new status of invasive.

(24) ***Oxalis stricta* L.** [≡*Oxalis europaea* Jord.; *Oxalis fontana* Bunge; *Xanthoxalis stricta* (L.) Small; *Oxalis corniculate* var. stricta (L.) C.C. Huang & L.R. Xu; *Oxalis stricta* f. *lejeunei* Rouy, *Oxalis chinensis* Haw. ex G. Don; *Oxalis cymose* Small; *Oxalis lejeunei* (Rouy) A.W. Hill; *Xanthoxalis cymose* (Small) Small; *Xanthoxalis europaea* (Jord.) Moldenke; *Xanthoxalis fontana* (Bunge) Holub]

Oxalidaceae Neophyte Northern America Scapose hemicryptophyte

Confirmation for Calabria (casual)

*Specimen*: 14 March 2020, Via della Fonderia, Catona (Reggio Calabria province), sidewalk in a roadside, 38.189965°N–15.644670°E, 17 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO). *Observata*: 4 March 2020, Occhio di Pellaro (Reggio Calabria province), sidewalk, 38.035157°N–15.657916°E, 7 m a.s.l., *obs. et det.* V.L.A. Laface; 28 March 2020, Ortì Inferiore (Reggio Calabria province), between the steps of a stairway, 38.147584°N–15.711343°E, 610 m a.s.l., *obs. et det.* V.L.A. Laface.

Note. *O. stricta* grows in the crevices of the walls and sidewalks. It was probably introduced through nurseries or horticultural material. This species is naturalized or invasive in northern Italy and in some regions of central Italy, whereas it is reported as doubtful for Calabria [1]. Our record confirms its presence in the region.

(25) ***Passiflora caerulea* L.**

Passifloraceae Neophyte Southern America Climbing phanerophyte

First record for Calabria (casual)

*Specimen*: 13 September 2019, SP1 Taurianova-Cittanova (Reggio Calabria province), roadside, climbed to a wire mesh, 38.352809°N–16.058705°E, 355 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. Species native to South America, introduced as an ornamental species together with numerous species of the genus *Passiflora* [93]. The only plant found grew by climbing on the wire mesh of an olive grove, very far from inhabited areas. The seeds were probably transported there by birds or small mammals as the fruits are very appetizing to wildlife. *P. caerulea* is reported

as a casual alien in almost all regions of Italy (Abruzzo, Basilicata, Friuli Venezia Giulia, Lazio, Liguria, Lombardia, Marche, Molise, Puglia, Sardegna, Sicilia, Trentino-Alto Adige, Umbria, and Veneto). It is naturalized only in Toscana and Campania [1].

(26) ***Portulaca grandiflora* Hook.**

Portulacaceae Neophyte Southern America Scapose therophyte

First record for Calabria (casual)

*Observata*: 29 July 2019, Via Mercato, Catona (Reggio Calabria province), roadside, 38.185898°N–15.638733°E, 4 m a.s.l., *obs. et det.* V.L.A. Laface; 25 July 2019, Via Nazionale, Catona (Reggio Calabria province), sidewalk, 38.178500°N–15.648642°E; 18 m a.s.l., *obs. et det.* V.L.A. Laface.

Note. *P. grandiflora* cultivated for ornamental purposes in pots and flower beds produces very showy and colorful flowers. The plants observed grew in the crevices of the sidewalk. The species easily reproduces by seed, it is likely that the observed plants are derived from the seeds of pots and flowerbeds nearby. It was previously recorded as a casual alien in Emilia Romagna, Lazio, Liguria, Lombardia, Marche, Piemonte, Sardegna, Trentino Alto Adige, and Veneto, whereas it is naturalized only in Sicilia [1].

(27) ***Prunus armeniaca* L.**

Rosaceae Archeophyte Culton Scapose phanerophyte

First record for Calabria (casual)

*Specimen*: 4 April 2019, Piani di San Nicola, Ortì (Reggio Calabria province), olive grove, 38.151968°N–15.695646°E, 560 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. *P. armeniaca* reproduces very easily by seed, often transported by man. It was not previously recorded as a casual alien species in Italy only for Valle d'Aosta, Puglia, and Friuli Venezia Giulia [1].

(28) ***Prunus dulcis* (Mill.) D.A. Webb** [≡*Amygdalus dulcis* Mill.]

Rosaceae Archeophyte Feral Scapose phanerophyte

First record for Calabria (casual)

*Specimina*: 6 February 2020, C.da Fornace, Strada Gallina-Santa Venere (Reggio Calabria province), near an abandoned almond grove, 38.075486°N–15.724071°E, 491 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 13 September 2019, C.da Pietra, San Carlo (Reggio Calabria province), rocks emerging from the ground, 37.944144°N–15.864352°E, 173 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 13 September 2019, C.da Pietra, San Carlo (Reggio Calabria province), rocks emerging from the ground, 37.943588°N–15.864148°E, 172 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 13 September 2019, C.da Monte Callea (Reggio Calabria province), uncultivated field, 37.935116°N–15.922699°E, 76 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 19 May 2020, C.da Cambareri (Reggio Calabria province), roadside, 38.000372°N–15.676193°E, 357 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 19 May 2020 Motta San Giovanni (Reggio Calabria province) roadside, 37.999761°N–15.685197°E, 414 m a.s.l., leg. et det. V.L.A. Laface (REGGIO).

*Observata*: 6 February 2020, Aretina Superiore (Reggio Calabria province), roadside, 38.068723°N–15.705494°E, 368 m a.s.l., *obs. et det.* V.L.A. Laface; 9 June 2020, Aretina Superiore (Reggio Calabria province), roadside, 38.099403°N–15.722838°E, 380 m a.s.l., *obs. et det.* V.L.A. Laface and CM Musarella.

Note. Fruit tree cultivated mainly for the production of almonds, *P. dulcis* is used as food and in the confectionery industry. The species spreads rapidly by seed; all plants found were grown near almond groves nearby. According to Galasso et al. [1], this species is a casual alien throughout Italy excluding Lombardia, Valle d'Aosta, and Puglia where the species is naturalized.

(29) ***Salpichroa origanifolia* (Lam.) Baill.** [≡*Physalis origanifolia* Lam.]

Solanaceae Neophyte Southern America Frutescent chamaephyte

Change of status for Calabria: from naturalized to invasive (invasive)

*Specimina*: 5 January 2020, Reggio Calabria (Reggio Calabria province), roadside, climbed to a wire mesh, 38.122064°N–15.664753°E, 59 m a.s.l., *leg.* G. Messineo, *det.* C.M. Musarella (REGGIO); 21 February 2020, Pentimele (Reggio Calabria province), roadside, climbed to a wire mesh, 38.142236°N–15.656332°E, 18 m a.s.l., *leg. et det.* C.M. Musarella (REGGIO); 4 March 2020, Catona (Reggio Calabria province), roadside, climbed to a wire mesh, 38.174193°N–15.649876°E, 27 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 3 March 2020, Gallico Inferiore (Reggio Calabria province), roadside, climbed to a wire mesh and on the wall of an old house, 38.166172°N–15.653259°E, 16 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 3 March 2020, Gallico Inferiore (Reggio Calabria province), climbed to a wire mesh and grow in uncultivated garden, 38.165846°N–15.652497°E, 14 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 3 March 2020, Gallico Inferiore (Reggio Calabria province) climbed to a wire mesh, 38.164773°N–15.650404°E, 9 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO); 3 March 2020, Fiumara Scaccioti (Reggio Calabria province), climbing on the bridge span, 38.156481°N–15.657227°E, 18 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

*Observata*: 17 January 2020, Bolano, tra Catona e Villa San Giovanni (Reggio Calabria province), roadside, climbed to a wire mesh, 38.195878°N–15.636748°E, 15 m a.s.l., *obs. et det.* V.L.A. Laface; 10 February 2020, Marinella di Catona (Reggio Calabria province), roadside, climbed to a wire mesh, 38.192642°N–15.635087°E, 4 m a.s.l., *obs. et det.* V.L.A. Laface; 10 February 2020, Spontone (Reggio Calabria province), roadside, climbed to a wire mesh, 38.194584°N–15.635778°E, 5 m a.s.l., *obs. et det.* V.L.A. Laface.

Note. Species already known for Calabria, it has recently been reported as naturalized for the region [49]. The plants observed often grow by climbing on wire mesh in very anthropized areas. In Italy, according to Galasso et al. [1], *S. origanifolia* is naturalized in Abruzzo, Calabria, Lazio, Marche, Piemonte, Puglia, Sicilia, Toscana, Umbria, invasive in Campania, and casual in Emilia-Romagna, Liguria, and Sardegna. For the several new stations found in which this species is so widespread and reproduces itself, we propose here the change of status from naturalized to invasive for Calabria.

(30) ***Sesbania punicea* (Cav.) Benth.** [≡*Piscidia punicea* Cav.]

Fabaceae Neophyte Southern America Scapose phanerophyte

Change of status for Calabria: from naturalized to invasive (invasive)

*Specimen*: 21 August 2019, Lamezia Terme (Catanzaro province), 9 m a.s.l., in a water drainage channel near the airport, between the way and a cultivated field, 38.910900°N–16.252251°E, *leg. et det.* C.M. Musarella (REGGIO).

Note. Recently reported as naturalized for Calabria in the province of Cosenza in 2015 [94], this is the second record for the region of *S. punicea*. This alien species shows a high degree of invasiveness in the new locality; it occupies more or less 100 m in length of a narrow water drainage channel along a road. The plants found were flowering and fruiting and several seedlings were also growing (Appendix B, Figure A9). For this reason, due to its rapid widespread and continuous reproduction, we propose the new status of invasive.

(31) ***Solanum tuberosum* L.**

Solanaceae Neophyte Culton Scapose therophyte

First record for Calabria (casual)

*Specimen*: 11 January 2020, Sambatello (incrocio tra Via 25 Luglio e S.P.7) (Reggio Calabria province), roadside, water drainage channel, 38.179731°N–15.694848°E, 299 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. The sampled plant has probably escaped cultivation from nearby gardens or inadvertently been thrown by man and subsequently transported by water. *S. tuberosum* is reported for all Italian regions as a casual alien excluding Valle d'Aosta, Liguria, Basilicata, and Sicilia [1].

(32) ***Tecoma stans* (L.) Juss. ex Kunth** [≡*Bignonia stans* L.; *Stenolobium stans* (L.) D. Don; *Tecoma stans* (L.) Kunth var. *stans*; *Tecoma stans* (L.) Kunth var. *velutina* DC.]

Bignoniaceae Neophyte Northern America Climbing phanerophyte

First record for Europe (casual)

*Specimen*: 19 October 2019, Svincolo Bocale - S.S. Jonica 106 (Reggio Calabria province), sidewalk, 37.987339°N–15.651794°E, 12 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. Native to southern USA, Mexico, the Caribbean, Peru, and Ecuador [93]. The dispersion occurs mainly through winged seeds dispersed by the wind, produced in large quantities almost all year round [95,96]. The plant observed probably originates from seeds of nearby houses, grown in the cracks of the sidewalk near a high traffic state road (Appendix B, Figure A10). Widely spread worldwide, *T. stans* is reported in Europe only for Malta as *T. stans* var. *sambucifolia* [97], whereas it is not given as present in Malta according to Euro+Med PlantBase [83]. Therefore, we consider this as the first report for Europe.

(33) ***Tradescantia sillamontana* Matuda**

Commelinaceae Neophyte Southern America Rhizome geophyte

First record for Calabria (casual)

*Observata*: 1 December 2019, C.da Monte Callea (Reggio Calabria province), uncultivated field, 37.935131°N–15.922646°E, 76 m a.s.l., *obs. et det.* V.L.A. Laface (REGGIO).

Note. Succulent species cultivated as an ornamental plant for its characteristic "hairy" leaves, it reproduces easily by vegetative way, and the plant probably escaped the cultivation from the nearby villas, after being thrown together with waste material (Appendix B, Figure A11). After the first record for Italy in Campania [98], this is the second one for the country and the first for Calabria.

(34) ***Washingtonia filifera* (Linden ex André) H. Wendl. ex de Bary** [≡*Pritchardia filifera* Linden ex André]

Arecaceae Neophyte Northern America Scapose phanerophyte

First record for Calabria (casual)

*Specimen*: 10 January 2020, lungo la strada tra i dipartimenti di Agraria e di Ingegneria (Reggio Calabria province), sidewalk, 38.120043°N–15.666549°E, 85 m a.s.l., *leg. et det.* V.L.A. Laface (REGGIO).

Note. Several individuals were found along a sidewalk. The seeds that are highly appetizing to birds are transported even at great distances. *W. filifera* has no particular ecological needs; it adapts easily to growing even in unfavorable conditions and is often found in the cracks in

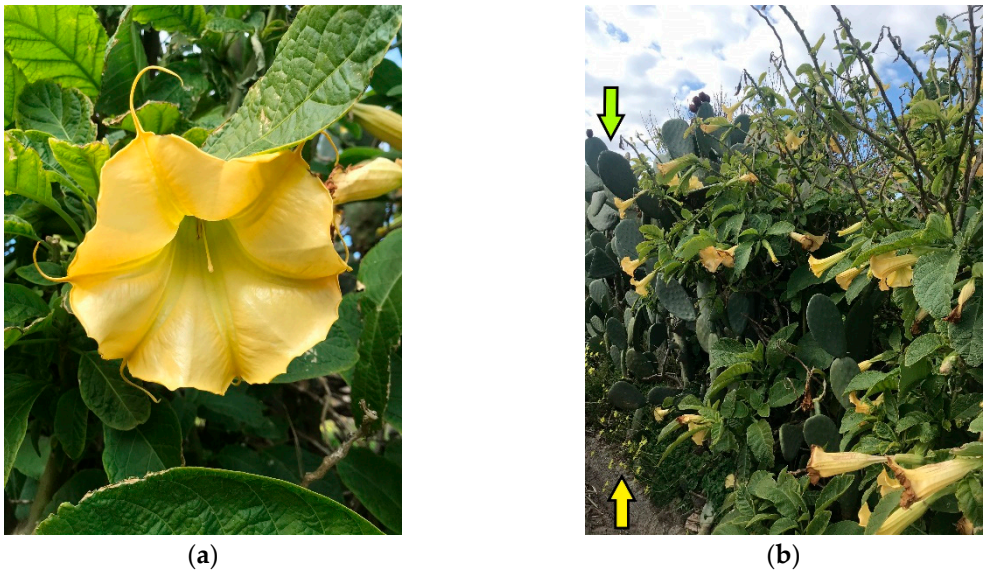
the walls and sidewalks. In Italy, based on Galasso et al. [1], the species is a casual alien in Abruzzo, Campania, Liguria, Puglia, Sardegna, and is naturalized in Sicilia. Recently, Lazzaro et al. [60] proposed this species for its inclusion on a national list of invasive species according to Regulation (EU) No. 1143/2014.

## Appendix B



(**a**) (**b**)

**Figure A1.** Two different cultivars of *Narcissus cv.* collected in the Reggio Calabria province. (**a**) *Narcissus 'Cotinga'* in Piani di Reggio, in grazing-meadow (Photograph VLA Laface); (**b**) *Narcissus 'Erlicheer'* in Pellaro, in a roadside along a wall (Photograph CM Musarella).



(**a**) (**b**)

**Figure A2.** *Brugmansia aurea* Lagerh. found in a roadside in Brancaleone (Reggio Calabria province): (**a**) flower; (**b**) several individuals of *B. aurea* mixed with *Oxalis pes-caprae* L. (yellow arrow) and *Opuntia ficus-indica* (L.) Mill. (green arrow) (Photographs VLA Laface).



(**a**) (**b**)

**Figure A3.** *Cascabela thevetia* (L.) Lippold found (**a**) in a water drainage channel in Melito di Porto Salvo (Reggio Calabria province) and (**b**) mixed with *Phyllostachys aurea* Carrière ex Rivière & C. Rivière in Reggio Calabria (Reggio Calabria province) (Photographs VLA Laface).

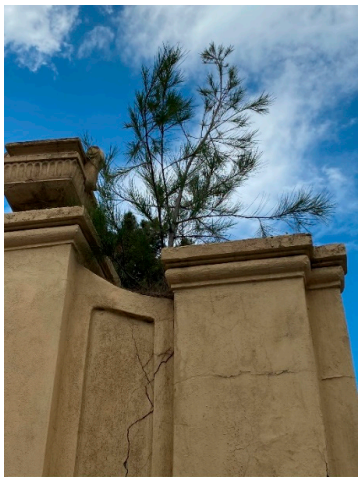


**Figure A4.** Juvenile of *Casuarina equisetifolia* L. on a wall in the city of Reggio Calabria.



(**a**) (**b**)

**Figure A5.** *Cenchrus setaceus* (Forssk.) Morrone widespread both (**a**) in a natural field in Saline Joniche (Reggio Calabria province) (Photograph VLA Laface) and (**b**) along a communication route in Reggio Calabria (Reggio Calabria province) (Photograph CM Musarella).

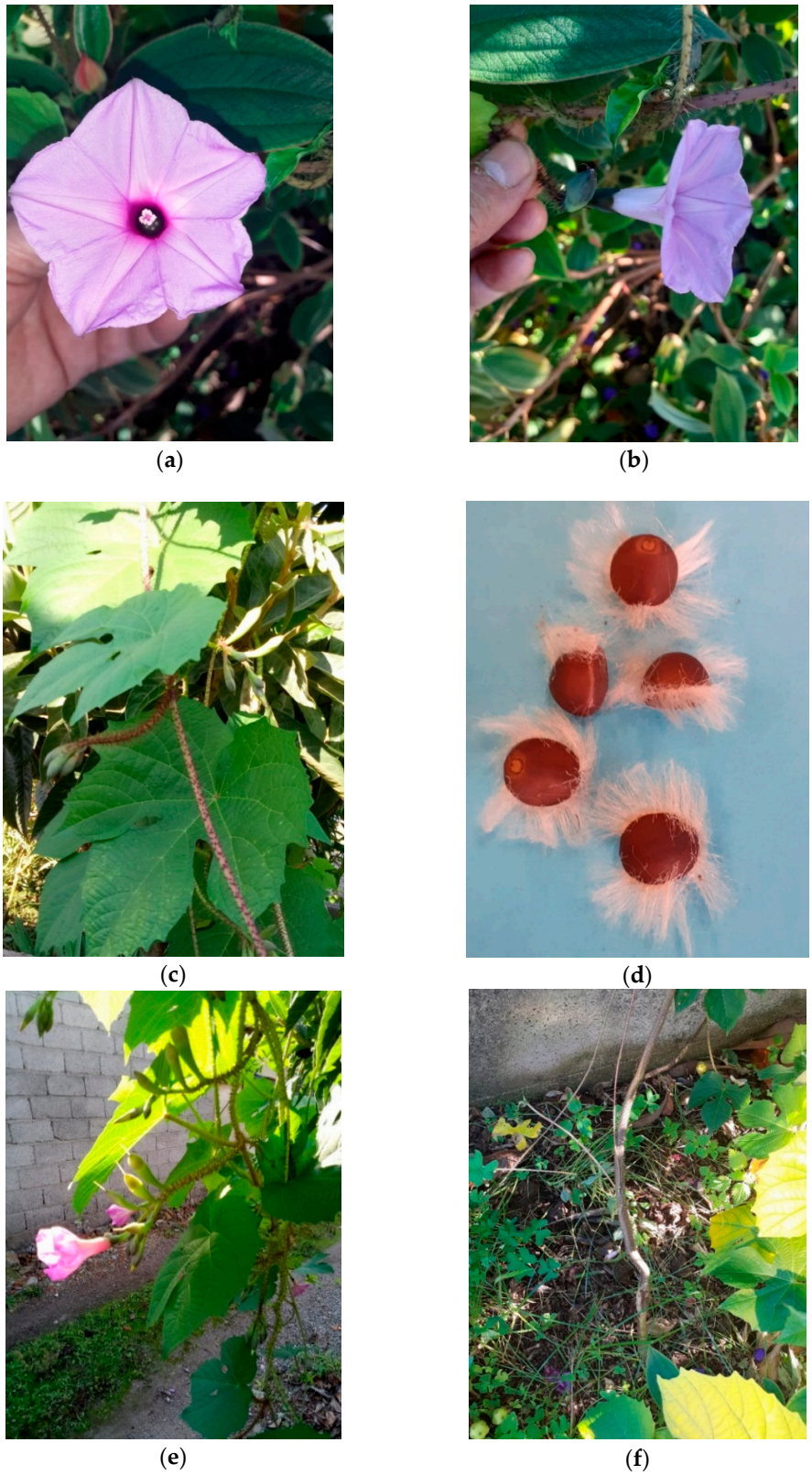


**Figure A6.** *Ipomoea setosa* Ker-Gawl. subsp. *pavonii* (Hallier f.) J.R.I. Wood & Scotland found for the first time in Europe in Rizziconi (Reggio Calabria province). (**a**) Flower in front view; (**b**) flower in side view; (**c**) stem and leaves; (**d**) hairy seeds; (**e**) location of the new record; (**f**) particular of the low part of the plant born along a rural way (Photographs S Cannavò).



(**a**) (**b**)

**Figure A7.** Juveniles of *Juglans regia* L. recorded along the roadside in Reggio Calabria province. (**a**) in Solano; (**b**) in Melia di Scilla (Photographs VLA Laface).



(**a**) (**b**)

**Figure A8.** *Luffa aegyptiaca* Mill. in Fiumara Acrifa (Reggio Calabria province). (**a**) Immature fruits, leaves, and flowers; (**b**) several plants along the riverbed of the fiumara (Photographs VLA Laface).



(**a**) (**b**)

**Figure A9.** *Sesbania punicea* (Cav.) Benth. in a water drainage channel near the airport, between the way and a cultivated field in Lamezia Terme (Catanzaro province). (**a**) Bordered in red, part of the drainage channel occupied by *S. punicea*, together with *Rubus ulmifolius* Schott (yellow arrow) and an individual of *Phoenix canariensis* H. Wildpret (green arrow); (**b**) Fruits and, in the box above on the left, inflorescences of *S. punicea* of the new location of Lamezia Terme (Photographs CM Musarella).



(**a**) (**b**)

**Figure A10.** The individual of *Tecoma stans* (L.) Juss. ex Kunth collected in Bocale (Reggio Calabria province) along the sidewalk of S.S. Jonica 106. (**a**) *T. stans* and, in the background, the S.S. Jonica 106; (**b**) *T. stans* grown between the sidewalk and the road (Photographs VLA Laface).



**Figure A11.** Juvenile of *Tradescantia sillamontana* Matuda found in a crevice in Contrada Monte Callea (Reggio Calabria province) (Photograph VLA Laface).

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ALIEN FLORAS AND FAUNAS 16

# Alien flora in Calabria (Southern Italy): an updated checklist

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**Abstract** An updated checklist of the Calabrian alien vascular flora is presented. By way of field, bibliographic, and herbarium research, we recorded 382 alien taxa (representing almost 14% of all regional flora), of which 371 are angiosperms, nine gymnosperms, and two ferns. In relation to the state of spread, the majority of alien species are casual (207 taxa; 54%), followed by naturalized (127; 33%) and invasive (48; 13%), these last include four on the list of Union Concern, *sensu* Regulation (EU) no. 1143/2014. The most represented families are Asteraceae (39 taxa) and Poaceae (39). Among genera, *Amaranthus* (nine taxa), *Prunus*, *Euphorbia*, and *Oxalis* (seven taxa) make up those with the greatest number of taxa. A total of 21 taxa were reported for the first time, three of them are new to the European flora (*Camptosema rubicundum, Musa* ×*paradisiaca* and, only for continental Europe, *Ipomoea hederacea*), two to the Italian peninsula (*Pelargonium graveolens, Schinus terebinthifolia*) and 16 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, Kalanchoë laxiflora, Nicotiana tabacum, Phytolacca dioica*, *Portulaca umbraticola, Talinum paniculatum, Tecomaria capensis*). In terms of residence status, there are 291 neophytes (76%), 73 archaeophytes (19%), and 18 regional aliens (5%); neophytes are the most represented group (45 out of 48) among invasive taxa. Concerning life forms, the two most abundant groups are therophytes (30.1%, 115 taxa) and phanerophytes (29.6%, 113 taxa). Regarding habitats, 72% of alien taxa occur in artificial (199 taxa, 52%) and agricultural habitats (75 taxa, 20%). The majority of alien taxa are native to the Americas (159; 41.6%), numerous aliens also originated in Asia (76; 19.9%) and Africa (56; 14.7%). The majority of taxa were introduced for ornamental purposes (55%). Over the past decade, alien taxa in the flora in Calabria have

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increased from 190 to the current 382 taxa. While this trend could be linked to some extent to increasing awareness of the problem of alien species and the increasing intensity of research over recent decades, it is also most probably due to new introductions resulting from the globalization that relentlessly affects the whole planet.

**Keywords** Alien species · Biodiversity · Exotic plant · Floristic data · Herbarium specimens · IAS · Invasiveness · New floristic records · Plant diversity

## Introduction

Biological invasions are one of the greatest threats to biodiversity in the world, second only, in terms of severity, to the destruction of natural habitats (Lawler et al. 2006; Pyšek et al. 2020). The annual rate of first records worldwide has increased since 1800, and 37% of these have occurred over the last 44 years (Seebens et al. 2017). Alien species are recognized as a significant component of human-caused environmental global change, which also affects the conservation of biodiversity and the function of invaded ecosystems (Weber 2003; Pyšek et al. 2004; Richardson and Pyšek 2006). Alien species 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 wild floras and are a real challenge for current and future environmental and habitat management (Maes 2013; Pyšek et al. 2020; Gigante et al. 2018; Raposo et al. 2021).

Checklists are essential for studies on biogeography and provide an important tool for biodiversity conservation (Perrino and Signorile 2009; Perrino et al. 2013; Musarella et al. 2018; Wong and Joling 2021). Alien plant checklists are critical to understanding plant invasion 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) Datasets on the floristic state, biological attributes, and the geographic distribution of alien species are significant tools for understanding the invasiveness of alien species (Pyšek et al. 2002, 2004; Haq et al. 2021).

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

Many studies on alien plants are available for Italy on a national or regional scale (Stinca et al. 2017, 2021; Rosati et al. 2020; Galasso et al. 2018a) reported 1741 alien species for the Italian territory, of which 236 are invasive; 20 of these species are included in the EU list according to Regulation 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 up to the present (Galasso et al. 2018b, c, 2019a, b, 2020a, b, 2021a, b). Furthermore, Lazzaro et al. (2019) proposed a list of 96 alien species that should be included in the Italian national list according to EU Regulation 1143/2014.

Calabria, located at the southern end of the Italian peninsula in the centre of the Mediterranean Sea, has been identified by historical and environmental data as a refuge area during Quaternary for several plant taxa, very important for their conservation (Médail and Diadema 2009). Calabria is one of the regions with the highest number of endemic plant taxa (Pignatti 1994). Indeed, after the two large Italian islands of Sicily and Sardinia, Calabria is the third richest region in endemics (Peruzzi et al. 2014).

Various authors have dealt with alien flora in Calabria (Viegi et al., 1974; Celesti-Grapow et al. 2009; Galasso et al. 2018a). Moreover, information on the regional alien flora is available in certain Italian checklists and floras Pignatti 1982, 2017a,b, 2018; Conti et al. 2005; Pignatti et al. 2019). More recently, Bartolucci et al. (2021) provided an updated overview of native and alien vascular flora of Italy, with details on occurrences at national and regional administrative level.

For Calabria, there is a number of recent contributions mainly thanks to the research of this working group (Spampinato et al. 2019; Musarella et al. 2019, 2020; Musarella 2020; Rosati et al. 2020; Laface et al. 2020; Stinca et al. 2021), including many new records, that improved knowledge on alien flora in

this region. Yet, there a comprehensive analysis of the regional alien vascular flora of this region is missing.

The aim of this study is to present an updated checklist of alien vascular flora within the Calabrian region (Southern Italy), with information on the origin, distribution, and invasion status of alien taxa and their habitats. This new and updated data should contribute to filling the knowledge gap on alien species in the Mediterranean region and Southern Europe to the same degree as the better-known alien flora of Central and Northern Italy and temperate Europe.

## Materials and methods

### Study area

Calabria is the southernmost region of the Italian Peninsula (Fig. 1). It has an area of 15,081 km$^2$ with a population of 1,877,728 inhabitants (ISTAT 2021), corresponding to an average density of 126.6 inhabitants/km$^2$.

Calabria is a narrow peninsula in 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 at varying altitudes between 1,400 m and 2,200 m a.s.l., which together constitute the Calabrian Apennines, a continuation of the southern Apennines. The territory is mostly hilly (49% of the area), there are few




**Fig. 1** Geographical position of Calabria region

plains (9%), and large areas are mountainous (42%). As regards land use in Calabria, the following Land Cover Corine categories (ISPRA 2019) are indicated: level 1-artificial surfaces (3.7%), level 2-agricultural areas (48.6%), level 3-forest and seminatural areas 48.3% (of which 31% are forested), level 4-wetlands (0.003%), level 5-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 to ~ 1000–1100 m a.s.l., at higher altitudes, it is the oceanic temperate type (Pesaresi et al. 2017).

The native flora of the Calabria region is estimated at 2,768 native taxa (species and subspecies) (Bartolucci et al. 2018, 2021), with additional 342 aliens reported by previous studies (Galasso et al. 2018a; Bartolucci et al. 2018, 2021).

## Data sources and terminology

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 alien vascular flora in Calabria. The dataset for the current checklist originates from a 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 surveys. Collected specimens are preserved at the Herbarium of the Mediterranean University of Reggio Calabria (REGGIO; acronym according to Thiers 2021). Historical records (species no longer registered for 50 years, probably casual alien that have not established), and doubtful records (doubtfully occurring in the region, probably reported by mistake or confused with other species), are listed in the Online Resource 1 but not analyzed in this study.

Each species record is supplemented with data on taxonomy, life form and growth type, presence status, invasion and residence status, habitats, and frequency. The nomenclature of taxa follows Galasso et al. (2018a) and Bartolucci et al. (2018), that of the 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 assignment of alien plants to genera and families to allow for comparison with native species follows Bartolucci et al. (2018, 2021). Introduction pathways were assessed by distinguishing the following categories: ornamental, forestry, agricultural and unknown (species without information on the purpose of introduction).

We classified the invasion status of alien plant species according to Richardson et al. (2000, 2011) and Pyšek et al. (2004) to distinguish casual (alien plants that may occasionally reproduce outside cultivation without forming 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), and invasive (a subset of naturalized plants with the potential to spread over a large area in natural or man-made habitats, thanks to high reproductive efficiency and their long-distance dispersion ability from parent plants). We also recognized regional aliens that are native to other parts of Italy but alien in Calabria (according to Bartolucci et al. 2018). Plants kept only in cultivation are not included in this study.

Taxa with uncertainty as to whether they are native or alien are considered cryptogenic (Carlton 1996). They are listed in the checklist (Online Resource 1) but not considered in this study.

Alien taxa were distinguished with respect to the residence time, as archaeophytes (introduced before ~ 1500) or neophytes (introduced after ~ 1500), following the criteria suggested by Richardson et al. (2000) and Pyšek et al. (2004). Life forms, according to Raunkiaer classification (Raunkiaer 1934), followed Pignatti (2017a, b, 2018; Pignatti et al. 2019).

The following habitat groups were distinguished according to the Corine Land Cover system (CEC 1994): 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, shrubland, wetland (including water bodies), woodland, and coast. The distribution of taxa among the different habitats was inferred from literature and from

field observations on the frequency of occurrence. When a taxon is present in more than one habitat, the prevailing one is reported.

### Statistical analysis

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

## Results

### Taxonomic diversity

The alien flora of Calabria includes 382 taxa (species, subspecies, and hybrids), belonging to 245 genera and 84 families (Online Resource 1). The taxa recorded belong mainly to angiosperm eudicots (68 families, 283 taxa), followed by monocots (19 families, 88 taxa), gymnosperms (two families, nine taxa), ferns and allies (two families, two taxa). When taking into account the regional vascular flora (Bartolucci et al. 2018, 2021), alien taxa represent 14% of Calabrian flora.

The distribution of alien taxa among the families is strongly unbalanced (Fig. 2). The majority of taxa are members of a few families, mainly Asteraceae (39 taxa), Poaceae (39), Fabaceae (28), and Solanaceae (23), while many families contain one or two alien taxa (Fig. 2).

The genera with the highest number of alien taxa are *Amaranthus* (nine taxa), *Prunus*, *Euphorbia* and *Oxalis* (seven), *Bidens* (six), *Vitis*, *Cyperus*, and *Solanum* (five taxa). Most genera include only one taxon. The richest genera include weed species or species of agronomic interest.

### New aliens to calabrian flora

The field research carried out in this study has identified several new alien vascular taxa for the flora of Calabria. A complete list of these taxa is given in Online Resource 2 with complete information on collection locations and their environmental conditions. Three taxa are new to the European alien flora

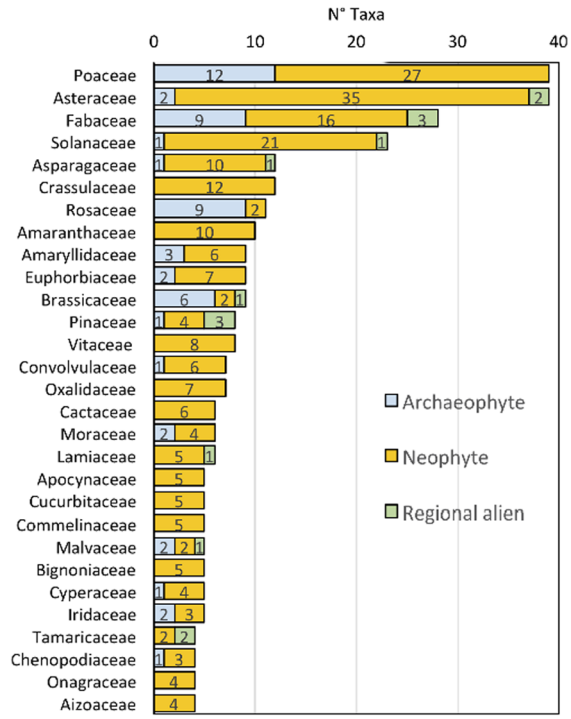



**Fig. 2** The families most represented in Calabrian alien flora (≥4 taxa). Residence status is indicated

(*Camptosema rubicundum, Musa* ×*paradisiaca* and, only for continental Europe, *Ipomoea hederacea*), two to the Italian peninsula (*Pelargonium graveolens*, *Schinus terebinthifolia*) and 16 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, Kalanchoë laxiflora, Nicotiana tabacum, Phytolacca dioica*, *Portulaca umbraticola, Talinum paniculatum, Tecomaria capensis*).

### Species status

In relation to invasion status (Fig. 3), casuals (207 taxa) account for 54% of the flora, naturalized (127 taxa) for 33% and invasive (48 taxa) for 13%. Four invasive species of these are included in the European Union list: *Acacia saligna, Cenchrus setaceus, Ailanthus altissima*, and *Hydrocotyle ranunculoides* (European Commission 2019). The latter species represents new record for the region.

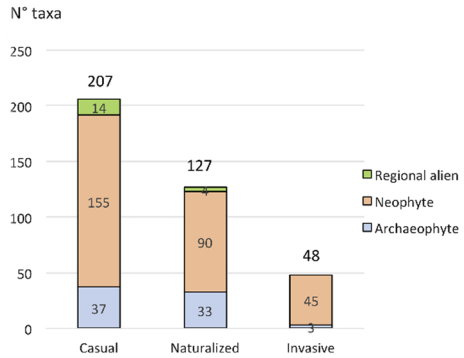



**Fig. 3** Number of taxa by invasion (casual, naturalized and invasive) and residence status (archaeophytes, neophytes, regional aliens)

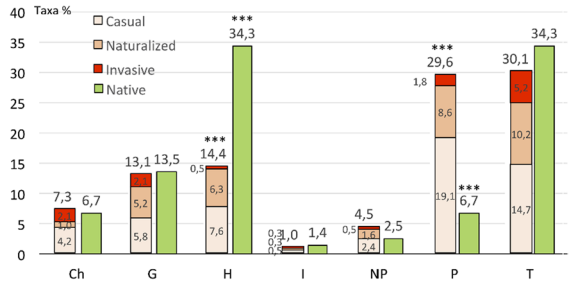



**Fig. 4** Distribution of life forms among casual, naturalized and invasive alien taxa compared with native flora in the Calabria region. Significant differences in the distribution of alien and native flora in particular life-history groups, based on chi-square test, are indicated above the bars (* < 0.05, ** < 0.01, *** < 0.001). Ch–chamaephyte, G–geophyte, H–hemicryptophyte, I–hydrophytes, NP–nanophanerophyte, P–phanerophyte, T–therophyte

Regarding residence status, 76% of Calabrian alien taxa are neophytes (291), 19% are archaeophytes (73) and 5% are regional aliens (18). When comparing residence status and invasion status, neophytes are over-represented among invasive aliens, where they make 94% (45 out of 48 taxa). Archeophytes are over-represented among naturalized taxa (26%), followed by casuals (18%) and invasives (6%). In general, regional aliens are poorly represented in Calabrian flora, being more present among casuals (7%), followed by naturalized (3%) and completely absent among invasives.

## Life forms

The life forms spectrum (Fig. 4) highlights that therophytes (30.1%, 115 taxa) and phanerophytes (29.6%, 113 taxa) are the dominant life forms among Calabrian alien flora, followed by hemicryptophytes (14.4%, 55 taxa), geophytes (13.1%, 50 taxa). Other life forms such as chamaephytes (7.6%, 29 taxa), nanophanerophytes (4.5%, 17 taxa), and hydrophytes (1%, four taxa) are less represented.

Compared to native flora, alien taxa are over-represented among phanerophytes and under-represented among hemicryptophytes, the differences being highly significant ($P < 0.001$). There were no significant differences for the other categories of life forms (Fig. 4). The higher frequency of phanerophytes results from the introduction and widespread use of trees and shrubs for ornamental purposes, such as *Acer negundo, Amorpha fruticosa, Austrocylindropuntia subulata*, *Schinus molle, Sesbania punicea*, but also in forestry (*Acacia saligna, Robinia pseudacacia, Populus* ×*canadensis, Eucalyptus camaldulensis, E. occidentalis*) and in agriculture (i.e., crops such as *Ricinus communis, Vitis rupestris, Opuntia ficus-indica*).

The distribution of phanerophytes and nanophanerophytes compared for casual vs. naturalized taxa, including invasive, was significantly different; taxa of this life form were recorded as casuals with lower frequency than expected and with higher than expected among naturalized. For the other life form categories the differences were not significant (Fig. 5).

## Habitat

In Calabria, alien taxa grow mostly on artificial surfaces (199 taxa, 52%), especially in the urban and suburban territory. There is also significant representation for taxa growing on agricultural surfaces (75 taxa, 20%) such as crops and orchards. As many as 108 taxa (28%) occur in natural and seminatural habitats, especially in riparian places (6%), wetlands (6%), scrublands (5%), and grasslands (5%). Finally, woodlands and coasts are less represented with 3% each.

## Geographical origin

Most of the alien taxa (159) are native to the Americas with 41.6% (97 from South America: 25.4%; 62 from North America: 16.2%). The second most important source region is Asia, providing 76 alien

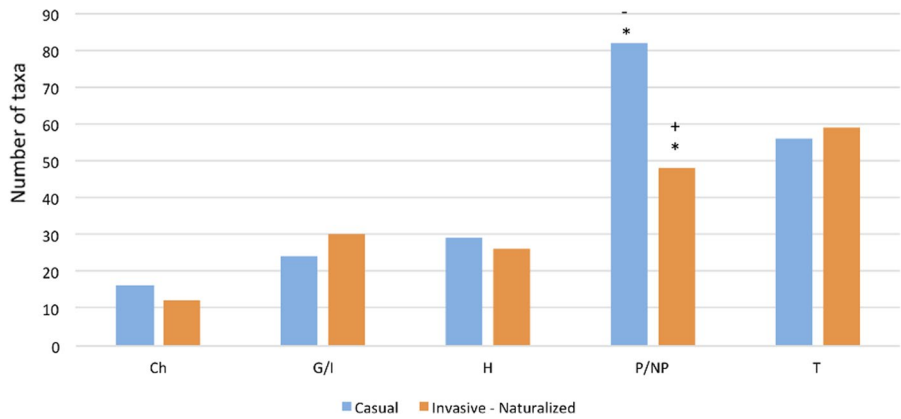



**Fig. 5** Alien taxa in Calabria classified according to life forms, shown for casual and naturalized taxa (including invasive). Significant differences, based on the chi-square test, among these two invasion status groups are indicated for each life form above the bars (-, lower than expected; +, higher than expected, *: $P < 0.05$). Ch–chamaephyte, G–geophyte, H–hemicryptophyte, I–hydrophytes, NP–nanophanerophyte, P–phanerophyte, T–therophyte

taxa (19.9%); Africa follows with 56 (14.7%). Fewer species are native to the Mediterranean region (8.9%), Europe (4,7%), and Eurasia (3.9%). Finally, 2.4% are currently spread over a large distribution area (cosmopolitan), 2.1% come from Australia, and another 1.8% are of uncertain origin (Fig. 6).

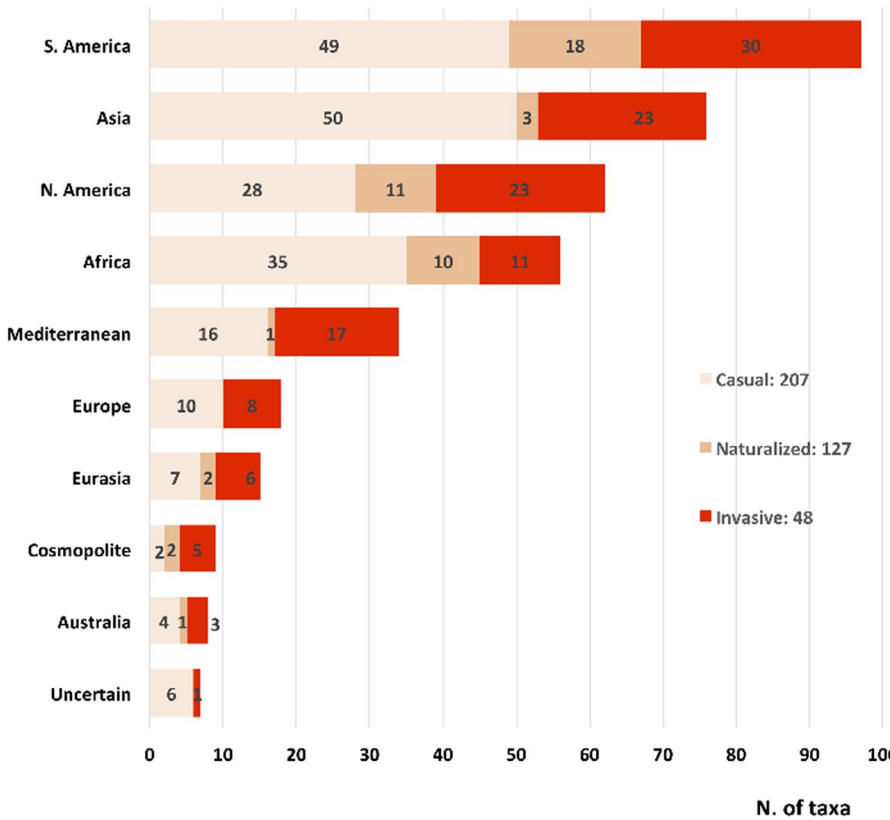



**Fig. 6** Geographical origin of alien vascular flora of Calabria. The numbers of taxa are shown, with residence status indicated

Introduction pathways

Most alien species were introduced intentionally as ornamental plants (55.2%), for agriculture (19.1%) and forestry (3.4%). Unintentional introductions account for 22.3%, often as contaminated seed supply or with soils.

## Discussion

The data reported by several scholars highlights a hyperbolic increase of alien species in Calabria, especially in recent years. The records of alien plant taxa to Calabrian flora increased from just 12 in 1974 (Viegi et al. 1974), to 163 (Pignatti 1982), 190 in 2009 by Celesti-Grapow et al. (2009), 267 of Galasso et al. (2018a), 284 (Pignatti 2017a,b; Pignatti et al. 2019), and, finally, 342 taxa were recorded by Bartolucci et al. (2021). Moreover, Conti et al. (2005) reported 119 invasive and naturalized taxa for Calabrian flora, excluding casual ones, as previously recorded by other authors. Our survey yielded 382 taxa for alien Calabrian vascular flora. According to Bartolucci et al. (2018, 2021), the native regional flora of Calabria includes 2,786 taxa (including species, subspecies and hybrids), therefore, approximately 14% of the regional flora is made up of alien taxa. The rapid increase in alien taxa is due to new introductions, as a result of globalization, which affect the entire planet, producing biotic homogenization (Stohlgren et al. 2011). However, there is an awareness of the problem of alien species and an increase of studies in recent decades.

The comparison with other Mediterranean countries, such as Algeria (211 alien plant taxa) (Meddour et al. 2020), Turkey (340 taxa) (Uludağ et al. 2017) or Greece (343) (Arianoutsou 2010a), highlights the abundance of alien taxa (including casual, naturalized and invasive aliens) in Calabrian flora, considering that these Mediterranean territories are much larger. This data is confirmed by the density of alien taxa in Calabria (log taxa/log $km^2$ of area), which is 0.62, and ranks Calabria among the Mediterranean territories with the highest levels of invasion; the corresponding value for Greece is 0.50, for Algeria 0.36 and Turkey 0.43. Compared to other Italian regions, the number of alien taxa in Calabria corresponds to other less populated agricultural regions, such as Puglia (202.2 inhabitants/$km^2$; 361 alien taxa) and Abruzzo (117.6 inhabitants/$km^2$; 350), far from the industrialized and densely populated regions of the north of Italy, such as Lombardy (417.6 inhabitants/$km^2$; 776) and Veneto (264.6 inhabitants/$km^2$; 618) (ISTAT 2021; Galasso et al. 2018a).

The richest families of Calabrian alien flora are Asteraceae, Poaceae, Fabaceae, and Solanaceae, which are also dominant in other European alien floras (Pyšek et al. 2002; Lambdon et al. 2008; Galasso et al. 2018a) and globally (Pyšek et al. 2017). Poaceae, Fabaceae, and Asteraceae are also the largest families in the native Mediterranean flora (Heywood et al. 2007). On the other hand, the Solanaceae family is less represented in native Calabrian flora but is mainly an extra-European plant family with many taxa introduced as cultivated plants (Tutin et al. 1972).

The genus *Amaranthus* is the most representative in Calabrian alien flora, among other genera, as well as in several countries of the world (Pyšek et al. 2017; Galasso et al. 2018a; Weber et al. 2008; Lambdon et al. 2008). In addition to this genus of North American origin, there are also others, such as *Bidens*, *Cyperus*, and *Solanum*, comprising mainly urban and agricultural weeds (Lambdon et al. 2008).

The prevailing life form among aliens in Calabria are therophytes and phanerophytes that have approximately the same percentage; overall, woody species (phanerophytes and nanophanerophytes) are more abundant than therophytes. This pattern is different from the native flora of Calabria, where the most represented groups are therophytes and hemicryptophytes (Fig. 4). The preponderance of phanerophytes/nanophanerophytes among aliens is a common character in invasive floras in various territories due to the preference of gardeners for ornamental trees (Crawley et al. 1996). In the alien flora of other Mediterranean territories, such as Greece (Arianoutsou et al. 2010b) and Sardinia (Podda et al. 2012), a common feature is the dominance of phanerophytes/nanophanerophytes and therophytes that appear best suited to overcome the long dry seasons typical of the Mediterranean bioclimate (Wagner et al. 2017). They occupy different niches, and their success in colonizing new territories is based on them possessing different strategies – phanerophytes cope with water scarcity through their architecture, while therophytes avoid the dry season (Allen 2001).

Alien taxa are present in Calabria in artificial, comprising human-disturbed and urban sites, and agricultural habitats, but a significant percentage occur in natural and seminatural habitats. This is quite alarming because it shows that about a third of alien taxa grow in natural environments that are vulnerable due to the anthropic pressure linked to urbanization.

Most Calabrian alien taxa are of neotropical origin. These are thermophilous taxa coming from South America that are favoured by the Mediterranean bioclimate that affects a large part of the region, up to about 1000 m of altitude. An important group of alien plants also comes from Asia; these are plants of warm environments, too, that easily spread in the Mediterranean territories. Some studies show that global warming favours the spread of alien tropical or subtropical taxa in Europe, mainly introduced into gardens for ornamental purposes (Dullinger et al. 2017). The majority of alien taxa are introduced as ornamental plants, including in Calabria, and especially in urban areas, which represent preferential routes for invasive taxa; favoured by global warming, such species can easily spread to the surrounding areas (Géron et al. 2021).

## Conclusions

This study highlights a progressive and constant increase in alien taxa in the vascular flora of Calabria and provides a baseline for further studies on the management of invasive species and invasion ecology. The habitats located at lower altitudes (0–200 m a.sl.m.) are most threatened by the spread 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 invasions of alien taxa (See ESM 2). 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 that have escaped from gardens, confirming the importance of ornamental plant cultivation as a source of such introductions.

Any 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 make citizens aware of the rules and behaviour needed, especially in nursery fields (Caddeo et al. 2020).

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RESEARCH ARTICLE

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# Notulae to the Italian alien vascular flora: 8

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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, confirmations, exclusions, and status changes for Italy or for Italian administrative regions of taxa in the genera *Bunias*, *Calocedrus*, *Calycanthus*, *Celosia*, *Clerodendrum*, *Convolvulus*, *Crassula*, *Cyclamen*, *Datura*, *Dicliptera*, *Eragrostis*, *Erigeron*, *Gamochaeta*, *Gazania*, *Impatiens*, *Kolkwitzia*,

*Leucaena*, *Ludwigia*, *Medicago*, *Muscari*, *Nigella*, *Oenothera*, *Opuntia*, *Paulownia*, *Petroselinum*, *Phyllostachys*, *Physalis*, *Pseudosasa*, *Quercus*, *Reynoutria*, *Roldana*, *Saccharum*, *Sedum*, *Semiarundinaria*, *Senecio*, *Sisyrinchium*, *Solanum*, *Sporobolus*, *Tulipa*, *Vachellia*, *Verbena*, and *Youngia*. Nomenclatural and distribution updates published elsewhere are provided as Suppl. material 1.

**Keywords**
Alien species, floristic data, Italy

## How to contribute

The text for the new records should be submitted electronically to Chiara Nepi (chiara.nepi@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 (typifications only for accepted names), status changes, exclusions, and confirmations should be submitted electronically to: Gabriele Galasso (gabriele.galasso@comune.milano.it). Each text should be within 2,000 characters (spaces included).

## Floristic records

### *Bunias orientalis* L. (Brassicaceae)

+ (NAT) **EMR**. – Status change from casual to naturalized alien for the flora of Emilia-Romagna.

In Italy, this species was already cultivated in botanical gardens in the late 18$^{th}$ century (e.g., in Pavia, see Anonymous 1785) and was first recorded as a casual alien in 1897 (Penzig 1897; Béguinot and Mazza 1916). *Bunias orientalis* now occurs as a casual alien in most of the northern regions, with the exceptions of Piemonte and Friuli Venezia Giulia, where it is considered naturalized (Galasso et al. 2018a). In Emilia-Romagna, it is known as casual in the province of Ferrara (Piccoli et al. 2014). On July 2$^{nd}$, 2019, a large population was discovered in the locality Casino of the former municipality of Nibbiano (now Alta Val Tidone), province of Piacenza (WGS84: 44.945631N, 9.332003E). Here, fruiting individuals form a thick stand of 3,350 m$^2$, with a 75% cover, on waste land colonized by *Artemisia vulgaris* L., *Cirsium arvense* (L.) Scop., *Elymus repens* (L.) Gould subsp. *repens*, and *Sambucus ebulus* L. More than 1,200 rosettes were counted across a mowed wheat field of 31,000 m$^2$ in locality Casa Castellina (WGS84: 44.946498N, 9.330900E) and further individuals were observed along the nearby roadsides. This species, similarly to other European countries (see e.g., Clement and Foster 1994), was likely introduced as a grain impurity. The pronounced tendency to invasiveness in these localities needs to be monitored.

N.M.G. Ardenghi, S. Bodino, S. Lodetti

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

+ (CAS) **TOS**: Firenze (Firenze), Parco delle Cascine, alla confluenza tra il Torrente Mugnone e il Fiume Arno (WGS84: 43.790598N, 11.197569E), 50 m, 3 February 2019, *L. Pinzani* (FI). – Casual alien species new for the flora of Toscana.

*Calocedrus decurrens* has been already recorded as casual in Lombardia, Umbria, and Sardegna (Galasso et al. 2018a). Some young individuals originated by seeds from nearby cultivated plants were found in Firenze, at the Cascine Park.

L. Pinzani

***Calycanthus floridus* L. (Calycanthaceae)**

+ (CAS) **MAR**: San Benedetto del Tronto (Ascoli Piceno), aiuola presso Viale delle Palme (WGS84: 42.949722N, 13.884780E), epifita su stipite di *Phoenix canariensis*, ca. 8 m, 9 July 2019, *N. Olivieri* (FI). – Casual alien species new for the flora of Marche.

*Calycanthus floridus* is an ornamental species native to southeastern North America and introduced in Italy in 1788 (Maniero 2015). In Italy, it is known as casual alien only in Toscana (Galasso et al. 2018a). Some young individuals of the species have developed as epiphytes on the trunk of a young *Phoenix canariensis* H.Wildpret, settling among the remains of fibrous tissue present among the stumps of the leaf rachids. The plants developed from seeds produced by a shrub cultivated in a flowerbed at a short distance. The area is located in a rather sheltered position due to the presence of groups of *Pinus halepensis* Mill. subsp. *halepensis* and alignments of buildings that limit insolation and reduce the influence of the eastern sea winds, creating a cooler microclimate.

N. Olivieri

***Celosia argentea* L. (Amaranthaceae)**

+ (CAS) **SIC**: Polizzi Generosa (Palermo), strada SS643 (WGS84: 37.839167N, 13.960000E), bordo stradale, ca. 550 m, 12 September 2005, *G. Domina*, *S.L. Jury* (PAL); Ciminna (Palermo), strada SP33 (WGS84: 37.895676N, 13.544894E), bordi stradali, ca. 600 m, 7 October 2018, leg. *F. Scafidi*, det. *F. Scafidi*, *G. Domina* (FI). – Casual alien species confirmed for the flora of Sicilia.

This species was likely introduced in Italy for ornamental purposes, and the individuals found along the roadside may have originated from cultivated plants growing nearby. This species was identified according to Iamonico (2013). In Galasso et al. (2018a), it is reported as casual alien for many Italian administrative regions, but not recently recorded from Sicilia.

F. Scafidi, G. Domina

***Clerodendrum trichotomum* Thunb. (Lamiaceae)**

+ (CAS) **TOS**: Borgo San Lorenzo (Firenze), fraz. Panicaglia, ex stazione ferroviaria lungo la ferrovia Faentina (WGS84: 43.978605N, 11.407556E), alcune piante spontaneizzate ai

margini di un giardino in vicinanza di piante adulte coltivate, 281 m, 8 November 2018, *M. Mugnai*, *A. Misuri*, *G. Ferretti* (FI). – Casual alien species new for the flora of Toscana.

This species was already recorded in Italy as naturalized, mostly in northern Italy. Some young individuals were found at the railway station of Panicaglia, probably originating from adult fruiting plants of a neighboring garden. Given the ephemeral condition of the occurrence site, we consider this species as casual for Toscana.

M. Mugnai, A. Misuri, L. Lazzaro

***Convolvulus sabatius* Viv. subsp. *mauritanicus* (Boiss.) Murb. (Convolvulaceae)**

+ (NAT) **PUG**: Giovinazzo (Bari), tra Giovinazzo e Santo Spirito (comune di Bari) (WGS84: 41.179111N, 16.689172E), margine stradale, 3 m, 29 May 2019, leg. *V. Buono*, det. *R.P. Wagensommer* (FI, BI Nos. 42141, 42142); Lecce (Lecce), presso il cimitero (WGS84: 40.359449N, 18.165857E), aiuola incolta, 40 m, 15 June 2019, *P. Medagli* (LEC). – Naturalized alien subspecies new for the flora of Puglia.

*Convolvulus sabatius* was first recorded from Puglia near Giovinazzo (Bianco 1969) and then collected in Salento (Marchiori et al. 1993), Bari and Monopoli (Perrino et al. 2013). These collections were all attributed to *C. sabatius* subsp. *sabatius*. Our gatherings, from Giovinazzo and Lecce, show long spreading hairs on stems, leaves and calyx and are, therefore, attributed to *C. sabatius* subsp. *mauritanicus*, according to Carine and Robba (2010) and Wood et al. (2015). Consequently, we consider *C. sabatius* subsp. *sabatius* as recorded from Puglia by mistake (Bartolucci et al. 2019).

R.P. Wagensommer, V. Buono, P. Medagli

***Crassula muscosa* L. (Crassulaceae)**

+ (CAS) **MAR**: San Benedetto del Tronto (Ascoli Piceno), Via C. Colombo (WGS84: 42.956186N, 13.882666E), epifita su stipite di *Phoenix canariensis*, ca. 6 m, 9 July 2019, *N. Olivieri* (FI). – Casual alien species new for the flora of Marche.

*Crassula muscosa* is native to southern Africa and is widely cultivated as ornamental. In Italy, it is known as casual alien in Toscana, Campania, and Sicilia, while it is considered naturalized in Liguria, Calabria, and Sardegna (Galasso et al. 2018a). Some individuals of this species grow as epiphytes on the trunk of a *Phoenix canariensis* H.Wildpret inside the city. The plants have developed among the residues of fibrous tissue between the remains of the cut leaf rachids, in a partially shaded position. Individuals may have arisen *via* vegetative propagation from fragments of plants grown for ornamental purposes in nearby buildings.

N. Olivieri

***Cyclamen persicum* Mill. (Primulaceae)**

+ (CAS) **LIG**: Genova (Genova), lungo Via Tortona (WGS84: 44.42558N, 8.95276E), a bordo strada, nelle crepe dell'asfalto, 81 m, 18 April 2019, *A. Di Turi*, *C. Aristarchi* (FI, GE). – Casual alien species new for the flora of Liguria.

*Cyclamen persicum* is a widely cultivated plant, whose native range extends from Algeria to the eastern Mediterranean. It is reported in Italy as a casual alien for Lombardia (Banfi and Galasso 2010), Sardegna (Lazzeri et al. 2015), and Lazio (Nicolella 2018). Well-developed specimens were first recorded in 2000 in Viale G. Odino in the centre of Genova. Recently other specimens have been found at three different sites, both in the city centre (Via Fieschi, WGS84: 44.403397N, 8.935548E, 36 m) and in more peripheral sites (Via V. Bocciardo, WGS84: 44.404441N, 8.993866E, 168 m; and Via Tortona). All grow in the cracks of sidewalks, without any other species nearby. One of them was in bloom when recorded (April 2019).

A. Di Turi, C. Aristarchi

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

+ (CAS) **MAR**: Urbino (Pesaro e Urbino), fraz. Canavaccio, lungo il Fiume Metauro (WGS84: 43.688780N, 12.700244E), greto fluviale, ca. 175 m, 13 September 2018, *L. Gubellini*, *N. Hofmann* (FI, PESA). – Casual alien species new for the flora of Marche.

*Datura wrightii* is an annual plant native to the southwestern United States and Mexico (Verloove 2008). It is reported as casual alien in almost all regions of northern and central Italy (Lombardia, Veneto, Trentino-Alto Adige, Friuli Venezia Giulia, Liguria, Emilia-Romagna, Umbria, Lazio, Abruzzo, Campania, Puglia, and Calabria), as naturalized alien for Toscana and Sicilia, and as invasive alien for Sardegna (Galasso et al. 2018a). In Marche, a single individual was observed with abundant flowers and fruits in a stony bank along the Metauro River, far from gardens and urban centre. This species has been long confused with the related *D. inoxia* Mill., less common in Italy, which differs from *D. wrightii* for the type of indument (Verloove 2008).

L. Gubellini, N. Hofmann

***Dicliptera squarrosa* Nees (Acanthaceae)**

+ (CAS) **ITALIA** (**TOS**): Seravezza (Lucca), fraz. Querceta, vicino all'ingresso della stazione ferroviaria "Forte dei Marmi-Seravezza-Querceta", Via Ragazzi del '99 (WGS84: 43.978158N, 10.198074E), margine stradale, 18 m, 23 October 2018, *M. Mugnai*, *L. Lazzaro*, *G. Ferretti* (FI). – Casual alien species new for the flora of Italy (Toscana).

*Dicliptera squarrosa* is an ornamental plant native to South America, which presents several forms, separated mostly geographically and hardly forming discrete units (Wasshausen and Wood 2004). This species is currently widely available for sale worldwide and is largely used also in Italy. We found one flowering individual clearly escaped from cultivation close to the Querceta railway station. According to some authors (J. Wood, pers. commun.), the forms cultivated in Europe should be referred to *Dicliptera suberecta* (André) Bremek., currently considered as a synonym of *D. squarrosa* (Zuloaga et al. 2008). Nevertheless, further studies are needed to solve this issue and we prefer to provisionally maintain this record under *D. squarrosa*.

M. Mugnai, L. Lazzaro, F. Pasquini, G. Ferretti

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

+ (CAS) **MAR**: Gradara (Pesaro e Urbino), presso il cimitero comunale (WGS84: 43.942494N, 12.769445E), incolto erboso (oliveto abbandonato), ca. 330 m, 16 November 2018, *L. Gubellini*, *N. Hofmann* (FI, PESA). – Casual alien subspecies new for the flora of Marche.

*Eragrostis mexicana* subsp. *virescens* is an alien annual grass from South America recorded in Europe since 1927, and in Italy since 1975 (Martini and Scholz 1998). Until now, it was reported in Italy as naturalized alien in northern regions (Piemonte, Liguria, Lombardia, Veneto, Trentino-Alto Adige, Friuli Venezia Giulia, Emilia-Romagna) and Calabria, and as casual alien for Valle d'Aosta, Lazio, Campania, and Puglia (Galasso et al. 2018a). A large number of individuals were detected by S. Montanari (pers. commun.) in an uncultivated grassy field, and the abundance of specimens suggests a naturalization of the species, which can be confirmed by monitoring the site.

L. Gubellini, N. Hofmann

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

+ (NAT) **MAR**: Ancona (Ancona), porto antico (WGS84: 43.623791N, 13.509335E), mura in pietra del porto antico e degli scavi adiacenti, 10 m, 28 August 2018, *G. Mei* (*Herb. G. Mei*); Sirolo (Ancona), piazzetta del belvedere e centro storico (Piazzale Marino) (WGS84: 43.522444N, 13.621030E), mura in pietra e bordure degli spazi verdi, 110 m, 12 November 2018, *G. Mei* (FI, ANC, *Herb. G. Mei*); Piobbico (Pesaro e Urbino), vicino al ponte sul Torrente Biscubio (WGS84: 43.352610N, 12.303703E), mura in pietra, ca. 330 m, 21 November 2018, *L. Gubellini*, *N. Hofmann* (FI, PESA). – Naturalized alien species new for the flora of Marche.

*Erigeron karvinskianus* is an American perennial species native to Mexico and Guatemala which occurs all over western Europe, probably escaped from floriculture. To date, it is present in almost all the Italian territory, with the exception of Valle d'Aosta, Molise, Basilicata, and Sardegna (Galasso et al. 2018a). In all the recorded localities, this species was also observed near road edges and in unmanaged flowerbeds, mainly colonizing the gaps in walls, where it seems to be more competitive than other species, such as *Cymbalaria muralis* G.Gaertn., B.Mey. & Scherb. subsp. *muralis*, *Linaria vulgaris* Mill. subsp. *vulgaris*, and *Parietaria judaica* L. In all the sites, this species is in expansion, in particular in Piobbico, a site monitored since 2016.

L. Gubellini, N. Hofmann, G. Mei

+ (INV) **CAM**: Castellammare di Stabia (Napoli), tra il Castello Angioino e Quisisana (WGS84: 40.687474N, 14.481252E), muro in pietra calcarea, 135 m, 24 April 2013, *A. Stinca* (PORUN-Herb. Stinca); *ibidem* (WGS84: 40.687493N, 14.481536E), muro in pietra calcarea, 130 m, 29 September 2018, *A. Stinca* (PORUN-Herb. Stinca); Ravello (Salerno), Villa Rufolo (WGS84: 40.648479N, 14.613078E), muro in pietra cal-

carea, 353 m, 10 March 2014, leg. *A. Stinca*, *M. Ravo*, det. *A. Stinca* (PORUN-Herb. Stinca). – Status change from naturalized to invasive alien for the flora of Campania.

*Erigeron karvinskianus* was reported as naturalized for Campania by Galasso et al. (2018a). However, we found this alien plant, in dense and extensive populations, mostly on walls of limestone and tuff blocks of several sites in the Sorrento peninsula. In these environments, it easily spreads by abundant seed production and competes strongly with endemic species, such as *Campanula fragilis* Cirillo subsp. *fragilis*. Therefore, this species should be considered invasive in Campania.

A. Stinca, A. Esposito

***Gamochaeta pensylvanica* (Willd.) Cabrera (Asteraceae)**

+ (NAT) **CAL**: Reggio Calabria (Reggio Calabria), Catona (WGS84: 38.185074N, 15.637955E), marciapiedi, 2 m, 12 June 2019, leg. *V.L.A. Laface*, det. *V.L.A. Laface*, *C.M. Musarella*, *G. Spampinato* (FI, REGGIO); Villa San Giovanni (Reggio Calabria), Viale U. Zanotti Bianco (WGS84: 38.214703N, 15.637015E), marciapiedi, 8 m, 26 June 2019, *V.L.A. Laface* (REGGIO); Reggio Calabria (Reggio Calabria), Cittadella Universitaria (WGS84: 38.121004N, 15.662473E), aiuola, 80 m, 26 June 2019, *V.L.A. Laface*, *C.M. Musarella*, *G. Spampinato* (REGGIO); Campo Calabro (Reggio Calabria), Musalà (WGS84: 38.214607N, 15.672014E), bordo strada, 154 m, 30 June 2019, *V.L.A. Laface* (REGGIO); Reggio Calabria (Reggio Calabria), Gallico Marina (WGS84: 38.169410N, 15.651119E), marciapiedi, 16 m, 10 July 2019, *V.L.A. Laface* (REGGIO). – Naturalized alien species new for the flora of Calabria.

*Gamochaeta pensylvanica* is native to North America. In Italy, its first record by Moraldo and La Valva (1989) for Campania, was erroneously attributed by these authors to *G. purpurea* (L.) Cabrera (Soldano 2000) and then recorded in the same region by Stinca et al. (2016, 2018). The origin of the introduction of this species in Italy is uncertain. Probably, *G. pensylvanica* arrived in Italy through the importation of potting soil used in plant nurseries. Currently, according to Galasso et al. (2018a), *G. pensylvanica* is a naturalized alien species in Campania, Piemonte, Lombardia, Emilia-Romagna, and Sicilia, whereas it is casual in Toscana, Lazio, and Puglia. In Calabria, this species was observed for the first time in 2008 in locality Catona (Reggio Calabria).

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

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

+ (CAS) **CAL**: San Calogero (Vibo Valentia), Via L. Pirandello (WGS84: 38.576041N, 16.023808E), bordo strada, 256 m, 9 June 2019, *C.M. Musarella* (FI, REGGIO). – Casual alien species new for the flora of Calabria.

*Gazania linearis* has its native range in South Africa and Lesotho. Since it has been cultivated as an ornamental plant since the 19$^{th}$ century, it has become an invasive plant in several regions of the world (Hassler 2019). In Italy, according to Galasso et

al. (2018a), this species is a casual alien to Toscana, Molise, and Puglia, whereas it is doubtfully recorded for Sardegna.

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

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

+ (INV) **TOS**: Abetone Cutigliano (Pistoia), fra Pianosinatico e Cecchetto in loc. Serrabosco, versante SE di Poggio del Romito (WGS84: 44.125410N, 10.717628E), bosco misto di conifere di impianto con residui di faggeta, 900 m, 21 July 2019, *F. Roma-Marzio*, *M. D'Antraccoli*, *L. Peruzzi* (PI No. 025544). – Status change from naturalized to invasive alien for the flora of Toscana.

*Impatiens parviflora* is native to central and eastern Asia and represents one of the most widespread aliens in central Europe, being the only alien plant widespread in European forests (Godefroid and Koedam 2010; Hejda 2012). In Italy, this species is reported as naturalized in Friuli Venezia Giulia, Emilia-Romagna, Liguria, Toscana, and Lazio, and as invasive in Valle d'Aosta, Piemonte, Lombardia, Trentino-Alto Adige, and Veneto (Galasso et al. 2018a). During a field survey conducted in the Tuscan Apennines, we noticed a large population of this species. The plants are particularly dense, totally covering the herbaceous layer in shady sites and showing a preference for dry, acidic and nutrient-poor soil conditions, as also highlighted by Godefroid and Koedam (2010). Accordingly, we retain the status of invasive species as more appropriate for *I. parviflora* in Toscana.

F. Roma-Marzio, M. D'Antraccoli, L. Peruzzi

***Kolkwitzia amabilis* Graebn. (Linnaeaceae)**

+ (CAS) **PIE**: Avigliana (Torino), piazzola di sosta lungo la via che porta alla Sacra di San Michele (WGS84: 45.065342N, 7.375007E), margine stradale, ca. 400 m, 8 May 2019, *M. Arnoul*, *M. Lonati* (FI, TO). – Casual alien species new for the flora of Piemonte.

This ornamental species is native to China. It is reported in Italy as casual only for Lombardia (Galasso et al. 2018a).

M. Arnoul, M. Lonati

***Leucaena leucocephala* (Lam.) de Wit subsp. *glabrata* (Rose) Zárate (Fabaceae)**

+ (CAS) **SAR**: Sestu (Cagliari), loc. Su Moriscau, presso la strada provinciale (WGS84: 39.165891N; 9.044471E), aree incolte, 26 m, 11 July 2019, *A. Lallai* (FI, CAG); Monserrato (Cagliari) (WGS84: 39.150639N, 9.084440E), bordo strada, 15 m, 13 July 2019, *L. Podda* (CAG). – Casual alien subspecies new for the flora of Sardegna.

This subspecies is native to central America and southern Mexico, and it was introduced in many countries for several purposes, sometimes becoming invasive (Hughes 1998a, 1998b). In Italy, it has been reported as naturalized in Sicilia (Raimondo and Domina 2007; Pignatti et al. 2017; Galasso et al. 2018a). In Sardegna, it has been ob-

served since 2006 in the industrial area of Sestu, where some plants are growing not far from the cultivated parental plants. Some saplings and young trees have also been observed in the surroundings of Monserrato, in fallow land and roadsides close to Via C. Cabras.

A. Lallai, L. Podda, G. Bacchetta

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

+ (NAT) **LAZ**: Bracciano (Roma), fraz. Vigna di Valle, Museo Storico dell'Aeronautica Militare, sul Lago di Bracciano (WGS84: 42.085342N, 12.218902E), sulla spiaggia e sulla riva del lago, 162 m, 12 June 2019, *S. Buono* (FI). – Naturalized alien species new for the flora of Lazio.

*Ludwigia hexapetala* is a herbaceous perennial plant native to central and South America; its habitat includes lakeshores, ponds, ditches, and streams. The large tolerance of this species to the variations of hydrological and climatic conditions, as well as the strong ability to colonize both beaches and swamps, make it a noxious invader of aquatic ecosystems in North America and in Europe, where it is reported (as included in *L. grandiflora* (Michx.) Greuter & Burdet) in the list of invasive alien species of Union concern (Regulation (EU) n. 1143/2014). It was recorded for Italy by Galasso (2007), based on specimens collected in Lombardia and Veneto and, later, as invasive for Emilia-Romagna (Alessandrini et al. 2017). This species is already established around the coasts of Bracciano Lake, where large populations with hundreds of plants regularly develop flowers and fruits. Nowadays, it occurs with dense populations on about 2 km of the coast near Vigna di Valle, together with other aliens, such as *Amorpha fruticosa* L., *Datura wrightii* Regel, *Eclipta prostrata* (L.) L., *Oenothera glazioviana* Micheli, *Physalis peruviana* L., *Salvia hispanica* L. (see also Galasso et al. 2018b, 2018c, 2019). Moreover, it is widespread near Trevignano Romano (Roma), loc. Pantane, where it was wrongly reported as *L. peploides* (Kunth) P.H.Raven subsp. *montevidensis* (Spreng.) P.H.Raven (Azzella and Iberite 2010). Some individuals can be observed on the east coast of the lake (Lungolago di Polline).

S. Buono, M.M. Azzella, S. Magrini

***Medicago* ×*varia* Martyn (Fabaceae)**

+ (CAS) **TOS**: Greve in Chianti (Firenze), Monte San Michele, Valico del Morellino (WGS84: 43.550176N, 11.398473E), lungo strada, ca. 10 individui, 748 m, 27 June 2018, *T. Fiaschi* (FI). – Casual alien nothospecies new for the flora of Toscana.

This nothospecies (*Medicago falcata* L. subsp. *falcata* × *M. sativa* L.) is likely much more widespread in Italy than currently recorded (Galasso et al. 2018a).

G. Bonari, T. Fiaschi, C. Angiolini

***Muscari armeniacum* Leichtlin ex Baker (Asparagaceae)**

+ (CAS) **PIE**: Verbania (Verbano Cusio Ossola), fraz. Pallanza, Via Prossano, a lato dell'ingresso dei Giardini Botanici di Villa Taranto (WGS84: 45.926149N,

8.565000E), muro di cinta, crepa nel cemento, 206 m, N, 22 April 2019, *N.M.G. Ardenghi*, *S. Mossini* (FI). – Casual alien species new for the flora of Piemonte.

*Muscari armeniacum*, usually grown for ornamental purposes, is known as a casual alien in different regions of northern and central Italy, except Piemonte (Galasso et al. 2018a). A single individual was found within the crack of a wall near the entrance of the Botanical Gardens of Villa Taranto, where this species is widely cultivated in flowerbeds.

N.M.G. Ardenghi, S. Mossini

***Nigella sativa* L. (Ranunculaceae)**

+ (CAS) **PUG**: Bari (Bari), Lungomare N. Sauro (WGS84: 41.122055N, 16.878997E), fessure di marciapiede, 1 m, 22 May 2019, leg. *G. Picella*, det. *L. Forte*, *R.P. Wagensommer* (BI No. 42139); *ibidem*, 17 June 2019, leg. *L. Forte*, det. *L. Forte*, *R.P. Wagensommer* (FI, BI No. 42140). – Casual alien species new for the flora of Puglia.

*Nigella sativa* grows in many countries of the temperate regions, where it is cultivated for its aromatic seeds (Zohary 1983). In Italy, it was already cultivated in Ancient Rome (Arrigoni and Viegi 2011), and it is currently reported as a casual alien in Sardegna, extinct in Piemonte, and not recently recorded for Friuli Venezia Giulia and Toscana (Galasso et al. 2018a). In the latter region, Arcangeli (1882) already indicated its occurrence in Casentino as doubtful. No recent information about cultivation of this species in Puglia is available.

L. Forte, R.P. Wagensommer, G. Picella

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

+ (NAT) **MAR**: Fano (Pesaro e Urbino), loc. Rosciano (WGS84: 43.822978N, 12.995544E), margini stradali e campi, ca. 28 m, 2 June 2017, *L. Gubellini* (FI, PESA). – Naturalized alien species confirmed for the flora of Marche.

*Oenothera speciosa* is a showy perennial alien introduced as ornamental, native to prairies in the United States of America (Missouri and Nebraska) and northern Mexico (Wager et al. 2007; Keener et al. 2019). In Italy, this species is reported as casual alien for Lombardia, Veneto, Toscana, and as naturalized for Emilia-Romagna (Galasso et al. 2018a). For Marche, the occurrence of a *Oenothera* with pink flowers near Senigallia was reported by G. Mazzufferi (pers. commun.). The same data was later verified and recorded by Montanari and Marconi (2010), but no precise locality information was provided. In Rosciano, several specimens have been observed for some years along roadsides and uncultivated areas, where they are slowly spreading.

L. Gubellini, N. Hofmann

+ (CAS) **SIC**: Augusta (Siracusa), centro urbano, villetta comunale tra Via A. Gramsci e Via Papa Giovanni XXIII (WGS84: 37.247270N, 15.221336E), 25 May 2019, leg. *R. Romano*, det. *N.M.G. Ardenghi* (FI). – Casual alien species new for the flora of Sicilia.

Many individuals grow in an abandoned urban garden, probably introduced a few years ago for ornamental purposes in a small flowerbed. Currently, *O. speciosa* displays an 80% cover of the flowerbed and is expanding in the surrounding areas.

R. Romano, O. Caldarella, A. La Rosa, F. Luchino, N.M.G. Ardenghi

***Opuntia scheeri* F.A.C.Weber (Cactaceae)**

+ (CAS) **UMB**: Castiglione del Lago (Perugia), loc. Badiaccia, vicino alla sponda del Lago Trasimeno, lungo la strada SR71, presso l'ingresso di un'abitazione privata (WGS84: 43.168985N, 12.014299E), coltivata e spontaneizzata lungo un fosso, 261 m, 9 October 2018, *M. Mugnai*, *S. Di Natale*, *G. Ferretti* (FI). – Casual alien species new for the flora of Umbria.
+ (CAS) **TOS**: Sesto Fiorentino (Firenze), fraz. Montorsoli, nei pressi della ex stazione ferroviaria lungo la ferrovia Faentina (WGS84: 43.836202N, 11.284043E), pianta spontaneizzata sulla scarpata al margine stradale, 265 m, 7 February 2019, *M. Mugnai* (FI). – Casual alien species new for the flora of Toscana.

*Opuntia scheeri* is a species native to Mexico, often cultivated as an ornamental plant. It was recorded for the first time in Italy in 1994 (Guiggi 2008), and currently occurs in several regions of northern Italy (Piemonte, Lombardia, Trentino-Alto Adige, Veneto, Emilia-Romagna: Galasso et al. 2018a). Both the records reported here refer to individuals growing close to inhabited areas and derived most likely from cultivated plants. The record from Umbria refers to several well-established plants, probably originated by vegetative means from individuals cultivated nearby. The Tuscan occurrence, instead, consists of a single established individual.

M. Mugnai, E. Corti, S. Di Natale

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

+ (CAS) **TOS**: Vaglia (Firenze), fraz. Fontebuona, ex stazione ferroviaria lungo la ferrovia Faentina (WGS84: 43.880886N, 11.289335E), numerose piante spontaneizzate nei pressi dei marciapiedi e degli edifici della stazione, 332 m, 8 November 2018, *M. Mugnai*, *A. Misuri*, *G. Ferretti* (FI). – Casual alien species new for the flora of Toscana.

*Paulownia tomentosa* is an ornamental plant native to China and introduced to Europe. It is usually cultivated in parks and gardens, but it is also used for timber production thanks to its fast growth and high-quality wood. The size of plantations in Italy has been increasing rapidly since 1989 (Mezzalira and Colonna 2002). This species occasionally escapes cultivation and becomes invasive, growing rapidly in disturbed areas. It is considered as invasive in the USA, and a potentially invasive species in Europe and South America, where it has been introduced (CABI 2019). We observed an abundant population at the Fontebuona railway station, close to a large cultivated plant. The population consists of numerous individuals of various ages, deriving from both seeds and root suckers. Recently (May 8$^{th}$, 2019) this species was detected in another site, on the right bank of the Arno River in loc. Riscaggio (Reggello, Firenze, WGS84: 43.7249776N, 11.4662411E).

A. Misuri, L. Pinzani, G. Ferretti

***Petroselinum crispum* (Mill.) Fuss (Apiaceae)**

+ (NAT) **ITALIA** (**SAR**). Status change from casual to naturalized alien for the flora of Italy (Sardegna).

In Italy, *Petroselinum crispum* is reported for most of the regions (Galasso et al. 2018a). Although an agronomic study on populations naturalized in Trentino-Alto Adige was published recently (Fusani et al. 2016), it is considered as casual alien at national level. We detected numerous plants inhabiting steep and shady calcarenitic cliffs at Capo Sant'Elia (Cagliari, Sardegna). This population displays a well-structured partition in age classes, with seedlings, juveniles, and fruiting individuals that suggest the establishment of a naturalized population. Interestingly, the presence in this area of the phyto-toponym "su perdusemini", clearly referring to parsley, and used at least from the 18$^{th}$ century to name a tower probably built during the 16$^{th}$ century, suggests that naturalized populations may be present in this area since a long time. However, *P. crispum* was not previously recorded in the accurate flora of Capo Sant'Elia compiled by Martinoli (1950). In this context, it must be pointed out that the origin of this widely cultivated plant has not yet been identified with certainty, though it possibly originates in the eastern or central Mediterranean region (Agyare et al. 2017; Pignatti et al. 2018). It is noteworthy that Linnaeus (1753) stated its wild habitat to be Sardegna, close to springs.

M.C. Fogu, M. Marignani, L. Rosati

***Phyllostachys viridiglaucescens* (Carrière) Rivière & C.Rivière (Poaceae)**

– **VDA**. – Alien species to be excluded from the flora of Valle d'Aosta.

*Phyllostachys viridiglaucescens* in Valle d'Aosta was recorded for two localities (Mainetti and Banfi 2018). Surveys in 2018 [Champdepraz (Aosta), terrazzamenti abbandonati a ca. 300 m dalla fraz. Chef-Lieu (WGS84: 45.68873546N, 7.65795915E), terrazzamenti abbandonati, ca. 540 m, 7 October 2018, *A. Mainetti*, *S. Ravetto Enri*, *V. Mezzasalma* (FI); Arnad (Aosta), boscaglia a lato della strada SS26 sul confine con il comune di Hône (WGS84: 45.624517N, 7.736778E), boscaglia ripariale, ca. 350 m, 7 October 2018, *A. Mainetti*, *S. Ravetto Enri*, *V. Mezzasalma* (FI)] revealed short oblique internodes at the base of the culms for both the localities. This is a distinctive feature of *P. aurea* Carrière ex Rivière & C.Rivière (Tison and de Foucault 2014), a species already reported from Valle d'Aosta (Galasso et al. 2018a). Furthermore, the identity of this plant was confirmed by a DNA fingerprinting (RAPD) analysis performed by FEM2-Environment Company (spin-off of the University of Milano-Bicocca) within the BambApp Project (BambApp 2019) (Dipartimento di Scienze Agrarie, Forestali e Alimentari, Università di Torino), using samples from a private botanical collection (T. Froese: Cravanzana, Cuneo, Italy) verified by us as reference base. Consequently, *P. viridiglaucescens* should be excluded from the flora of Valle d'Aosta.

A. Mainetti, S. Ravetto Enri, V. Mezzasalma

***Phyllostachys viridis* (R.A.Young) McClure (Poaceae)**

+ (NAT) **PIE**: Arona (Novara), fraz. Montrigiasco, zona Cascina Motto (WGS84: 45.77122N, 8.51728E), bosco a *Robinia pseudoacacia* dominante, ca. 425 m, 15 January 2018, *M. Pittarello*, *A. Mainetti*, *F. De Mattia* (FI). – Status change from casual to naturalized alien for the flora of Italy; naturalized alien species new for the flora of Piemonte.
+ (NAT) **VDA**: Antey-Saint-André (Aosta), loc. Filey, nei pressi della riva orografica sinistra del Torrente Marmore (WGS84: 45.81154804N, 7.58866366E), prato da sfalcio, ca. 1030 m, 21 July 2018, *M. Lonati*, *S. Pirani*, *J. Frigerio* (FI). – Naturalized alien species new for the flora of Valle d'Aosta.

According to Galasso et al. (2018a), *Phyllostachys viridis* was previously reported in Italy only for Lombardia. Its identity was confirmed by a DNA fingerprinting (RAPD) analysis performed by FEM2-Environment Company (spin-off of the University of Milano-Bicocca) within the BambApp Project (BambApp 2019), using samples from a private botanical collection (T. Froese: Cravanzana, Cuneo, Italy) verified by us as reference base. These populations originated from agamic propagation of nearby cultivated plants.

M. Pittarello, A. Mainetti, F. De Mattia, M. Lonati, S. Pirani, J. Frigerio

***Physalis angulata* L. (Solanaceae)**

+ (CAS) **UMB**: Otricoli (Terni), area archeologica Utriculum, riva idrografica sinistra del Fiume Tevere (WSG84: 42.408889N, 12.458889E), coltivo, 42 m, 30 July 2015, *E. Scarici*, *M. Scarici* (FI). – Casual alien species new for the flora of Umbria.

*Physalis angulata* is a tropical American species that it is occasionaly cultivated for its edible fruits (Hawkes 1972). It is reported in Italy only in Lombardia, Veneto, and Lazio (Galasso et al. 2018a). Many individuals grow in cultivated areas along the river.

E. Scarici, M. Scarici

***Pseudosasa japonica* (Siebold & Zucc. ex Steud.) Makino ex Nakai (Poaceae)**

+ (NAT) **VDA**: Châtillon (Aosta), traversa di Strada Chemin de Barat che porta alla stazione di servizio autostradale (direzione Aosta) (WGS84: 45.747689N, 7.618339E), prato da sfalcio, ca. 490 m, 13 October 2018, *S. Ravetto Enri*, *M. Lonati*, *L. Guzzetti* (FI). – Naturalized alien species new for the flora of Valle d'Aosta.

In Italy, *Pseudosasa japonica* was reported for all northern regions with the exception of Liguria and Valle d'Aosta (Galasso et al. 2018a). Single branches per node and palmfont-like leaves clearly permitted to identify the species (Li et al. 2006; Tison and de Foucault 2014). In addition, the identity was confirmed by a DNA fingerprinting (RAPD) analysis conducted by FEM2-Environment Company (spin-off of the University of Milano-Bicocca) within the BambApp Project (BambApp 2019), using samples from a private botanical collection (T. Froese: Cravanzana, Cuneo, Italy) verified by us as reference base. The recorded population originated from agamic propagation of nearby cultivated plants.

S. Ravetto Enri, M. Lonati, L. Guzzetti

***Quercus rubra* L. (Fagaceae)**

+ (CAS) **SAR**: Villagrande Strisaili (Nuoro), Monte Idolo (WGS84: 39.940833N, 9.488056E), graniti, 881 m, 2 June 2019, *G. Bacchetta* (FI, CAG). – Casual alien species new for the flora of Sardegna.

The red oak is an American taxon, which was imported in Europe starting from the 17th century (Magni Diaz 2004), and in Italy from 1803 (Maniero 2015). In Sardegna, it was introduced in reforestations and for ornamental purposes (Veri and Bruno 1974; Arrigoni 2006). In recent years, numerous trees and saplings were found on the eastern side of the Gennargentu Massif (Monte Idolo), all growing close to reforestations with red oak and other alien trees.

G. Bacchetta, G. Calvia, L. Podda

***Reynoutria bohemica* Chrtek & Chrtková (Polygonaceae)**

+ (NAT) **MAR**: Urbino (Pesaro e Urbino), lungo la strada SS73bis (WGS84: 43.730503N, 12.635836E), scarpata stradale, ca. 410 m, 16 November 2018, *N. Hofmann* (FI, PESA). – Naturalized alien species new for the flora of Marche.

*Reynoutria bohemica* is of hybrid origin between the alien species *R. japonica* Houtt. and *R. sachalinensis* (F.Schmidt) Nakai, and it has been recognized and described only at the end of the last century in the Czech Republic (Chrtek and Chrtková 1983). Like other congener species, *R. bohemica* colonizes ruderal environments, roadsides and waterways, and forms dense stands that shade and crowd out all other plants, thereby reducing the biodiversity of invaded plant communities and damaging habitats beyond repair (Padula et al. 2008). In Italy, it has been reported, so far, for Valle d'Aosta, Piemonte, Lombardia, Veneto, and Toscana as invasive alien, for Friuli Venezia Giulia and Emilia-Romagna as naturalized alien, and for Trentino-Alto Adige, Liguria as casual alien (Galasso et al. 2018a). In the Urbino site, which represents the first record for Marche, a large number of individuals has been monitored for several years, and a considerable increase of the population was observed. For this reason, containment measures should be taken.

L. Gubellini, N. Hofmann

***Roldana petasitis* (Sims) H.Rob. & Brettell (Asteraceae)**

+ (CAS) **SIC**: Librizzi (Messina), Via A. Cullurafi (WGS84: 38.096521N, 14.957978E), su scarpata stradale alberata con suolo profondo, 8 April 2019, *C.D. Rifici* (FI). – Casual alien species confirmed for the flora of Sicilia.

*Roldana petasitis* is native to central America (Jeffrey 1986). According to Galasso et al. (2018a), this species is naturalized in Liguria, while in Lazio, Puglia, and Basilicata it is considered as a casual alien. Although Fiori (1927) reported this taxon as growing wild in Sicilia, Giardina et al. (2007) excluded it from this region. A few individuals of different age were found in Librizzi, growing along the roadside with other

nitrophilous species typical of urban areas. The population, monitored since 2013, is particularly resilient, despite the continuous cuts made during ordinary maintenance of public flowerbeds. In Sicilia, this species occurs also in Siracusa, at Latomia dei Cappuccini, in a limestone quarry (R. Genovese, pers. commun.).

C.D. Rifici, A. La Rosa, O. Caldarella, F. Luchino

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

+ (NAT) **PUG**: Melendugno (Lecce) lungo la Circonvallazione di Melendugno (WGS84: 40.270194N, 18.343408E), bordo strada, 35 m, 22 August 2019, *G. Laghetti*, *G. Maruca*, *C.M. Musarella* (REGGIO). – Naturalized alien species confirmed for the flora of Puglia.

For Italy, *Saccharum biflorum* was known, until now, only in Sicilia and Sardegna, whereas it was not, until recently, recorded in Puglia (Galasso et al. 2018a). A population was found also in Puglia, between a road and an abandoned field, covering a surface of about 20 $m^2$. Due to its extension and to the number of the flowering stems, we can consider this species as naturalized in this locality.

C.M. Musarella, G. Maruca, G. Laghetti

***Sedum palmeri* S.Watson (Crassulaceae)**

+ (CAS) **PIE**: Verbania (Verbano Cusio Ossola), fraz. Pallanza, Viale G. Azari (WGS84: 45.928311N, 8.552684E), marciapiede, 214 m, 22 April 2019, *N.M.G. Ardenghi*, *S. Mossini* (FI). – Casual alien species new for the flora of Piemonte.

*Sedum palmeri*, commonly cultivated as an ornamental pot plant, has been recorded from many northern Italian regions, except Piemonte (Galasso et al. 2018a). Some individuals were discovered growing within the cracks of a sidewalk. This species may be more widespread across the region, especially in urban areas.

N.M.G. Ardenghi, S. Mossini

+ (CAS) **TOS**: Figline e Incisa Valdarno (Firenze), loc. C. Torrione (WGS84: 43.6586857N, 11.4246546E), interno cipresseta, 310 m, 24 February 2019, *L. Pinzani* (FI). – Casual alien species new for the flora of Toscana.

In Italy, *Sedum palmeri* is recorded from Lombardia, Veneto, Friuli Venezia Giulia, Emilia-Romagna, Liguria, Lazio, Campania, and Sardegna (Galasso et al. 2018a). Various groups of individuals grow within a cypress wood. The main one is represented by more than 100 individuals.

L. Pinzani

***Semiarundinaria fastuosa* (Lat.-Marl. ex Mitford) Makino (Poaceae)**

+ (NAT) **ITALIA** (**PIE**): Borgo San Dalmazzo (Cuneo), Via Mangiacane (WGS84: 44.34109541N, 7.50195817E), canale di irrigazione e margine di seminativo, ca.

620 m, 1 February 2018, *M. Pascale*, *G. Nota*, *V. Mezzasalma* (FI). – Naturalized alien species new for the flora of Italy (Piemonte).

*Semiarundinaria fastuosa* is a bamboo native to Japan (south-western Honshu). The recorded population originated from agamic propagation from a private garden and colonized a nearby canal bank. Several branches per node, partially deciduous culm sheaths and minute auricles allowed us to identify this species (Li et al. 2006; Tison and de Foucault 2014). The identification was confirmed by DNA fingerprinting (RAPD) analysis performed by FEM2-Environment Company (spin-off of the University of Milano-Bicocca) within the BambApp Project (BambApp 2019), using samples from a private botanical collection (T. Froese: Cravanzana, Cuneo, Italy) verified by us as reference base.

M. Pascale, G. Nota, V. Mezzasalma

***Senecio angulatus* L.f. (Asteraceae)**

+ (CAS) **ABR**: San Vito Chietino (Chieti), loc. Marina, muro di contenimento coperto da vegetazione presso la strada SS16 Adriatica (WGS84: 42.305208N, 14.450116E), ca. 15 m, SW, 18 May 2019, *N. Olivieri* (FI). – Casual alien species new for the flora of Abruzzo.

*Senecio angulatus* is a succulent climbing plant native to South Africa, introduced for ornamental purposes in southern Europe, Macaronesia, northern Africa, California, Chile, Australia, and New Zealand. Currently, it is naturalized in Albania (Barina et al. 2011), Croatia (Milović et al. 2010), Iberian peninsula (Romero Buján 2007; Pyke 2008), and Chile (Ugarte et al. 2011) and is considered one of the most invasive species in the western Mediterranean area (Brundu et al. 1999), Mediterranean France (Brunel and Tison 2005), Australia (Ross and Walsh 2003; Randall 2007), and New Zealand (Bergin 2006). This species was introduced in Italy in 1875 (Maniero 2015). It is known as a casual alien in Lazio and Calabria, while it is naturalized in Puglia, Campania, Basilicata, Sicilia, and invasive in Liguria, Toscana, and Sardegna (Galasso et al. 2018a). In San Vito Chietino, this species grows on a brick retaining wall, located below the site of the Adriatic State Road, in a sunny and sheltered position, close to the Adriatic Sea. Here the plant is established along with *Arundo plinii* Turra, *Ficus carica* L., and *Rubus ulmifolius* Schott.

N. Olivieri

***Senecio inaequidens* DC. (Asteraceae)**

+ (INV) **TOS**. – Status change from naturalized to invasive alien for the flora of Toscana.

*Senecio inaequidens* is native to South Africa. It was recorded in Europe for the first time in the mid-twentieth century and observed in Italy in 1947 (Carrara Pantano and Tosco 1959; Anzalone 1976). It was reported as present throughout central and northern Italy and has been rapidly expanding since the beginning of the 1980s (Pignatti 1982). Now it is widespread in all Italian regions and often considered invasive (Galasso et al.

2018a). Our recent field investigations revealed the presence of this species in all Tuscan provinces, confirming many previous observations and adding several new occurrences (Peruzzi et al. 2019). Consequently, this species is abundant and well distributed in anthropized sites of Toscana, where it is spreading notwithstanding the control actions often undertaken. Moreover, this species has been observed in some natural sites. Accordingly, we regard the status of invasive alien as the most appropriate.

A. Misuri, G. Ferretti, M. Mugnai

***Sisyrinchium rosulatum* E.P.Bicknell (Iridaceae)**

+ (CAS) **SAR**: Olbia (Sassari), Parco F. Noce, presso il canale di Via L. Galvani (WGS84: 40.554511N, 9.295523E), prati e aiuole, 1–2 m, 25 June 2017, *G. Calvia* (FI); *ibidem*, Parco F. Noce, lato Via G. D'Annunzio, ai lati della pista (WGS84: 40.554352N, 9.300366E), aiuole e prati inglesi, 2 m, 25 June 2017, *G. Calvia* (*Herb. G. Calvia*). – Casual alien species new for the flora of Sardegna.

*Sisyrinchium rosulatum* is a species native to North America, introduced in Europe and other continents, and now naturalized in several countries (Nicolella and Ardenghi 2013). In Italy, this species has been reported as casual alien in Lazio (Nicolella and Ardenghi 2013; Galasso et al. 2018a). In Sardegna, it has been observed starting to 2015 in the town of Olbia, where it grows in the Fausto Noce community park and neighboring areas, above all in lawns but also in flowerbeds and along paths. It probably arrived there thanks to seed dispersed in lawns.

G. Calvia

***Solanum bonariense* L. (Solanaceae)**

+ (CAS) **LIG**: Genova (Genova), lungo Via Apparizione, nel tratto pedonale (WGS84: 44.40443N, 8.98889E), bordo strada, 42 m, 20 April 2019, *A. Di Turi*, *C. Aristarchi* (FI, GE, GDOR). – Casual alien species new for the flora of Liguria.

*Solanum bonariense* is a perennial shrub native to Uruguay, northern Argentina, and southern Brazil where it is widespread in pastures. Introduced in Europe as an ornamental, it is nowadays recorded in Italy as a casual species for Lombardia, Lazio, Campania, and as naturalized for Toscana and Sicilia (Galasso et al. 2018a). A well-developed specimen, growing together with *Parietaria judaica* L., has been recorded in a pedestrian street of Genova among houses surrounded by orchards and gardens.

A. Di Turi, C. Aristarchi

***Solanum laciniatum* Aiton (Solanaceae)**

+ (NAT) **ITALIA** (**TOS**): Monte Argentario (Grosseto), lungo la strada sterrata Via Panoramica, sopra Cala dell'Acqua Dolce (WGS84: 42.374541N, 11.185636E), macchia, 70 m, 22 June 2019, *F. Roma-Marzio*, *P. Liguori* (FI, *Herb. F. Roma-Marzio*). – Naturalized alien species confirmed for the flora of Italy and new for the flora of Toscana.

*Solanum laciniatum* is a species native to New Zealand and Australia from south-eastern Australia, Victoria, and Tasmania (Simon 1981). This species belongs to *Solanum* subg. *Archaesolanum* Bitter ex Marzell, composed of eight species occurring only in the SW-Pacific region (Poczai et al. 2011). In the Euro+Med area, *S. laciniatum* is recorded in Morocco, France, Spain, Israel, and Tunisia (Valdés 2012), whereas in Italy it is doubtfully occurring based on a record for Puglia (Beccarisi et al. 2015; Galasso et al. 2018a). This species is similar to *S. aviculare* G.Forst, that mainly differs from *S. laciniatum* in the shape of petals (notched in *S. laciniatum* and acute in *S. aviculare*), and in the colour of mature fruits (orange-yellow in *S. laciniatum* and orange-red to scarlet in *S. aviculare*). About six big tufts, probably originated from cultivated plants at a nearby hotel, were counted mixed with native species typical of the Mediterranean scrub. Furthermore, in the same area plants are present since 2006, as highlighted by some photos published on the Portal to the Flora of Italy (http://dryades.units.it/floritaly/index.php?procedure=taxon_page&tipo=all&id=11471).

F. Roma-Marzio

***Sporobolus indicus* (L.) R.Br. (Poaceae)**

+ (CAS) **MAR**: Piobbico (Pesaro e Urbino), alla confluenza tra il Torrente Biscubio e il Fiume Candigliano (WGS84: 43.589956N, 12.510999E), greto fluviale, ca. 335 m, 10 December 2018, *N. Hofmann* (FI, PESA). – Casual alien species new for the flora of Marche.

This perennial grass is naturalized throughout peninsular and insular Italy, except for Valle d'Aosta, Marche, Umbria, and Puglia (Galasso et al. 2018a). In Marche, a few individuals grow in the grassy edge of a riverbed on alluvial sandy soil. The occurrence of *Sporobolus indicus* could be due to the abundant presence in the site of migratory birds (especially ducks), that inhabit riverbanks and contribute to the conveyance of seeds.

L. Gubellini, N. Hofmann

***Sporobolus vaginiflorus* (Torr. ex A.Gray) Alph.Wood (Poaceae)**

+ (NAT) **TOS**: Fiesole (Firenze), fraz. Caldine, stazione ferroviaria di Caldine-Fiesole (WGS84: 43.830543N, 11.308060E), marciapiedi lungo il binario, 169 m, 8 November 2018, *M. Mugnai*, *A. Misuri*, *G. Ferretti* (FI). – Naturalized alien species new for the flora of Toscana.

*Sporobolus vaginiflorus* is a North American species already present in most of northern regions of Italy (Galasso et al. 2018a). The population reported here displayed several mature fruiting individuals spanning alongside the sidewalks of the Caldine-Fiesole railway station and in the surrounding areas.

M. Mugnai, S. Di Natale, A. Padula

***Tulipa clusiana* Redouté (Liliaceae)**

+ (NAT) **VEN**: Soave (Verona), alla 'Colombara' (WGS84: 45.44168063N, 11.24953327E), boschetto termofilo, 168 m, 2 March 2019, *G. Bommartini*, *G. Zanoni*, *F. Menini* (VER No. FDC7708). – Status change from casual to naturalized alien for the flora of Veneto.

*Tulipa clusiana* is native to Syria and Persia, in the Middle East (Banfi and Galasso 2010), and is recorded as a casual alien in several central-northern Italian regions, and as naturalized in Piemonte, Lombardia, and Marche (Galasso et al. 2018a). In Veneto, there was only one confirmed report by Busnardo (2000) in Bassano del Grappa (Vicenza). For the Verona province, there is only a historical sample collected by Goiran (1897, 1900, VER) and a recent indication of occasional presence in Custoza (F. Prosser, pers. commun.). In the locality reported here, the population consists of thousands of seedlings, which grow both within a thermophilic grove formed by different species, such as *Dioscorea communis* (L.) Caddick & Wilkin, *Fraxinus ornus* L. subsp. *ornus*, *Ligustrum vulgare* L., *Quercus pubescens* Willd. subsp. *pubescens*, *Robinia pseudoacacia* L., *Rubus ulmifolius* Schott, and *Sambucus nigra* L., and inside olive groves. This species was found in two small woods about 250 meters apart, and more on two other adjacent banks. Other localities have been found on the slopes of Monte Tenda, just above the medieval castle of Soave (WGS84: 45.44145545N, 11.24924856E, 95 m), more than 2 km away from the above-mentioned sites. The total area occupied, albeit discontinuously, by *T. clusiana* is over 10,000 m$^2$ and hosts thousands of individuals.

G. Bommartini, G. Zanoni, F. Menini, S. Andreatta

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

+ (CAS) **CAL**: Bova Marina (Reggio Calabria), loc. Vena (WGS84: 37.937774N, 15.911936E), scarpata bordo strada, 44 m, 27 April 2019, leg. *V.L.A. Laface*, det. *V.L.A. Laface*, *C.M. Musarella*, *G. Spampinato* (FI, REGGIO); Reggio Calabria (Reggio Calabria), Gallico, loc. Pietre della Zita (WGS84: 38.161215N, 15.663414E), scarpata bordo strada, 47 m, 9 October 2019, *V.L.A. Laface* (REGGIO); Brancaleone (Reggio Calabria), loc. Fiumarella (WGS84: 37.982290N, 16.089573E), bordo strada, 35 m, 28 October 2019, *V.L.A. Laface* (REGGIO). – Casual alien species new for the flora of Calabria.

The native range of *Vachellia farnesiana* is considered to be the New World (New 1984), and in particular North America (Gilman and Watson 1993). However, its exact origin is nowadays debated (Luken and Thieret 1996; Roskov 2006). In Europe, it occurs in France, Italy, and Spain (Roskov 2006). Currently, according to Galasso et al. (2018a), it is a casual alien in Sicilia and Sardegna. In this new Calabrian locality, we observed several seedlings near the mature plants. This is the first record for peninsular Italy.

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

***Verbena bonariensis* L. (Verbenaceae)**

+ (CAS) **FVG**: Gorizia (Gorizia), Borgo Castello, sulle mura del castello subito dopo Porta Leopoldina (WGS84: 45.942638N, 13.628783E), su mura di arenaria, 100 m, 25 April 2019, *F. Roma-Marzio*, *P. Liguori* (FI, *Herb. F. Roma-Marzio*). – Casual alien species new for the flora of Friuli Venezia Giulia.

*Verbena bonariensis* is native to South America (southern Brazil, Uruguay, Paraguay, northern Argentina) and has been introduced in many countries of Africa, Asia,

Australia, and Europe and in the USA (Munir 2002; Nesom 2010). In Italy, it is reported as naturalized alien in Liguria and as casual in Lombardia, Trentino-Alto Adige, Emilia-Romagna, Toscana, Umbria, and Lazio (Galasso et al. 2018a). About five plants were found on the ancient walls, probably as a result of escaped cultivated plants. Specimens were identified using the key reported by Nesom (2010).

F. Roma-Marzio

***Youngia japonica* (L.) DC. subsp. *japonica* (Asteraceae)**

+ (CAS) **SIC**: Messina (Messina), Rodia, loc. Contrada Marmora, presso il complesso residenziale Baia Verde (WGS84: 38.267442N, 15.478063E), fessure nella pavimentazione del marciapiede e interstizi tra marciapiede e muro, 14 February 2019, *F. Luchino* (FI). – Casual alien species new for the flora of Sicilia.

According to Shi and Kilian (2011), the Sicilian populations of *Youngia japonica* belong to the autonymic subspecies, native probably to China and naturalized in warm areas of all continents (Galasso et al. 2016). The single Italian record of this species in Genova (Liguria) is very recent (Galasso et al. 2016). We found approximately 30 individuals growing inside sidewalk cracks and in shady micro-soil located at the base of the walls. In the same area, the herbaceous vegetation consists mainly of several ruderal species linked to anthropic environments. *Y. japonica* has been observed as alien also in north-eastern Sicilia (A. Crisafulli and R.M. Picone, pers. commun.), namely in Messina along urban roads (Via F. Bisazza), in the flowerbeds and lawns of the Comando Arma dei Carabinieri (near Villa Mazzini) and in Milazzo (Messina) at C.da Scaccia in an uncultivated wet habitat.

F. Luchino, O. Caldarella, A. La Rosa, R. De Luca

**Nomenclatural and distribution updates from other literature sources**

Nomenclatural, status, and distribution updates according to Saccardo (1909), Viegi et al. (1974), Ricciardi and Anzalone (1988), Greuter et al. (1989), Prosser et al. (2009), Castellano and Spadaro (2011), Licitra and Napoli (2011), Schaefer and Renner (2011), Himmelreich et al. (2012), Pasta (2012), Sebastian et al. (2012), Coulot and Rabaute (2013), Gestri and Peruzzi (2016), Pasta et al. (2016), Thiede (2017), Ardenghi (2018), Carta et al. (2018), Gallo et al. (2018), Rich et al. (2018), Trejo-Torres et al. (2018), Antonietti and Dellavedova (2019), Ardenghi (2019), Badalamenti (2019), Benetti (2019), Berselli et al. (2019), Buccheri et al. (2019), Compton et al. (2019), Del Guacchio et al. (2019), Galasso (2019), Gallo (2019), Gariboldi and Frezzini (2019), Groom (2019), Marchetti (2019), Musarella (2019), Musarella et al. (2019), Pascale and Pellegrino (2019), Paton et al. (2019), Picco et al. (2019), Prosser et al. (2019), Sarmati et al. (2019), Stinca and Mei (2019), Stinca et al. (2019), Verloove et al. (2019), and corrections to Galasso et al. (2018a) 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: species data

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

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# Notulae to the Italian alien vascular flora: 9

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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, confirmations, exclusions, and status changes for Italy or for Italian administrative regions. Furthermore, three new combinations are proposed. Nomenclatural and distribution updates published elsewhere are provided as Suppl. material 1.

**Keywords**

Alien species, floristic data, Italy, new combinations, nomenclature

## How to contribute

The text for the new records should be submitted electronically to Chiara Nepi (chiara.nepi@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 (typifications only for accepted names), status changes, exclusions, and confirmations should be submitted electronically to Gabriele Galasso (gabriele.galasso@comune.milano.it). Each text should be within 1,000 characters (spaces included).

## Floristic records

### *Acacia dealbata* Link subsp. *dealbata* (Fabaceae)

+ (NAT) **CAL**: San Marco Argentano (Cosenza), fraz. Scalo Ferroviario, nei pressi dello svincolo autostradale (WGS84: 39.621743N, 16.222419E), margine strada, 120 m, 2 January 2020, *L. Peruzzi* (FI). – Naturalized alien subspecies new for the flora of Calabria.

Hundreds of ramets of heterogeneous size form a small dense wood, about 40 m long and 5 m thick, along a road. According to local people, one individual was planted in the area around 30 years ago, when there was not any road crossing this countryside, rich in olive groves and vineyards.

L. Peruzzi

### *Aeonium arboreum* (L.) Webb & Berthel. (Crassulaceae)

+ (CAS) **MOL**: Termoli (Campobasso), parete rocciosa del promontorio sul quale sorge il borgo antico (WGS84: 42.004633N, 14.998402E), parete rocciosa, ca. 5 m, SE, 14 July 2019, *N. Olivieri* (FI). – Casual alien species new for the flora of Molise.

Some individuals belonging to the cultivar Atropurpureum grow on a subvertical portion of a conglomerate calcareous rock wall.

N. Olivieri

***Albizia julibrissin* Durazz. (Fabaceae)**

+ (CAS) **BAS**: Pisticci (Matera), Strada Provinciale Pozzitello-San Basilio (WGS84: 40.387222N, 16.572222E), bordo strada, 271 m, 3 November 2019, *C.M. Musarella* (FI, REGGIO); *ibidem* (WGS84: 40.385555N, 16.575553E), bordo strada, 228 m, 3 November 2019, *C.M. Musarella* (REGGIO). – Casual alien species new for the flora of Basilicata.

Several individuals at different growth stages were found along the way, probably born from seeds scattered from plants growing in nearby private areas.

C.M. Musarella

***Amaranthus emarginatus* Salzm. ex Uline & W.L.Bray subsp. *emarginatus* (Amaranthaceae)**

+ (CAS) **MAR**: Ancona (Ancona), lungo Via Cardeto nei pressi della Caserma Villarey (WGS84: 43.62065N, 13.51668E), marciapiede, ca. 50 m, 9 July 2018, *N. Hofmann* (PESA); *ibidem*, lungo Via Volterra nei pressi dei giardini del Passetto (WGS84: 43.61569N, 13.53292E), marciapiede, 40 m, 21 October 2019, *N. Hofmann* (FI). – Casual alien subspecies new for the flora of Marche.

According to Iamonico (2015), the population can be referred to *Amaranthus emarginatus* var. *emarginatus*.

L. Gubellini, N. Hofmann, D. Iamonico

***Amaranthus palmeri* S.Watson (Amaranthaceae)**

+ (NAT) **VEN**: Camposampiero (Padova), among the localities Cesere, Zanon and Ferro (WGS84: 45.554528N, 11.951444E), soybean field, 2 August 2018, leg. *A. Milani*, det. *A. Milani*, *D. Iamonico* (FI); Verona (Verona), stazione ferroviaria di Porta Vescovo (WGS84: 45.435721N, 11.016411E), decine di esemplari lungo i binari morti della stazione dei treni, 54 m, no exp., 17 October 2019, *A. Bertolli* (FI, ROV No. 74208). – Naturalized alien species new for the flora of Veneto.

Another population was found in a nearby soybean field (WGS84: 45.575639N, 11.912194E). According to ongoing research on herbicide-resistance (Milani et al. 2018), *A. palmeri* in Veneto is resistant to acetolactate inhibitors, allowing it to self-sustain and spread. At the train station "Verona Porta Vescovo", the population is represented by many fertile plants, which occupy an area of about 50 m in length.

A. Bertolli, D. Iamonico, A. Milani, R.R. Masin

***Amaranthus viridis* L. (Amaranthaceae)**

+ (NAT) **LIG**: Pietra Ligure (Savona), Via F. Crispi (WGS84: 44.153079N, 8.285099E), margine stradale, 4 m, no exp., 11 August 2018, leg. *G. Galasso*, det. *G. Galasso, E. Banfi* (MSNM). – Status change from casual to naturalized alien for the flora of Liguria.

G. Galasso, E. Banfi

+ (CAS) **MAR**: Fano (Pesaro e Urbino), fraz. Caminate, lungo la Strada delle Caminate (WGS84: 43.779363N, 13.036444E), margine stradale, 90 m, 25 September 2019, *N. Hofmann* (FI, PESA). – Casual alien species new for the flora of Marche.

A small population of this species grows along a grassy roadside.

L. Gubellini, N. Hofmann

***Broussonetia papyrifera* (L.) Vent. (Moraceae)**

+ (CAS) **CAL**: Melito di Porto Salvo (Reggio Calabria), Via Pilati (WGS84: 37.920426N, 15.802819E), canale di scolo, 9 m, 5 October 2019, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); Montebello Jonico (Reggio Calabria), fraz. Saline Joniche, Borgata Sant'Elia (WGS84: 37.931162N, 15.740749E), bordo strada, 19 m, 11 October 2019, *V.L.A. Laface* (FI, REGGIO). – Casual alien species confirmed for the flora of Calabria.

This species was first reported by Pignatti (1982) for Calabria, and then recorded as not confirmed by Bernardo et al. (2009).

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

***Buxus microphylla* Siebold & Zucc. (Buxaceae)**

+ (CAS) **ITALIA** (**TAA**): Stenico (Trento), fraz. Sclemo, Via della Breda 3 (WGS84: 46.054415N, 10.882023E), margine su terreno smosso, 757 m, SE, 14 March 2018, leg. *M. Merli*, det. *E. Banfi*, *G. Galasso* (FI, MSNM, *Herb. M. Merli*). – Casual alien species new for the flora of Italy (Trentino-Alto Adige).

This species was first described from Japan (Ohba 1999) based on a cultivar possibly corresponding today to the one named 'Faulkner'. In Japan, *B. microphylla* var. *japonica* (Müll.Arg.) Rehder & E.H.Wilson identifies the possible wild relative from which the main cultivated forms are derived.

M. Merli, E. Banfi, G. Galasso

***Canna indica* L. (Cannaceae)**

+ (CAS) **BAS**: Policoro (Matera), Via San Giusto (WGS84: 40.217961N, 16.690133E), canale di scolo, 10 m, 3 November 2019, *C.M. Musarella* (FI, REGGIO). – Casual alien species new for the flora of Basilicata.

This species was found in an area of about 2 $m^2$ along a water drainage channel.

C.M. Musarella

***Casuarina cunninghamiana* Miq. subsp. *cunninghamiana* (Casuarinaceae)**

+ (CAS) **LIG**: Pietra Ligure (Savona), Stazione FFSS di Pietra Ligure/Largo Veterani dello Sport (WGS84: 44.145790N, 8.277779E), nata spontaneamente da seme di *plantae cultae* poste nelle vicinanze, 6 m, no exp., 3 July 2016, *G. Galasso* (FI); *ibidem*,

28 July 2016, *G. Galasso* (FI, MSNM). – Casual alien subpecies new for the flora of Liguria.

G. Galasso, E. Banfi

***Celosia argentea* L. (Amaranthaceae)**

+ (CAS) **CAL**: San Lucido (Cosenza), nel cimitero (WGS84: 39.308302N, 16.058392E), nelle fessure della pavimentazione, 157 m, 21 September 2019, *N.G. Passalacqua*, *M. Aversa* (FI, CLU). – Casual alien species new for the flora of Calabria.

Several individuals grow in between tiles, probably originating from cultivated plants in the neighborhood.

N.G. Passalacqua, M. Aversa, L. Bernardo

***Cenchrus longisetus* M.C.Johnst. (Poaceae)**

+ (NAT) **LIG**: Sarzana (La Spezia), parcheggio lungo Via Sarzanello (WGS84: 44.105626N, 9.985910E), margine erboso, presenza continua lungo Via Sarzanello da 44.105325N, 9.985314E a 44.106434N, 9.987646E, 38 m, no exp., 28 October 2019, *D. Marchetti* (FI, MSNM). – Status change from casual to naturalized alien for the flora of Liguria.

E. Banfi, D. Marchetti, G. Galasso

***Cenchrus longispinus* (Hack.) Fernald (Poaceae)**

+ (CAS) **LOM**: Milano (Milano), Stazione Milano-Centrale, binari e massicciata ferroviaria a sinistra del binario 1 (WGS84: ca. 45.490013N, 9.207040E), binari ferroviari, 130 m, no exp., 21 September 2018, leg. *G. Galasso*, det. *G. Galasso*, *E. Banfi* (FI, MSNM). – Casual alien species new for the flora of Lombardia.

E. Banfi, G. Galasso, R. Gentili, C. Toffolo

***Ceratostigma plumbaginoides* Bunge (Plumbaginaceae)**

+ (CAS) **TOS**: Pontassieve (Firenze), fraz. Santa Brigida (WGS84: 43.852532N, 11.394439E), su un muro a secco, 400 m, 17 October 2019, *L. Pinzani* (FI, *Herb. L. Pinzani*). – Casual alien species new for the flora of Toscana.

A small population, likely derived from plants grown nearby as ornamentals.

L. Pinzani

***Citrullus lanatus* (Thunb.) Matsum. & Nakai subsp. *lanatus* (Cucurbitaceae)**

+ (CAS) **LIG**: Sarzana (La Spezia), ZSC "IT1345101 Piana della Magra", spiaggia di Marinella di Sarzana (WGS84: 44.046169N, 10.017139E), spiaggia, 2 m, 29 September 2019, *C. Turcato* (FI, GE No. 1422). – Casual alien subspecies new for the flora of Liguria.

This taxon was found in the habitat of community interest Code 2120 "Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)".

D. Dagnino, D. Longo, C. Turcato

+ (CAS) **CAL**: Rosarno (Reggio Calabria), Strada Consortile Melicucco "C.N. Eranov" (WGS84: 38.478225N, 15.979856E), bordo strada, 21 m, 13 September 2019, *C.M. Musarella* (FI, REGGIO); Trebisacce (Cosenza), lungo la linea ferroviaria (WGS84: 39.864318N, 16.531330E), ferrovia, 8 m, 27 October 2019, *C.M. Musarella* (REGGIO). – Casual alien subspecies new for the flora of Calabria.

C.M. Musarella

***Clerodendrum trichotomum* Thunb. (Lamiaceae)**

+ (CAS) **CAM**: Pietradefusi (Avellino), SP50 (WGS84: 41.043000N, 14.883660E), fessure del marciapiede, 392 m, 13 October 2019, leg. *C. Villano*, det. *C. Villano*, *C.M. Musarella* (FI, REGGIO). – Casual alien species new for the flora of Campania.

A single individual was observed, probably originating from a nearby adult fruiting plant.

C.M. Musarella, C. Villano

***Coix lacryma-jobi* L. (Poaceae)**

+ (CAS) **CAL**: Gerocarne (Vibo Valentia), fraz. Ariola (38.579422N, 16.261365E), incolto, 4 November 2015, *G. Spampinato* (FI); San Demetrio Corone (Cosenza), C.da Calamia (39.547517N, 16.372544E), giardino incolto, 5 November 2015, leg. *M. Zaretta*, det. *V.L.A. Laface*, *C.M. Musarella*, *G. Spampinato* (REGGIO). – Casual alien species new for the flora of Calabria.

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

***Cucurbita moschata* Duchesne (Cucurbitaceae)**

+ (CAS) **LIG**: Pietra Ligure (Savona), Torrente Scarincio (WGS84: 44.160524N, 8.278689E), greto ghiaioso, 10 m, no exp., 11 August 2018, leg. *G. Galasso*, det. *G. Galasso*, *E. Banfi* (FI). – Casual alien species new for the flora of Liguria.

In Pietra Ligure and neighboring territories, the cultivar Trombetta di Albenga is very common.

G. Galasso, E. Banfi

***Cylindropuntia spinosior* (Engelm.) F.M.Knuth (Cactaceae)**

+ (CAS) **MAR**: Serra San Quirico (Ancona), presso le mura della città medievale (WGS84: 43.445366N, 13.017760E), pratello arido, 245 m, 5 August 2019, *G. Mei* (FI, ANC, *Herb. G. Mei*). – Casual alien species new for the flora of Marche.

We observed numerous individuals of different ages originating from seeds and rooting cladodes fallen to the ground. If confirmed in the coming years, this condition could allow the naturalization of the species.

G. Mei, A. Stinca, A. Ilari

***Cyperus glomeratus* L. (Cyperaceae)**

+ (NAT) **LIG**. – Status change from casual to naturalized alien for the flora of Liguria.

In the past, this species was observed in the Trebbia (province of Genova) and Nervia (province of Imperia) valleys, according to the Ottone Penzig's handwritten notes found on a copy of De Notaris (1844). We found numerous small populations in gravelly and muddy banks of the Magra and Vara rivers (province of La Spezia), in the Special Area of Conservation "IT1343502 Parco della Magra-Vara".

D. Dagnino, M.G. Mariotti, C. Turcato

***Dichondra micrantha* Urb. (Convolvulaceae)**

+ (NAT) **SAR**. – Status change from casual to naturalized alien for the flora of Sardegna.

Recently, this species has started a slow colonization in Sardegna, mainly in urban environments of Cagliari. Moreover, since 2018, it has been observed naturalized in the countryside of Oristano, in wet meadows of abandoned quarries.

G. Bacchetta, M. Fois, A. Lallai, L. Podda

***Digitaria ciliaris* (Retz.) Koeler (Poaceae)**

+ (CAS) **SIC**: Giardini Naxos (Messina) (WGS84: 37.840427N, 15.276211E), lungo un corso d'acqua perenne, ca. 14 m, 22 September 2019, *G. Tavilla*, *S. Cambria*, *S. Sciandrello* (FI, CAT). – Casual alien species confirmed for the flora of Sicilia.

According to Galasso et al. (2018), *Digitaria ciliaris* does not occur in Sicilia, even though it was already reported by Wilhalm (2009).

G. Tavilla, S. Cambria, S. Sciandrello

***Dimorphotheca ecklonis* DC. (Asteraceae)**

+ (CAS) **PUG**: Otranto (Lecce), muro presso la stazione ferroviaria (WGS84: 40.149166N, 18.481388E), muro in cemento e pietra calcarea, ca. 20 m, S, 21 August 2019, *N. Olivieri* (FI). – Casual alien species new for the flora of Puglia.

Some individuals of the species developed on an old sloping concrete and limestone wall, along with *Parietaria judaica* L.

N. Olivieri

***Euphorbia marginata* Pursh (Euphorbiaceae)**

+ (CAS) **CAL**: Guardia Piemontese (Cosenza), fraz. Guardia Piemontese Marina (WGS84: 39.280614N, 15.584257E), fessure e margine di marciapiedi con accumulo di suolo e detriti, 30 m, 29 November 2019, *S. Fascetti, L. Rosati* (FI, HLUC). – Casual alien species new for the flora of Calabria.

S. Fascetti, L. Rosati

***Fagopyrum esculentum* Moench (Polygonaceae)**

+ (CAS) **LIG**: Pietra Ligure (Savona), Torrente Maremola, presso la foce, subito a monte di Corso Italia (WGS84: 44.150564N, 8.286511E), greto, 1 m, no exp., 11 August 2018, *G. Galasso* (FI, MSNM). – Casual alien species confirmed for the flora of Liguria.

The presence of this species can be explained by the random dispersal of seeds, since they are frequently sold in food markets.

G. Galasso, E. Banfi

***Ficus benjamina* L. (Moraceae)**

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

An incomplete verification of literature sources generated mistaken reports of this cultivated species as casual alien in Sardegna. We argue that the record by Camarda et al. (2016) is due to a transcription mistake in the database supporting this work.

G. Bacchetta, G. Brundu, A. Lallai, L. Podda

***Ficus elastica* Roxb. ex Hornem. (Moraceae)**

– **SAR**. – Alien species to be excluded from the flora of Sardegna.

This species was first reported for the island of La Maddalena (Sassari) by Bocchieri (1996). Later, it was indicated by several authors as a casual alien (Camarda et al. 2004; Bacchetta et al. 2009; Podda et al. 2012; Puddu et al. 2016). This is a misidentification with *Ficus macrophylla* Pers. subsp. *columnaris* (C.Moore) P.S.Green, only cultivated as ornamental.

G. Bacchetta, G. Brundu, A. Lallai, L. Podda

***Ficus microcarpa* L.f. (Moraceae)**

+ (NAT) **SAR**. – Status change from casual to naturalized alien for the flora of Sardegna.

This species was introduced in the Botanical Gardens of Cagliari during the second half of the 19$^{th}$ century, and then cultivated as ornamental (Vannelli 1986). In recent years, many seedlings and saplings have been observed in different parts of Cagliari,

often close to the parental trees (Puddu et al. 2016). We found propagules in fallow land, roadsides, and ruderal sites, growing as a lithophyte on walls and cliffs, and even as an epiphyte on *Phoenix canariensis* H.Wildpret and *Jacaranda mimosifolia* D.Don. In Sardinian botanical literature, *Ficus microcarpa* has been reported under some incorrect names (Gennari 1874; Cavara 1901; Chiappini 1967, 1985; Vannelli 1986; Podda et al. 2012), such as *F. retusa* L. or *F. benjamina* L.

G. Bacchetta, G. Brundu, A. Lallai, L. Podda

***Ficus retusa* L. (Moraceae)**

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

The first report of *Ficus retusa* as a casual alien was by Podda et al. (2012). However, this record is due to a confusion with *F. microcarpa* L.f., the only naturalized *Ficus* in Sardegna.

G. Bacchetta, G. Brundu, A. Lallai, L. Podda

***Froelichia gracilis* (Hook.) Moq. (Amaranthaceae)**

+ (NAT) **ITALIA** (**PIE**): Trecate (Novara), Via Vigevano, all'esterno della raffineria SARPOM (WGS84: 45.26147N, 8.47086E), piazzale asfaltato a bordo strada, 131 m, 10 July 2019, leg. *S. Assini*, *F. Bracco*, *G. Gheza*, det. *N.M.G. Ardenghi* (FI); *ibidem*, 25 July 2019, leg. *S. Assini*, det. *N.M.G. Ardenghi* (FI). – Naturalized alien species new for the flora of Italy (Piemonte).

The Central American *Froelichia gracilis* has been recorded as an alien in eastern United States, Japan, Australia, and Hungary (Harden 2001; McCauley 2003, 2004; Balogh et al. 2004). The plants recorded for Italy were identified according to McCauley (2003, 2004) and Merkingler et al. (2014). They grow in cracks of the asphalt in two unloading sites close to a refinery where they form a dense, almost monospecific, vegetation.

S. Assini, F. Bracco, G. Gheza, N.M.G. Ardenghi

***Galinsoga parviflora* Cav. (Asteraceae)**

+ (INV) **SIC**. – Status change from naturalized to invasive alien for the flora of Sicilia.

Recent investigations on the urban flora of Palermo (Domina et al. 2019) revealed that this species grows abundantly in all anthropized sites of the city, such as flowerbeds and interstices.

F. Scafidi, E. Di Gristina

***Hedera algeriensis* Hibberd (Araliaceae)**

+ (NAT) **LIG**: Framura (La Spezia), ZSC "IT1343419 Monte Serro", loc. Fornaci (WGS84: 44.21469N, 9.52060E), sottobosco di lecceta, 14 m, 2 August 2019, *D. Dagnino*, *C. Turcato* (FI, GE No. 873). – Naturalized alien species new for the flora of Liguria.

We observed a small population of this species in the undergrowth of a holm oak wood (habitat of community interest Code 9340 "*Quercus ilex* and *Quercus rotundifolia* forests").

D. Dagnino, L. Minuto, C. Turcato

+ (CAS) **CAL**: Oriolo (Cosenza), sulle mura del centro storico presso Vico I San Giacomo (WGS84: 40.050482N, 16.450353E), muro in pietra, sfuggita a coltura, 400 m, 1 January 2020, *F. Roma-Marzio*, *P. Liguori* (FI). – Casual alien species new for the flora of Calabria.

Several plants originated from a nearby potted plant were found in the cavity of a wall.

F. Roma-Marzio

***Heuchera sanguinea* Engelm. (Saxifragaceae)**

+ (CAS) **ABR**: Campotosto (L'Aquila), fraz. Ortolano, SS80 del Gran Sasso (WGS84: 42.519680N, 13.424938E), muro sul bordo della strada, ca. 1020 m, 23 June 2019, *N. Olivieri* (FI). – Casual alien species new for the flora of Abruzzo.

Some individuals, probably originated from seeds produced by plants once cultivated as ornamentals nearby, have settled on a wall made of cement and limestone blocks.

N. Olivieri

***Hordeum vulgare* L. subsp. *vulgare* (Poaceae)**

+ (CAS) **LIG**: Serra Riccò (Genova), ZSC "IT1330893 Rio Ciaè", Valle del Rio Ciaè, pendici SE del Monte Pizzo, lungo la SP3 (WGS84: 44.50302N, 8.96627E), scarpata erbosa a bordo strada, 385 m, 13 October 2019, *G. Barberis*, *D. Dagnino*, *D. Longo*, *S. Peccenini* (FI, GE No. 1496). – Casual alien subspecies new for the flora of Liguria.

D. Dagnino, D. Longo

***Lamium galeobdolon* (L.) L. subsp. *argentatum* (Smejkal) J.Duvign. (Lamiaceae)**

+ (NAT) **VDA**: Aosta (Aosta), sentiero sotto il parcheggio lungo la Strada Regionale Roisan (WGS84: 45.754196N, 7.326396E), sottobosco di latifoglie, 696 m, W, 9 July 2017, leg. *G. Galasso*, det. *G. Galasso*, *E. Banfi* (FI, MSNM). – Naturalized alien subspecies new for the flora of Valle d'Aosta.

G. Galasso, E. Banfi

+ (CAS) **TOS**: Massa (Massa-Carrara), Via Capannelle, tra i Prati della Ciocca e Altagnana (WGS84: 44.052663N, 10,170231E), margine della strada che attraversa un castagneto, su scisti silicei, 260 m, 14 April 2003, *D. Marchetti* (FI, ROV No. 45056). – Casual alien subspecies new for the flora of Toscana.

D. Marchetti, F. Prosser

***Lantana camara* L. subsp. *aculeata* (L.) R.W.Sanders (Verbenaceae)**

+ (CAS) **LAZ**: Roma (Roma), area incolta situata presso la Via Tiburtina (WGS84: 41.908333N, 12.526150E), incolto, ca. 23 m, 25 July 2019, *N. Olivieri* (FI). – Casual alien subspecies new for the flora of Lazio.

*Lantana camara* is generically reported by Celesti-Grapow et al. (2013) and Galasso et al. (2018) for Lazio, without reference to the subspecies. Some fruiting individuals grow in an uncultivated degraded area.

N. Olivieri

***Lemna minuta* Kunth (Araceae)**

+ (INV) **BAS**: Bernalda (Matera), in un canale artificiale lungo Via Dompablo (WGS84: 40.379124N, 16.843067E), in acque a lento scorrimento, 0 m, 4 October 2019, *S. Ceschin*, *F. Mariani* (FI); *ibidem*, loc. Santa Palagina (WGS84: 40.374560N, 16.838382E), in acque a lento scorrimento, 0 m, 4 October 2019, *S. Ceschin*, *F. Mariani* (URT). – Invasive alien species new for the flora of Basilicata.

This species occurs in dense monospecific and multilayered free-floating mats of about one-cm thickness, suggesting an invasive behaviour.

S. Ceschin, F. Mariani

***Mazus pumilus* (Burm.f.) Steenis (Mazaceae)**

+ (NAT) **LOM**: Cremona (Cremona), Via Mercatello, di fronte al numero civico 27 e altrove nella via (WGS84: 45.134603N, 10.026109E), fessure della pavimentazione stradale (cubetti di porfido), 40 m, 19 May 2019, *A. Selvaggi* (MSNM). – Status change from casual to naturalized alien for the flora of Lombardia.

This new record combined with the presence and persistence also in other parts of the town leads us to consider this species as naturalized in Lombardia.

A. Selvaggi, F. Bonali

***Ocimum basilicum* L. (Lamiaceae)**

+ (CAS) **EMR**: Fontevivo (Parma), fraz. Ponte Taro, Fiume Taro (WGS84: 44.827128N, 10.225855E), greto fluviale, 55 m, 15 October 2019, *M. Adorni* (FI). – Casual alien species new for the flora of Emilia-Romagna.

A single flowering and fruiting individual was found in the gravel bed of the river Taro, probably born from seeds transported by water.

M. Adorni

***Oenothera lindheimeri* (Engelm. & A.Gray) W.L.Wagner & Hoch (Onagraceae)**

+ (CAS) **SAR**: Carbonia (Sud Sardegna), lungo la ciclabile a N di Via Lubiana (WGS84: 39.92800N, 8.30216E), incolti aridi, 70 m, 31 July 2019, *G. Calvia* (*Herb. G. Calvia*);

Sassari (Sassari), loc. Predda Niedda (WGS84: 40.737891N, 8.528253E), margine stradale ruderale, 153 m, 14 August 2019, *G. Brundu*, *V. Lozano* (FI, *Herb. UniSS Agraria*); Donori (Sud Sardegna), lungo la SP11 (WGS84: 39.2670N, 9.0822E), margine stradale, 150 m, 12 January 2020, *A. Lallai* (CAG). – Casual alien species new for the flora of Sardegna.

In Sardegna, this species is locally escaped in fallow land roadsides close to cultivation sites, as observed also in Florinas (Sassari) (WGS84: 40.651485N, 8.667238E, 350 m, 14 August 2019, *G. Brundu*).

G. Brundu, G. Calvia, A. Lallai, V. Lozano

***Panicum barbipulvinatum* Nash (Poaceae)**

+ (INV) **FVG**: Venzone (Udine), Via A. Bidernuccio (WGS84: 46.3365N, 13.0891E), in the cracks of pavements, accompanied by *Eragrostis frankii*, 250 m, 6 October 2019, *G. Király*, *A. Király* (FI, BP); *ibidem*, 1.1 km SW of Pioverno on the left bank of river Tagliamento (WGS84: 46.3288N, 13.1219E), dry semi-ruderal grasslands, along with *Digitaria sanguinalis*, *Gypsophila repens*, *Sporobolus* spp., 234 m, 6 October 2019, *G. Király*, *A. Király* (FI, BP); Bordano (Udine), 0.2 km N of the village along the road Via Bordano (WGS: 46.3175N, 13.1122E), ruderal vegetation, along with *Artemisia verlotiorum*, *Panicum capillare*, *Oenothera* spp., 233 m, 6 October 2019, *G. Király, A. Király* (FI, BP). – Invasive alien species new for the flora of Friuli Venezia Giulia.

*Panicum barbipulvinatum* is a taxonomically critical species (Amarell et al. 2014; Király and Alegro 2015) that is quite common in the surroundings of Venzone, especially the Tagliamento valley. It was seen along several mountain roads of the area as well.

G. Király, A. Király

***Panicum virgatum* L. (Poaceae)**

+ (CAS) **TOS**: Aulla (Massa-Carrara), stazione ferroviaria di Aulla, presso Via R. Accorsi (WGS84: 44.219659N, 9.978081E), incolto, 78 m, no exp., 16 October 2018, leg. *D. Marchetti*, det. *E. Banfi* (FI); *ibidem*, 17 September 2019, leg. *D. Marchetti*, det. *E. Banfi* (MSNM). – Casual alien species new for the flora of Toscana.

E. Banfi, D. Marchetti, G. Galasso

***Passiflora morifolia* Mast. (Passifloraceae)**

+ (NAT) **ITALIA** (**SAR**): Assemini (Cagliari), fraz. Su Carroppu (WGS84: 39.298837N, 8.986744E), lungo le siepi e nei frutteti, 7 m, 23 October 2019, *G. Bacchetta*, *L. Onnis*, *L. Podda*, *M. Sarigu* (FI, CAG). – Naturalized alien species new for the flora of Italy (Sardegna).

The South American *Passiflora morifolia* (Miller 1997; Imig et al. 2018) has been recently introduced into Europe, mainly for ornamental purposes, similarly to other species of the genus *Passiflora*. In Assemini, its presence has been observed since 2006,

close to the regional nursery "Is Bagantinus". Since then, this species has spread as far as about 2 km from there, colonizing orchards, walls, ruderal places, and fallow land.

G. Bacchetta, L. Onnis, L. Podda, M. Sarigu

***Persicaria capitata* (Buch.-Ham. ex D.Don.) H.Gross (Polygonaceae)**

+ (CAS) **SAR**: Nuoro (Nuoro) (WGS84: 40.320602N, 9.336254E), bordi stradali, nelle fessure dei marciapiedi, 546 m, 13 September 2019, leg. *M. Manca*, det. *M. Manca*, *G. Brundu* (FI, *Herb. FoReSTAS Orgosolo*). – Casual alien species new for the flora of Sardegna.

M. Manca, G. Brundu

***Phyllostachys aurea* Carrière ex Rivière & C.Rivière (Poaceae)**

+ (CAS) **PUG**: Galatina (Lecce), fraz. Collemeto, SS101 Salentina di Gallipoli (WGS84: 40.214713N, 18.099997E), bordo strada, 48 m, 25 August 2019, *C.M. Musarella* (FI, REGGIO). – Casual alien species new for the flora of Puglia.

Several individuals of the species were observed, probably escaped from a nearby garden.

C.M. Musarella

***Platanus hispanica* Mill. ex Münchh. (Platanaceae)**

+ (NAT) **LIG**: Genova (Genova), quartiere Marassi, Torrente Bisagno, poco a monte dello stadio Luigi Ferraris (WGS84: 44.418133N, 8.948721E), greto del torrente, 16 m, 16 May 2019, *C. Turcato* (FI, GE No. 797); *ibidem*, 29 July 2019, *D. Dagnino*, *C.N. Macrì* (FI, GE No. 798); *ibidem*, quartiere Bolzaneto, Torrente Polcevera, presso Ponte Luigi Ratto (WGS84: 44.464201N, 8.898426E), greto, 46 m, 1 August 2019, *D. Dagnino* (FI, GE No. 568). – Naturalized alien species new for the flora of Liguria.

Both populations are large, showing well established individuals of several age classes, and possibly originated from old individuals of the nearby tree-lined avenues.

D. Dagnino, C. Turcato, D. Longo, L. Minuto

***Platycladus orientalis* (L.) Franco (Cupressaceae)**

+ (CAS) **TOS**: Altopascio (Lucca), stazione ferroviaria, lungo i binari (WGS84: 43.817002N, 10.672046E), massicciata ferroviaria, 14 m, 23 October 2018, *M. Mugnai*, *L. Lazzaro*, *G. Ferretti* (FI). – Casual alien species new for the flora of Toscana.

Young individuals of *Platycladus orientalis* may present a notable leaf dimorphism in their juvenile leaves (Dörken 2013), possibly leading to misidentification as *Calocedrus decurrens* (Torr.) Florin.

M. Mugnai, L. Lazzaro, G. Ferretti

***Pleuropterus multiflorus* (Thunb.) Nakai (Polygonaceae)**

+ (INV) **TOS**: Siena (Siena), Porta Tufi (WGS84: 43.313989N, 11.331430E), margine stradale, 340 m, 11 October 2017, leg. et det. *P. Castagnini*, *F. Serafino*, conf. *G. Galasso* 8 March 2019 (FI). – Invasive alien species new for the flora of Toscana.

G. Bonari, I. Bonini, P. Castagnini

+ (CAS) **MAR**: Ancona (Ancona), giardini del Passetto (WGS84: 43.615943N, 13.533277E), siepi, 40 m, 6 November 2019, *L. Gubellini*, *N. Hofmann* (FI, PESA). – Casual alien species new for the flora of Marche.

L. Gubellini, N. Hofmann

***Pseudosasa japonica* (Siebold & Zucc. ex Steud.) Makino ex Nakai (Poaceae)**

+ (CAS) **TOS**: Siena (Siena), podere La Vigna, lungo il Fosso Ravacciano (WGS84: 43.3205681N, 11.3400000 E), margine di fosso, 250 m, 17 June 2019, leg. *M. Apruzzese*, det. *L. Pinzani* (FI, *Herb. L. Pinzani*). – Casual alien species new for the flora of Toscana.

The species grows in the city centre of Siena, along a river that crosses a relic forest (Bosco di Busseto), forming a dense population. Another small population has been observed nearby (Siena, Fonte di Follonica, WGS84: 43.3205117N, 11.3353871E, 285 m).

L. Pinzani, M. Apruzzese, C. Angiolini

***Raphanus raphanistrum* L. subsp. *sativus* (L.) Schmalh. (Brassicaceae)**

+ (CAS) **LIG**: Serra Riccò (Genova), ZSC "IT1330893 Rio Ciaè", Valle del Rio Ciaè, pendici SE del Monte Pizzo, lungo la SP3 (WGS84: 44.50468N, 8.96785E), bordo strada, al margine di ostrieto, 400 m, 13 October 2019, *G. Barberis*, *D. Dagnino*, *D. Longo*, *S. Peccenini* (FI, GE No. 1008). – Casual alien subspecies new for the flora of Liguria.

G. Barberis, D. Dagnino, D. Longo, S. Peccenini

***Rhus coriaria* L. (Anacardiaceae)**

+ (CAS) **CAL**: Reggio Calabria (Reggio Calabria), fraz. Pellaro, SS106 Jonica (WGS84: 38.034271N, 15.658410E), scarpata stradale, 15 m, 9 August 2019, *C.M. Musarella* (REGGIO); *ibidem*, Via Eremo Pietrastorta (WGS84: 38.113496N, 15.673585E), bordo strada, giardino abbandonato, 537 m, 28 September 2019, *V.L.A. Laface* (REGGIO); *ibidem*, Cittadella Universitaria (WGS84: 38.121697N, 15.662514E), scarpata bordo strada, 72 m, 10 January 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella*, *G. Spampinato* (REGGIO); Sant'Alessio in Aspromonte (Reggio Calabria), SS184 Gallico-Gambarie (WGS84: 38.170131N, 15.768870E), bordo strada, 537 m, 28 September 2019, *V.L.A. Laface* (FI, REGGIO). – Casual alien species confirmed for the flora of Calabria.

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

***Salvia abrotanoides* (Kar.) Sytsma × *S. yangii* B.T.Drew (Lamiaceae)**

+ (CAS) **LAZ**: Bracciano (Roma), fraz. Vigna di Valle, presso l'Aeroporto di Vigna di Valle, di fronte all'hangar "Tricampate", sul Lago di Bracciano (WGS84: 42.084687N, 12.221944E), riva lacustre, su suolo sabbioso, 162 m, 19 September 2019, *S. Buono* (FI). – Casual alien nothospecies new for the flora of Lazio.

A single mature individual grows on sandy soil near the coasts of Lake Bracciano, along with other alien species such as *Amorpha fruticosa* L., *Datura stramonium* L., and *Xanthium italicum* Moretti.

S. Buono, S. Magrini

***Salvia hispanica* L. (Lamiaceae)**

+ (CAS) **VEN**: San Martino Buon Albergo (Verona), sponda dx del Fiume Adige, subito a W di San Procolo, presso Zevio (WGS84: 45.3799085N, 11.1055010E), sponda sabbiosa, 3 esemplari, 30 m, 23 October 2015, leg. *F. Prosser*, *A. Bertolli*, *G. Tomasi*, *S. Andreatta*, det. *F. Prosser* (ROV No. 69728); Verona (Verona), sponda sx del Fiume Adige, 250 m a W del Ponte di San Pancrazio (WGS84: 45.4274692N, 11.0185053E), greto sassoso, 2 esemplari, 50 m, 11 November 2015, leg. *F. Prosser*, *A. Bertolli*, *S. Andreatta*, *G. Tomasi*, det. *F. Prosser* (ROV No. 69916); *ibidem*, ENE di Corte Garofalo, sull'isola presso la sponda dx del Fiume Adige (WGS84: 45.4060915N, 11.0282974E), greto sassoso, 3 esemplari, 44 m, 11 November 2015, leg. *F. Prosser*, *A. Bertolli*, *S. Andreatta*, *G. Tomasi*, det. *F. Prosser* (FI, ROV No. 71302). – Casual alien species new for the flora of Veneto.

Further data for the province of Verona are: river Adige, north of Perzacco (16 November 2015, 2 individuals); the creek known as Illasi, between Tregnago and Illasi (3 October 2019, 100 scattered individuals); Progno (creek) di Valpantena, between Grezzana and Quinto (17 October 2019, a dozen scattered individuals); Verona, river Adige, just downstream of the railway bridge (25 October 2019, one individual). All observations refer to sterile or budding plants. Along the Illasi creek, the plants reached full bloom in early November 2019, so that reproduction is possible.

F. Prosser, A. Bertolli, G. Tomasi, F. Menini

***Sedum praealtum* A.DC. (Crassulaceae)**

+ (CAS) **MOL**: Termoli (Campobasso), versante orientale del promontorio sul quale sorge il borgo antico (WGS84: 42.004633N, 14.998402E), parete rocciosa assolata di natura conglomeratica, ca. 5 m, 14 July 2019, *N. Olivieri* (FI). – Casual alien species new for the flora of Molise.

N. Olivieri

***Setaria pumila* (Poir.) Roem. & Schult. subsp. *pallide-fusca* (Schumach.) B.K.Simon (Poaceae)**

+ (CAS) **ITALIA** (**TOS**): Aulla (Massa-Carrara), stazione ferroviaria di Aulla, presso Via R. Accorsi (WGS84: 44.219469N, 9.978091E), incolto, 78 m, no exp., 16 October 2018, leg. *D. Marchetti*, det. *E. Banfi* (FI, MSNM). – Casual alien subspecies new for the flora of Italy (Toscana).

This subspecies can be easily distinguished from the autonym by the smaller spikelets (2.0–2.5 mm) and the copper-reddish bristles (Rominger 2003). Some authors (e.g., Morrone et al. 2014) consider it as a synonym of *S. pumila*.

E. Banfi, D. Marchetti, G. Galasso

***Sporobolus indicus* (L.) R.Br. (Poaceae)**

+ (NAT) **UMB**: Magione (Perugia), fraz. San Feliciano, sul lungolago (WGS84: 43.117928N, 12.165532E), aiuola, 279 m, 29 September 2019, *N. Hofmann* (FI, PESA). – Naturalized alien species new for the flora of Umbria.

L. Gubellini, N. Hofmann

***Stachys byzantina* K.Koch (Lamiaceae)**

+ (CAS) **LIG**: Sant'Olcese (Genova), loc. Tullo, ZSC "IT1330893 Rio Ciaè", presso una carrareccia (WGS84: 44.493684N, 8.982430E), margine di prati aridi, 453 m, 8 July 2019, *A. Di Turi* (FI, GDOR, GE). – Casual alien species new for the flora of Liguria.

A cluster of well-developed individuals was found close to a cart track, next to arid grasslands.

A. Di Turi

***Thinopyrum obtusiflorum* (DC.) Banfi (Poaceae)**

+ (NAT) **TOS**: Aulla (Massa-Carrara), stazione ferroviaria di Aulla, presso Via R. Accorsi (WGS84: 44.219379N, 9.977977E), incolto, numerosi individui fino a 44.218973N, 9.977592E, 78 m, no exp., 16 October 2018, leg. *D. Marchetti*, det. *E. Banfi* (FI); *ibidem*, 17 September 2019, leg. *D. Marchetti*, det. *E. Banfi* (MSNM). – Naturalized alien species new for the flora of Toscana.

E. Banfi, D. Marchetti, G. Galasso

***Thuja plicata* Donn ex D.Don (Cupressaceae)**

+ (CAS) **ITALIA** (**PIE**): Meugliano (Torino), Lago di Meugliano, nei pressi della strada sterrata che percorre il crinale a S del lago (WGS84: 45.475116N, 7.790035E),

boschi misti di latifoglie, 745 m, 8 May 2019, *M. Lonati*, *M. Pittarello*, *S. Ravetto Enri* (FI). – Casual alien species new for the flora of Italy (Piemonte).

This species was identified according to Chambers (1993), Schulz et al. (2005), and Tison and de Foucault (2014). It was introduced in the surroundings of Lake Meugliano in the 1930s for reforestation purposes. Offspring of this species is abundant near seed-bearing plants; some young individuals have also been found *ca*. 200 m away as the crow flies.

M. Lonati, M. Pittarello, S. Ravetto Enri

***Tradescantia pallida* (Rose) D.R.Hunt (Commelinaceae)**

+ (CAS) **MOL**: Termoli (Campobasso), lungo Viale d'Italia (WGS84: 41.999713N, 14.990261E), bordo di chiusino per la raccolta delle acque piovane, ca. 35 m, 14 July 2019, *N. Olivieri* (FI). – Casual alien species new for the flora of Molise.

The observed individuals probably originated from fragments of plants cultivated as ornamentals in nearby houses.

N. Olivieri

***Tradescantia virginiana* L. (Commelinaceae)**

+ (CAS) **FVG**: Paluzza (Udine), Via Nazionale (WSG84: 46.527719N, 13.013224E), prato incolto nei pressi del margine stradale, 605 m, 15 July 2019, *J. Lupoletti*, *A. Pica* (FI). – Casual alien species new for the flora of Friuli Venezia Giulia.

A small population occupying an area of approximately 5 $m^2$ was observed.

J. Lupoletti, A. Pica

***Ulmus pumila* L. (Ulmaceae)**

+ (NAT) **LIG**: Vado Ligure (Savona), Via Trieste, in prossimità dei cantieri navali (WGS84: 44.267120N, 8.439779E), incolto, 4 m, 13 July 2019, *M. Lonati*, *A. Mainetti*, *S. Ravetto Enri* (FI); *ibidem*, Via Leon Pancaldo 158 (WGS84: 44.271611N, 8.438521E), aiuole prospicenti al lungomare, 10 m, 13 July 2019, *M. Lonati*, *A. Mainetti*, *S. Ravetto Enri* (FI). – Naturalized alien species new for the flora of Liguria.

This species has widely colonized uncultivated and abandoned areas and roadsides. Some individuals have reached big dimensions (6–7 m high) and are already fructifying. The documented risk of hybridization with the native *Ulmus* species (Cogolludo-Augustin et al. 2000; Brunet et al. 2013) suggests monitoring its spread in the region.

M. Lonati, A. Mainetti, S. Ravetto Enri

***Verbena bonariensis* L. (Verbenaceae)**

+ (CAS) **VEN**: Legnaro (Padova), sul margine stradale di Via Orsaretto (WSG84: 45.343510N, 11.954306E), margine di campo coltivato a monocoltura di *Glycine max*, 10 m, 3 July 2019, *J. Lupoletti*, *A. Pica* (FI). – Casual alien species new for the flora of Veneto.

We found a single plant at the border of a soybean field.

J. Lupoletti, A. Pica

***Washingtonia filifera* (Linden ex André) H.Wendl. ex de Bary (Arecaceae)**

+ (CAS) **LAZ**: Roma (Roma), nel giardino pubblico di Villa Lazzaroni (WGS84: 41.521909N, 12.312398E), aiuola, 46 m, 7 August 2019, *G. Buccomino* (FI). – Casual alien species new for the flora of Lazio.

In the site, there are three cultivated palms, two of which produce a large amount of seeds; some young seedlings were observed at their base.

G. Buccomino

***Wisteria sinensis* (Sims) DC. (Fabaceae)**

+ (CAS) **PUG**: Arnesano (Lecce), SP119 (WGS84: 40.331384N, 18.090544E), bordo strada, 30 m, 24 August 2019, *C.M. Musarella* (FI, REGGIO). – Casual alien species new for the flora of Puglia.

Some young individuals were also found, maybe arisen *via* vegetative propagation.

C.M. Musarella

## Nomenclatural novelties

***Cenchrus americanus* (L.) Morrone subsp. *chudeaui* (Maire & Trab.) Banfi & Galasso, comb. et stat. nov.**
urn:lsid:ipni.org:names:77209604-1

*Pennisetum chudeaui* Maire & Trab., Bull. Mus. Natl. Hist. Nat. s. 2, 3(6): 523. 1931 [25 June 1931]

Recently Sosef (2019) published the new combination in *Cenchrus* L. for *Pennisetum chudeaui* Maire & Trab. subsp. *monodii* Maire, the progenitor of pearl millet, *Cenchrus americanus* (L.) Morrone subsp. *americanus* (Burgarella et al. 2018). However, the correct epithet at subspecific rank is '*chudeaui*' since '*monodii*', described simultaneously to the species (Maire 1931), is now considered a heterotypic synonym. Consequently, a new combination is required due to the priority of the autonym (Art. 11.6 of the ICN: Turland et al. 2018) that Maire automatically established when describing its subspecies (Art. 26.3 of the ICN).

E. Banfi, G. Galasso

***Cucumis sativus* L. subsp. *hardwickii* (Royle) Banfi & Galasso, comb. et stat. nov.**
urn:lsid:ipni.org:names:77209607-1

*Cucumis hardwickii* Royle, Ill. Bot. Himal. Mts. [Royle] 7: 220 (218, 219, pl. 47 fig. 3). 1835 [24 August 1835]

Molecular analyses (Sebastian et al. 2010; Qi et al. 2013; Liu et al. 2015) confirmed the exclusive role of the Indian wild cucumber *Cucumis hardwickii* in the genesis of the cultivated cucumber *C. sativus* (de Wilde and Duyfjes 2008). Regarding taxonomy, we have already emphasized (Galasso et al. 2018) that the rank of subspecies is preferable when distinguishing between a crop and its wild ancestor whenever domestication has proceeded linearly from the second to the first without any external genetic contribution.

E. Banfi, G. Galasso

***Rhaphiolepis bibas* (Lour.) Galasso & Banfi, comb. nov.**
urn:lsid:ipni.org:names:77209608-1

*Crataegus bibas* Lour., Fl. Cochinch. 1: 319. 1790 [September 1790]
*Pyrus bibas* (Lour.) M.F.Fay & Christenh., Global Fl. 4: 98. 2018 [9 February 2018]

Based on molecular, morphological, and geographic evidences, Liu et al. (2020) merged *Eriobotrya* Lindl. within *Rhaphiolepis* Lindl. For the loquat, *Eriobotrya japonica* (Thunb.) Lindl., the authors chose the replacement name *Rhaphiolepis loquata* B.B.Liu & J.Wen, because the epithet '*japonica*' was unavailable in *Rhaphiolepis* due to *Rhaphiolepi japonica* Siebold & Zucc. However, the new epithet is superfluous, although not illegitimate, in comparison with *Crataegus bibas*, also reported by the above-cited authors in synonymy, which holds priority at species level (Art. 11.4 of the ICN).

G. Galasso, E. Banfi

## Nomenclatural and distribution updates from other literature sources

Nomenclatural, status, distribution updates, and corrections to Galasso et al. (2018) 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: species data

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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# Notulae to the Italian alien vascular flora: 10

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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, confirmations, exclusions, and status changes for Italy or for Italian administrative regions. Nomenclatural and distribution updates published elsewhere are provided as Suppl. material 1.

**Keywords**

Alien species, floristic data, Italy, nomenclature

## How to contribute

The text for the new records should be submitted electronically to Chiara Nepi (chiara.nepi@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 (typifications only for accepted names), status changes, exclusions, and confirmations should be submitted electronically to Gabriele Galasso (gabriele.galasso@comune.milano.it). Each text should be within 1,000 characters (spaces included).

## Floristic records

### *Achillea filipendulina* Lam. (Asteraceae)

+ (CAS) **MAR**: Urbino (Pesaro e Urbino), Monti delle Cesane, basso versante W del Monte della Cesana, tra Case Peschiera e Ca' Mignone (WGS84: 43.730999°N, 12.650354°E), luoghi maceriosi ai margini di una gariga arbustata, ca. 460 m, 1 July 2020, *N. Hofmann* (FI, PESA). – Casual alien species new for the flora of Marche.

*Achillea filipendulina* is a neophyte native to central and south-western Asia (Ghafoor 2002) and cultivated as ornamental. Recently, a single individual has been detected, growing in a ruderal habitat at the edge of a garrigue, along with *Cotinus coggygria* Scop. and *Spartium junceum* L.

L. Gubellini, N. Hofmann

### *Bidens lanceolata* (L.) Banfi, Galasso & Bartolucci (Asteraceae)

+ (CAS) **TAA**: Trento (Trento), Tangenziale Ovest, uscita Piedicastello, in una rotonda al termine del Lungadige San Nicolò (WGS84: 46.065557°N, 11.111498°E), rotonda stradale, 195 m, 31 May 2020, *G. Bonari* (FI). – Casual alien species new for the flora of Trentino-Alto Adige.

The species, occurring with less than 10 individuals, was found in a flowerbed-like roundabout. Therefore, the place might have been subjected to wildflower seed mixture sown in the past. However, the site looks abandoned. On the other hand, this species might have also arrived from the nearby motorway. Unfortunately, these two explanations are speculative as we don't have data in this respect. In any case, we believe the record is noteworthy, because it suggests the persistence ability of the species.

G. Bonari, C. Wellstein, S. Zerbe

### *Bidens subalternans* DC. (Asteraceae)

+ (NAT) **LAZ**: Alatri (Frosinone), fondovalle in loc. Cosciano (WGS84: 46.719662°N, 13.346098°E), luoghi erbosi a bordo strada, 337 m, 15 October 2018, *E. Fanfarillo* (RO); Orte (Viterbo), nei pressi del casello autostradale (WGS84: 42.453581°N, 12.409637E), stazioni ruderali a bordo strada, 55 m, 27 October 2018, *E. Fanfarillo* (RO); Genzano di Roma (Roma), loc. Ponte Tre Armi (WGS84: 41.677850°N, 12.727938°E), incolti e margini stradali, 265 m, 26 August 2020, *M. Latini* (RO); *ibidem*, tra Ponte San Gennaro e Ponte Tre Armi (WGS84: 41.678913°N, 12.727939°E), incolti e orti, 275 m, 26 August 2020, *M. Latini* (RO). – Status change from casual to naturalized alien for the flora of Lazio.

In Lazio, *Bidens subalternans* was first reported as a casual alien in 2016 in Genzano di Roma (Galasso et al. 2016), where it still occurs and has spread to neighbor-

ing areas. This annual species was also observed by G. Abbate in other localities of Colli Albani at Velletri (Roma), Via Fontana Marcaccio (WGS84: 41.712511°N, 12.782465°E) and Via Passo dei Coresi (WGS84: 41.619027°N, 12.755517°E). This species regularly produces abundant flowers and fruits. Its presence in the same locality for several years, and its occurrence in other provinces, lead us to consider *B. subalternans* as naturalized in Lazio.

M. Latini, G. Nicolella, E. Fanfarillo

***Campsis radicans* (L.) Bureau (Bignoniaceae)**

+ (CAS) **CAL**: Reggio Calabria (Reggio Calabria), fraz. Ortì (WGS84: 38.147734°N, 15.710454°E), scarpata, 607 m, 29 June 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); *ibidem*, fraz. Archi rione Carmine (WGS84: 38.159076°N, 15.666590°E), bordo strada, 56 m, 1 July 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); *ibidem*, loc. Pentimele (WGS84: 38.152204°N, 15.657830°E), bordo strada arrampicata su una rete metallica, 9 m, 17 July 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); Montebello Jonico (Reggio Calabria), contrada Masella (WGS84: 38.004679°N, 15.643481°E), arrampicata su un muro, 56 m, 3 July 2020, leg. *C.M. Musarella*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); *ibidem*, fraz. Saline, borgata Sant'Elia, SS106 (WGS84: 37.932926°N, 15.736238°E), bordo strada, 31 m, 4 July 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); Condofuri (Reggio Calabria), fraz. San Carlo, SS106 (WGS84: 37.928938°N, 15.884340°E), bordo strada, 9 m, 5 July 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); Palizzi (Reggio Calabria), fraz. Spropoli, SS106 (WGS84: 37.924085°N, 16.024619°E), bordo strada, 10 m, 5 July 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO). – Casual alien species new for the flora of Calabria.

*Campsis radicans* is an ornamental used to cover nets and pergolas. We have observed numerous individuals originating both from seed reproduction and vegetative propagation.

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

***Cascabela thevetia* (L.) Lippold (Apocynaceae)**

+ (NAT) **ITALIA** (**SIC**): Campofelice di Roccella (Palermo) (WGS84: 37.996910°N, 13.886166°E), in un canale di scolo dell'acqua piovana, 9 July 2019, *G. Domina* (FI); Monreale (Palermo), Via Olio di Lino (WGS84: 38.076133°N, 13.310443°E), bordo strada, 15 July 2020, *E. Di Gristina* (SAF). – Status change from casual to naturalized alien for the flora of Italy; naturalized alien species new for the flora of Sicilia.

*Cascabela thevetia* is native to Central and South America (Alvarado-Cárdenas et al. 2017), it is cultivated frequently as an ornamental in Sicilia, and was recorded as a casual alien in Calabria (Laface et al. 2020). Several individuals of this species at different growth stages were found in a rainwater drain and on a road edge. These plants

were identified according to Alvarado-Cárdenas et al. (2017), and originated from dispersed seeds from ornamentals growing in nearby private gardens.

E. Di Gristina, F. Scafidi, G. Barone

***Cedrus deodara* (Roxb.) G.Don (Pinaceae)**

+ (CAS) **LIG**: Magliolo (Savona), impluvio del Torrente Maremola (WGS84: 44.18919°N, 8.24017°E), macchia mediterranea, 260 m, 7 December 2019, *A. Alberto, A. Baroni, F. Baroni, I. Briozzo, S. Briozzo, C. Cibei, D. Dagnino, D. Dozza, D. Longo, M. Ottonello, R. Paneri, S. Peccenini, E. Rodi* (FI, GE No. 1613). – Casual alien species new for the flora of Liguria.

D. Longo, C. Cibei

***Cenchrus americanus* (L.) Morrone subsp. *americanus* (Poaceae)**

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

The record published by Englmaier and Wilhalm (2018) for Veneto as casual alien and cited by Galasso et al. (2020) is based on a cultivated plant: WSW di Castagnaro (Verona), ca. 500 m a ESE del Ponte di Pietra, campo a riposo, pianta coltivata, 11 m, 28 March 2002, *F. Prosser* (ROV No. 41991 under the name *Pennisetum glaucum* (L.) R.Br.).

F. Prosser

***Cotoneaster hjelmqvistii* Flinck & B.Hylmö (Rosaceae)**

+ (CAS) **TOS**: Pomarance (Pisa), Riserva Naturale Monterufoli-Caselli, presso Podere Monterufolino (WGS84: 43.244828°N, 10.780255°E), margine boschivo, 500 m, 12 June 2020, leg. *L. Pinzani, F. Olivieri*, det. *F. Roma-Marzio* (FI, *Herb. L. Pinzani*). – Casual alien species new for the flora of Toscana.

L. Pinzani, F. Roma-Marzio

***Cotoneaster salicifolius* Franch. (Rosaceae)**

+ (CAS) **PUG**: Brindisi (Brindisi), aiuole in Via Bastioni di San Giorgio (WGS84: 40.636294°N, 17.938775°E), aiuola semi-ombreggiata, ca. 19 m, 24 August 2019, *N. Olivieri* (FI). – Casual alien species new for the flora of Puglia.

Some young individuals of the species have developed in semi-shady flowerbeds. The plants originated from seeds produced by adult individuals growing nearby.

N. Olivieri

***Crocus tommasinianus* Herb. (Iridaceae)**

+ (NAT) **ITALIA** (**LOM**): Olgiate Molgora (Lecco), loc. Bruggione, boschetto nei pressi di Via Consortile Bruggione (WGS84: 45.735548°N, 9.400043°E), bosco misto mesofilo, 300 m, 14 February 2014, *M. Villa* (*Herb. Parco di Montevecchia e della Valle del Curone*); *ibidem*, 25 February 2019, *M. Villa* (PI025542); *ibidem*, 22 Febru-

ary 2020, *F. Roma-Marzio, L. Peruzzi* (FI); Montevecchia (Lecco), Parco Regionale di Montevecchia e della Valle del Curone, loc. Ceresè, boschetto nei pressi di Via Monza (WGS84: 45.68947°N, 9.37343°E), bosco misto mesofilo, 300 m, 22 February 2020, *F. Roma-Marzio, L. Peruzzi, A. Spalma, P. Bolzani, M. Villa* (PI033382). – Naturalized alien species new for the flora of Italy (Lombardia).

+ (NAT) **FVG**: Mezzana del Turgnano (Udine), Bosco Baredi-Selva Aruonchi, al margine destro del sentiero principale (Stradon di Miez), precisamente all'ingresso del bosco (WGS84: 45.786111°N, 13.115033°E), 7 m, 26 February 2020, *M. Bianco* (FI). – Naturalized alien species new for the flora of Friuli Venezia Giulia.

*Crocus tommasinianus* is native to the NW Balkan peninsula (Harpke et al. 2015), but it is known as introduced alien for Great Britain and Netherlands (Barker 2020). Other localities where this species was observed are: La Valletta Brianza (Lecco), loc. Lissolo (WGS84: 45.736751°N, 9.348045°E); Latisana (Udine), lungo l'argine del Fiume Tagliamento (WGS84: 45.755100°N, 13.006976°E); Lignano Sabbiadoro (Udine), Lungomare A. Kechler (WGS84: 45.666355°N, 13.110460°E); Talmassons (Udine), fraz. Flambro, lungo un fossato appena fuori il centro abitato in Via Tagliamento (WGS84: 45.931594°N, 13.084167°E).

M. Villa, M. Bianco, P. Bolzani, F. Roma-Marzio, L. Peruzzi

***Echinochloa colona* (L.) Link (Poaceae)**

+ (CAS) **MAR**: Fermo (Fermo), fraz. Lido di Fermo, sulla spiaggia (WGS84: 43.2215278°N, 13.7823888°E), sabbie, 1 m, 1 September 2019, *M. Tiburtini* (FI). – Casual alien species new for the flora of Marche.

Several plants have grown in a human-disturbed area where mechanical beach cleaning frequently occurs.

M. Tiburtini, J. Franzoni, F. Roma-Marzio

***Erythrostemon gilliesii* (Wall. ex Hook.) Klotzsch (Fabaceae)**

+ (CAS) **CAL**: Reggio Calabria (Reggio Calabria), loc. Bocale (WGS84: 37.968386°N, 15.756872°E), collina sabbiosa, 298 m, 26 May 2020, leg. *C.M. Musarella*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO). – Casual alien species new for the flora of Calabria.

*Erythrostemon gilliesii* is commonly cultivated as ornamental. The observed individual probably escaped from the gardens of nearby houses.

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

***Heliotropium amplexicaule* Vahl (Heliotropiaceae)**

+ (NAT) **SIC**: Catania (Catania), porto di Catania (WGS84: 37.501733°N, 15.096016°E), bordo strada, ca. 1 m, 13 October 2020, *G. Tavilla, D. Azzaro, V. Ranno* (FI, CAT). – Naturalized alien species confirmed for the flora of Sicilia.

For Sicily, *Heliotropium amplexicaule* is reported by Costa and Pavone (2018) inside the Botanical Garden of Catania, and by Pignatti et al. (2018) without invasiveness status. The presence of this species is confirmed as naturalized along the roadside of the port of Catania.

G. Tavilla, D. Azzaro, V. Ranno

***Hesperocyparis glabra* (Sudw.) Bartel (Cupressaceae)**

+ (NAT) **MAR**: Acqualagna (Pesaro e Urbino), Monti del Furlo, versante W-NW del Monte Pietralata, nella parte sommitale del Monte Bregno (WGS84: 43.662655°N, 12.693646°E), pascoli aridi e sassosi, ca. 705 m, 22 July 2020, *L. Gubellini* (FI, PESA). – Naturalized alien species new for the flora of Marche.

*Hesperocyparis glabra* is a neophyte native to the SW United States of America (Adams et al. 2009; Farjon 2010), widely used as ornamental and for reforestation. The observed population consists of a few dozen young individuals, whose propagation has probably been favoured by a recent forest fire.

L. Gubellini, N. Hofmann

***Houttuynia cordata* Thunb. (Saururaceae)**

+ (CAS) **ITALIA** (**FVG**): Palazzolo dello Stella (Udine), rive del Fiume Stella (WGS84: 45.809452°N, 13.079030°E), bosco ripariale disturbato, 5 m, 16 June 2020, *F. Liccari* (FI); *ibidem* (45.809453°N, 13.079031°E), bosco ripariale disturbato, 5 m, 16 June 2020, *F. Boscutti* (FI). – Casual alien species new for the flora of Italy (Friuli Venezia Giulia).

*Houttuynia cordata* is a perennial herb native to temperate and tropical Asia, cultivated worldwide as ornamental. It has become naturalized in wetland habitats in New Zealand and the USA (Louisiana), where it is considered invasive (Wunderlin et al. 2010; USDA, NRCS 2020). In Europe it was first reported in Belgium, where it is considered a casual alien (Saintenoy-Simon 2013; Verloove 2020). We found this species growing in a disturbed riverine wood along the river Stella. We observed a few individuals in July 2019, but the species is rapidly spreading due to vegetative propagation; we also observed several flowering individuals. This trend suggests an ongoing naturalization process, with an invasive potential.

F. Liccari, F. Boscutti

***Ibicella lutea* (Lindl.) Van Eselt. (Martyniaceae)**

+ (CAS) **ITALIA** (**SAR**): Laerru (Sassari) (WGS84: 40.814497°N, 8.851962°E), in un erbaio a dominanza di *Sulla coronaria*, 97 m, 1 July 2020, leg. *G. Rivieccio, S. Bagella, V. Bica, L. Lunesu*, det. *L. Lunesu* (FI, SS). – Casual alien species new for the flora of Italy (Sardegna).

Native to South America, *Ibicella lutea* has been reported in Europe for different areas (Verloove 2006; Yannitsardos and Bazos 2006; Tison et al. 2014). The population of Laerru occupies two small portions of a cultivated field (around 3,000 $m^2$).

G. Rivieccio, L. Lunesu, S. Bagella

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

+ (CAS) **ABR**: Teramo (Teramo), strada secondaria presso Via A. De Gasperi (WGS84: 42.662158°N, 13.707497°E), margine erboso, ca. 250 m, 10 June 2020, *N. Olivieri* (FI). – Casual alien species new for the flora of Abruzzo.

N. Olivieri

***Lantana camara* L. subsp. *camara* (Verbenaceae)**

+ (CAS) **ITALIA** (**PUG**): Brindisi (Brindisi), aiuole in Via Bastioni di San Giorgio (WGS84: 40.636294°N, 17.938775°E), aiuola semi-ombreggiata, ca. 19 m, 24 August 2019, *N. Olivieri* (FI). – Casual alien subspecies new for the flora of Italy (Puglia).

Some young individuals of this taxon are growning in semi-shaded flowerbeds. The plants, identified according to Sanders (2012), originated from seeds produced by some adult specimens present nearby. This subspecies is widely cultivated in Italy as ornamental in areas with a Mediterranean climate, however, unlike *L. camara* subsp. *aculeata* (L.) R.W.Sanders (Thaman 1974), it rarely gives rise to adventitious populations.

N. Olivieri

***Liriope spicata* (Thunb.) Lour. (Asparagaceae)**

+ (CAS) **CAL**: Scilla (Reggio Calabria) (WGS84: 38.239889°N, 15.719085°E), bordo strada vicino ad un castagneto, 378 m, 14 July 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO). – Casual alien species new for the flora of Calabria.

The only plant found probably escaped from cultivation or was thrown together with the waste material from nearby gardens.

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

***Lobelia erinus* L. (Campanulaceae)**

+ (CAS) **SIC**: Palermo (Palermo), Via Cluverio, nei pressi di Piazza San Francesco di Paola (WGS84: 38.121652°N, 13.351802°E), negli interstizi dei marciapiedi, 22 m, 11 May 2020, *E. Di Gristina* (FI). – Casual alien species new for the flora of Sicilia.

Some mature individuals have been found in sidewalk crevices, probably coming from nearby adult fruiting plants.

E. Di Gristina, F. Scafidi, G. Barone

***Nandina domestica* Thunb. (Berberidaceae)**

+ (CAS) **LAZ**: Roma (Roma), aiuola in Piazza B. Cairoli (WGS84: 41.893619°N, 12.475277°E), margine di aiuola semi-ombreggiata, ca. 31 m, 20 September 2019, *N. Olivieri* (FI). – Casual alien species new for the flora of Lazio.

A few young individuals of this species originated from seeds produced by some adults grown as ornamentals in a nearby flowerbed. *Nandina domestica* is native to China and Japan, and was introduced in Italy in 1821 (Maniero 2015).

N. Olivieri

***Nassella neesiana* (Trin. & Rupr.) Barkworth (Poaceae)**

+ (NAT) **LAZ**: Roma (Roma), Villa Ada (WGS84: 41.928728°N, 12.505276°E), incolto, 40 m, 29 June 2020, *G. Nicolella* (RO). – Status change from casual to naturalized alien for the flora of Lazio.

This species was first recorded in Lazio in 1970 at Villa Ada (Anzalone and Veri 1975) and then collected there also in the following years (Moraldo 1986; Anzalone et al. 2010). Its presence in the same locality 50 years later leads us to consider *Nassella neesiana* as naturalized in this administrative region.

G. Nicolella, M. Latini

***Nothoscordum gracile* (Aiton) Stearn (Amaryllidaceae)**

+ (CAS) **SIC**: Messina (Messina), Viale Boccetta (WGS84: 38.198263°N, 15.551971°E), marciapiede, 26 m, 17 June 2020, leg. *C.M. Musarella*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO); Catania (Catania), Via A. Longo, vicino Orto Botanico (WGS84: 37.515272°N, 15.082627°E), bordo strada, 33 m, 18 June 2020, leg. *C.M. Musarella*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); *ibidem*, Via S. Paola (WGS84: 37.514850°N, 15.081857°E), marciapiede, 37 m, 19 June 2020, leg. *C.M. Musarella*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO). – Casual alien species new for the flora of Sicilia.

Some plants of the species grow in the crevices of sidewalks, having probably escaped from nearby pots or flowerbeds.

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

***Oxalis dillenii* Jacq. (Oxalidaceae)**

+ (NAT) **SIC**: Palermo (Palermo), Via G. La Farina, angolo Via N. Garzilli (WGS84: 38.1292592°N, 13.3504172°E), negli interstizi dei marciapiedi, 16 m, 16 May 2019, *G. Barone* (FI). – Naturalized alien species new for the flora of Sicilia.

Recent expansion of the range of the species, not yet reported in the recent flora of Palermo (Domina et al. 2020).

E. Di Gristina, F. Scafidi, G. Barone

+ (NAT) **SAR**: Gairo (Nuoro), presso il Rio Sammuccu (WGS84: 39.904900°N, 9.427900°E), bordo stradale moderatamente fresco-umido, 900 m, 21 June 2020, *G. Mereu* (FI). – Naturalized alien species confirmed for the flora of Sardegna.

This species has been indicated as naturalized alien in Sardegna by Arrigoni (2010), but its presence on the island was considered doubtful by Galasso et al. (2018).

G. Mereu

***Papaver orientale* L. (Papaveraceae)**

+ (CAS) **ITALIA** (**UMB**): Norcia (Perugia), Parco Nazionale dei Monti Sibillini, Fonte delle Fate (WGS84: 42.852796°N, 13.240533°E), ghiaia, 1,996 m, 19 July 2020, *F. Miconi* (FI). – Casual alien species new for the flora of Italy (Umbria).

A single plant of *Papaver orientale* bearing four flowers was found on gravelly soil. It was identified according to Cullen (1995).

F. Miconi

***Passiflora incarnata* L. (Passifloraceae)**

+ (CAS) **LAZ**: Tuscania (Viterbo), Via XI Febbraio, lungo il muro del campo di calcio (WGS84: 42.420996°N, 11.870770°E), base di muro, 180 m, 13 July 2020, *S. Magrini* (FI). – Casual alien species new for the flora of Lazio.

Several plants of the species grow along a wall, having probably escaped from nearby gardens; they produce many fruits every year.

S. Magrini, S. Buono

***Phyllostachys aurea* Carrière ex Rivière & C.Rivière (Poaceae)**

+ (CAS) **LAZ**: Latina (Latina), loc. Astura, lungo la sponda sinistra del Torrente Astura, a monte del ponte della SP106b (WGS84: 41.423738°N, 12.774910°E), area di ripa incolta occupata nella porzione basale da *Phragmites australis*, 1 m, 4 January 2020, *S. Ravetto Enri, M. Pittarello, M. Lonati* (FI). – Casual alien species new for the flora of Lazio.

A large population of this species, occupying an area of approximately 10×10 m, has been observed along a scarp of the Astura stream. The expansion probably occurred through leptomorph underground rhizomes. A recent project (BampApp 2020+) provided comprehensive information for evaluating and updating the presence of bamboo species in Piemonte and Valle d'Aosta, and a similar approach could be replicated to increase current knowledge regarding the status of bamboos in other Italian regions as well.

S. Ravetto Enri, M. Pittarello, M. Lonati

***Robinia hispida* L. (Fabaceae)**

+ (CAS) **ABR**: L'Aquila (L'Aquila), presso il Parco del Sole (WGS84: 42.341639°N, 13.403482°E), incolto, 680 m, 12 May 2020, *F. Conti, V. Giacanelli* (FI, APP). – Casual alien species new for the flora of Abruzzo.

F. Conti, V. Giacanelli, F. Bartolucci

***Sedum palmeri* S.Watson (Crassulaceae)**

+ (CAS) **ABR**: Teramo (Teramo), Via A. De Gasperi (WGS84: 42.662222°N, 13.708197°E), muro di contenimento in cemento situato al di sotto della sede stradale, ca. 256 m, S, 20 April 2020, *N. Olivieri* (FI). – Casual alien species new for the flora of Abruzzo.

Some individuals have settled on the rough surface of a vertical south-facing wall, which is, however, partially shaded by buildings.

N. Olivieri

***Siphonostylis unguicularis* (Poir.) Wern.Schulze (Iridaceae)**

+ (NAT) **ABR**: Atri (Teramo), margine stradale di Via D. Tinozzi (WGS84: 42.580874°N, 13.986662°E), scarpata a vegetazione ruderale con presenza di *Robinia pseudoacacia, Sambucus nigra, Laurus nobilis* e vegetazione erbacea nitrofila, 400 m, 29 January 2020, *J. Lupoletti, A. Pica* (FI). – Naturalized alien species new for the flora of Abruzzo.

Several individuals of different ages grow in an area of approximately 80 $m^2$. The surrounding areas and closest gardens do not host the species.

J. Lupoletti, A. Pica

***Sisyrinchium montanum* Greene (Iridaceae)**

+ (CAS) **MAR**: Apecchio (Pesaro e Urbino), Serre della Stretta, margine settentrionale del Bosco della Brugnola lungo la Strada Provinciale Pianditebbio (WGS84: 43.559302°N, 12.463115°E), luoghi acquitrinosi, ca. 600 m, 10 May 2020, *L. Gubellini, N. Hofmann* (FI, PESA). – Casual alien species new for the flora of Marche.

This neophyte is native to North America (Banfi and Galasso 2010; Cholewa and Henderson 2002). The small recorded population consists of about 10 individuals, and it grows in a grassy wet depression of a high hilly area.

L. Gubellini, N. Hofmann

***Viola sororia* Willd. (Violaceae)**

+ (CAS) **MAR**: Cagli (Pesaro e Urbino), loc. Case San Pietro (WGS84: 43.541383°N, 12.654030°E), siepe camporile e fessure del ciottolato di sentiero e capezzagna, 300 m, 6 April 2020, leg. *G. Mei*, det. *G. Mei, A. Stinca* (FI, PORUN-Stinca, *Herb. G. Mei*); *ibidem* (WGS84: 43.541230°N, 12.653035°E), suolo rimaneggiato, 285 m, 12 April 2020, leg. *G. Mei*, det. *G. Mei, A. Stinca* (PORUN-Stinca, *Herb. G. Mei*). – Casual alien species new for the flora of Marche.

G. Mei, A. Stinca

***Viola wittrockiana* Gams ex Nauenb. & Buttler (Violaceae)**

+ (CAS) **TOS**: Empoli (Firenze), Via E. Fermi (WGS84: 43.712452°N, 10.952261°E), circa 10 piantine sfuggite a coltura dalle abitazioni vicine, 25 m, 10 May 2020, *F. Roma-Marzio, P. Liguori* (FI). – Casual alien species new for the flora of Toscana.

F. Roma-Marzio

***Wisteria sinensis* (Sims) DC. (Fabaceae)**

+ (CAS) **SIC**: Misilmeri (Palermo), SP38 (WGS84: 38.052065°N, 13.434617°E), bordo strada, 239 m, 15 June 2020, *F. Scafidi* (FI). – Casual alien species new for the flora of Sicilia.

Some individuals of the species were also found, probably originated by vegetative propagation from plants cultivated nearby.

F. Scafidi, G. Barone, E. Di Gristina

***Yucca gigantea* Lem. (Asparagaceae)**

+ (CAS) **CAL**: Reggio Calabria (Reggio Calabria), fraz. Catona, ex Centro Svizzero (WGS84: 38.185560°N, 15.636418°E), incolto, 4 m, 7 January 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO). – Casual alien species new for the flora of Calabria.

The observed individual probably escaped from cultivation after being thrown away with waste material.

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

**Nomenclatural and distribution updates from other literature sources**

Nomenclatural, status, distribution updates, and corrections to Galasso et al. (2018) 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: Species data

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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# Notulae to the Italian alien vascular flora: 11

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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, confirmations, exclusions, and status changes for Italy or for Italian administrative regions. Nomenclatural and distribution updates published elsewhere are provided as Suppl. material 1.

**Keywords**

Alien species, floristic data, Italy, nomenclature

## How to contribute

The text for the new records 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 (typifications only for accepted names), status changes, exclusions, and confirmations should be submitted electronically to Gabriele Galasso (gabriele.galasso@comune.milano.it). Each text should be within 1,000 characters (spaces included).

## Floristic records

### *Acacia dealbata* Link (Fabaceae)

+ (NAT) **SIC**: Castelbuono (Palermo), c.da Vicaretto (WGS84: 37.901537°N, 14.125820°E), pascolo abbandonato, 7 July 2018, *G. Domina* (SAF); Cefalù (Palermo), c.da Carbonara (WGS84: 38.005208°N, 14.027224°E), vicinanze di oliveto e frutteti, 580 m, 8 August 2020, *G. Domina* (FI, SAF). – Naturalized alien species new for the flora of Sicilia.

Several individuals originating from seeds produced by nearby trees were observed at different growth stages.

F. Scafidi, G. Barone, E. Di Gristina

***Acalypha australis* L. (Euphorbiaceae)**

+ (NAT) **VEN**: Sommacampagna (Verona), a SW di Sommacampagna, loc. Balconi Rossi (WGS84: 45.395550°N, 10.807802°E), campo di mais, 107 m, 22 October 2020, *F. Prosser*, *G. Tomasi*, *M. Gecchelin* (ROV); Valeggio sul Mincio (Verona), a NW di Valeggio sul Mincio presso Ca' Forneletti (WGS84: 45.373276°N, 10.711337°E), campi di mais e zucchine, 65 m, 23 October 2020, *A. Bertolli*, *F. Festi* (ROV); Castel d'Azzano (Verona) (WGS84: 45.355930°N, 10.942225°E), aiuola incolta, 46 m, 27 October 2020, *F. Prosser*, *G. Tomasi*, *M. Gecchelin* (FI, ROV); Sona (Verona), fraz. San Giorgio in Salici (WGS84: 45.42800998°N, 10.79159430°E), margine vigneto, 30 October 2020, *A. Bertolli*, *F. Festi*, *M. Gecchelin* (ROV). – Naturalized alien species new for the flora of Veneto.

In Veneto, this species was found in the western part close to the border with Lombardia (Ca' Forneletti); in this site, the species' occurrence is widespread, thereby becoming a dangerous weed.

A. Bertolli, F. Festi, F. Prosser, G. Tomasi

***Acer saccharinum* L. subsp. *saccharinum* (Sapindaceae)**

+ (CAS) **LIG**: Carasco (Genova), ZSC "IT1332717 Foce e medio corso del Fiume Entella", loc. San Quirico, riva sinistra (WGS84: 44.35271°N, 9.35779°E), bosco ripario di salici e pioppi (Habitat Natura 2000 cod. 92A0), 19 m, 23 July 2020, leg. *D. Dagnino*, *C. Turcato*, det. *E. Banfi*, *D. Dagnino*, *C. Turcato* (FI, GE No. 2693). – Casual alien species new for the flora of Liguria.

D. Dagnino, C. Turcato, E. Banfi

***Actinidia deliciosa* (A.Chev.) C.F.Liang & A.R.Ferguson (Actinidiaceae)**

+ (CAS) **PIE**: Vistrorio (Torino), loc. Ciapies, bosco ripariale in sinistra orografica del Torrente Chiusella (WGS84: 45.442472°N, 7.759771°E), bosco ripariale, 465 m, 12 June 2020, *S. Ravetto Enri*, *A. Mainetti*, *D. Barberis* (FI); Rueglio (Torino), scarpata a monte della Strada per Bossola (WGS84: 45.477199°N, 7.763217°E), castagneto ceduo, 650 m, 26 September 2020, *S. Ravetto Enri* (FI). – Casual alien species new for the flora of Piemonte.

Two individuals were found in the above-mentioned sites: a well-developed fruiting female individual climbing along a 5 m tall *Salix alba* L. and a young male individual *ca.* 1 m tall.

S. Ravetto Enri, A. Mainetti, D. Barberis

***Ajuga dictyocarpa* Hayata (Lamiaceae)**

+ (CAS) **ITALIA** (**LOM**): Milano (Milano), Via C. Valvassori Peroni (WGS84: ca. 45.480805°N, 9.236509°E), casuale in un vaso di ligustro, 116 m, W, 15 May 2020, *E. Banfi* (FI, MSNM No. 50727). – Casual alien species new for the flora of Italy (Lombardia).

This species, native to East Asia, was identified with Flora of China (Li and Hedge 1994).

E. Banfi, G. Galasso

***Alcea biennis* Winterl subsp. *biennis* (Malvaceae)**

+ (CAS) **CAL**: Reggio Calabria (Reggio Calabria), Piani di San Nicola, fraz. Ortì (WGS84: 38.152106°N, 15.695742°E), bordo strada, 559 m, 29 June 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface*, *C.M. Musarella*, *G. Spampinato* (FI). – Casual alien species new for the flora of Calabria.

The recorded individuals originated from seeds of plants cultivated in a nearby monastery for medicinal purposes.

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

***Allium tuberosum* Rottler ex Spreng. (Amaryllidaceae)**

+ (NAT) **TOS**: Anghiari (Arezzo), lungo la strada SS73 Senese-Aretina (E78) al km 172 (WGS84: 43.511004°N, 12.084579°E), erbosi ai margini della strada, 313 m, 22 September 2020, *F. Selvi*, *L. Lazzaro*, *A. Coppi* (FI). – Naturalized alien species new for the flora of Toscana.

*Allium tuberosum* is native to Asia, but is nowadays widely cultivated for ornamental and culinary purposes (Blattner and Friesen 2006). We observed several flowering individuals forming a well-established population at the edge of the road SS73 (from km 170 to 172). We also observed a few other individuals along the same road between Le Lastre and Arezzo at km 147 (WGS84: 43.424812°N, 11.920076°E).

F. Selvi, L. Lazzaro, A. Coppi

***Amaranthus muricatus* (Moq.) Gillies ex Hieron. (Amaranthaceae)**

+ (NAT) **LAZ**: Roma (Roma), Via Monte Ruggero (WGS84: 41.948146°N, 12.529498°E), marciapiede, 30 m, 28 November 2017, *G. Nicolella* (RO); *ibidem*, 15 July 2020, *D. Iamonico*, *G. Nicolella* (HFLA, RO); *ibidem*, Via Sarandi (WGS84: 41.948286°N, 12.529817°E), marciapiede, 39 m, 15 July 2020, *D. Iamonico*, *G. Nicolella* (HFLA, RO); *ibidem*, Via Monte Cardoneto (WGS84: 41.947950°N, 12.529648°E), terrapieno, 28 September 2020, *G. Nicolella* (HFLA, RO). – Status change from casual to naturalized alien for the flora of Lazio.

*Amaranthus muricatus* was observed for the first time in Roma in 2017 as a casual alien (Nicolella 2018). In recent years, we noticed that this species regularly produces abundant fruits. Despite recurrent cuts, it still occurs in the place of first discovery and has also spread to some nearby streets.

D. Iamonico, G. Nicolella, A. Noor Hussain

***Amaranthus palmeri* S.Watson (Amaranthaceae)**

+ (NAT) **MAR**: Fano (Pesaro e Urbino), sponda destra del Fiume Metauro, poco a monte del ponte autostradale (WGS84: 43.8108333°N, 13.0391666°E), greto fluviale ghiaioso, ca. 5 m, 8 October 2020, *L. Gubellini* (FI, PESA). – Naturalized alien species new for the flora of Marche.

A few individuals were observed growing in the stony riverbed of the Metauro river about 4 km from its mouth.

L. Gubellini, N. Hofmann

***Asparagus aethiopicus* L. (Asparagaceae)**

+ (CAS) **CAL**: Reggio Calabria (Reggio Calabria), Via G. De Nava (WGS84: 38.119775°N, 15.653339°E), marciapiedi, 18 m, 22 September 2020, *V.L.A. Laface*, *C.M. Musarella*, *G. Spampinato* (FI, REGGIO). – Casual alien species new for the flora of Calabria.

Only two individuals were found growing in a crack in the sidewalk, probably escaped from the balconies of nearby houses.

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

***Begonia grandis* Dryand. subsp. *grandis* (Begoniaceae)**

+ (CAS) **SIC**: Palermo (Palermo), Via G. Malvica, nei pressi del civico 24 (WGS84: 38.1292592°N, 13.3504172°E), negli interstizi dei marciapiedi, 15 July 2020, *E. Di Gristina* (FI). – Casual alien species new for the flora of Sicilia.

Some mature individuals of this cultivated perennial native to Japan were found in the interstices of the sidewalks, probably coming from nearby adult fruiting plants.

E. Di Gristina, F. Scafidi, G. Barone

***Bidens subalternans* DC. (Asteraceae)**

+ (NAT) **TAA**: Rovereto (Trento), riva sinistra del Fiume Adige a monte del ponte di Villa Lagarina (WGS84: 45.918331°N, 11.046048°E), un esemplare, 174 m, 19 September 2019, leg. *C. Raffaelli*, det. *F. Prosser* (ROV); Ala (Trento), sponda destra del Fiume Adige presso Chizzola (WGS84: 45.80800950°N, 11.01131898°E), una decina di esemplari, 146 m, 20 July 2020, leg. *A. Bertolli*, *G. Tomasi*, det. *F. Prosser* (ROV); Trento (Trento), riva destra del Fiume Adige di fronte alla loc. Acquaviva (WGS84:

45.98892636°N, 11.11568431°E), un migliaio di esemplari per un tratto di ca. 1 km, 186–187 m, 6 October 2020, *C. Raffaelli* (FI, ROV). – Naturalized alien species new for the flora of Trentino-Alto Adige.

In Trentino, this species is spreading along the Adige river, probably starting from the vast settlement near Acquaviva, thanks to the transport of sheep. This is confirmed by a further observation, again along the Adige, just south of Avio (WGS84: 45.720804°N, 10.936019°E).

C. Raffaelli, A. Bertolli, G. Tomasi, F. Prosser

***Bidens vulgata* Greene (Asteraceae)**

+ (NAT) **VEN**: Verona (Verona), Porto San Pancrazio (WGS84: 45.431196°N, 11.020334°E), diversi esemplari in fiore sulla sponda di un fossato, 42 m, 6 October 2020, *S. Andreatta* (FI, VER No. SA459). – Naturalized alien species new for the flora of Veneto.

Until recently, this species has been misidentified with *Bidens frondosa* L. (Veerlove and Ardenghi 2015; Galasso et al. 2016). During field surveys in 2020, we also observed consistent populations of this taxon in other localities, such as San Bonifacio (Verona, WGS84: 45.40250°N, 11.25814°E), Cerea (Verona, WGS84: 45.199084°N, 11.203187°E), San Martino Buon Albergo (Verona).

F. Menini, M. Trenchi, S. Andreatta

***Bothriochloa saccharoides* (Sw.) Rydb. subsp. *saccharoides* (Poaceae)**

+ (NAT) **ITALIA** (**VEN**): Thiene (Vicenza), Via del Terziario SP349, nelle aree contermini all'ipermercato (WGS84: 45.6933378°N, 11.4826360°E), migliaia di esemplari distribuiti sul bordo strada, nelle scarpate stradali, negli incolti erbosi, 124 m, no exp., 21 September 2019, leg. *D. Tomasi*, det. *A.S. Vega* (FI, MSNM Nos. 50878, 50879, *Herb. D. Tomasi*). – Naturalized alien species new for the flora of Italy (Veneto).

*Bothriochloa saccharoides* is a grass native to the American continent (Vega 2000). The systematics of the *B. saccharoides* complex is quite complex. Indeed, this species had already been previously reported in Italy for western Liguria by Barberis and Orsino (1984), but later the record was attributed to *B. laguroides* (DC.) Herter subsp. *laguroides* (Verloove and Lambonon 2008; Galasso et al. 2018). A similar report for France was, instead, attributed to *B. barbinoidis* (Lag.) Herter (Lambinon 1995), so this record is the first for Europe. The discovery site consists of a large area of *ca.* 100 m in radius characterized by a herbaceous cenosis, in which *B. saccharoides* is dominant.

D. Tomasi

***Bougainvillea glabra* Choisy (Nyctaginaceae)**

+ (CAS) **ITALIA** (**TOS**): Vecchiano (Pisa), Tenuta di Migliarino, vicino al confine con Torre del Lago, all'interno della ZSC "IT5170001 Dune litoranee di Torre del Lago",

nella parte litoranea della Tenuta (WGS84: 43.8124°N, 10.2626°E), zone retrodunali con aree aperte, alberi e arbusti sparsi, 20 June 2018, *D. Viciani*, *S. Sarmati* (FI). – Casual alien species new for the flora of Italy (Toscana).

*Bougainvillea glabra* is an ornamental vine, very similar to *B. spectabilis* Willd. from which it differs for leaves glabrous to sparsely pubescent, generally elliptical with acute to attenuate base (*vs* usually densely pubescent, ovate with obtuse to rounded base), and for branches with generally straight (*vs* recurve) spines (Lu and Gilbert 2003; Udulutsch et al. 2020). We observed a wild individual in a seemingly little disturbed dune environment.

D. Viciani, S. Sarmati, G. Ferretti

***Bulbine asphodeloides* (L.) Spreng. (Asphodelaceae)**

+ (CAS) **TOS**: Massarosa (Lucca), Via Padule in Quiesa (WGS84: 43.838382°N, 10.355687°E), scarpata su muro a bordo strada, in espansione, 20 m, 16 January 2021, *L. Pinzani* (FI, *Herb. L. Pinzani*). – Casual alien species new for the flora of Toscana.

L. Pinzani

***Carex tribuloides* Wahlenb. (Cyperaceae)**

+ (NAT) **ITALIA** (**LOM**): Arsago Seprio (Varese), ZSC "IT2010011 Paludi di Arsago", Palude Pollini (WGS84: 45.69967°N, 8.72270°E), sponde di stagno periodicamente inondate, 293 m, no exp., 31 May 2020, leg. *M. Martignoni*, *N. Pilon*, det. *P. Jiménez-Mejías*, conf. *A. Hipp*, *A.A. Reznicek* (FI, MSNM No. 50819, UPOS); *ibidem*, 20 June 2020, leg. *M. Martignoni*, *N. Pilon*, det. *P. Jiménez-Mejías*, conf. *A. Hipp*, *A.A. Reznicek* (MSNM No. 50820, UPOS). – Naturalized alien species new for the flora of Italy (Lombardia).

*Carex tribuloides* is native to eastern North America, where it inhabits wet to moist open habitats. It belongs to the species-rich section *Cyperoideae* G.Don, including 3 species in Europe and *ca.* 90 species in North America. It can be confused with two other North American relatives that are also introduced in Europe, *C. bebbii* (L.H.Bailey) Fernald and *C. scoparia* Willd., from which it can be easily distinguished (Mastrogiuseppe et al. 2002) by the leaf sheaths (apex expanded upwards beyond the insertion of the blade *vs* truncate) and the utricles (wingless or very narrowly winged towards the base *vs* conspicuously winged towards the base). *C. tribuloides* was previously reported from Sweden, from where it seems to have disappeared (Wallnöfer and Essl 2016). Two large tufts of about 1 $m^2$ were observed.

M. Martignoni, N. Pilon, G. Galasso, P. Jiménez-Mejías

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

+ (CAS) **ABR**: Campli (Teramo), loc. Battaglia, zona Pianevie, nella vallata del Torrente Fosso Grande (WGS84: 42.704166°N, 13.618888°E), orlo di vegetazione

boschiva, ca. 720 m, N, 4 October 2020, *N. Olivieri* (FI). – Casual alien species new for the flora of Abruzzo.

Some young individuals of the species grow in a cool and shady area located at the bottom of a narrow valley subjected to thermal inversion, where the soil is a calcareous rendzina. The plants originated from seeds produced by a nearby artificial reforestation area.

N. Olivieri

***Chasmanthe aethiopica* (L.) N.E.Br. (Iridaceae)**

– **TOS**. – Alien species to be excluded from the flora of Toscana.

According to literature data, the presence of this species in Toscana has been reported for the Tuscan Archipelago and for Monte Argentario (Baldini 1995). In the Tuscan Archipelago, it was first reported by Sommier (1900), based on specimens collected on the islands of Capraia (FI!) and Elba (FI!). Subsequently, it was confirmed for both islands (Lastrucci et al. 2012a; Lazzaro et al. 2014). A further report for the island of Gorgona (Arrigoni 2017) lacks herbarium documentation in FI. A review, based on de Vos (1985), Grandis (2016), and Lazzeri (2016), of all herbarium material preserved in FI for Toscana and linked to the records cited above, has allowed us to attribute all the specimens to *Chasmanthe floribunda* (Salisb.) N.E.Br. (Tuscan Archipelago) or to *C. bicolor* (Gasp.) N.E.Br. (Monte Argentario).

G. Ferretti, L. Lazzaro

***Chasmanthe floribunda* (Salisb.) N.E.Br. (Iridaceae)**

+ (NAT) **TOS**. – Alien status indication for the flora of Toscana.

On the basis of the previous records wrongly referred as to *Casmanthe aethiopica* (L.) N.E.Br., *C. floribunda* should be considered as naturalized in Toscana.

G. Ferretti, L. Lazzaro

+ (INV) **ITALIA** (**SAR**). – Status change from casual to invasive alien for the flora of Italy (Sardegna).

In recent years, this species has become invasive in several semi-natural habitats, such as fallows, abandoned vineyards, reforested areas, rivers banks, and road margins. It is particularly invasive on the island of San Pietro (Carloforte, Sud Sardegna). It remains to be ascertained if the majority of the former records of *Chasmanthe aethiopica* (L.) N.E.Br., presently considered invasive in Sardegna, should be referred to *C. floribunda*.

G. Sotgiu Cocco, M. Marignani, S. Bardi, L. Rosati

***Cistus* ×*purpureus* Lam. nothosubsp. *purpureus* (Cistaceae)**

+ (CAS) **ITALIA** (**PUG**): Brindisi (Brindisi), loc. Punta Penne (WGS84: 40.683468°N, 17.935878°E), su suoli sabbiosi, 5 m, 12 May 2018, *V. Tomaselli* (FI, *Herb. V. Tomaselli*). – Casual alien nothospecies new for the flora of Italy (Puglia).

This widely cultivated taxon was identified according to Sweet (1825–1830) and was found in garrigues with *Thymbra capitata* (L.) Cav. and *Poterium spinosum* L., on sandy soils, in Habitat of Community Interest code 5420 "S*arcopoterium spinosum* phryganas".

V. Tomaselli, R.P. Wagensommer

***Colocasia esculenta* (L.) Schott (Araceae)**

+ (CAS) **SIC**: Messina (Messina), fraz. Santo Stefano Medio (WGS84: 38.106583°N, 15.488588°E), lungo un canale ai margini di coltivi, 95 m, 27 February 2020, *F. Luchino* (FI). – Casual alien species confirmed for the flora of Sicilia.

Giardina et al. (2007), on the basis of historical records, indicated this species for several localities in Sicilia. Many individuals were found along a canal used for irrigation and for conveying rainwater, on the edge of several cultivated fields. The plants are distributed in small groups of 1–10 individuals, over a distance of 200 m, in a partially shaded environment. A second small population was observed a decade ago in western Sicilia, along the Frattina stream near Corleone (Palermo), several hundred kilometres away from the above locality, in similar environments.

F. Luchino, O. Caldarella, A. La Rosa

***Cotoneaster bullatus* Bois (Rosaceae)**

+ (NAT) **ITALIA** (**LOM**): Rovetta (Bergamo), Val Bielone, bosco presso Via del Lò (WGS84: 45.893956°N, 9.977416°E), bosco di latifoglie, 674 m, SSW, 1 September 2019, *G. Galasso* (MSNM No. 50690); *ibidem* (WGS84: 45.893214°N, 9.976903°E), bosco di latifoglie, 663 m, SSW, 1 September 2019, *G. Galasso* (FI, MSNM No. 50693); *ibidem* (WGS84: 45.893214°N, 9.976903°E), bosco di latifoglie, 663 m, SSW, 28 June 2020, *G. Galasso* (FI, MSNM Nos. 50694, 50695). – Naturalized alien species new for the flora of Italy (Lombardia).

This species was identified according to Fryer and Hylmö (2009), Dickoré and Kasperek (2010), and Stace (2010). Native to China, it presents bullate leaves, 3.5–9.0 cm long, with 6–9 very deeply impressed veins. Several dozen individuals fruit abundantly and occupy about 13,000 m$^2$.

G. Galasso, E. Banfi

***Cotoneaster divaricatus* Rehder & E.H.Wilson (Rosaceae)**

+ (CAS) **ITALIA** (**LOM**): Rovetta (Bergamo), Val Bielone, Via del Lò, verso il fondo, sulla sinistra (WGS84: 45.897723°N, 9.978366°E), margine stradale, 726 m, E, 22 July 2019, leg. et det. *G. Galasso*, conf. *A.N. Sennikov* (FI, MSNM No. 50672); *ibidem*, Val Bielone, bosco presso Via del Lò (WGS84: 45.894927°N, 9.978532°E), bosco di latifoglie, 668 m, SSW, 14 October 2020, leg. *G. Galasso*, det. *A.N. Sennikov* (FI, MSNM No. 50846). – Casual alien species new for the flora of Italy (Lombardia).

This species was identified according to Fryer and Hylmö (2009), Dickoré and Kasperek (2010), and Stace (2010). Native to China, it differs from

*Cotoneaster horizontalis* Decne. in leaves 1.0–3.0 cm long and 0.7–1.9 cm wide (*vs* 0.5–1.2×0.5–0.9 cm), and branches never forming regular herring-bone pattern, and from *C. simonsii* Baker in leaves to 2.5 cm long (*vs* 3.5 cm), ± lanceolate-ovate to ovate-rhombic (*vs* ovate to oblong) with 3–4 veins lightly impressed (*vs* 4–5 not impressed). Two plants were observed, one of which fruits regularly.

G. Galasso, E. Banfi, A.N. Sennikov

***Cotoneaster franchetii* Bois (Rosaceae)**

+ (INV) **ITALIA** (**LOM**): Rovetta (Bergamo), Val Bielone, bosco presso Via del Lò (WGS84: 45.893850°N, 9.976254°E), bosco di latifoglie, 660 m, SSW, 22 July 2019, leg. et det. *G. Galasso*, conf. *A.N. Sennikov* (FI, MSNM Nos. 50670, 50671); *ibidem* (WGS84: 45.895240°N, 9.978740°E), bosco di latifoglie, 695 m, SSW, 1 September 2019, leg. et det. *G. Galasso*, conf. *A.N. Sennikov* (MSNM Nos. 50683, 50684); *ibidem* (WGS84: 45.895171°N, 9.978434°E), bosco di latifoglie, 695 m, SSW, 1 September 2019, leg. et det. *G. Galasso*, conf. *A.N. Sennikov* (FI, MSNM No. 50686); *ibidem* (WGS84: 45.894274°N, 9.977392°E), bosco di latifoglie, 678 m, SSW, 1 September 2019, leg. et det. *G. Galasso*, conf. *A.N. Sennikov* (FI, MSNM Nos. 50688, 50689); *ibidem* (WGS84: 45.893569°N, 9.976769°E), bosco di latifoglie, 666 m, SSW, 1 September 2019, leg. et det. *G. Galasso*, conf. *A.N. Sennikov* (FI, MSNM No. 50692); *ibidem* (WGS84: 45.893463°N, 9.976788°E), bosco di latifoglie, 665 m, SSW, 28 June 2020, leg. et det. *G. Galasso*, conf. *A.N. Sennikov* (FI, MSNM Nos. 50696, 50697, 50698); *ibidem* (WGS84: 45.895701°N, 9.978775°E), bosco di latifoglie, 700 m, W, 28 June 2020, leg. et det. *G. Galasso*, conf. *A.N. Sennikov* (FI, APP, MSNM Nos. 50706, 50707, 50708); *ibidem* (WGS84: 45.893887°N, 9.976804°E), bosco di latifoglie, 668 m, SSW, 14 October 2020, leg. et det. *G. Galasso*, conf. *A.N. Sennikov* (FI, MSNM Nos. 50842, 50843). – Status change from casual to invasive alien for the flora of Italy (Lombardia).

The species was recently recorded as casual alien in Lombardia by Mauri (2020). It presents (Fryer and Hylmö 2009; Dickoré and Kasperek 2010; Stace 2010) ovate to elliptic leaves, to 4 cm long, with 3–5 impressed veins, silevery tomentose underside. It can be mistaken for *Cotoneaster pannosus* Franch., with patent instead of erect petals. According to Dickoré and Kasperek (2010), and Tison and de Foucault (2014), we consider *C. mairei* H.Lév. as a synonym of *C. franchetii*. Several hundred individuals fruit abundantly and occupy the entire undergrowth of about 33,000 m$^2$, and also grow up along the mountainside.

G. Galasso, E. Banfi, A.N. Sennikov

***Cotoneaster horizontalis* Decne. (Rosaceae)**

+ (CAS) **PIE**: Giaglione (Torino), bassa Val Clarea, in prossimità del cavalcavia dell'autostrada A32 del Frejus (WGS84: 45.130574°N, 6.990841°E), radura in bosco di latifoglie, 680 m, 29 May 2020, *M. Lonati*, *D. Barberis*, *M. Pittarello* (FI). – Casual alien species new for the flora of Piemonte.

Some young individuals were found growing near the Clarea creek, in the understory of a young broadleaf forest.

M. Lonati, D. Barberis, M. Pittarello

+ (INV) **ITALIA** (**LOM**): Rovetta (Bergamo), Val Bielone, bosco presso Via del Lò (WGS84: 45.893850°N, 9.976254°E), bosco di latifoglie, 660 m, SSW, 22 July 2019, *G. Galasso* (MSNM No. 50669); *ibidem* (WGS84: 45.895171°N, 9.978434°E), bosco di latifoglie, 695 m, SSW, 1 September 2019, *G. Galasso* (FI, MSNM No. 50687); Fino del Monte (Bergamo), Val di Bi, sentiero tra Masù e la Cappelletta degli Alpini (WGS84: 45.898205°N, 9.998142°E), bosco di latifoglie, 768 m, SE, 5 September 2020, *G. Galasso* (FI, MSNM No. 50811); *ibidem*, Val di Bi, strada forestale poco oltre la Cappelletta degli Alpini (WGS84: 45.903189°N, 9.997746°E), bosco di latifoglie, 910 m, W, 5 September 2020, *G. Galasso* (FI, MSNM No. 50816). – Status change from naturalized to invasive alien for the flora of Italy (Lombardia).

In Rovetta, several hundred individuals fruit abundantly and occupy the entire undergrowth of an area of about 33,000 m$^2$; they also grow up along the mountainside.

G. Galasso, E. Banfi

***Cotoneaster simonsii* Baker (Rosaceae)**

+ (NAT) **LOM**: Sirtori (Lecco), loc. Cascina Giuditta, presso Via G. Besana (WGS84: 45.737215°N, 9.342631°E), margine di sentiero boschivo, 520 m, NE, 7 September 2016, leg. *M. Villa*, det. *A.N. Sennikov* (FI); *ibidem*, 7 November 2016 (MSNM No. 48298); *ibidem*, 29 May 2017 (MSNM No. 48299); Rovetta (Bergamo), Val Bielone, bosco presso Via del Lò (WGS84: 45.895171°N, 9.978434°E), bosco di latifoglie, 695 m, SSW, 1 September 2019, leg. *G. Galasso*, det. *G. Galasso*, *E. Banfi* (FI, MSNM No. 50685); *ibidem* (WGS84: 45.895167°N, 9.978475°E), bosco di latifoglie, 695 m, SSW, 28 June 2020, leg. *G. Galasso*, det. *G. Galasso*, *E. Banfi* (MSNM No. 50699); *ibidem* (WGS84: 45.895455°N, 9.978239°E), bosco di latifoglie, 712 m, SSW, 28 June 2020, leg. *G. Galasso*, det. *G. Galasso*, *E. Banfi* (FI, MSNM No. 50705); *ibidem*, 14 October 2020, leg. *G. Galasso*, det. *G. Galasso*, *E. Banfi* (FI, MSNM No. 50836). – Status change from casual to naturalized alien for the flora of Lombardia.

This species was recently recorded as casual alien in Lombardia by Villa (2020). It presents ovate to broadly elliptic leaves, deciduous or semi-evergreen, 1.9–3.3 cm long, with 4–5 not impressed veins, sparsely strigose, with flat margins (Fryer and Hylmö 2009; Dickoré and Kasperek 2010; Stace 2010; Fryer and Zika 2014). In Sirtori, only one individual occours, while in Rovetta there are a few plants scattered over about 20,000 m$^2$ of woodland, some regularly fruiting.

M. Villa, E. Banfi, G. Galasso, A.N. Sennikov

+ (CAS) **TAA**: Stenico (Trento), c/o fraz. Seo, loc. Fratte (WGS84: 46.056010°N, 10.866876°E), scarpata presso alcune villlette, 850 m, S, 2 December 2017, leg. *M. Merli*, det. *G. Galasso*, conf. *A.N. Sennikov* (*Herb. M. Merli*); *ibidem*, 22 November

2018 (*Herb. M. Merli*); *ibidem*, 23 November 2018 (FI, MSNM No. 50847); *ibidem*, 8 June 2020 (*Herb. M. Merli*); *ibidem*, 10 June 2020 (FI, MSNM No. 50848, ROV). – Casual alien species new for the flora of Trentino-Alto Adige.

Only one individual was observed.

M. Merli, E. Banfi, G. Galasso, A.N.Sennikov

***Cotula australis* (Sieber ex Spreng.) Hook.f. (Asteraceae)**

+ (NAT) **LAZ**: Roma (Roma), Via del Mascherino 30 (WGS84: 41.903479°N, 12.458651°E), selciato a blocchetti di leucitite (sanpietrini), ca. 19 m, 10 April 2021, *R. Guarino* (FI, MSNM Nos. 50880, 50881). – Status change from casual to naturalized alien for the flora of Lazio.

The first record for Lazio of this species (Lucchese 2017) was for a casual presence on the lakeshore of Trevignano Romano (Roma), at about 33 km NW from the current finding. This new population grows on cobblestones paving the streets near the Vatican City (Borgo Pio). Considering that it consists of several hundred individuals scattered in multiple meta-populations, it is proposed to consider the species as naturalized in Lazio.

R. Guarino

***Cotula coronopifolia* L. (Asteraceae)**

+ (NAT) **MAR**: Porto Recanati (Macerata), loc. Scossicci, stagni artificiali ad uso venatorio ("guazzi") presso la foce del Fiume Musone (WGS84: 43.4567660°N, 13.6442480°E), stagni, ca. 3 m, 29 September 2020, *N. Hofmann*, *S. Orlandini* (FI, PESA). – Naturalized alien species new for the flora of Marche.

This species grows at the edge of artificial ponds used for hunting, where it has probably been carried by birds from neighbouring areas.

L. Gubellini, N. Hofmann, S. Orlandini

***Cuscuta campestris* Yunck. (Convolvulaceae)**

+ (NAT) **CAL**: Tarsia (Cosenza), a N della diga sul Lago di Tarsia, lungo il Fiume Crati (WGS84: 39.6142582°N, 16.3064010°E), su *Xanthium italicum*, 75 m, 28 August 2020, *L. Peruzzi* (FI). – Naturalized alien species new for the flora of Calabria.

L. Peruzzi

***Cyclospermum leptophyllum* (Pers.) Sprague ex Britton & P.Wilson (Apiaceae)**

+ (CAS) **SAR**: Oristano (Oristano), presso il Vivaio Produttivo di Campulongu (WGS84: 39.961387°N, 8.600895°E), incolto, ruderale, infestante nella coltivazione, 6 m, 30 July 2020, leg. *G. Brundu*, *V. Lozano*, det. *G. Brundu* (FI, *Herb. Uniss Agraria*). – Casual alien species new for the flora of Sardegna.

This species was likely introduced accidentally to Sardegna through nursery growing substrates.

G. Brundu, V. Lozano

***Cyperus alternifolius* L. subsp. *flabelliformis* Kük. (Cyperaceae)**

+ (NAT) **CAM**: Pellezzano (Salerno), riva destra dell'Irno, sotto via F. Wenner (WGS84: 40.695469°N, 14.775396°E), sponde cementificate ed inerbite, 34 m, 24 October 2020, *E. Del Guacchio* (NAP, *Herb. E. Del Guacchio*). – Status change from casual to naturalized alien for the flora of Campania.

In Campania this taxon is widespread and propagates both vegetatively and by seed dispersal, as already noted by Del Guacchio and La Valva (2017). The new, small population regularly produces seeds and is well established.

E. Del Guacchio

***Cyperus esculentus* L. (Cyperaceae)**

+ (NAT) **UMB**: Perugia (Perugia), fraz. Ponte San Giovanni, lungo le rive del Fiume Tevere (WGS84: 43.010449°N, 12.428761°E), 166 m, 5 August 2008, leg. *L. Lastrucci*, *R. Barocco*, *R. Venanzoni*, det. *L. Lastrucci* (FI barcode FI060282); Deruta (Perugia), area agricola nei pressi di Fanciullata, a margine di campo coltivato a tabacco vicino alla sponda destra del Fiume Tevere (WGS84: 42.982128°N, 12.399031°E), margine di coltivo, 164 m, 23 October 2020, *F. Bonini*, *D. Gigante* (FI, PERU-DSA3). – Naturalized alien species confirmed for the flora of Umbria.

In Umbria, a plant community dominated by *Cyperus esculentus* was previously mentioned by Lastrucci et al. (2012b), but the status of this species has never been specified. Both new stands consist of many individuals of different generations, probably originated by vegetative reproduction given the conspicuous presence of tubers, and covering in one case an area of *ca.* 1,500 m$^2$.

F. Bonini, D. Gigante, L. Lastrucci

***Cyperus schweinitzii* Torr. (Cyperaceae)**

+ (NAT) **VEN**: Verona (Verona), stazione ferroviaria di Verona Porta Nuova, sulla massicciata (WGS84: 45.42530201°N, 10.96320326°E), massicciata ferroviaria, 67 m, 17 September 2020, *A. Bertolli*, *F. Prosser* (FI, ROV No. 74209); *ibidem*, stazione ferroviaria di Verona Porta Vescovo, sulla massicciata (WGS84: 45.43345724°N, 11.01062515°E), massicciata ferroviaria, 58 m, 17 September 2020, *A. Bertolli*, *F. Prosser* (ROV No. 74210). – Naturalized alien species new for the flora of Veneto.

This species grows and settles on stabilized pebbly embankments, often naked due to weeding. In the Porta Nuova railway station, there are *ca.* 100 plants distributed in three groups growing in the train maintenance sector over a stretch of *ca.* 150 m. In the Porta Vescovo station, there are about 100 plants in several groups in the freight yard

over a stretch of *ca*. 700 m. A subsequent survey carried out in all the other railway stations in the province of Verona gave negative results.

A. Bertolli, F. Prosser

***Dimorphotheca ecklonis* DC. (Asteraceae)**

+ (CAS) **SAR**: Selargius (Cagliari), loc. San Lussorio, lungo il sentiero che percorre la zona umida (WGS84: 39.261238°N, 9.155397°E), 9 m, 12 May 2020, *G. Bacchetta*, *M. Fois* (FI, CAG); Santa Giusta (Oristano), loc. Pauli sa Figu, presso la strada SS131 (WGS84: 39.860250°N, 8.612755°E), 2 m, 27 June 2020, *G. Bacchetta*, *M. Fois* (CAG); Villasimius (Sud Sardegna), loc. Simius, lungo la spiaggia (WGS84: 39.124728°N, 9.526095°E), 2 m, 15 September 2020, *G. Bacchetta*, *A. Lallai*, *L. Podda* (CAG). – Casual alien species new for the flora of Sardegna.

The observed individuals of this species probably originated from plants cultivated as ornamentals in nearby gardens or established from dumped garden cuttings.

G. Bacchetta, M. Fois, A. Lallai, L. Podda

***Dysphania pumilio* (R.Br.) Mosyakin & Clemants (Amaranthaceae)**

+ (NAT) **LIG**: Pietra Ligure (Savona), Via Don G. Bado, lungomare, presso il deposito delle barche (WGS84: 44.148011°N, 8.283063°E), pavimentazione stradale con mattonelle, 3 m, no exp., 23 August 2020, *G. Galasso* (FI, MSNM No. 50834); *ibidem*, Via Don G. Bado, lungomare, presso il locale "Blue Bay" (WGS84: 44.148344°N, 8.283942°E), pavimentazione stradale con mattonelle, 5 m, no exp., 23 August 2020, *G. Galasso* (FI, MSNM No. 50835); *ibidem*, Via Don G. Bado, lungomare (WGS84: 44.148627°N, 8.284586°E), pavimentazione stradale con mattonelle, 5 m, no exp., 24 August 2020, *G. Galasso* (FI). – Naturalized alien species new for the flora of Liguria.

G. Galasso

***Elsholtzia stauntonii* Benth. (Lamiaceae)**

+ (CAS) **ITALIA** (**TAA**): Trento (Trento), argine sinistro del Torrente Fersina in loc. Ghiaie (WGS84: 46.047903°N, 11.119232°E), scarpata cespugliata, 195 m, 19 September 2020, leg. *M. Merli*, det. *F. Verloove* (FI, MSNM No. 50849, ROV, *Herb. M. Merli*). – Casual alien species new for the flora of Italy (Trentino-Alto Adige).

We observed two flowering bushes of this ornamental Chinese species, identified according to Whiteley (2000).

M. Merli, F. Prosser, F. Verloove

***Eragrostis frankii* (Fisch., C.A.Mey. & Avé-Lall.) Steud. (Poaceae)**

+ (CAS) **SIC**: Catania (Catania) (WGS84: 37.509255N, 15.088711E), lungo il bordo strada, 13 m, 31 December 2018, leg. *S. Brullo*, det. *E. Banfi*, *G. Galasso* (FI, CAT). – Casual alien species new for the flora of Sicilia.

Several individuals grow in a small area of the city centre of Catania along roadsides.
G. Tavilla, S. Cambria

***Erigeron annuus* (L.) Desf. subsp. *lilacinus* Sennikov & Kurtto (Asteraceae)**

+ (NAT) **ITALIA** (**PIE**): Verrua Savoia (Torino), ruderi della Rocca, lungo il sentiero alla base delle mura (WGS84: 45.17433°N, 8.10005°E ± 70 m), incolto arido, 280 m, 3 July 1988, leg. *A. Pistarino*, det. *A. Sennikov* December 2018 (H barcode C.411491, MRSN); Azeglio (Torino), Lago di Viverone (WGS84: 45.41175°N, 8.01931°E ± 1 km), margine di sentiero, 230 m, 15 June 1992, leg. *A. Pistarino*, det. *A. Sennikov* December 2018 (H barcode C.411496, MRSN). – Naturalized alien subspecies new for the flora of Italy (Piemonte).

This taxon is very easy to recognise because of its broader, coarsely dentate leaves, long pubescence and noticeably lilac ray flowers (the ray flower colour may be rather indistinctly pale in some plants, whereas flowers in other plants in the same area may be intensely coloured). Sennikov and Kurtto (2019) observed that this taxon tends to occur close to houses and gardens, probably due to its dispersal with garden soil or other material.

A.N. Sennikov, G. Galasso

***Erigeron annuus* (L.) Desf. subsp. *strigosus* (Muhl. ex Willd.) Wagenitz (Asteraceae)**

+ (NAT) **ITALIA** (**VEN**): Orgiano (Vicenza), 8 km SE of Lonigo on minor road from Este (WGS84: 45.35°N, 11.45°E), rough ground by pool, 60 m, 1 August 1983, leg. *J.R. Akeroyd*, *S.L. Jury*, *C.J. Miles*, *F.J. Rumsey 4272*, det. *A. Sennikov* December 2018 (H barcode C.411011). – Naturalized alien subspecies new for the flora of Italy (Veneto).

The circumscription of this taxon in Sennikov and Kurtto (2019) corresponds exactly to the traditional definition given by Wagenitz (1965) in central Europe and by Tzvelev (1994) in eastern Europe. According to Frey et al. (2003), the previous records from Lombardia (Arietti and Crescini 1980; Aeschimann et al. 2004) are considered erroneous (Galasso et al. 2018) as are those from Piemonte and Veneto (Aeschimann et al. 2004). In light of these new observations, it is more appropriate to consider the presence in Lombardia and Piemonte as doubtful.

A.N. Sennikov, G. Galasso

***Euphorbia hypericifolia* L. (Euphorbiaceae)**

+ (NAT) **SAR**: Quartu Sant'Elena (Cagliari), giardino privato (WGS84: 39.234936°N, 9.176933°E), 5 m, 10 July 2020, *G. Campus*, *G. Bacchetta* (FI, CAG); Decimomannu (Cagliari), loc. Bagantinus, lungo le stradine del vivaio (WGS84: 39.300743°N, 8.970782°E), stradine, 5 m, 20 July 2020, *G. Bacchetta*, *M. Fois*, *L. Podda* (FI, CAG); Oristano (Oristano), presso il Vivaio Produttivo di Campulongu (WGS84: 39.961387°N, 8.600895°E), incolto, ruderale, infestante nella coltivazione, 6 m, 30

July 2020, leg. *G. Brundu*, *V. Lozano*, det. *G. Brundu* (FI, *Herb. Uniss Agraria*); Cagliari (Cagliari), Pirri, aiuole in Via Barracca Manna (WGS84: 39.253179°N, 9.119715°E), aiuole, 48 m, 21 November 2020, G. Bacchetta, M. Fois (CAG). – Status change from casual to naturalized alien for the flora of Sardegna.

This species was reported as a casual alien for Sardegna (Mugnai et al. 2021).

G. Bacchetta, G. Brundu, G. Campus, M. Fois, V. Lozano, L. Podda

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

+ (NAT) **SAR**. – Status change from casual to naturalized alien for the flora of Sardegna.

A well-established, currently expanding, population was found in Stintino (Sassari, WGS84: 40.938422°N, 8.221278°E). It grows within Mediterranean shrubland and along roadsides, occupying more than 9 ha, thus behaving as a spontaneous geophyte.

G. Rivieccio, C.M. Caria, S. Bagella

***Glandularia tenera* (Spreng.) Cabrera (Verbenaceae)**

+ (CAS) **SIC**: Marsala (Trapani), c.da Conca (WGS84: 37.844405°N, 12.520455°E), ai margini di un prato artificiale, ca. 100 m, 7 June 2020, leg. *G. Domina*, det. *G. Domina*, *G. Barone* (FI, PAL). – Casual alien species new for the flora of Sicilia.

This species was identified according to O'Leary and Thode (2016).

G. Barone, E. Di Gristina, F. Scafidi

***Hedera hibernica* (G.Kirchn.) Bean (Araliaceae)**

+ (NAT) **MAR**: Pesaro (Pesaro e Urbino), nei pressi del parcheggio di San Decenzio (WGS84: 43.904490°N, 12.914932°E), scarpata stradale e massicciata della ferrovia, ca. 7 m, 12 November 2020, *L. Gubellini* (FI, PESA); *ibidem*, lungo la Strada dell'Angelo Custode (WGS84: 43.868528°N, 12.922919°E), siepi, ca. 190 m, 25 February 2021, *L. Gubellini* (PESA). – Naturalized alien species new for the flora of Marche.

This species is cultivated as ornamental and often escapes from cultivation (McAllister and Rutherford 1990). As for other alien species of *Hedera*, it was hitherto rather neglected.

L. Gubellini, N. Hofmann

***Hedera* ×*sepulcralis* R.H.Marshall & McAll. (Araliaceae)**

+ (NAT) **MAR**: Falconara Marittima (Ancona), ai margini di un parcheggio lungo Via G. Marconi, al confine con il comune di Castelferretti (WGS84: 43.6129920°N, 13.3759990°E), incolto erboso, ca. 18 m, 10 December 2020, *N. Hofmann* (FI, PESA). – Naturalized alien nothospecies new for the flora of Marche.

A large population of the hybrid *Hedera algeriensis* Hibberd × *H. hibernica* (G.Kirchn.) Bean (Marshall et al. 2017) grows at the edge of an uncultivated field.

L. Gubellini, N. Hofmann

***Hesperocyparis macrocarpa* (Hartw. ex Gordon) Bartel (Cupressaceae)**

+ (CAS) **ABR**: Vasto (Chieti), loc. Vasto Marina, presso la strada SS16 Adriatica (WGS84: 42.083055°N, 14.741388°E), margine di incolto, ca. 4 m, S, 12 August 2020, *N. Olivieri* (FI). – Casual alien species new for the flora of Abruzzo.

A young individual of this species grows on the edge of an uncultivated area, on a slight slope quite close to the Adriatic Sea, on sandy soil.

N. Olivieri

***Hibiscus syriacus* L. (Malvaceae)**

+ (CAS) **CAL**: Cutro (Crotone), fraz. Steccato di Cutro, strada E90 (WGS84: 38.946331°N, 16.935111°E), canale di scolo delle acque piovane a bordo strada, 19 m, 25 September 2020, *V.L.A. Laface*, *C.M. Musarella*, *G. Spampinato* (FI, REGGIO). – Casual alien species new for the flora of Calabria.

A small group of scattered individuals was found, along with other alien species.

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

***Hydrangea macrophylla* (Thunb.) Ser. (Hydrangeaceae)**

+ (CAS) **PIE**: Cellio con Breia (Vercelli), fraz. Breia, scarpata che dalla strada SP102 scende verso il Rio Galletto (WGS84: 45.781481°N, 8.297819°E), bosco misto di latifoglie, due individui, 765 m, 28 July 2019, *M. Lonati*, *M. Probo* (FI); *ibidem*, scarpata a valle della strada SP102 (WGS84: 45.775540°N, 8.294707°E), castagneto con latifoglie miste, numerosi individui, 780 m, 28 July 2019, *M. Lonati*, *M. Probo* (FI). – Casual alien species new for the flora of Piemonte.

Both the above-mentioned populations form small stands in the undergrowth of the road slopes, both located in illegal landfills of plant material derived from private gardens. This species is frequently cultivated as ornamental in the surrounding villages and the young plants have probably originated from rooting of pruning residuals.

M. Lonati, M. Probo

***Lobelia erinus* L. (Campanulaceae)**

+ (CAS) **MAR**: Amandola (Fermo), Via Roma, centro storico (WGS84: 42.9807230°N, 13.3591715°E), tra gli interstizi del selciato, 500 m, 18 October 2020, *A. Pica*, *J. Lupoletti* (FI). – Casual alien species new for the flora of Marche.

Several mature individuals were found, probably escaped from nearby pots or flowerbeds.

A. Pica, J. Lupoletti

***Lonicera ligustrina* Wall. subsp. *yunnanensis* (Franch.) P.S.Hsu & H.J.Wang (Caprifoliaceae)**

+ (NAT) **ITALIA** (**LOM**): Rovetta (Bergamo), Val Bielone, bosco presso Via del Lò (WGS84: 45.894740°N, 9.978517°E), bosco di latifoglie, 688 m, SSW, 28 June 2020, *G. Galasso* (FI, MSNM Nos. 50700, 50701, 50702, 50703, 50704); *ibidem*, 14 October 2020, *G. Galasso* (FI, MSNM No. 50841). – Status change from casual to naturalized alien for the flora of Italy (Lombardia).

This species covers several square metres, leaning against other shrubs and forming offshoots.

G. Galasso, E. Banfi

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

+ (INV) **LAZ**. – Status change from naturalized to invasive alien for the flora of Lazio.

Recent investigations along the edges of Lake Bracciano revealed that, since the last report by Galasso et al. (2019), this species has colonised also the western shore, between Vicarello and Bracciano (Roma), as well as other areas (Arrone river, Anguillara Sabazia, Roma province) for a total of *ca.* 12 km, showing high invasiveness both in aquatic habitats and on the beaches.

S. Magrini, E. Argenti, S. Buono

***Lychnis chalcedonica* L. (Caryophyllaceae)**

+ (CAS) **ITALIA** (**TAA**): Santa Cristina Valgardena (Bolzano), Strada Cisles (WGS84: 46.559133°N, 11.728848°E), sponde del rio a lato della strada, 1420 m, 18 July 2019, *F. Bonali* (FI, *Herb. F. Bonali*). – Casual alien species confirmed for the flora of Italy; casual alien species new for the flora of Trentino-Alto Adige.

*Lychnis chalcedonica* was reported in Italy only in the Marche as no longer recorded (Galasso et al. 2018). Some flowering individuals were observed.

F. Bonali

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

+ (CAS) **ABR**: Lanciano (Chieti), presso la strada SP82 per Treglio (WGS84: 42.224444°N, 14.401666°E), area ghiaiosa, ca. 260 m, 14 August 2020, *N. Olivieri* (FI). – Casual alien species new for the flora of Abruzzo.

Some individuals of different ages grow in a calcareous gravelly area with a sparse ruderal vegetation. The plants developed from seeds dispersed by the wind from individuals cultivated in flowerbeds located a few dozen metres away.

N. Olivieri

***Nephrolepis cordifolia* (L.) C.Presl (Nephrolepidaceae)**

+ (NAT) **LIG**: Pietra Ligure (Savona), Via Aurelia, presso una scalinata, sul lato del muro che guarda verso il paese (WGS84: 44.149920°N, 8.283200°E), muro, 14 m, SSE, 20 August 2019, *G. Galasso* (FI, MSNM Nos. 50663, 50664). – Status change from casual to naturalized alien for the flora of Liguria.

A well established, numerous population was observed.

G. Galasso

***Oenothera lindheimeri* (Engelm. & A.Gray) W.L.Wagner & Hoch (Onagraceae)**

+ (CAS) **MAR**: Civitanova Marche (Macerata), Piazza Don E. Scorolli (Via G. Matteotti) (WGS84: 43.310663°N, 13.728768°E), aiuola ai margini del parcheggio, 2 m, 7 November 2020, *A. Pica*, *J. Lupoletti* (FI). – Casual alien species new for the flora of Marche.

Some individuals were found in a flowerbed near the parking area.

A. Pica, J. Lupoletti

***Oxalis latifolia* Kunth (Oxalidaceae)**

+ (NAT) **LIG**. – Status change from casual to naturalized alien for the flora of Liguria.

This species is widespread in the province of La Spezia and in the eastern part of the province of Genova, sometimes with quite large populations (e.g., in the Magra and Entella valleys).

D. Marchetti, D. Dagnino

***Phyllostachys viridiglaucescens* (Carrière) Rivière & C.Rivière (Poaceae)**

+ (NAT) **MAR**: Cagli (Pesaro e Urbino) (WGS84: 43.540092°N, 12.648702°E), vegetazione ripariale, 240 m, 5 August 2016, *G. Mei* (*Herb. G. Mei*); *ibidem* (WGS84: 43.541887°N, 12.652201°E), area periodicamente allagata di coltivi abbandonati, 290 m, 19 May 2020, *G. Mei* (FI, *Herb. G. Mei*). – Naturalized alien species new for the flora of Marche.

G. Mei

***Plumbago auriculata* Lam. (Plumbaginaceae)**

+ (CAS) **MOL**: Termoli (Campobasso), mura del borgo antico (WGS84: 42.003611°N, 14.996944°E), ca. 18 m, SW, 29 August 2020, *N. Olivieri* (FI). – Casual alien species new for the flora of Molise.

Some individuals of this species have settled on the upper part of the walls surrounding the old town, on a sub-vertical substrate formed by limestone and sandstone blocks, colonized mainly by *Capparis spinosa* L.

N. Olivieri

***Rhaphiolepis bibas* (Lour.) Galasso & Banfi (Rosaceae)**

+ (NAT) **PUG**: Vico del Gargano (Foggia), loc. San Nicola (WGS84: 41.916107°N, 15.948185°E), incolto, 80 m, 28 August 2020, *N. Biscotti*, *D. Bonsanto* (FI); Rodi Garganico (Foggia), loc. Canneto (WGS84: 41.919412°N, 15.920386°E), agrumeto incolto, 40 m, 1 September 2020, *N. Biscotti*, *D. Bonsanto* (FI). – Naturalized alien species new for the flora of Puglia.

N. Biscotti, D. Bonsanto

***Rudbeckia laciniata* L. (Asteraceae)**

+ (CAS) **TOS**: Abetone Cutigliano (Pistoia), fraz. Pian degli Ontani, appena oltre l'abitato in direzione di Pian di Novello (WGS84: 44.105877°N, 10.717935°E), spontaneizzata al margine stradale, 930 m, 20 August 2020, *G. Ferretti*, *R. Ferretti* (FI). – Casual alien species new for the flora of Toscana.

A single nucleus of *ca.* 10 flowering individuals was observed on the road edge, near a small mountain village. This species reproduces very efficiently by rhizome fragmentation and produces copious amounts of achenes (EPPO 2009), so careful monitoring of the population is recommended.

G. Ferretti, L. Lazzaro, M. Mugnai

***Rudbeckia triloba* L. (Asteraceae)**

+ (CAS) **LIG**: Varese Ligure (La Spezia), Val di Vara, nei pressi di Cavizzano, sotto Chinela, loc. Carmelo (WGS84: 44.403376°N, 9.553931°E), margine stradale, 525 m, 26 August 2020, *D. Marchetti* (FI); Maissana (La Spezia), strada SP523R, presso San Pietro Vara verso Varese Ligure (WGS84: 44.343645°N, 9.590019°E), siepi al margine della strada, 310 m, 16 September 2020, *D. Marchetti* (FI, GE No. 4431). – Casual alien species new for the flora of Liguria.

This species was found in disturbed environments near the road edge.

D. Marchetti, D. Dagnino

***Salvia hispanica* L. (Lamiaceae)**

+ (CAS) **LIG**: *Molineri* [Imperia (Imperia), Oneglia (WGS84: ca. 43.88905°N, 8.05034°E), oliveti, s.d., *I. Molineri*)] (BOLO-Hortus Siccus Florae Italicae barcode BOLOHSFI102871). – Casual alien species new for the flora of Liguria.

The locality, cited by Bertoloni (1833) as "Nascitur in olivetis di *Oneglia* in Liguria occidua. Habui a Molinerio", is the same of a previous record by Allioni (1785). These are the first records of its occurrence as a casual alien in Italy, *ca.* 200 years earlier than the report from the Marche (Ballelli et al. 2015).

S. Peccenini, G. Galasso

***Setaria parviflora* (Poir.) Kerguélen (Poaceae)**

+ (CAS) **ABR**: Montesilvano (Pescara), Riserva Naturale Pineta di Santa Filomena, presso il lungomare (WGS84: 42.505879°N, 14.172151°E), bordo strada, 2 m, 16 August 2020, *A. Stinca*, *F. Conti* (FI, APP, PORUN-Stinca). – Casual alien species new for the flora of Abruzzo.

A. Stinca, F. Conti

***Tetragonia tetragonoides* (Pall.) Kuntze (Aizoaceae)**

+ (NAT) **SAR**. – Status change from casual to naturalized alien for the flora of Sardegna.

The first records reported in the literature for *Tetragonia tetragonoides* in Sardegna were in the "Sassarese" and in Siddi (Viegi 1993). We observed this species as naturalized along the coastal strip of Siniscola (Nuoro), in the locality of "S'Ena e sa Chitta" (ItIsWet 2019). Like other invasive alien species, this established population is outcompeting the native coastal flora.

G. Bacchetta, M. Fois, L. Podda

***Tradescantia pallida* (Rose) D.R.Hunt (Commelinaceae)**

+ (CAS) **PUG**: Castrignano del Capo (Lecce), loc. Santa Maria di Leuca, presso la strada SP358 "Delle terme salentine" (WGS84: 39.797222°N, 18.369722°E), incolto, ca. 60 m, S, 20 August 2020, *N. Olivieri* (FI). – Casual alien species new for the flora of Puglia.

In this site, the species grows in an uncultivated area located along the roadside, on a substrate consisting of Mediterranean red soil and limestone fragments.

N. Olivieri

***Vachellia karroo* (Hayne) Banfi & Galasso (Fabaceae)**

+ (INV) **ITALIA** (**SAR**). – Status change from naturalized to invasive alien for the flora of Italy (Sardegna).

This species is common throughout Sardegna, but in recent years it was recorded as spreading in the southern coastal areas (Campidano, Sarrabus-Gerrei, and Sulcis-Iglesiente), especially at Villasimius (Sud Sardegna), near the "Stagno Santa Gilla" (Cagliari province), and at Santa Margherita di Pula (Pula, Cagliari), where it exhibits a clearly invasive behaviour, thereby threatening natural habitats.

G. Bacchetta, G. Brundu, G. Calvia, M. Fois, L. Podda

***Verbena brasiliensis* Vell. (Verbenaceae)**

+ (CAS) **MAR**: Montelabbate (Pesaro e Urbino), lungo l'argine destro del Fiume Foglia (WGS84: 43.8552960°N, 12.8048870°E), incolti erbosi, ca. 35 m, 28 October 2020, *F. Furlani*, *L. Gubellini* (FI, PESA). – Casual alien species new for the flora of Marche.

A few individuals of this species grow in an uncultivated grassland along the banks of the Foglia river.

F. Furlani, L. Gubellini

***Yucca gigantea* Lem. (Asparagaceae)**

+ (CAS) **PUG**: Otranto (Lecce), strada SP87, Borgo Minerva (WGS84: 40.138597°N, 18.494417°E), pineta, 22 m, 23 August 2019, leg. *C.M. Musarella*, det. *V.L.A. Laface*, *C.M. Musarella* (REGGIO); *ibidem*, Porto Badisco (WGS84: 40.079231°N, 18.482242°E), bordo strada, 16 m, 23 August 2019, leg. *C.M. Musarella*, det. *V.L.A. Laface*, *C.M. Musarella* (FI, REGGIO); Salve (Lecce), strada SP91 Strada Litoranea (WGS84: 39.838917°N, 18.231917°E), bordo strada, 12 m, 17 August 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface*, *C.M. Musarella* (REGGIO); Porto Cesareo (Lecce), Spunnulate di Torre Castiglione (WGS84: 40.287500N, 17.825278E), bordo strada, 3 m, 17 August 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface*, *C.M. Musarella* (REGGIO); Spongano (Lecce), strada SP166 Spongano-Andrano (WGS84: 40.002800°N, 18.372314°E), bordo strada, 112 m, 18 August 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface*, *C.M. Musarella* (REGGIO); Otranto (Lecce), strada SP151, Alìmini Grande (WGS84: 40.201194°N, 18.433508°E), bordo strada, 23 m, 18 August 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface*, *C.M. Musarella* (REGGIO). – Casual alien species new for the flora of Puglia.

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

***Zantedeschia aethiopica* (L.) Spreng. (Araceae)**

+ (INV) **SAR**. – Status change from casual to invasive alien for the flora of Sardegna.

We detected several populations of *Zantedeschia aethiopica* colonizing wetlands and humid habitats. In particular, it is widespread along the Rio Posada (Torpè, Nuoro) with numerous lush individuals in full bloom within reed beds (28 February 2021), on the island of La Maddalena (Sassari) in the artificial lake of Puzzoni within wet meadows (10 June 2020), and in an artificial canal for facilitating freshwater runoff in the vicinity of the town of Alghero (Sassari) in the locality named Caragol (4 March 2021).

M. Marignani, E. Farris, L. Rosati

## Nomenclatural and distribution updates from other literature sources

Nomenclatural, status, distribution updates, and corrections to Galasso et al. (2018) 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: Species data

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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# Notulae to the Italian alien vascular flora: 12

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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, confirmations, exclusions, and status changes for Italy or for Italian administrative regions. Nomenclatural and distribution updates published elsewhere are provided as Suppl. material 1.

**Keywords**
Alien species, floristic data, Italy, nomenclature

## How to contribute

The text for the new records 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 (typifications only for accepted names), status changes, exclusions, and confirmations should be submitted electronically to Gabriele Galasso (gabriele.galasso@comune.milano.it). Each text should be within 1,000 characters (spaces included).

## Floristic records

***Albizia julibrissin* Durazz. (Fabaceae)**

+ (CAS) **MAR**: Pesaro (Pesaro e Urbino), Via S. Pertini ai margini del Ponte Giovanni XXIII (WGS84: 43.900625N, 12.875721E), margine stradale erboso, ca. 10 m, 18 July 2021, *L. Gubellini* (FI, PESA). – Casual alien species new for the flora of Marche.

A single individual has been observed, flowering in a roadside verge.

L. Gubellini, N. Hofmann

***Aubrieta deltoidea* (L.) DC. (Brassicaceae)**

+ (CAS) **PIE**: Salbertrand (Torino), fraz. San Romano, presso il Camping Gran Bosco (WGS84: 45.062215N, 6.867815E), interstizi tra un muretto e la strada asfaltata in prossimità di una aiuola coltivata, 1023 m, 3 April 2021, *M. Probo, M. Lonati* (FI). – Casual alien species new for the flora of Piemonte.

Some individuals occur spontaneously near a private garden where the species is cultivated as ornamental.

M. Probo, M. Lonati

***Bothriochloa pertusa* (L.) A.Camus (Poaceae)**

+ (NAT) **ITALIA** (**LIG**): Sestri Levante (Genova), ZSC "IT1333308 Punta Manara", loc. Ginestra (WGS84: 44.2617N, 9.4158E), bordo del sentiero, a margine di oliveto in coltura, ca. 110 m, SE, 23 July 2020, leg. *D. Dagnino, C. Turcato*, det. *E. Banfi* (FI, GE No. 4891, MSNM Nos. 50854, 50855). – Naturalized alien species new for the flora of Italy (Liguria).

This species is similar to *Bothriochloa insculpta* (Hochst. ex A.Rich.) A.Camus, represented in Italy by subsp. *panormitana* (Parl.) Giardina & Raimondo, from which is distinguished by the number and color of the racemes (3–8 brown-straw *vs* of 10–15 blackish) and by the lower glume bearing long woolly whitish hairs grouped in the distal half (Vega 2000). It is native to warm temperate and tropical Old World from where it has been introduced in Mesomerica, South America (Colombia) and southern North America (Alabama, Florida, Louisiana, Mississippi), while in Europe is reported from Sweden and considered doubtfully alien in Greece (Valdés and Scholz 2009+; POWO 2019+). It prefers uncultivated and grassy places, but at present it is impossible to evaluate the potential aggressiveness of the species.

E. Banfi, D. Dagnino, C. Turcato, G. Galasso

***Brugmansia aurea* Lagerh. (Solanaceae)**

+ (CAS) **CAM**: San Giorgio a Cremano (Napoli), al confine con Napoli, Via Cupa Rubinacci (WGS84: 40.834822N, 14.328418E), bordo strada, 32 m, 7 April 2021, leg. *R. Motti*, det. *R. Motti, A. Cozzolino, A. Stinca* (FI, PORUN-Motti); *ibidem*, 9 July 2021, *A. Stinca* (PORUN-Stinca). – Casual alien species new for the flora of Campania.

In Italy, two species belonging to the South American genus *Brugmansia* Pers. have been recorded: *B. aurea* in Calabria (Laface et al. 2020) and *B. suaveolens* (Humb. & Bonpl. ex Willd.) Sweet in Campania (Stinca 2020). The new finding refers to an individual probably originated vegetatively from plants cultivated nearby.

R. Motti, A. Cozzolino, A. Stinca

***Centaurea diluta* Aiton (Asteraceae)**

+ (NAT) **BAS**: Matera (Matera), confine tra Puglia e Basilicata, in prossimità del vulcanello di Gravina di Puglia (WGS84: 40.700063N, 16.428955E), incolti in prossimità di colture di orzo, 208 m, 3 June 2021, *M. Terzi, F.S. D'Amico* (FI). – Naturalized alien species new for the flora of Basilicata.

A population of *Centaurea diluta* was found on clayey soils along the edge of a path close to the border between Basilicata and Puglia.

M. Terzi, F.S. D'Amico

***Chasmanthe bicolor* (Gasp.) N.E.Br. (Iridaceae)**

+ (NAT) **SAR**: La Maddalena (Sassari), Parco Nazionale dell'Arcipelago di La Maddalena, Isola La Maddalena (WGS84: 41.236234N, 9.410872E), in prossimità delle strade e nelle radure della macchia, 67 m, 27 March 2021, *G. Brundu, V. Lozano, V. Lazzeri* (FI, *Herb. Uniss Agraria*). – Naturalized alien species new for the flora of Sardegna.

*Chasmanthe bicolor* is a perennial herb native to the Western Cape Province in South Africa (de Vos 1985; Duncan 2001).

V. Lozano, G. Brundu, V. Lazzeri

***Cupressus sempervirens* L. (Cupressaceae)**

+ (NAT) **CAL**: Reggio Calabria (Reggio Calabria), Via V. Florio, nei pressi del porto (WGS84: 38.119704N, 15.649376E), dentro il tronco cavo di una pianta di *Melia azedarach*, 23 m, 13 April 2021, leg. *G. Spampinato*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO); *ibidem*, Piani di San Nicola, fraz. Ortì (WGS84: 38.151801N, 15.695425E), bordo strada, 559 m, 18 July 2021, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); *ibidem*, Diminniti di Sambatello, nei pressi del cimitero (WGS84: 38.174036N, 15.702576E), terreno abbandonato, 425 m, 18 July 2021, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); Condofuri (Reggio Calabria), fraz. Straci (WGS84: 37.924573N, 15.844811E), nel bosco e a bordo strada, 33 m, 11 May 2021, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); *ibidem*, Trombia (WGS84: 37.937525N, 15.866372E), eucalipteto e bordo strada, 106 m, 18 July 2021, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); *ibidem*, fraz. Pietra (WGS84: 37.947734N, 15.865268E), pineta e bordo strada, 151 m, 18 July 2021, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); Montebello Jonico (Reggio Calabria), Canale (WGS84: 37.958997N, 15.695899E), eucalipteto e bordo strada, 148 m, 18 July 2021, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO). – Naturalized alien species new for the flora of Calabria.

*Cupressus sempervirens* reproduces easily by seed and at most of the reported localities, the species has formed small populations, with some mature and reproductive adult individuals.

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

***Cuscuta campestris* Yunck. (Convolvulaceae)**

+ (NAT) **LIG**. – Status change from casual to naturalized alien for the flora of Liguria.

We found several populations of *Cuscuta campestris* along the Magra Valley (La Spezia), showing a high number of individuals growing on different host plants (e.g., *Convolvulus arvensis* L., *Euphorbia maculata* L., *Xanthium italicum* Moretti, etc.) in ruderal environments linked to the riverside terraces or the anthropized areas of the Magra plain. We collected several herbarium specimens of these populations, currently housed in GE.

D. Dagnino, I. Briozzo, C. Turcato

***Cyrtomium falcatum* (L.f.) C.Presl (Dryopteridaceae)**

+ (CAS) **SAR**: Cagliari (Cagliari), Via Vittorio Veneto (WGS84: 39.225230N, 9.105523E), fessure di un muro di contenimento in pietra calcarea, 41 m, 25 February 2021, *L. Rosati, M. Marignani* (FI). – Casual alien species new for the flora of Sardegna.

We observed, growing on a wall colonized also by *Adiantum capillus-veneris* L. and *Cymbalaria muralis* G.Gaertn., B.Mey. & Scherb. subsp. *muralis*, a single individual.

L. Rosati, M. Marignani

***Delosperma cooperi* (Hook.f.) L.Bolus (Aizoaceae)**

+ (CAS) **ABR**: Teramo (Teramo), Via Conte Contin (WGS84: 42.656388N, 13.696388E), bordo stradale, ca. 254 m, 15 May 2021, *N. Olivieri* (FI). – Casual alien species new for the flora of Abruzzo.

Some individuals of the species are settled on the concrete roadside, sometimes covered with moss, together with *Sedum dasyphyllum* L. subsp. *dasyphyllum* and sporadically *S. palmeri* S.Watson, in an area not subject to foot traffic.

N. Olivieri

***Dimorphotheca fruticosa* (L.) Less. (Asteraceae)**

+ (CAS) **SAR**: Carloforte (Sud Sardegna), Isola di San Pietro, loc. Nasca (WGS84: 39.157107N, 8.264874E), bordo strada, dietro ad un muretto a secco nella macchia, 96 m, 6 March 2021, leg. *L. Rosati, M. Marignani, G. Cocco, S. Bardi*, det. *L. Rosati* (HLUC); *ibidem*, loc. Tacca Rossa (WGS84: 39.161726N, 8.302175E), scarpata stradale, 48 m, 7 March 2021, leg. *L. Rosati, M. Marignani, G. Cocco, S. Bardi*, det. *L. Rosati* (FI). – Casual alien species new for the flora of Sardegna.

Some flowering individuals were observed growing in garrigues dominated by *Cistus monspeliensis* L.

G. Sotgiu Cocco, L. Rosati, S. Bardi, M. Marignani

***Dracaena draco* (L.) L. subsp. *draco* (Asparagaceae)**

+ (CAS) **SAR**: Cagliari (Cagliari), Viale Buon Cammino (WGS84: 39.222723N, 9.115725E), epifita su *Celtis australis*, 94 m, 15 April 2021, *A. Lallai, G. Bacchetta, L. Podda* (FI, CAG). – Casual alien species new for the flora of Sardegna.

This species is native to Macaronesia and Morocco, where it grows on slopes in association with other xerophilous taxa (Almeida Pérez 2003). The juvenile specimen found in Sardegna grows epiphytic in the bifurcation of the branches on a decayed *Celtis australis* L. subsp. *australis*, approximately 20 m away from a mature individual.

A. Lallai, G. Bacchetta, L. Podda

***Erigeron philadelphicus* L. (Asteraceae)**

+ (CAS) **EMR**: Ferrara (Ferrara), Via Dosso Dossi (WGS84: 44.842018N, 11.619414E), vegetazione sinantropica ruderale, 10 m, 7 May 2021, leg. *M. Curuzzi, G. Mei*, det. *G. Mei* (FI, *Herb. G. Mei*). – Casual alien species new for the flora of Emilia-Romagna.

G. Mei, M. Curuzzi

***Euthamia graminifolia* (L.) Nutt. (Asteraceae)**

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

The report of *Euthamia graminifolia* in Piemonte (Soldano and Sella 1988) is to be referred to *E. lanceolata* (L.) G.L.Nesom (see below).

G. Galasso, A. Soldano

***Euthamia lanceolata* (L.) G.L.Nesom (Asteraceae)**

+ (NAT) **ITALIA** (**PIE**): Castelletto Cervo (Biella), baraggia sul lato W della strada provinciale verso San Giacomo di Masserano (WGS84: 45.53388N, 8.24138E), brughiera, 229 m, no exp., 20 August 1990, *A. Soldano 8801* (*Herb. A. Soldano* sub. *E. graminifolia*); *ibidem*, baraggia lungo la strada SP315 San Giacomo–Buronzo (WGS84: 45.536587N, 8.240707E ± 10 m), brughiera, ca. 221 m, no exp., 12 September 2009, *G. Galasso* (MSNM Nos. 43684, 43685, 43686 sub. *E. graminifolia*); Masserano (Biella), lato W della Baraggia delle Quattro Madame (WGS84: 45.54800N, 8.25416E), brughiera, 235 m, no exp., 4 September 1993, *A. Soldano 9436* (*Herb. A. Soldano* sub. *E. graminifolia*). – Naturalized alien species new for the flora of Italy (Piemonte).

According to the recent revision of the genus *Euthamia* (Nesom 2021a, b), our specimens previously attributed to *E. graminifolia* (L.) Nutt. belong to *E. lanceolata*. Although the height of the involucres (4.0–4.2 mm) is more or less intermediate between the two species (3.6–4.2 mm in *E. lanceolata vs* 4.0–5.0 mm in *E. graminifolia*), stem and leaf surfaces are clearly hirtellous (*vs* glabrous).

G. Galasso, A. Soldano

***Gazania rigens* (L.) Gaertn. (Asteraceae)**

+ (NAT) **SAR**. – Status change from casual to naturalized alien for the flora of Sardegna.

*Gazania rigens* was detected as naturalized in the sand dunes of Torre dei Corsari (Arbus, Sud Sardegna) and in the small peninsula of Capo Coda Cavallo (San Teodoro, Sassari). These self-sustaining populations are fast-spreading, after a recent introduction as ornamentals in gardens.

M. Fois, A. Cuena-Lombraña, G. Brundu

***Honorius boucheanus* (Kunth) Holub (Asparagaceae)**

+ (CAS) **LOM**: Mantova (Mantova), Corte Cherubine, Via Legnago 17 (WGS84: 45.165820N, 10.832494E), all'ombra di un filare d'alberi, 19 m, no exp., 24 April 2021, leg. *E. Guidotti, P. Lanfredini, M. Marchini*, det. *E. Guidotti, M. Pallanza, S. Orsenigo* (FI). – Casual alien species new for the flora of Lombardia.

E. Guidotti, P. Lanfredini, M. Marchini, M. Pallanza

***Hyacinthoides non-scripta* (L.) Chouard ex Rothm. (Asparagaceae)**

+ (CAS) **UMB**: Gualdo Tadino (Perugia), Appennino di Gualdo Tadino, Valle del Fònno, versante SW (WGS84: 43.226585N, 12.815555E), margine erboso delimitato da rocce calcaree rivestite da una fitta lecceta, 790 m, 2 April 2021, *M. Loreti, P. Salerno* (FI). – Casual alien species new for the flora of Umbria.

Only a group of five plants was found in an impervious Appennine area with a high level of wilderness, included into the ZSC "IT5210014 Monti Maggio-Nero (sommità)".

M. Loreti, P. Salerno

***Ipheion uniflorum* (Lindl.) Raf. (Amaryllidaceae)**

+ (CAS) **LOM**: Concorezzo (Monza e Brianza), lungo Via G. Mazzini (WGS84: 45.585790N, 9.341909E), incolto, 172 m, 2 April 2021, *G. Patera* (FI). – Casual alien species new for the flora of Lombardia.

A few individuals of this species originated from seeds produced by some adults growing in a nearby garden.

G. Patera

***Koelreuteria paniculata* Laxm. (Sapindaceae)**

+ (NAT) **VDA**: Arnad (Aosta), presso la Chiesa di San Martino, dietro il giardino pubblico, lungo l'argine del Torrente d'Arnad (WGS84: 45.6446009N, 7.7206899E), greto e argini del torrente, molti esemplari in fruttificazione, 361 m, 2 August 2021, *A. Selvaggi* (FI); *ibidem*, più in basso, scendendo lungo il Torrente d'Arnad, nel greto (WGS84: 45.64437562N, 7.71966776E), greto fluviale, 358 m, 2 August 2021, *A. Selvaggi* (AO). – Naturalized alien species new for the flora of Valle d'Aosta.

The naturalized population extends more than 100 metres along the river Torrente d'Arnad and includes numerous individuals at different stages of growth. All the individuals originate from few cultivated plants grown in the public garden situated behind the San Martino church.

A. Selvaggi, P. Ferraris

***Melinis repens* (Willd.) Zizka subsp. *repens* (Poaceae)**

+ (INV) **SAR**. – Status change from naturalized to invasive alien for the flora of Italy (Sardegna).

Since the first report in 2018 (Galasso et al. 2019a) we have observed a rapid expansion of this taxon, which is spreading from roadsides of coastal areas to inland fields, to the extent that we believe it is becoming a problematic weed for the nearby crops.

G. Bacchetta, G. Calvia, L. Podda

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

+ (CAS) **LOM**: Costa Volpino (Bergamo), nei pressi della ex cava di gesso lungo il margine destro della strada di recente costruzione che sale alla fraz. Volpino (WGS84: 45.836317N, 10.102783E), margine stradale, 202 m, SE, 28 May 2021, leg. *A. Federici*, det. *G. Galasso, E. Banfi* (FI, MSNM No. 50996); Milano (Milano), passaggio pedonale parallelo a Via E. Fieramosca, presso la Residenza Arcimboldi, recinzione al di sopra della trincea della linea tramviaria (WGS84: 45.515361N, 9.214027E), fughe nella pavimentazione stradale a mattonelle, 134 m, no exp., 2 June 2021, *G. Galasso* (FI, MSNM Nos. 50984, 50985). – Casual alien species new for the flora of Lombardia.

In both cases, the collected specimens were growing very far from the mother plants.

G. Galasso, E. Banfi, A. Federici

***Nelumbo nucifera* Gaertn. (Nelumbonaceae)**

+ (NAT) **TOS**. – Status change from casual to naturalized alien for the flora of Toscana.

The first records of this species for Toscana date back to Montelucci (1964, 1970) from Massarosa (Lucca province), where it has been recorded again in 2017 (Peruzzi and Bedini 2021+). Here, new records from Parco di Fonte Santa (Bagno a Ripoli, Firenze, WGS84: 43.710670N, 11.372633E, 578 m, 29 July 2021, *L. Lazzaro, L. Lastrucci*, FI) and from Piazza delle Gondole in Pisa (WGS84: 43.716768N, 10.409048E, obs. *B. Pierini, L. Peruzzi*) are added. In these sites, the populations are in an evident naturalized status, with the presence of many flowers and fruits. We therefore propose the change of status for this species in Toscana from casual to naturalized.

L. Lazzaro, L. Lastrucci

+ (NAT) **MAR**: Potenza Picena (Macerata), c.da Castelletta, stagno artificiale (WGS84: 43.346644N, 13.657330E), stagno, 24 m, 10 July 2021, *D. Fiacchini* (FI). – Naturalized alien species new for the flora of Marche.

*Nelumbo nucifera* grows inside the artificial pond located less than 30 metres from the right bank of the Asola stream. The species occupies a total area of *c.* 1,500–2,000 m$^2$.

D. Fiacchini, L. Gubellini

***Parasenegalia visco* (Lorentz ex Griseb.) Seigler & Ebinger (Fabaceae)**

– **SAR**. – Alien species to be excluded from the flora of Sardegna.

*Parasenegalia visco* was first reported by Podda et al. (2010) from Rio Santa Lucia in Capoterra (Cagliari) as a new casual alien species for Sardegna. Later, it was indicated by the same authors as a naturalized alien (Podda et al. 2012; Puddu et al. 2016). Field insights and a review of specimens in CAG have shown that these records are due to a misidentification of *Paraserianthes lophantha* (Willd.) I.C.Nielsen subsp. *lophantha*.

L. Podda, A. Lallai, G. Bacchetta

***Parkinsonia aculeata* L. (Fabaceae)**

+ (INV) **SAR**. – Status change from casual to invasive alien for the flora of Sardegna.

Recently, rapid colonization from seeds in dense thickets have been observed in several areas from Cagliari to the road SS131 and to Santa Margherita (Pula, Cagliari), or wetlands near Cagliari such "Stagno di Santa Gilla", and "Stagno di Molentargius" (Cagliari province).

G. Bacchetta, M. Fois, L. Podda

***Passiflora caerulea* L. (Passifloraceae)**

+ (NAT) **LAZ**. – Status change from casual to naturalized alien for the flora of Lazio.

During the last four years, investigations revealed that this species is widespread in northern Lazio with well-established populations in the provinces of Viterbo (e.g., Viterbo, Montalto di Castro, Oriolo Romano) and Roma, where it also grows on the beaches of Lake Bracciano. These populations regularly produce fruits and propagate both vegetatively and by seed.

S. Magrini, S. Buono

***Platanus hispanica* Mill. ex Münchh. (Platanaceae)**

+ (INV) **ITALIA** (**LAZ**). – Status change from naturalized to invasive alien for the flora of Italy (Lazio).

Recent investigations in the province of Roma revealed that this species has largely colonized the shores of the river Tiber and Aniene, all along the urban and suburban area and beyond, as well as other riparian habitats. From there, it is currently spreading also along roadsides and in archaeological sites (Celesti-Grapow and Ricotta 2020).

L. Celesti-Grapow

***Platycladus orientalis* (L.) Franco (Cupressaceae)**

+ (NAT) **VDA**: Saint-Vincent (Aosta), sulla collina tra Cillian e Felliey (WGS84: 45.739636N, 7.663596E), un esemplare inselvatichito in fessura delle rupi di serpentino, 660 m, 26 May 2012, leg. *M. Bovio, G.P. Mondino*, det. *G.P. Mondino* (AO); Bard (Aosta), presso il sentiero che costeggia le rocce alla base del Forte di Bard (WGS84: 45.60614630N, 7.74672678E), fessure delle rocce "montonate", 400 m, S, 27 July 2021, *A. Selvaggi* (FI); *ibidem* (WGS84: 45.6066190N, 7.7471075E), fessure delle rocce, 420 m, 2 August 2021, *A. Selvaggi* (AO). – Naturalized alien species confirmed for the flora of Valle d'Aosta.

Many individuals of this species have colonized the rock cracks at different points around the base of Forte di Bard; some of these plants are already fertile or ready to disperse the seeds. The presence of the species in Valle d'Aosta was previously an-

notated by Bovio (2014) as casual, but not by Galasso et al. (2018a). Other findings were recorded also in Collina di Châtillon (WGS84: 45.739636N, 7.663596E and 45.753752N, 7.615628E, 17 April 2019, obs. *M. Bovio, C. Ganz, M. Broglio, G. Trompetto*), Pont-Saint-Martin (WGS84: 45.598159N, 7.801948E, 1 May 2019, obs. *M. Bovio*), and between Plan de Brun and Perloz (WGS84: 45.606255N, 7.802994E, 21 May 2021, obs. *M. Bovio, C. Ganz, O. Deval, G. Jacquemet*).

A. Selvaggi, M. Bovio, G.P. Mondino

***Populus* ×*canadensis* Moench (Salicaceae)**

+ (INV) **ITALIA** (**LAZ**). – Status change from naturalized to invasive alien for the flora of Italy (Lazio).

+ (INV) **SAR**. – Status change from casual to invasive alien for the flora of Sardegna.

Recent investigations in Lazio revealed that this nothospecies has largely spread in riparian habitats along the shores of the river Tevere and its affluents, in the urban and suburban area of Roma and beyond. It is also currently spreading in archaeological sites and on the top of buildings, particularly in roof gutters. Similarly, in Sardegna, it is spreading in suburban areas and in riparian sites from planted stands (e.g., along the river Tirso at Fordongianus, Oristano, WGS84: 39.997N, 8.807E, obs. *G. Brundu*).

G. Brundu, L. Celesti-Grapow

***Pteris multifida* Poir. (Pteridaceae)**

+ (CAS) **TOS**: Pisa (Pisa), Via Roma 56 (WGS84: 43.719187N, 10.395475E), in tombino, 4 m, 10 June 2021, *L. Pinzani* (FI, *Herb. L. Pinzani*). – Casual alien species new for the flora of Toscana.

L. Pinzani

***Quercus palustris* Münchh. (Fagaceae)**

+ (CAS) **ITALIA** (**LOM**): Milano (Milano), piazza d'Armi, tra Via delle Forze Armate, Via della Rovere e Via G. Mazzarino (WGS84: 45.464368N, 9.122097E), boscaglia umida, 123 m, no exp., 7 July 2021, leg. *G. Galasso*, det. *G. Galasso, E. Banfi* (FI, MSNM Nos. 51005, 51006, 51007, 51008); Besnate (Varese), stagno Lagozzetta (WGS84: 45.703333N, 8.744722E), spontaneizzata sulle rive boschive dell'area umida, 276 m, no exp., 18 July 2021, leg. *M. Martignoni*, det. *G. Galasso, E. Banfi* (FI, MSNM No. 51038). – Casual alien species new for the flora of Italy (Lombardia).

In Milano, some individuals of the species, identified according to Jensen (1997), grow in a former semi-natural military area, with temporary pools rich in particularly interesting species.

G. Galasso, E. Banfi, M. Martignoni, N. Pilon

***Rhus typhina* L. (Anacardiaceae)**

+ (CAS) **ABR**: Bellante (Teramo), loc. Bellante Stazione, Via del Commercio (WGS84: 42.706944N, 13.852777E), vegetazione lungo il bordo stradale, ca. 98 m, 19 July 2021, *N. Olivieri* (FI). – Casual alien species new for the flora of Abruzzo.

Several young shrubby individuals occur in the record site, some of which bearing fruit, on both sides of a road.

N. Olivieri

***Robinia neomexicana* A.Gray (Fabaceae)**

+ (CAS) **MAR**: Pietrarubbia (Pesaro e Urbino), lungo la strada SP1 (WGS84: 43.790709N, 12.361800E), siepi, ca. 715 m, 10 June 2021, *L. Gubellini* (FI, PESA); *ibidem*, 13 August 2021, *L. Gubellini* (FI, PESA). – Casual alien species new for the flora of Marche.

The species was identified according to Peabody (1984) and Isely and Peabody (1984).

L. Gubellini, N. Hofmann

***Salvia hispanica* L. (Lamiaceae)**

+ (CAS) **CAL**: Cirò (Crotone), nei pressi dell'abitato, poco a N di Via Madonna delle Grazie (strada SP7) (WGS84: 39.382263N, 17.063990E), incolto, 290 m, 12 September 2019, *G. De Fine* (CLU). – Casual alien species new for the flora of Calabria.

N.G. Passalacqua, G. De Fine

***Scirpus atrovirens* Willd. subsp. *hattorianus* (Makino) Verloove & Lambinon (Cyperaceae)**

+ (CAS) **LAZ**: Latina (Latina), fraz. Borgo Piave (WGS84: 41.486944N, 12.846667E), sponde di un piccolo pantano, suolo sabbioso e argilloso, 28 m, 5 July 1999, leg. *F. Minutillo*, det. *L. Lastrucci*, conf. *F. Verloove* (FI). – Casual alien subspecies new for the flora of Lazio.

The specimen was identified according to Whittemore and Schuyler (2002).

F. Minutillo, G. Tondi

***Sedum rubrotinctum* R.T.Clausen (Crassulaceae)**

+ (CAS) **MAR**: Cupra Marittima (Ascoli Piceno), margine della strada SS16 Adriatica (WGS84: 43.0291619N, 13.8575740E), margine stradale, ca. 6 m, 3 August 2020, *N. Olivieri* (FI). – Casual alien species new for the flora of Marche.

This Mexican species, identified according to Groendijk-Wilders and Springate (2011) and Horwath (2014), was recently reported as a casual alien in Campania by Del Guacchio et al. (2020). In Cupra Marittima this culton has colonized the edge of the sidewalk in an area of limited extension within the town. The plant grows on a thin and not very developed substrate.

N. Olivieri

***Semiarundinaria fastuosa* (Lat.-Marl. ex Mitford) Makino (Poaceae)**

+ (CAS) **LOM**: Bergamo (Bergamo), Parco Regionale dei Colli di Bergamo, inizio del sentiero di Via dei Vasi partendo da Via Castagneta, lato a valle (WGS84: 45.71567N, 9.65165E), ex ceduo di castagno in evoluzione verso un bosco misto di farina, carpino bianco e acero campestre, ca. 380 m, NE, 13 July 2021, *E. Banfi* (FI); *ibidem*, 24 July 2021, *E. Banfi* (MSNM Nos. 51032, 51033, 51034, 51035, 51036, 51037, 51352, 51353). – Casual alien species new for the flora of Lombardia.

*Semiarundinaria fastuosa* is a bamboo native to central-southern Japan, cultivated as ornamental in Italy and escaped in Piemonte (Galasso et al. 2019b), to whose report we refer for the diagnostic characters of the species. Other individuals have been observed in the semi-abandoned garden of a property in Via F. Cavagnis, about 1 km away, testifying to a previous historical use of the species in Bergamo.

E. Banfi, G. Galasso

***Sesbania punicea* (Cav.) Benth. (Fabaceae)**

+ (INV) **SAR**. – Status change from naturalized to invasive alien for the flora of Sardegna.

The species is currently considered as naturalized, especially along freshwater courses (Galasso et al. 2018b). However, a large and spreading population has been observed along 'Bau sa Teula' (Villagrande Strisaili, Nuoro), where it is rapidly colonizing the coastal sector of the same river basin (Tortolì and Lotzorai, Nuoro). Accordingly, its status needs to be changed to invasive.

M. Fois, A. Cuena-Lombraña, G. Bacchetta

***Sorbaria tomentosa* (Lindl.) Rehder (Rosaceae)**

+ (CAS) **EMR**: Castell'Arquato (Piacenza), muro a secco di Via Sforza Caolzio (WGS84: 44.851962N, 9.868245E), muro a secco, 198 m, 1 September 2020, *D. Barberis, A. Mainetti, G. Nota* (FI). – Casual alien species new for the flora of Emilia-Romagna.

A single specimen, about 1 m tall and bearing fruits, has settled in the interstices of a dry-stone wall near private gardens and vegetable gardens. The identification was done according to Rahn (1989) and Tomaszewski (2001) who reported the hairiness of the follicles as diagnostic. This is in contrast with the identification key by Pignatti et al. (2019), which uses the characters number of nerves per leaflet and direction of the follicles in the infructescence, thus giving a false determination in favour of the similar *Sorbaria sorbifolia* (L.) A.Braun.

D. Barberis, A. Mainetti, G. Nota

***Stenotaphrum secundatum* (Walter) Kuntze (Poaceae)**

+ (CAS) **CAL**: Motta San Giovanni (Reggio Calabria), fraz. Lazzaro (WGS84: 37.973402N, 15.661162E), bordo strada, 4 m, 9 July 2021, *G. Mei* (REGGIO, *Herb. G. Mei*); Reggio Calabria (Reggio Calabria), Catona (WGS84: 38.190620N,

15.646328E), bordo strada, 20 m, 11 July 2021, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO). – Casual alien species new for the flora of Calabria.

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

***Tecomaria capensis* (Thunb.) Spach (Bignoniaceae)**

+ (CAS) **LAZ**: Gaeta (Latina), pendice W di Monte Orlando, Via Santa Maria Ausiliatrice (WGS84: 41.208235N, 13.581049E), boscaglie incolte sul bordo strada, 88 m, 9 January 2020, *S. Ravetto Enri, M. Pittarello, M. Lonati* (FI). – Casual alien species new for the flora of Lazio.

A small population of this species, occupying an area of approximately 5×5 m, has been found on the edge of the road between Gaeta and Monte Orlando. Several seedlings occur near an adult individual.

S. Ravetto Enri, M. Pittarello, M. Lonati

***Ulmus pumila* L. (Ulmaceae)**

+ (NAT) **TOS**: Siena (Siena), Viale Sardegna (strada SR2) (WGS84: 43.327430N, 11.331531E), margini stradali e ruderi, 281 m, 14 June 2020, leg. *E. Fanfarillo*, det. *E. Fanfarillo, T. Fiaschi, C. Angiolini* (FI, SIENA); *ibidem*, 22 February 2021, leg. *E. Fanfarillo*, det. *E. Fanfarillo, T. Fiaschi, C. Angiolini* (FI, SIENA); *ibidem*, 13 April 2021, leg. *T. Fiaschi*, det. *T. Fiaschi, E. Fanfarillo, C. Angiolini* (FI, SIENA). – Naturalized alien species new for the flora of Toscana.

*Ulmus pumila* is present with several individuals, sometimes of medium-large size, colonizing roadsides, sidewalks, and wasteland.

E. Fanfarillo, T. Fiaschi, C. Angiolini

***Yucca aloifolia* L. (Asparagaceae)**

+ (CAS) **TAA**: Naturno (Bolzano), Val Venosta (WGS84: 46.6506277N, 10.9882332E), radura boschiva di un bosco termofilo a roverella, 590 m, 1 August 2020, *G. Bonari* (FI). – Casual alien species new for the flora of Trentino-Alto Adige.

Sporadic individuals of this species were observed.

G. Bonari, E. Kindermann, C. Wellstein

## Nomenclatural and distribution updates from other literature sources

Nomenclatural, status, distribution updates, and corrections to Galasso et al. (2018a) are provided in Suppl. material 1.

G. Galasso, F. Bartolucci

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## Supplementary material 1

**Supplementary data**

Authors: Gabriele Galasso, Fabrizio Bartolucci (Eds)

Data type: species data

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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# Notulae to the Italian alien vascular flora: 13

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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, confirmations, exclusions, and status changes for Italy or for Italian administrative regions. Nomenclatural and distribution updates published elsewhere are provided as Suppl. material 1.

**Keywords**
Alien species, floristic data, Italy, nomenclature

## How to contribute

The text for the new records 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 (typifications only for accepted names), status changes, exclusions, and confirmations should be submitted electronically to Gabriele Galasso (gabriele.galasso@comune.milano.it). Each text should be within 1,000 characters (spaces included).

## Floristic records

### *Acer negundo* L. (Sapindaceae)

+ (INV) **TOS**. – Status change from naturalized to invasive alien for the flora of Toscana.

The presence of *Acer negundo* is increasingly common in disturbed areas of Toscana. Numerous individuals colonize urban areas and roadsides (Peruzzi and Bedini 2022+). From observations made in 2020 in the provinces of Siena and Arezzo, we noticed that in some areas with a strong disturbance the species grows abundant, sometimes in dense stands. In Chiusi [(Siena), fraz. Montallese, lungo la strada SP326, WGS84: 43.052790°N, 11.920611°E, margini stradali e ambienti ruderali, 255 m, 17 September 2021, *T. Fiaschi, E. Fanfarillo* (SIENA)] and other localities (e.g., Monteriggioni (Siena), WGS84: 43.392968°N, 11.217782°E), we observed abundant, fructifying adult individuals and seedlings. We therefore propose the change of status from naturalized to invasive.

C. Angiolini, E. Fanfarillo, T. Fiaschi

### *Allium tuberosum* Rottler ex Spreng. (Amaryllidaceae)

+ (CAS) **LOM**: Seriate (Bergamo), Via G. Venezian, rotatoria del ponte sul Fiume Serio per Via C. Cerioli (CFCE: 0324/1) (WGS84: 45.689694°N, 9.721861°E), scarpata erbosa, 252 m, no exp., 13 November 2021, leg. *G. Federici*, det. *E. Banfi, G. Galasso* (BER-HbFAB No. 107483); *ibidem*, 15 November 2021, leg. *G. Federici*, det.

*E. Banfi, G. Galasso* (FI, MSNM Nos. 51386, 51387, 51388, 51389). – Casual alien species new for the flora of Lombardia.

G. Federici, E. Banfi, G. Galasso

***Amaryllis belladonna* L. (Amaryllidaceae)**

+ (CAS) **SAR**: Carbonia (Sud Sardegna), Domu Beccia (WGS84: 39.223889°N, 8.483611°E), scarpata incolta a bordo strada, 148 m, 16 September 2021, leg. *A. Mammoliti*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI). – Casual alien species new for the flora of Sardegna.

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

***Ambrosia artemisiifolia* L. (Asteraceae)**

+ (NAT) **UMB**: Orvieto (Terni), Lago di Corbara (WGS84: 42.726658°N, 12.247858°E), greto sassoso della parte alta delle sponde del Lago di Corbara, con *Xanthium italicum*, 135 m, 28 August 2020, *R. Venanzoni, S. Praleskouskaya* (FI, PERU barcode PERU-2099). – Naturalized alien species new for the flora of Umbria.

R. Venanzoni, S. Praleskouskaya

***Ammannia verticillata* (Ard.) Lam. (Lythraceae)**

+ (NAT) **VEN**: Vigasio (Verona), Corte Brigafatta Nuova (WGS84: 45.327162°N, 10.970611°E), risaia, 37 m, 5 September 2021, leg. *G. Dal Corso*, det. *F. Prosser* (ROV No. 80116); *ibidem*, 7 October 2021, leg. *G. Dal Corso*, det. *F. Prosser* (FI). – Naturalized alien species confirmed for the flora of Veneto.

This species was historically widespread in the Venetian ricefields (Argenti et al. 2019), in which today it is almost totally replaced by *Ammannia coccinea* Rottb. Vigasio is among the localities reported by Goiran (1900) for the province of Verona.

G. Dal Corso, F. Prosser

***Bidens aurea* (Aiton) Sherff (Asteraceae)**

+ (CAS) **MAR**: Porto Sant'Elpidio (Fermo), Via XX Settembre, nei pressi di un cortile di una abitazione privata (WGS84: 43.237452°N, 13.756926°E), 21 m, 3 January 2021, *A. Pica, J. Lupoletti* (FI). – Casual alien species new for the flora of Marche.

The species covered about 10 $m^2$. It probably escaped from flowerbeds along the main road.

A. Pica, J. Lupoletti

***Bidens connata* Muhl. ex Willd. (Asteraceae)**

+ (NAT) **UMB**: Perugia (Perugia), fraz. Ponte San Giovanni, sponda destra del Tevere a monte del Nuovo Ponte vecchio (WGS84: 43.09193055°N, 12.45186388°E),

183 m, 18 October 2020, *R. Venanzoni, S. Praleskouskaya* (FI, PERU barcode PERU-2102). – Naturalized alien species new for the Flora of Umbria.

The species can be found sporadically to frequently along the banks of the river Tevere in Umbria.

R. Venanzoni, S. Praleskouskaya

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

+ (CAS) **TAA**: Roncegno Terme (Trento), Cadenzi (WGS84: 46.052056°N, 11.403447°E), margine stradina presso orti, avventizia, 584 m, 18 October 2020, *F. Prosser* (FI). – Casual alien species new for the flora of Trentino-Alto Adige.

This species was also observed in San Lorenzo Dorsino (Trento), loc. Glolo (6 September 2021, obs. *M. Merli*, det. *E. Banfi*).

F. Prosser, M. Merli, E. Banfi

***Cardiospermum halicacabum* L. (Sapindaceae)**

+ (CAS) **LAZ**: Roma (Roma), parco pubblico presso Via di Grotta Perfetta (WGS84: 41.828746°N, 12.516325°E), siepe, dove si arrampica su individui di *Olea europaea*, *Pittosporum tobira* e *Phyllostachys* sp., ca. 254 m, 3 October 2021, *N. Olivieri* (FI). – Casual alien species new for the flora of Lazio.

N. Olivieri

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

+ (CAS) **PIE**: Almese (Torino), al di sotto della pista tagliafuoco del Musinè (WGS84: 45.105475°N, 7.442177°E), popolamento misto di latifoglie autoctone e individui adulti di *Cedrus atlantica* derivanti da rimboschimento, 350 m, 20 May 2021, *D. Barberis, A. Mainetti, G. Nota* (FI). – Casual alien species new for the flora of Piemonte.

Several young individuals were found in a mixed stand with native broadleaf trees and a few planted *Cedrus atlantica* trees. The young specimens varied in height from 20 cm to 2 m.

D. Barberis, A. Mainetti, G. Nota

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

+ (CAS) **PIE**: Germagnano (Torino), loc. Colbeltramo, scarpata della strada che collega Colbeltramo a Castagnole (WGS84: 45.252557°N, 7.440891°E), scarpata stradale, 668 m, 2 April 2021, *M. Lonati, M. Pittarello, S. Ravetto Enri* (FI). – Casual alien species new for the flora of Piemonte.

A young individual, about 80 cm tall, was found in a shady area under broadleaf trees.

M. Lonati, M. Pittarello, S. Ravetto Enri

***Cotoneaster salicifolius* Franch. (Rosaceae)**

+ (CAS) **MAR**: Fermignano (Pesaro e Urbino), loc. Serra Alta (WGS84: 43.659679°N, 12.645607°E), scarpata stradale ai margini di una boscaglia diradata, ca. 340 m, 5 December 2021, *N. Hofmann* (FI, PESA). – Casual alien species new for the flora of Marche.

A single individual (2–3 m tall) has been observed.

L. Gubellini, N. Hofmann

***Cyperus odoratus* L. (Cyperaceae)**

+ (INV) **ITALIA** (**UMB**): Magione (Perugia), fraz. San Feliciano, Oasi La Valle (WGS84: 43.106111°N, 12.184722°E), sui resti del canneto degradato (morto!), vegetazione a dominanza di *Cyperus fuscus*, 280 m, 18 August 2021, *R. Venanzoni, S. Praleskouskaya* (FI, PERU barcode PERU-2091); Tuoro sul Trasimeno (Perugia), Punta Navaccia (WGS84: 43.189981°N, 12.075511°E), al margine del canneto, 258 m, 18 September 2021, *R. Venanzoni, S. Praleskouskaya* (PERU barcode PERU-2100). – Status change from naturalized to invasive alien for the flora of Italy; invasive alien species new for the Flora of Umbria.

In Umbria, *Cyperus odoratus* is found in the strongly nitrophilous muddy beach of Lake Trasimeno covered by vegetation with *Cyperus fuscus* L. and *Oxybasis chenopiodioides* (L.) S.Fuentes, Uotila & Borsch. In various sites, it tends to form locally dense populations of the sublittoral belt.

R. Venanzoni, S. Praleskouskaya

***Datura inoxia* Mill. (Solanaceae)**

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

The indication in Galasso et al. (2018) is based on the report for Cilento ("Torre Ficaiola", i.e., Spiaggia Ficaiola near Torre Caprioli, Pisciotta municipality, Salerno province) by De Natale and Strumia (2007), already questioned by Del Guacchio and La Valva (2017). The relevant specimen (Torre Caprioli, 6 July 1998, *Herb. A. De Natale* No. 3671) is to be attributed to *Datura wrightii* Regel, indeed new to Cilento.

E. Del Guacchio, A. De Natale

***Eclipta prostrata* (L.) L. (Asteraceae)**

+ (NAT) **MAR**. − Status change from casual to naturalized alien for the flora of Marche.

This species was recorded as casual in the Natural Reserve of Sentina (Conti and Bracchetti 2016), where it is no longer present due to the erosion of the coast. In the new locality [Grottammare (Ascoli Piceno), tra Cupra Marittima e Grottammare, WGS84: 43.008825°N, 13.865765°E, spiaggia, 1 m, 16 October 2018, *F. Conti, L. Bracchetti* (APP)], a well-established population can be found.

F. Conti, L. Bracchetti

***Elaeagnus pungens* Thunb. (Elaeagnaceae)**

+ (CAS) **TOS**: Pistoia (Pistoia), fraz. Santomoro, sopra il paese presso Case Buchetole (WGS84: 43.582308°N, 10.584183°E), margine sentiero, ca. 440 m, 12 December 2021, leg. *G. Gestri, P. Sandretti*, det. *G. Gestri. V. Lazzeri* (FI). – Casual alien species new for the flora of Toscana.

An adult plant with flowers and fruits occurs on the edge of a trail, with no current evidence of spontaneous reproduction.

G. Gestri

***Eragrostis pectinacea* (Michx.) Nees (Poaceae)**

+ (NAT) **TOS**. – Status change from casual to naturalized alien for the flora of Toscana.

This species is widespread in the lower stretch of the river Tevere [Pieve Santo Stefano (Arezzo), Lago di Montedoglio (WG84: 43.625417°N, 12.073081°E), sponde melmose originatesi al ritiro delle acque, 384 m, 20 August 2021, *R. Venanzoni* (FI, PERU barcode PERU-2113)]. It prefers the large stretches of stony and sandy beaches that emerge when the water withdraws.

R. Venanzoni, S. Praleskouskaya

***Erigeron lilacinus* (Sennikov & Kurtto) Sennikov (Asteraceae)**

+ (CAS) **LOM**: Milano (Milano), Parco Porto di Mare (WGS84: 45.431045°N, 9.231650°E), margine erboso, 103 m, no exp., 27 September 2020, *G. Galasso, E. Banfi* (MSNM No. 51428); *ibidem*, Via L. Ornato, lato dei numeri dispari, parcheggi sul lato della strada (WGS84: 45.520955°N, 9.191965°E), tra gli autobloccanti, 138 m, no exp., 19 June 2021, *G. Galasso* (FI). – Casual alien species new for the flora of Lombardia.

G. Galasso, E. Banfi

***Euphorbia nutans* Lag. (Euphorbiaceae)**

+ (NAT) **PUG**. – Status change from casual to naturalized alien for the flora of Puglia.

The population here reported [Taranto (Taranto), Mar Piccolo, Palude La Vela, WGS84: 40.476035°N, 17.325862°E, bordo strada, 10 m, 15 October 2021, *V. Tomaselli, F. Mantino* (FI, BI Nos. 42845, 42846, 42847, 42848)] consists of a few thousand individuals, regularly fruiting, widespread along roadsides.

V. Tomaselli, V. Cavallaro, F. Mantino

***Fraxinus pennsylvanica* Marshall (Oleaceae)**

+ (CAS) **ITALIA** (**VEN**): Verona (Verona), stazione dei treni di Verona Porta Nuova (CFCE: 0531/4) (WGS84: 45.428849°N, 10.977357°E), incolto ghiaioso, 64 m, 2 July 2021, leg. *F. Prosser, A. Bertolli, G. Tomasi*, det. *F. Prosser* (FI). – Casual alien species new for the flora of Italy (Veneto).

This species was identified according to Atha and Boom (2017). At least three 50–150 cm tall specimens were observed, born spontaneously from trees growing in the adjacent Via delle Coste. In some central European countries, *F. pennsylvanica* is an invasive species in riparian environments (Verloove 2016).

F. Prosser, G. Tomasi, A. Bertolli

***Gamochaeta pensylvanica* (Willd.) Cabrera (Asteraceae)**

+ (NAT) **TAA**: Trento (Trento), cortile in Via Vittorio Veneto (CFCE: 9932/2) (WGS84: 46.058487°N, 11.120500°E), aiuola erbosa poco curata, popolazione di oltre 100 esemplari (ca. 25 $m^2$) in fiore, in frutto e sterili, 194 m, 20 October 2021, *F. Prosser* (FI, ROV No. 80117). – Naturalized alien species new for the flora of Trentino-Alto Adige.

F. Prosser

***Hedera canariensis* Willd. (Araliaceae)**

+ (NAT) **TAA**: Bondone (Trento), a W di loc. Olte, a W di Baitoni (CFCE: 0129/3) (WGS84: 45.806493°N, 10.533911°E), boscaglia, 370 m, 18 October 2011, leg. *F. Prosser, A. Bertolli*, det. *F. Prosser* (FI, ROV No. 61339). – Naturalized alien species new for the flora of Trentino-Alto Adige.

F. Prosser, A. Bertolli

***Hedera hibernica* (G.Kirchn.) Bean (Araliaceae)**

+ (NAT) **VEN**: Bardolino (Verona), ca. 1 km a ENE di Bardolino, nella valletta con rivo a E di Monte Felice (CFCE: 0430/1) (WGS84: 45.554684°N, 10.739976°E), bosco termofilo, 180 m, 28 February 2004, *F. Prosser* (FI, ROV No. 44952); Torri del Benaco (Verona), a E di Punta Pontirola (WGS84: 45.618434°N, 10.701830°E), 240 m, 11 October 2006, leg. *F. Prosser, A. Bertolli*, det. *F. Prosser* (ROV No. 50876); Verona (Verona), fraz. Parona, stazione dei treni (CFCE: 0531/2) (WGS84: 45.477532°N, 10.941611°E), margine di massicciata, inselvatichita, tricomi appressati, in media con poco meno di 10 raggi, 75 m, 10 September 2020, leg. *F. Prosser, A. Bertolli, G. Tomasi*, det. *F. Prosser* (ROV No. 79310); *ibidem*, a W di Ca' di David presso Ca' Brusà (CFCE: 0631/2) (WGS84: 45.386698°N, 10.962959°E), siepe al margine della strada, 53 m, 27 October 2020, *F. Prosser, G. Tomasi, M. Gecchelin* (ROV No. 80038); Villafranca di Verona (Verona), lungo la linea ferroviaria dismessa a NW di Castel d'Azzano (CFCE: 0631/2) (WGS84: 45.364584°N, 10.920721°E), inselvatichita nel cespuglieto, 50 m, 27 October 2020, leg. *F. Prosser, G. Tomasi, M. Gecchelin*, det. *F. Prosser* (ROV No. 79588); Dolcè (Verona), fraz. Peri, stazione dei treni (WGS84: 45.660533°N, 10.901149°E), 129 m, 8 April 2021, *A. Bertolli, F. Prosser* (ROV No. 80123). – Naturalized alien species new for the flora of Veneto.

*Hedera hibernica* is quite widespread and was probably, at least partially, confused with *H. canariensis* Willd. by Argenti et al. (2019).

F. Prosser, A. Bertolli, F. Festi, G. Tomasi

***Jaborosa integrifolia* Lam. (Solanaceae)**

+ (NAT) **SAR**. – Status change from casual to naturalized alien for the flora of Sardegna.

Since the first report in 2011 (Podda et al. 2012), this species has been observed naturalized in the countryside of Batteria Boggio (Pula, Cagliari), near its first site known in loc. Is Loccis Santus (San Giovanni Suergiu, Sud Sardegna) and near Perdaxius and Terraseo (Narcao, Sud Sardegna).

G. Bacchetta, G. Calvia, A. Lallai

***Lagarosiphon major* (Ridl.) Moss (Hydrocharitaceae)**

+ (NAT) **EMR**: Sissa Trecasali (Parma), porto fluviale di Torricella di Sissa, vicino alla sponda (WGS84: 44.987640°N, 10.294034°E), profondità 0.5 m, 24 July 2019, *R. Bolpagni, A. Dalla Vecchia* (FI barcode FI065222). – Naturalized alien species new for the flora of Emilia-Romagna.

*Lagarosiphon major* is one of the most widespread and noxious invasive aquatic species in Europe and globally (Bolpagni 2021). It is, indeed, included in the European list of alien species of Union concern [Reg. (EU) no. 1143/2014]. In the river port of Torricella di Sissa, it forms small monophytic stands.

R. Bolpagni, A. Dalla Vecchia

***Miscanthus* ×*longiberbis* (Hack.) Nakai (Poaceae)**

+ (CAS) **ITALIA** (**LOM**): Iseo (Brescia), a S della rotonda tra Via per Rovato (Via Tangenziale Sud) e Viale Roma (WGS84: 45.649400°N, 10.042614°E), incolto, 191 m, no exp., 16 October 2021, leg. *A. Federici*, det. *E. Banfi, G. Galasso* (FI, MSNM Nos. 51406, 51407). – Casual alien nothospecies new for the flora of Italy (Lombardia).

This is a natural sterile hybrid between *Miscanthus sacchariflorus* (Maxim.) Benth. & Hook.f. ex Franch. (China, Korea, Japan) and *M. sinensis* Andersson (China, SE-Asia), no longer cultivated in Italy as an ornamental. It can be distinguished from *M. sinensis* by culms up to 2.5(–3.5) m, callus hairs 2–4 times as long as spikelet, spikelets unawned, and from *M. sacchariflorus* by pedicels of pedicellate spikelets mostly longer than 3 mm (Ibaragi et al. 2017).

E. Banfi, G. Galasso, A. Federici

***Nymphaea mexicana* Zucc. (Nymphaeaceae)**

+ (NAT) **TOS**: Castelnuovo Berardenga (Siena), nei pressi del Mulino di Piermaggiore sulla strada SP9 di Pievasciata (WGS84: 43.387002°N, 11.405236°E), laghetto artificiale, 272 m, 5 July 2021, leg. *G. Bonari, T. Fiaschi*, det. *C. Angiolini, G. Bonari, T. Fiaschi* (FI, SIENA). – Naturalized alien species new for the flora of Toscana.

This population widely colonizes the surface of an artificial lake. We detected numerous flowering individuals. This species is similar to the sterile hybrid *Nymphaea* × *thiona*

D.B.Ward, but the two taxa differ, according to Ward (1977), by the dimensions of the sepals (3–5 cm in *N. mexicana vs* 5–8 cm in *N.* × *thiona*).

C. Angiolini, G. Bonari, T. Fiaschi

***Opuntia anacantha* Speg. (Cactaceae)**

+ (CAS) **SAR**: Oschiri (Sassari), Diga Coghinas, rupi a ridosso della strada presso la chiesetta di Santa Barbara (WGS84: 40.788700°N, 9.024265°E), rupi, 205 m, 23 August 2019, *G. Calvia* (FI). – Casual alien species new for the flora of Sardegna.

In Oschiri the plant produces flowers and fruits, but its reproduction is primarily vegetative by cladode detachment or by the rooting of sterile fruits.

G. Calvia, A. Guiggi

***Opuntia engelmannii* Salm-Dyck ex Engelm. (Cactaceae)**

+ (NAT) **UMB**: Amelia (Terni), fraz. Fornole (WGS84: 42.539353°N, 12.459980°E), incolto con vegetazione a *Stipa bromoides* e *Cymbopogon hirtus*, 305 m, S-SE, 22 February 2022, *R. Venanzoni* (FI, PERU barcode PERU-2109); Montecchio (Terni), strada locale direzione Melezzole-Montecchio, scarpata inferiore della strada (WGS84: 42.668347°N, 12.305811°E), scarpata stradale, 633 m, S, 22 February 2022, *R. Venanzoni* (FI, PERU barcode PERU-2108); Spello (Perugia), fraz. Capitan Loreto, strada SS75bis Foligno-Perugia, prima dell'uscita per Capitan Loreto direzione Perugia, sommità della scarpata destra (WGS84: 43.017289°N, 12.647450°E), scarpata stradale, 210 m, SW, 22 February 2022, leg. *R. Venanzoni*, det. *F. Lucchese, A. Guiggi* (FI, PERU barcode PERU-2110). – Naturalized alien species new for the flora of Umbria.

Populations of this species have been observed for decades.

G. Ratini, A. Guiggi, F. Lucchese, R. Venanzoni

***Opuntia pilifera* F.A.C.Weber (Cactaceae)**

+ (CAS) **SIC**: Aci Castello (Catania), Scogliera Cannizzaro (WGS84: 37.538144°N, 15.131077°E), scogliera, 20 m, 10 October 2021, leg. *G. Spampinato*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO). – Casual alien species new for the flora of Sicilia.

In Sicily, *O. pilifera* grows along cliffs, on basaltic rocks of volcanic origin, where it lives with other *Opuntia* species.

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

***Opuntia spinulifera* Salm-Dyck (Cactaceae)**

+ (NAT) **SIC**: Terrasini (Palermo), Baia San Cataldo (WGS84: 38.089721°N, 13.077674°E), sea cliffs, 20 m, 28 April 2021, *G. Domina* (FI, PAL). – Naturalized alien species new for the flora of Sicilia.

A discontinuous area of over 200 m$^2$ near the coast is covered by this species, which reproduces abundantly by seed and vegetatively. In the Favorita Park, in the suburbs of Palermo, some individuals of the same species reproduce by seed and propagate vegetatively.

G. Barone, G. Di Gregorio

***Oxalis articulata* Savigny (Oxalidaceae)**

+ (CAS) **MAR**. – Alien status indication for the flora of Marche.

*Oxalis articulata* was indicated for the Marche without invasiveness status by Galasso et al. (2018). However, several individuals, escaped from cultivation, have been found by us in many localities of the municipalities of Cagli, Cantiano, Piandimeleto, and Mercatello. According to these observations, *O. articulata* should be considered casual for this administrative region.

G. Mei, A. Stinca

***Panicum dichotomiflorum* Michx. (Poaceae)**

+ (NAT) **UMB**: Baschi (Terni), Lago di Corbara, sponda destra (WGS84: 42.718358°N, 12.258800°E), sponde ciottolose e sabbiose con vegetazione a *Xanthium italicum* e *Abutilon theophrasti*, 134 m, September 2020, leg. *R. Venanzoni, S. Praleskouskaya*, det. *F.M. Tardella* (FI, PERU barcode PERU-2104). – Naturalized alien species new for the Flora of Umbria.

R. Venanzoni, S. Praleskouskaya, F.M. Tardella

***Persicaria filiformis* (Thunb.) Nakai (Polygonaceae)**

+ (CAS) **PIE**: Baveno (Verbano-Cusio-Ossola), Via Liberazione (WGS84: 45.911556°N, 8.504567°E), spigolo tra la strada e il marciapiede, 204 m, no exp., 1 October 2021, *G. Galasso* (FI, MSNM Nos. 51192, 51193); *ibidem*, leg. *A. Selvaggi*, det. *G. Galasso* (*Herb. A. Selvaggi*). – Casual alien species new for the flora of Piemonte.

A large clump of individuals of this species was observed.

G. Galasso, L. Gariboldi, A. Selvaggi

***Physalis angulata* L. (Solanaceae)**

+ (NAT) **SAR**: Villaspeciosa (Sud Sardegna), loc. Cuaddu Moriscu, Lago del Cixerri (WGS84: 39.275651°N, 8.861169°E), pratelli umidi sulle rive del lago, 39 m, 26 October 2021, *A.P. Lecis, F. Mascia, L. Podda* (FI, CAG). – Naturalized alien species new for the flora of Sardegna.

Hundreds of individuals were found sparsely along the shores of the Cixerri dam, occupying an area of approximately 5,000 m$^2$. We observed a tendency of the species to colonise also the adjacent areas due to its edible fruits dispersed by animals.

A.P. Lecis, F. Mascia, L. Podda

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

+ (CAS) **SIC**: Isnello (Palermo), Madonie, Piano Zucchi, edge of the road SP54 (WGS84: 37.889805°N, 13.999320°E), on a stone wall, 1150 m, 3 June 2021, *E. Di Gristina* (FI, PAL). – Casual alien subspecies new for the flora of Sicilia.

Some individuals grow on a vertical stone wall in the Madonie Regional Park, born from seeds produced by trees growing in a nearby reforested area.

E. Di Gristina, G. Barone

***Portulaca grandiflora* Hook. (Portulacaceae)**

+ (CAS) **PUG**: Brindisi (Brindisi), Via Taranto tra i numeri civici 3 e 29 (WGS84: 40.633188°N, 17.943848°E), interstizi del marciapiede, 25 m, 23 June 2021, *F. Roma-Marzio 1416* (FI, PI No. 044613). – Casual alien species new for the flora of Puglia.

The flowers of *Portulaca grandiflora* may occur with petals of different colours from yellow to magenta, and can show a double whorl of petals (Ocampus and Travis Columbus 2012). About ten plants were found, all with yellow petals.

F. Roma-Marzio

***Pueraria lobata* (Willd.) Ohwi (Fabaceae)**

+ (INV) **TOS**: Scandicci (Firenze), in prossimità dell'ingresso del Centro Don Gnocchi (WGS84: 43.760264°N, 11.205463°E), area incolta adiacente a un'azienda vivaistica, in contesto periurbano, 14 September 2021, *G. Ferretti* (FI); *ibidem*, 10 November 2021, *G. Ferretti* (FI). – Invasive alien species new for the flora of Toscana.

*Pueraria lobata* is a particularly noxious, invasive, densely-packed climbing species, considered among the 100 world's most invasive alien species (Lowe et al. 2004) and included in the black list of invasive alien species of Union concern [Reg. (EU) no. 2016/1141]. It has invaded an area of about 200 $m^2$, even climbing on some trees. This species shows a strong tendency to expand, even when limited by an urban context.

G. Ferretti

***Rubus laciniatus* Weston (Rosaceae)**

+ (NAT) **TOS**. – Status change from casual to naturalized alien for the flora of Toscana.

The species was recently recorded as casual alien in Toscana by Canzonieri et al. (2022). In Agliana (Pistoia) a few fruiting plants of fair size were observed among other brambles and roses in an extended uncultivated ground periodically mowed only in the area facing the park (loc. Castelletto, di fronte al centro commerciale di Via E. Berlinguer, WGS84: 43.909620°N, 10.996292°E, ca 45 m, 3 July 2021, *A. Messina*, FI).

A. Messina, G. Gestri

***Sedum palmeri* S.Watson**

+ (NAT) **LOM**. – Status change from casual to naturalized alien for the flora of Lombardia.

In Milano *Sedum palmeri* is largely naturalized on the masonry banks of the Naviglio della Martesana, with dozens of individuals for a stretch of at least 1.7 km in length (WGS84: from 45.514009°N, 9.253945°E to 45.504995°N, 9.237820°E).

G. Galasso, E. Banfi

***Setaria adhaerens* (Forssk.) Chiov. (Poaceae)**

+ (NAT) **LOM**: Breno (Brescia), loc. Lavarino, a monte della strada (Via Laverino Inferiore) per Case Bruciate (WGS84: 45.959875°N, 10.315386°E), margine stradale erboso, ca. 340 m, WNW, 24 October 2020, leg. et det. *A. Federici*, conf. *E. Banfi, G. Galasso* (FI ex *Hb. E. Bona No. 071242*); *ibidem*, 9 November 2021, leg. et det. *A. Federici*, conf. *E. Banfi, G. Galasso* (MSNM No. 51401). – Naturalized alien species new for the flora of Lombardia.

The species was observed also along Via Vigne in Piancogno (Brescia province, WGS84: 45.929961°N, 10.238172°E, 383 m, SE, 2021, obs. *A. Federici*).

E. Banfi, A. Federici, G. Galasso

***Sicyos angulatus* L. (Cucurbitaceae)**

+ (NAT) **MOL**: Oratino (Campobasso), argini del Fiume Biferno in loc. Bivaro (WGS84: 41.584596°N, 14.559886°E), argine fluviale, 395 m, 25 September 2021, *G. Salerno, E. D'Alessandro, B. Paura* (FI, *Herb. G. Salerno*). – Naturalized alien species new for the flora of Molise.

G. Salerno, E. D'Alessandro, B. Paura

***Solanum sisymbriifolium* Lam. (Solanaceae)**

+ (NAT) **SIC**: Pozzallo (Ragusa), Lungomare Pietrenere (WGS84: 36.729444°N, 14.851944°E), aiuole, 3 m, 20 August 2018, *A. Soldano 18531* (FI). – Naturalized alien species new for the flora of Sicilia.

Many individuals were observed along the seafront where the species was missing in previous years.

A. Soldano

***Sporobolus indicus* (L.) R.Br. (Poaceae)**

+ (NAT) **SAR**. – Status change from casual to naturalized alien for the flora of Sardegna.

This species was detected in 2016 (Campus and De Pascali 2017) near the Brotzu Hospital of Cagliari, where currently it has disappeared. In recent years, we have found it in Nora and Pula (Pula, Cagliari), where it was first introduced in green lawns and then started to produce viable seeds that are germinating in neighbouring areas.

M. Fois, A. Cuena-Lombraña, G. Campus

***Strigosella africana* (L.) Botsch. (Brassicaceae)**

+ (CAS) **TOS**: Montale (Pistoia), sopra Fognano, presso la zona di atterraggio elicotteri di soccorso (WGS84: 43.572342°N, 11.022752°E), incolto erboso periodicamente sfalciato, ca. 215 m, 14 April 2019, leg. *G. Gestri*, det. *G. Gestri, V. Lazzeri* (FI). – Casual alien species new for the flora of Toscana.

A few fruiting plants were observed.

G. Gestri, V. Lazzeri

***Styphnolobium japonicum* (L.) Schott (Fabaceae)**

+ (CAS) **SIC**: Catania (Catania), Via Ipogeo (WGS84: 37.512634°N, 15.079921°E), bordo strada, 38 m, 26 November 2021, leg. *C.M. Musarella*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO). – Casual alien species new for the flora of Sicilia.

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

***Tagetes minuta* L. (Asteraceae)**

+ (CAS) **TAA**: Arco (Trento), tra Massone e Bolognano in loc. Gambor (CFCE: 0032/3) (WGS84: 45.919668°N, 10.908787°E), scarpata incolta, 1 pianta alta 1.5 m, molto ramificata, 150 m, 22 January 2022, leg. *M. Merli*, det. *G. Galasso* (FI, ROV No. 80115, *Herb. M Merli*). – Casual alien species new for the flora of Trentino-Alto Adige.

G. Galasso, M. Merli

***Tetradium daniellii* (Benn.) T.G.Hartley (Rutaceae)**

+ (CAS) **ITALIA** (**TAA**): Ala (Trento), al termine della stradina presso la sponda destra del Fiume Adige a NE di Chiesurone (CFCE: 0232/1) (WGS84: 45.786316°N, 11.016831°E), margine stradina nella boscaglia con robinia, 147 m, 10 October 2020, *F. Prosser* (FI, ROV No. 79638). – Casual alien species new for the flora of Italy (Trentino-Alto Adige).

This species was identified according to Zhang and Hartley (2008). It is a plant of melliferous interest, planted near an apiary in the indicated locality. It features

abundant renewal up to 15 m away. In Europe, it sporadically escapes from cultivation, for example in southwestern Germany (Mazomeit 2016).

F. Prosser

***Thinopyrum obtusiflorum* (DC.) Banfi (Poaceae)**

+ (NAT) **LAZ**: Cittaducale (Rieti), presso Grotti, strada SR578 "Salto Cicolana", presso lo svincolo (WGS84: 42.352123°N, 12.957368°E), incolto ruderale, 405 m, 23 November 2020, *G. Filibeck, L. Cancellieri* (*Herb. L. Cancellieri*); *ibidem*, 22 July 2021, *G. Salerno, S. Maestri* (FI, *Herb. G. Salerno*); Castel Madama (Roma), Via San Quirico (WGS84: 41.976970°N, 12.877654°E), 25 July 2021, *G. Salerno* (*Herb. G. Salerno*). – Naturalized alien species new for the flora of Lazio.

This species was sown in 2016 for "greening" of a highway escarpment at Grotti, and some individuals now grow also in ruderal meadows nearby. Near Castel Madama, a large population grows on a highway escarpment and nearby areas. The use of this species for embankment greening followed by local naturalization is already reported for N-Italy and Switzerland (Bertolli and Prosser 2014 and references therein; Röthlisberger 2010). A germination test on spikelets collected from the Grotti plants confirmed that the population is able to reproduce.

L. Cancellieri, G. Filibeck, S. Maestri, G. Salerno

***Triticum turgidum* L. subsp. *durum* (Desf.) Husn. (Poaceae)**

+ (CAS) **SIC**: Caltagirone (Catania) (WGS84: 37.126671°N, 14.519971°E), lungo il bordo del sentiero, 329 m, 8 April 2021, *D. Azzaro, S. Cambria* (FI, CAT); Terrasini (Palermo), Baia San Cataldo (WGS84: 38.088381°N, 13.079131°E), 40 m, 28 April 2021, *G. Domina* (SAF No. 100039). – Casual alien subspecies new for the flora of Sicilia.

D. Azzaro, G. Tavilla, M. Di Stefano

***Zizania latifolia* (Griseb.) Hance ex F.Muell. (Poaceae)**

+ (CAS) **ITALIA** (**VEN**): Sant'Urbano (Padova), sinistra idrografica del Canale Gorzone, ca. 220 m a E di Ponte Zane (WGS84: 45.143497°N, 11.646712°E), sponda di stagno, in bosco, 9 m, July 2021, *L. Tosetto* (FI). – Casual alien species new for the flora of Italy (Veneto).

This species was identified according to Liu and Phillips (2006). The plant is cultivated in China for food use of the young shoots and rhizomes when infected by the fungus *Ustilago esculenta* Henn. (Basidiomycota), which renders the indicated parts edible and inhibits the normal development of the synflorescence. Since the plants found do not bloom, their presence at the site is almost certainly related to this use.

E. Banfi, L. Tosetto, R.R. Masin, R. Pellegrini

**Nomenclatural and distribution updates from other literature sources**

Nomenclatural, status, distribution updates, and corrections to Galasso et al. (2018) 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: Species data

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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# Notulae to the Italian alien vascular flora: 14

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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, confirmations, and status changes for Italy or for Italian administrative regions. Nomenclatural and distribution updates, published elsewhere, and corrections are provided as Suppl. material 1.

**Keywords**
Alien species, floristic data, Italy, nomenclature

## How to contribute

The text for the new records 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 (typifications only for accepted names), exclusions, and confirmations should be submitted electronically to Gabriele Galasso (gabriele.galasso@comune.milano.it). Each text should be within 1,000 characters (spaces included).

## Floristic records

***Abies nordmanniana* (Steven) Spach subsp. *nordmanniana* (Pinaceae)**

+ (CAS) **TAA**: Trento (Trento), fraz. Meano (WGS84: 46.133649°N, 11.124639°E), radura boschiva di un bosco termofilo a roverella, 455 m, 17 October 2021, *G. Bonari* (FI). – Casual alien species new for the flora of Trentino-Alto Adige.

This species occurs with an individual in a thermophilous oak forest of Adige Valley. The other herbarium specimens from bottom-valley sites testify for the use of this species in afforestation since many years and support the limited spread of this species at sites [e.g., Ala (Trento), fraz. Serravalle all'Adige, sentiero per loc. Fortini (WGS84: 45.815032°N, 11.018794°E), esemplari sparsi (piantati) nel bosco di pino nero, 400 m, 7 January 2005, leg. *F. Prosser* sub *Abies cephalonica*, rev. *F. Prosser* 2021 (ROV)]. Furthermore, this species is cultivated as Christmas tree in Val Sugana (G. Bonari pers. obs.) and sometimes planted in gardens (e.g., in Calamento valley, G. Bonari pers. obs.). This species can be distinguished from similar ones for having non-resinous buds, glabrous branches and non-prickly needles.

G. Bonari, F. Prosser

***Acacia dealbata* Link (Fabaceae)**

+ (NAT) **UMB**: Orvieto (Terni), loc. Tordimonte, lungo la strada SP98 (WGS84: 42.682246°N, 12.193114°E), margine stradale, 314 m, 20 February 2022, leg. *M.*

*Mugnai, M. Vinci*, det. *M. Mugnai, L. Lazzaro, G. Ferretti* (FI). – Naturalized alien species new for the flora of Umbria.

Several adult individuals along the provincial road originated from seeds produced by nearby trees. We observed a substantial spreading of the species with individuals at different growth stages occurring along the road.

M. Mugnai, L. Lazzaro

***Acacia pycnantha* Benth. (Fabaceae)**

+ (INV) **SAR**. – Status change from naturalized to invasive alien for the flora of Sardegna.

*Acacia pycnantha* was commonly used for afforestation and reforestation in Sardegna. Although less common in coastal areas, this species is showing similar invasive behavior to *A. saligna* (Labill.) H.L.Wendl. in several inland areas (up to ca. 500 m a.s.l.) but also in a few sites along the coast (e.g., at the edges of a *Pinus* plantation, WGS84: 40.466866°N, 9.775060°E).

M. Fois, A. Cuena-Lombraña, G. Brundu, V. Lozano

***Achillea filipendulina* Lam. (Asteraceae)**

+ (CAS) **SAR**: Capoterra (Cagliari), Rio Santa Lucia (WGS84: 39.1702743°N, 8.9973075°E), banco fluviale, 3 m, 5 July 2022, *A.P. Lecis, L. Podda, A. Lallai* (FI, CAG). – Casual alien species new for the flora of Sardegna.

A group of four flowering individuals was found along the riverbank, probably originated from seeds of plants growing nearby.

A.P. Lecis, L. Podda, A. Lallai

***Amaranthus viridis* L. (Amaranthaceae)**

+ (CAS) **MOL**: Isernia (Isernia), Via J.F. Kennedy 92 (WGS84: 41.59408°N, 14.23302°E), margine stradale, 463 m, 29 July 2021, leg. *A. Hussain*, det. *A. Hussain, P. Fortini, D. Iamonico* (FI, IS No. IS-1003, RO). – Casual alien species new for the flora of Molise.

A few individuals were found.

A.N. Hussain, P. Fortini, D. Iamonico

***Anethum graveolens* L. (Apiaceae)**

+ (CAS) **PUG**: Rocchetta Sant'Antonio (Foggia), loc. Santuario della Madonna del Pozzo (WGS84: 41.091227°N, 15.444830°E), margine stradale/coltivi, 452 m, 6 July 2022, *G. Buccomino* (FI). – Casual alien species new for the flora of Puglia.

G. Buccomino

***Bignonia capreolata* L. (Bignoniaceae)**

+ (CAS) **ITALIA** (**LOM**): Milano (Milano), piazza d'Armi, tra Via delle Forze Armate, Via della Rovere e Via G. Mazzarino (WGS84: 45.462558°N, 9.118055°E), margine incolto, 124 m, no exp., 24 May 2022, leg. *G. Galasso, R. Gentili, L.A. Quaglini*, det. *G. Galasso* (FI, MSNM barcode MSNM51826). – Casual alien species new for the flora of Italy (Lombardia).

*Bignonia capreolata* is a species native to SE-North America (Britton and Brown 1913). One sterile individual was found.

G. Galasso, R. Gentili, L.A. Quaglini

***Broussonetia papyrifera* (L.) Vent. (Moraceae)**

+ (INV) **LAZ**. – Status change from naturalized to invasive alien for the flora of Lazio.

In Ferentino (Frosinone), we found several sites where this species is widespread and colonizes ruderal areas and abandoned fields, even forming dense thickets (e.g., WGS84: 41.679429°N, 13.256788°E; 41.704276°N, 13.265966°E; 41.689602°N, 13.256781°E). We therefore propose its status change from naturalized to invasive alien.

E. Fanfarillo, T. Fiaschi

***Campanula portenschlagiana* Schult. (Campanulaceae)**

+ (CAS) **LAZ**: Jenne (Roma), centro storico (WGS84: 41.886577°N, 13.168036°E), vecchi muri, 815 m, 15 November 2021, leg. *L. Rosati*, det. *L. Rosati, L. Cancellieri* (FI). – Casual alien species new for the flora of Lazio.

L. Rosati, L. Cancellieri

***Cenchrus clandestinus* (Hochst. ex Chiov.) Morrone (Poaceae)**

+ (CAS) **ITALIA** (**CAL**): Catanzaro (Catanzaro), Parco della Biodiversità Mediterranea (WGS84: 38.922443°N, 16.580986°E), muro di contenimento in cemento da cui fuoriesce una perdita d'acqua, 404 m, 18 March 2022, *A. Capuano* (FI). – Casual alien species new for the flora of Italy (Calabria).

This species, identified according to Maire (1952) and Wipff (2003), has been used to create a small lawn in a nearby area. *Cenchrus clandestinus* is native to humid highlands of central and eastern Africa. It has been introduced as pasture and ornamental grass to temperate and subtropical regions of America and Australia, where it shows adaptations to different environmental conditions (Fraser et al. 2017). It usually reproduces by vegetative propagation by rhizomes (Arango Gaviria et al. 2019).

A. Capuano

***Centaurea diluta* Aiton (Asteraceae)**

+ (NAT) **PUG**: Gravina (Bari), agro di Gravina, al bordo del vulcanello (WGS84: 40.702861°N, 16.429033°E), incolto, 210 m, 27 April 2022, *M. Terzi, F.S. D'Amico* (FI). – Naturalized alien species new for the flora of Puglia.

*Centaurea diluta* is present along an uncultivated strip, near the border between Puglia and Basilicata. This species was also found close to the border on the Basilicata side (Galasso et al. 2021).

M. Terzi, F.S. D'Amico

***Chloris gayana* Kunth (Poaceae)**

+ (CAS) **CAL**: Catanzaro (Catanzaro), Parco della Biodiversità Mediterranea (WGS84: 38.920250°N, 16.581116°E), pendio erboso incolto, 403 m, 16 February 2022, *A. Capuano* (FI). – Casual alien species new for the flora of Calabria.

The few observed individuals have been uprooted in order to prevent a future colonisation.

A. Capuano

***Chrysanthemum morifolium* (Ramat.) Hemsl. (Asteraceae)**

+ (CAS) **ITALIA** (**VEN**): Verona (Verona), presso la città di Verona in Lungadige Cangrande, lungo la sponda dell'Adige, tra il fiume e l'argine murato (WGS84: 45.44243142°N, 10.98234527°E), sponda erbosa periodicamente inondata, un esemplare in fiore ben radicato nel terreno, 51 m, 15 December 2021, leg. *F. Menini*, det. *F. Menini, G. Galasso* (FI). – Casual alien species new for the flora of Italy (Veneto).

This species was reported as alien by several authors (Goiran 1900; Puccini 1950), but only cultivated or escaped within gardens (Galasso et al. 2018).

F. Menini, G. Galasso

***Cornus sericea* L. subsp. *sericea* (Cornaceae)**

+ (CAS) **VEN**: Roana (Vicenza), fraz. Camporovere, imbocco sentiero boschivo per il Tanzerloch (WGS84: 45.882409°N, 11.475303°E), margine boschivo al limitare di prato da sfalcio, 1030 m, 24 August 2022, *S. Tasinazzo* (FI). – Casual alien species new for the flora of Veneto.

A surface of 2 $m^2$ was occupied by a clump of non blooming individuals, already observed in August 2021.

S. Tasinazzo

***Dysphania pumilio* (R.Br.) Mosyakin & Clemants (Amaranthaceae)**

+ (NAT) **VEN**: Chioggia (Venezia), Ca' Lino (WGS84: 45.162913°N, 12.298620°E), orto, -1 m, 30 October 2021, *S. Tasinazzo* (FI); *ibidem*, Ca' Zadra (WGS84:

45.152445°N, 12.296484°E), coltivo, -1 m, 30 October 2021, *S. Tasinazzo* (*Herb. S. Tasinazzo*); *ibidem*, 26 September 2022, *S. Tasinazzo* (*Herb. S. Tasinazzo*). – Naturalized alien species new for the flora of Veneto.

S. Tasinazzo

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

+ (CAS) **CAL**: Catanzaro (Catanzaro), Parco della Biodiversità Mediterranea (WGS84: 38.918430°N, 16.580912°E), dentro alcune siepi e aiuole in posizione semiombreggiata, ca. 388 m, 10 February 2022, *A. Capuano* (FI); *ibidem*, Via Piave (WGS84: 38.913589°N, 16.585429°E), lungo il marciapiede, nelle aiuole sotto alcuni alberi e in un giardino incolto, 352 m, 2 August 2022, *A.Capuano* (FI). – Casual alien species new for the flora of Calabria.

Several individuals were observed.

A. Capuano

***Eragrostis pectinacea* (Michx.) Nees (Poaceae)**

+ (NAT) **CAL**: Santa Sofia d'Epiro (Cosenza), loc. Faudano, nei pressi del Fiume Crati (destra idrografica) (WGS84: 39.589711°N, 16.264669°E), fossato e ambiente umido a margine strada, 70 m, 17 July 2012, leg. *L. Bernardo, A. Soldano, D. Puntillo*, det. *F. Verloove* (FI, CLU No. 26304, *Herb. A. Soldano* No. 16014). – Naturalized alien species new for the flora of Calabria.

A. Soldano, L. Bernardo, F. Verloove

***Erythranthe guttata* (DC.) G.L.Nesom (Phrymaceae)**

+ (CAS) **VEN**: Zevio (Verona), loc. Ponte Perez, lungo la sponda destra del Fiume Adige (WGS84: 45.37996092°N, 11.13532127°E), greto ghiaioso/sabbioso del fiume, un esemplare in antesi, 27 m, 24 May 2022, *F. Menini* (FI); Belfiore (Verona), loc. Lorosi, lungo la sponda sinistra del Fiume Adige (WGS84: 45.37091748°N, 11.18414264°E), greto ghiaioso/sabbioso del fiume, 27 m, 24 June 2022, *F. Menini* (VER); Verona (Verona), loc. Porto San Pancrazio, lungo la sponda destra del Fiume Adige (WGS84: 45.42776403°N, 11.01548551°E), sponda melmosa del fiume, 46 m, 28 June 2022, *F. Menini* (VER). – Casual alien species new for the flora of Veneto.

F. Menini, S. Andreatta

***Eschscholzia californica* Cham. subsp. *californica* (Papaveraceae)**

+ (CAS) **BAS**: Lauria (Potenza), fraz. Pecorone (WGS84: 40.072333°N, 15.857557°E), bordo strada, 778 m, 18 June 2020, leg. *A. Montesano* (FI). – Casual alien species new for the flora of Basilicata.

A. Montesano, S. Fascetti, L. Rosati

***Fatoua villosa* (Thunb.) Nakai (Moraceae)**

+ (CAS) **ITALIA** (**SAR**): Pula (Cagliari), fraz. Santa Margherita di Pula (WGS84: 38.968344°N, 8.965075°E), aree marginali nei pressi di serre e vivai, 15 m, 17 June 2022, *G. Bacchetta, G. Loi, G. Calvia* (FI, CAG). – Casual alien species new for the flora of Italy (Sardegna).

*Fatoua villosa* is an annual herb native to East Asia, Pacific islands, and Australia (Zhekun and Gilbert 2003) and reported for Europe only in Corsica (Puddu et al. 2016). A few individuals have been observed.

G. Bacchetta, G. Loi, G. Calvia

***Graptopetalum paraguayense* (N.E.Br.) Walther subsp. *paraguayense* (Crassulaceae)**

+ (CAS) **LAZ**: Sant'Angelo Romano (Roma), Via Roma all'altezza del civico 82/a (WGS84: 42.036886°N, 12.714044°E), parete calcarea sul bordo della strada, 350 m, 18 January 2022, *M. Giardini* (FI). – Casual alien species new for the flora of Lazio.

In Sant'Angelo Romano, at least three luxuriant individuals grow spontaneously on a limestone wall, probably originated from specimens cultivated in the balconies above. Similarly, it is possible to explain the presence of *Sedum palmeri* S.Watson and *Aloë maculata* All. subsp. *maculata* in the same site.

M. Giardini

***Hertia cheirifolia* (L.) Kuntze (Asteraceae)**

+ (CAS) **ITALIA** (**LOM**): Bergamo (Bergamo), Via San Martino della Pigrizia, muro sul lato NW (WGS84: 45.702992°N, 9.648287°E), muro, 331 m, SE, 27 February 2022, *E. Banfi* (FI, MSNM barcode MSNM51577). – Casual alien species new for the flora of Italy (Lombardia).

A description of the plant is given by Iamonico and El Mokni (2021) along with the species' typification. It is native to Algeria and Tunisia and, since a few decades, it is the object of floricultural trade at least in Bergamo, where attempts at cultivation in flowerbeds in the Lower City have not had the same success as the plant growing spontaneously on the wall of the Upper City (Luca Mangili, pers. comm.).

E.Banfi, G. Galasso

***Honorius nutans* (L.) Gray (Asparagaceae)**

+ (CAS) **TOS**: Cavriglia (Arezzo), lungo strada SP408 di Montevarchi tra C. Olivacci e Tribolino (WGS84: 43.509780°N, 11.481830°E), margine di querceto ceduo, 100 m, 26 March 2022, *L. Pinzani* (FI, *Herb. L. Pinzani*). – Casual alien species confirmed for the flora of Toscana.

*Honorius nutans* was last reported in Toscana by Baroni (1908). At the site, this species forms a small population consisting of 20 mature individuals.

L. Pinzani

***Hydrangea macrophylla* (Thunb.) Ser. (Hydrangeaceae)**

+ (NAT) **VEN**. – Status change from casual to naturalized alien for the flora of Veneto.

In Veneto *Hydrangea macrophylla* is considered as casual alien in Vicenza province (Masin and Scortegagna 2012; Argenti et al. 2019). A new population was found in 2008 in Sedico (Belluno): fraz. Peron (CFCE: 9838/2), margin of road, 400 m, 7 July 2008, *C. Argenti* (RO, *Herb. C. Argenti*). Subsequent field surveys (up to July 2022) confirmed the occurrence of this population and led to discover further two populations in Borgo Valbelluna (Belluno), fraz. Cordellon and in Gosaldo (Belluno), fraz. Zavat. The species regularly produces abundant flowers and it is able to sustain itself. We consider *H. macrophylla* as naturalized in Veneto.

D. Iamonico, C. Argenti

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

+ (CAS) **MAR**: Apecchio (Pesaro e Urbino), fraz. Serravalle di Carda (WGS84: 43.537994°N, 12.503523°E), vegetazione arbustiva su suolo calcareo legata alla dinamica di rinaturalizzazione di un frutteto abbandonato, 680 m, 28 August 2022, leg. *G. Mei, E. Ligato, S. Tassone*, det. *G. Mei* (FI, *Herb. G. Mei*). – Casual alien species new for the flora of Marche.

A couple of young individuals originated from seed, about 30 cm tall, were observed in an uncultivated area occupied by disturbed vegetation dominated by shrubs and lianose plants. Nearby there is a walnut tree, about 10 m tall, residual of an old planting.

G. Mei, S. Tassone, E. Ligato

***Lepidium virginicum* L. subsp. *virginicum* (Brassicaceae)**

+ (NAT) **SAR**: Palau (Nord-Est Sardegna), loc. Porto Pollo (WGS84: 41.189607°N, 9.321279°E), duna fissa con *Ephedra distachya* e *Armeria pungens*, presente in una vasta area del sistema dunale e lungo le cunette stradali, 23 m, 2 June 2022, *G. Brundu, V. Lozano* (FI, *Herb. UniSS-Agraria*). – Naturalized alien species new for the flora of Sardegna.

This species was observed also on the eastern coast of Sardegna, in a dusty parking area (WGS84: 40.479964°N, 9.808424°E).

G. Brundu, V. Lozano

***Ligustrum lucidum* W.T.Aiton (Oleaceae)**

+ (INV) **LAZ**. – Status change from naturalized to invasive alien for the flora of Lazio.

In recent years, the rapid colonization by *Ligustrum lucidum* from seeds has been observed in several sites in the Rome metropolitan area (e.g., WGS84: 41.914809°N, 12.471324°E; 41.919734°N, 12.474257°E), particularly along the river Tevere, on monuments and in archaeological sites (Celesti-Grapow and Ricotta 2020).

L. Celesti-Grapow, F. Emili

\+ (CAS) **BAS**: Potenza (Potenza), Fiume Basento (WGS84: 40.628475°N, 15.808076°E), lungo le sponde, 665 m, 25 June 2022, leg. *L. Rosati*, det. *L. Rosati, G. Potenza, S. Fascetti* (FI, HLUC No. 13881). – Casual alien species new for the flora of Basilicata.

Several flowering individuals were observed within the patches of a *Salix alba* L. riparian forest.

G. Potenza, L. Rosati, S. Fascetti

***Lobelia erinus* L. (Campanulaceae)**

\+ (CAS) **SAR**: Villanovaforru (Sud Sardegna), ambiente urbano (WGS84: 39.632595°N, 8.865828°E), crepe dei muri e marciapiedi, 328 m, 8 June 2022, *F. Mascia, L. Podda, G. Bacchetta* (FI, CAG). – Casual alien species new for the flora of Sardegna.

Some individuals were found inside the village.

F. Mascia, L. Podda, G. Bacchetta

***Magnolia grandiflora* L. (Magnoliaceae)**

\+ (CAS) **LOM**: Gardone Riviera (Brescia), Piazza P. Scarpetta, di fronte al municipio (WGS84: 45.621831°N, 10.561928°E), aiuola, 116 m, no exp., 15 April 2022, leg. et det. *M. Merli*, conf. *G. Galasso* (FI). – Casual alien species new for the flora of Lombardia.

M. Merli, G. Galasso

***Melia azedarach* L. (Meliaceae)**

\+ (CAS) **LOM**: Milano (Milano), Parco del Ticinello (WGS84: 45.421100°N, 9.182687°E), boschina spontanea, 107 m, no exp., 15 June 2022, *G. Galasso* (FI, MSNM barcode MSNM51916, MSNM51917). – Casual alien species new for the flora of Lombardia.

G. Galasso

***Mesembryanthemum* × *vascosilvae* (Gideon F.Sm., E.Laguna, Verloove & P.P.Ferrer) L.Sáez & Aymerich (Aizoaceae)**

\+ (CAS) **CAM**: Positano (Salerno), arcipelago de Li Galli, Isola del Gallo Lungo (WGS84: 40.582144°N, 15.443412°E), margini della pineta su rupi calcaree

marittime, ca. 20 m, 30 June 2022, *E. Del Guacchio, R. Vallariello, L. Paino, C. Guidone* (FI). – Casual alien nothospecies new for the flora of Campania.

Massively planted as ground cover along paths on this islet and escaped. Formally described only in recent times (Smith et al. 2020, sub *Aptenia*), this overlooked hybrid is widely cultivated throughout Italy, nowadays more than its parental *Mesembryanthemum cordifolium* L.f. The repeated indications for Campania of the latter species (Capri Island) (Del Guacchio and La Valva 2017) need to be verified.

E. Del Guacchio, R. Vallariello, G. Galasso

***Narcissus* Jonquilla and Apodanthus Daffodil Group (Division 7) (Amaryllidaceae)**

+ (CAS) **VEN**: San Giovanni Ilarione (Verona), loc. Castello, a S della chiesa di San Giovanni Battista (WGS84: 45.52671016°N, 11.23706344°E), argine boscato, una decina di cespi, 295 m, 7 March 2022, leg. *F. Menini*, det. *E. Banfi* (FI, VER No. SA926). – Casual alien cultivar group new for the flora of Veneto.

The collected plants showed the characteristics of the cultivar 'Sweetness'.

F. Menini, E. Banfi, G. Galasso

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

+ (CAS) **SAR**: Masainas (Sud Sardegna), loc. Sa Reina (WGS84: 39.044167°N, 8.623333°E), incolti, 38 m, 29 April 2021, *A. Pisano, G. Bacchetta, A. Lallai* (FI, CAG). – Casual alien species new for the flora of Sardegna.

Some specimens have been found growing in the pastures near houses.

A. Pisano, G. Bacchetta, A. Lallai

***Oxalis purpurea* L. (Oxalidaceae)**

+ (CAS) **CAL**: Palmi (Reggio Calabria), Contrada Sant'Elia (WGS84: 38.332833°N, 15.839583°E), bordo sentiero in terra battuta, 550 m, 14 April 2022, leg. *G. Posillipo*, det. *V.L.A. Laface, C.M. Musarella, G. Posillipo, G. Spampinato* (FI, REGGIO). – Casual alien species new for the flora of Calabria.

The very small observed population occupies an area of approximately 5 $m^2$. In addition to Sicilia, it is naturalized in Campania, but only within the Portici Botanical Garden (Stinca and Motti 2009).

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

***Pachysandra terminalis* Siebold & Zucc. (Buxaceae)**

+ (CAS) **VEN**: Verona (Verona), Borgo Trento, Via IV Novembre lungo il marciapiede (WGS84: 45.44454303°N, 10.98968109°E), interstizio alla base del muro di un'abitazione, frammista a *Parietaria judaica*, 60 m, 21 March 2022, *F. Menini* (FI). – Casual alien species new for the flora of Veneto.

F. Menini, S. Andreatta

***Parthenocissus inserta* (A.Kern.) Fritsch (Vitaceae)**

+ (INV) **TOS**. – Status change from casual to invasive alien for the flora of Toscana.

On the ancient wall of the city of Pisa we found many plants covering a large area [sulle mura nei pressi della Torre Piezometrica (WGS84: 43.72034°N, 10.40914°E), invasiva sulle mura, 25 m, 21 May 2022, *F. Roma-Marzio 1798* (PI No. 061324)]. Many plants were also observed along the railroad tracks about 5 km from the railway station of Pisa in the direction of Firenze. Furthermore, after a revision of the specimens preserved in PI, it is also reported in the Regional Park of Migliarino-San Rossore-Massaciuccoli [Pisa (Pisa), Parco di Migliarino-San Rossore-Massaciuccoli, Tenuta di Tombolo al Bosco dell'Ulivo (WGS84: 43.60451°N, 10.35298°E), ambienti salmastri e sinantropici, 0–5 m, 9 June 2018, *Partecipanti all'escursione Wikiplantbase #Migliarino-San Rossore-Massaciuccoli* (PI No. 021484)]. In our opinion, most of the regional data concerning *Parthenocissus quinquefolia* (L.) Planch. (Peruzzi and Bedini 2013 [onwards]; Roma-Marzio et al. 2016) could be referred to *P. inserta*. Accordingly, we consider the status of invasive species as more appropriate for *P. inserta* in Toscana.

F. Roma-Marzio

***Paspalum dasypleurum* Kunze ex É.Desv. (Poaceae)**

+ (NAT) **LOM**. – Status change from casual to naturalized alien for the flora of Lombardia.

Abundant and frequent in Bergamo, Via Ghisleni Mazzola [(WGS84: 45.699891°N, 9.646808°E), margine erboso, 262 m, no exp., 23 July 2022, *E. Banfi* (FI, MSNM barcode MSNM52003, MSNM52004, MSNM52005)].

E. Banfi, G. Galasso

***Phlox caespitosa* Nutt. (Polemoniaceae)**

+ (CAS) **ITALIA** (**ABR**): L'Aquila (L'Aquila), loc. Palombara (WGS84: 42.342290°N, 13.429072°E), margine stradale, 666 m, 13 April 2020, leg. *F. Bartolucci*, det. *F. Bartolucci, F. Conti* (FI, APP No. 66130). – Casual alien species new for the flora of Italy (Abruzzo).

The collected specimen was identified following Wherry (1955) and Brown (2000). A few plants have been observed from 2019 to today, growing spontaneously along the roadside.

F. Bartolucci, F. Conti

***Phyllostachys viridis* (R.A.Young) McClure (Poaceae)**

+ (NAT) **LOM**. – Status change from casual to naturalized alien for the flora of Lombardia.

In several small woods in Milano [Boscoincittà (WGS84: 45.482703°N, 9.094525°E), robinieto, 131 m, no exp., 2 June 2022, leg. *G. Galasso*, det. *E. Banfi*

*& G. Galasso* (MSNM barcode MSNM51900, MSNM51901, MSNM51902, MSNM51903, MSNM51904); Parco del Ticinello, lungo la Roggia Ticinello, pressi di Cascina Campazzino (WGS84: 45.419655°N, 9.187769°E), boschetto su sponda di roggia, 108 m, no exp., 15 June 2022, leg. *G. Galasso*, det. *E. Banfi & G. Galasso* (MSNM barcode MSNM51918)] and Bergamo [Via San Sebastiano, lato a monte (WGS84: 45.710874°N, 9.635844°E), pendio erboso stradale, 380 m, NW, 17 June 2022, *E. Banfi* (MSNM barcode MSNM51922); Via Castagneta, lato a monte (WGS84: 45.718273°N, 9.656700°E), margine erboso stradale, 290 m, NE, 24 June 2022, *E. Banfi* (MSNM barcode MSNM51923)], crop residues expand widely within the undergrowth or along the edges.

E. Banfi, G. Galasso

***Picea orientalis* (L.) Peterm. (Pinaceae)**

+ (CAS) **PIE**: Torino (Torino), Collina di Torino, versante N presso il Colle della Maddalena (WGS84: 45.030659°N, 7.717236°E), bosco misto di latifoglie in prossimità di un piccolo nucleo artificiale di *Picea orientalis*, 658 m, 21 January 2022, *M. Lonati, G. Nota, D. Barberis* (FI). – Casual alien species new for the flora of Piemonte.

Numerous seedlings are present at this site below the canopy of broadleaf trees. Indeed, this species is markedly shade-tolerant in its juvenile stages.

M. Lonati, G. Nota, D. Barberis

***Platycladus orientalis* (L.) Franco (Cupressaceae)**

+ (NAT) **ABR**. – Status change from casual to naturalized alien for the flora of Abruzzo.

Abundant, sexually reproducing individuals were found on the vertical walls of the Spanish Fort, in the urban area of L'Aquila [(WGS84: 42.354040°N, 13.403478°E), muri, 730 m, 18 June 2022, *E. Fanfarillo, L. de Simone* (SIENA)].

E. Fanfarillo, L. de Simone

***Pseudotsuga menziesii* (Mirb.) Franco (Pinaceae)**

+ (CAS) **PIE**: Valchiusa (Torino), Meugliano, Lago di Meugliano (WGS84: 45.475756°N, 7.791080°E), aree boscate in prossimità di un rimboschimento artificiale a *Pseudotsuga menziesii*, 748 m, 16 May 2022, *S. Ravetto Enri, A. Mainetti, M. Pittarello* (FI). – Casual alien species new for the flora of Piemonte.

The spontaneous reproduction of this species has been observed in many Italian administrative regions in recent (Bartolucci et al. 2019) and former (Ciancio et al. 1981) times. In Piemonte, several young individuals (less than 1-m high) have been observed under the canopy cover of a plantation established in the 1930s.

S. Ravetto Enri, A. Mainetti, M. Pittarello

***Quercus palustris* Münchh. (Fagaceae)**

+ (NAT) **ITALIA** (**LOM**). – Status change from casual to naturalized alien for the flora of Italy (Lombardia).

Having had the opportunity to easily access the area of the former Piazza d'Armi in Milano, it was possible to verify that the population of *Quercus palustris* (Galasso et al. 2021) occurring there can be considered naturalized.

G. Galasso

***Sarcococca confusa* Sealy (Buxaceae)**

+ (CAS) **ITALIA** (**ABR**): Teramo (Teramo), Via dei Tribunali, fioriere sul bordo stradale, in zona ombrosa (WGS84: 42.658055°N, 13.708008°E), ca. 260 m, 10 November 2021, *N. Olivieri* (FI). – Casual alien species new for the flora of Italy (Abruzzo).

*Sarcococca confusa* is quite widespread in cultivation as ornamental in shady areas. Some young plants were identified according to McKean (2011).

N. Olivieri

***Senecio angulatus* L.f. (Asteraceae)**

+ (NAT) **MOL**: Termoli (Termoli), Via Corsica in prossimità dell'incrocio con Via Sant'Elena (WGS84: 41.991205°N, 14.999781°E), incolto sul bordo strada, 31 m, 4 January 2022, *M. Lonati, M. Probo* (FI). – Naturalized alien species new for the flora of Molise.

This species is widespread in Termoli, also occurring in some uncultivated areas near the medieval village.

M. Lonati, M. Probo

***Setaria adhaerens* (Forssk.) Chiov. (Poaceae)**

+ (NAT) **VEN**: Venezia (Venezia), Isola di Sant'Erasmo, 50 m a NE della chiesa (WGS84: 45.459477°N, 12.410954°E), orto, 0 m, 31 October 2021, *S. Tasinazzo* (FI); *ibidem*, Lido (WGS84: 45.364906°N, 12.337115°E), orto, 0 m, 14 October 2022, *S. Tasinazzo* (*Herb. S. Tasinazzo*); Cavallino-Treporti (Venezia), Via Sette Casoni (WGS84: 45.466540°N, 12.503309°E), campo di asparagi in stadio post-colturale, 0 m, 6 November 2021, *S. Tasinazzo* (*Herb. S. Tasinazzo*). – Naturalized alien species new for the flora of Veneto.

Some specimens were found on sandy soil.

S. Tasinazzo

***Sisyrinchium rosulatum* E.P.Bicknell (Iridaceae)**

+ (NAT) **TOS**: Lucca (Lucca) (WGS84: 43.8457678°N, 10.5153513°E), prati umidi, 14 m, 13 May 2022, *S. Maccherini, L. de Simone, E. Fanfarillo* (FI, SIENA). – Naturalized alien species new for the flora of Toscana.

Numerous fructifying adult individuals were found in an urban mowed grassland dominated by *Agrostis stolonifera* L. subsp. *stolonifera* and *Lolium perenne* L.

S. Maccherini, L. de Simone, G. Bacaro

***Solanum carolinense* L. (Solanaceae)**

+ (NAT) **LAZ**. – Status change from casual to naturalized alien for the flora of Lazio.

In Lazio, this species was first recorded in Roma in 2015 as a casual alien (Olivieri 2015). The new populations [Fumone (Frosinone), Vicinale Pozzi (WGS84: 41.73029511°N, 13.26961270°E), margine stradale, 621 m, 8 August 2022, *E. Fanfarillo* (SIENA); Alatri (Frosinone), strada SR155 (WGS84: 41.736187°N, 13.344255°E), 416 m, 9 August 2022, *E. Fanfarillo* (SIENA)] appear well-established, especially the one in Alatri, which was also observed in the past two years.

E. Fanfarillo

***Solanum sisymbriifolium* Lam. (Solanaceae)**

+ (NAT) **CAL**: Crotone (Crotone), lungo la strada SS106, in loc. Passovecchio, nei pressi della cartiera (WGS84: 39.106411°N, 17.097683°E), formazioni prative ruderali, 7 m, 28 September 2021, leg. *G De Fine*, det. *N.G. Passalacqua* (FI). – Naturalized alien species new for the flora of Calabria.

N.G. Passalacqua, G. De Fine

***Toxicodendron radicans* (L.) Kuntze subsp. *radicans* (Anacardiaceae)**

+ (NAT) **ITALIA** (**TOS**): Impruneta (Firenze), ai Sassi Neri nei pressi della fonte della Caldaia, lungo il fosso di Narbi (WGS84: 43.683644°N, 11.271573°E), bosco mesofilo e ambienti rocciosi umidi su serpentino, 230 m, 15 June 2022, leg. *G. Astuti, A. Cutroneo, F. Roma-Marzio, R. Vangelisti*, det. *F. Roma-Marzio, G. Astuti* (FI, PI Nos. 061456, 061458). – Status change from casual to naturalized alien for the flora of Italy; naturalized alien species new for the flora of Toscana.

In Italy, this species is reported as casual alien only in Trentino-Alto Adige (Galasso et al. 2018), based on two old records by Gelmi (1893) and Biasioni (1930). Accordingly, the Tuscan population is the only recent record for Italy and the first case reported as naturalized species. Special attention is recommended with this species, commonly known as poison ivy, which in North America is causing serious allergic contact dermatitis to millions of people every year (Kim et al. 2019).

G. Astuti, F. Roma-Marzio, R. Vangelisti

***Trigonella foenum-graecum* L. (Fabaceae)**

+ (NAT) **SAR**. – Status change from casual to naturalized alien for the flora of Sardegna.

The species was frequently found in marginal segetal habitats (fields of cereal crops, such as barley and oats) and in arid meadows of therophyte communities, mainly on

sandy-clayey substrates (Baràdili, Oristano; Collinas and Villanovaforru, Sud Sardegna). The populations are clearly established since some time in the territories and are to be related to intentional (cultivation of fenugreek for zootechnical purposes) or unintentional (cereal seed contamination) historical introductions.

F. Mascia, G. Bacchetta, M. Fois

***Triticum* ×*requienii* Ces., Pass. & Gibelli nothosubsp. *requienii* (Poaceae)**

+ (CAS) **TOS**: Asciano (Siena), loc. Biancane di Leonina (WGS84: 43.295584°N, 11.452733°E), calanchi, 225 m, 31 May 2022, leg. et det. *L. Pinzani, A. Stinca*, conf. *E. Banfi* (FI, IT, *Herb. L. Pinzani*). – Casual alien nothospecies new for the flora of Toscana.

*Triticum* ×*requienii* was first reported for Italy by Raimondo et al. (2010), under the name ×*Aegilotriticum triticoides* van Slageren, in Sicilia, then by Ardenghi and Polani (2016) in Lombardia. In Asciano, a few individuals of this nothotaxon have been observed within the therophytic plant communities of the clay flows at the base of the gullies (locally called 'Biancane').

L. Pinzani, A. Stinca, E. Banfi

***Tulipa gesneriana* L. subsp. *gesneriana* (Liliaceae)**

+ (CAS) **TOS**: Bagno a Ripoli (Firenze), loc. Candeli, tra Lasi e La Massa (WGS84: 43.764465°N, 11.340489°E), oliveto, 72 m, 16 April 2022, *L. Pinzani* (FI). – Casual alien species confirmed for the flora of Toscana.

This species forms a population consisting of a few scattered flowering individuals, distributed within an olive grove.

L. Pinzani

***Wisteria sinensis* (Sims) DC. (Fabaceae)**

+ (NAT) **PIE**: Gifflenga (Biella), sponde del Torrente Cervo, a monte del guado tra Gifflenga e Buronzo (WGS84: 45.49035°N, 8.24381°E), vegetazione alloctona sulle sponde e greto del Torrente Cervo, 176 m, 3 October 2021, *A. Selvaggi* (FI, *Herb. A. Selvaggi*); Carignano (Torino), sponda sinistra Fiume Po, presso imbarco Società canottieri Padus (WGS84: 44.90794°N, 7.69109°E), vegetazione alloctona sulle sponde del Fiume Po, 230 m, 17 July 2022, *A. Selvaggi* (FI, *Herb. A. Selvaggi*). – Naturalized alien species confirmed for the flora of Piemonte.

Previously recorded in Piemonte only in "Vignole Borbera, in luogo abbandonato" (Carrega and Silla 1995) and in the Natural Reserve of "Garzaia di Valenza" (Ostellino 1987), without any indication of the degree of naturalization. A couple of specimens escaped from cultivation have been also reported on the outskirts of Cherasco (Cuneo) (Rota and Cavallo 2012).

A. Selvaggi

***Yucca gloriosa* L. (Asparagaceae)**

+ (NAT) **SAR**. – Status change from casual to naturalized alien for the flora of Sardegna.

A dense population originating from clonal growth and formed by several shrubs was found in Porto Torres (Sassari), close to the Rio Mannu estuary (WGS84: 40.835207N, 8.391014E). Other small naturalized populations were found on sand dunes at Is Arenas [San Vero Milis (Oristano), WGS84: 40.059102°N, 8.466568°E] and in coastal areas of the island of San Pietro [e.g., Carloforte (Sud Sardegna), spiaggia La Caletta, WGS84: 39.117101°N, 8.257647°E].

G. Rivieccio, G. Brundu, S. Bagella

**Nomenclatural and distribution updates from other literature sources**

Nomenclatural, status, and distribution updates, and corrections to Galasso et al. (2018) and subsequent updates summarised in the Portal to the Flora of Italy (2022) 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: Species data

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

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# Italian Vascular Flora: New Findings, Updates and Exploration of Floristic Similarities between Regions

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**Abstract:** The tradition of floristic studies in Italy has made it possible to obtain a good knowledge of plant diversity both on a national and regional scale. However, the lack of knowledge for some areas, advances in plant systematics and human activities related to globalization, highlight the need for further studies aimed at improving floristic knowledge. In this paper, based on fieldwork and herbaria and literature surveys, we update the knowledge on the Italian vascular flora and analyze the floristic similarities between the administrative regions. Four taxa, all exotic, were recorded for the first time in Italy and Europe. In detail, *Elaeodendron croceum*, *Kalanchoë blossfeldiana*, and *Sedum spathulifolium* var. *spathulifolium* were found as casual aliens, while *Oxalis brasiliensis* was reported as historical record based on some herbarium specimens. Furthermore, *Kalanchoë laxiflora* was confirmed as a casual alien species for Italy and Europe. Status changes for some taxa were proposed at both national and regional levels, as well as many taxa were reported as new or confirmed at the regional level. Currently the Italian vascular flora comprises 9150 taxa of which 7547 are native (of which 1598 are Italian endemics) and 1603 are exotic at the national level. The multivariate analysis of updated floristic data on a regional scale showed a clear distribution along the latitudinal gradient, in accordance with the natural geographical location of the regions in Italy. This pattern of plants distribution was not affected by the introduction of alien species. Despite some taxonomic and methodological issues which are still open, the data obtained confirm the important role of floristic investigations in the field and in herbaria, as well as the collaborative approach among botanists, in order to improve the knowledge of the Italian and European vascular flora.

**Keywords:** Apennine peninsula; biological recording; exotic species; floristic inventories; floristic studies; herbaria; herborization; invasive plants; Italy; native species; new floristic records; plant diversity; regional flora

## 1. Introduction

Italy boasts a long tradition of floristic studies both nationally and locally. In the 15th and 16th centuries, many botanists (e.g., Benedetto Rinio, Luca Ghini and Ulisse Aldrovandi) mostly investigated the present-day area of northern Italy, while in the post-Linnaean period and until the early 1900s it was above all southern Italy and the islands that aroused the interest of researchers (e.g., Michele Tenore, Giovanni Gussone and Giuseppe Giacinto Moris) [1]. Starting from the second post-war period, floristic research was extended to most of Italy, making it possible to acquire good knowledge of plant biodiversity, also thanks to the activism of a large group of botanists belonging to the working group for Floristics, Systematics and Evolution of the Italian Botanical Society. Over time, field surveys, together with systematic studies performed in herbaria, have enabled the publication of national floras [1–7], some prior to the political unification of Italy [8–10]. However, in recent decades, Italy has witnessed considerable advances also in plant systematics. This has led to the description of many new taxa [11–14], the revision of some critical groups [15–18], and other taxonomic [19–23] and biogeographic insights [24–27]. Furthermore, a new flora of Italy was recently proposed for the identification of taxa [28–31], and many nomenclatural changes were put forward, often based on molecular studies carried out by other authors and poorly supported by clear morphological evidence (for example within Fabaceae, *Melilotus* Mill. was related with other genera of the tribe Trifolieae, first to *Medicago* L. and then to *Trigonella* L. [32]), which can cause confusion among scholars.

Thanks to the collaboration of many researchers, the Italian checklists of native and exotic flora was recently published [33,34], facilitating the work of botanists and providing a standardized nomenclature of vascular plants reported for Italy. Both floristic inventories report for Italy's 20 regions the distribution of species, subspecies and some hybrids (only for alien taxa) on the basis of knowledge updated to 2018. The above data have been subsequently updated by several researchers [35–45]. A first summary of these updates is given by Bartolucci et al. [46] who report 7528 native and 1564 exotic taxa as certainly occurring in Italy. However, despite the importance for scientific and conservation purposes [47], floristic knowledge of Italy's flora is far from exhaustive: in addition to the incomplete knowledge of some groups (e.g., *Anthyllis vulneraria* aggr., *Centaurea deusta* aggr., *Micromeria graeca* aggr. and *Ziziphora granatensis* aggr. [48]), for large swathes of the country the data are still scant or outdated [49]. Urban development is known to bring about the local extinction of species [50,51] and promote the invasion and dispersal of alien plant species [52,53]. As these processes are exacerbated by global climate change, updating past floristic inventories is a critical scientific endeavor to monitor, predict, and manage current and future impacts of climate change itself [54]. Therefore, it is important that frequent assessment of national and regional floras is undertaken not only to monitor the established populations (indigenous and naturalized), but also to update the distribution data to enable the early warning of declines in indigenous or endemic species, and to document the introduction of invasive plants [41]. Indeed, updating knowledge on vascular plant distribution represents a very important research topic in the Mediterranean area which is recognized as a global biodiversity hotspot [55].

The overall objective of this study is to improve the knowledge of Italian vascular flora. Specific goals of this research are: (a) to report new taxa for Italy; (b) to update the distribution of already known taxa and their status of presence at the national and regional level; (c) to make a synthesis on the current floristic knowledge in Italy; (d) to analyze the floristic similarities between the 20 Italian administrative regions, assuming a great differences between the native flora of the regions along the North—South geographic

gradient and an increase in similarities between regions due to the introduction of non-native species.

## 2. Materials and Methods

### *2.1. Study Area*

Italy is situated in South Europe on the central-northern shores of the Mediterranean basin (between 12°11′10″ E to 12°36′21″ E, and 47°05′31″ N to 35°29′35″ N) (Figure 1A). It is divided into 20 administrative regions and covers a total area of 302,068.3 km$^2$ (Figure 1B). From a geographical point of view, within its territory three macro-areas can be distinguished: continental Italy (i.e., northern areas between the border with France, Switzerland, Austria and Slovenia and the southern border of Emilia-Romagna), peninsular Italy (i.e., between the regional border indicated above and the South of the Italian Peninsula as far as Puglia and Calabria), and insular Italy (i.e., Sicilia and Sardegna which are the two largest islands in the Mediterranean Sea) (Figure 1B).

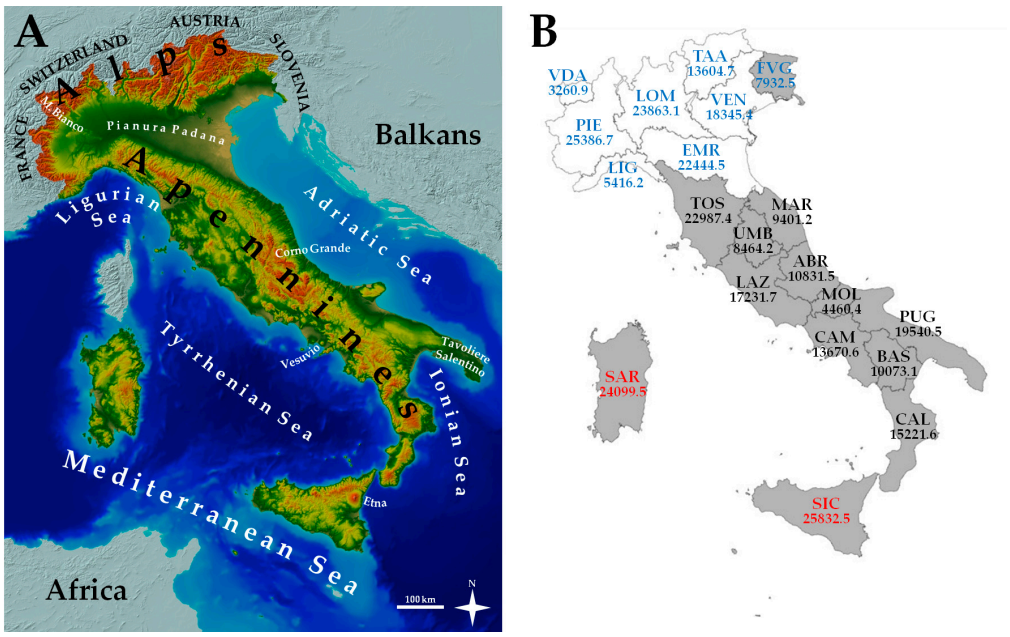



**Figure 1.** (**A**) Location and geographical features of Italy (from Tarquini et al. [56], modified). (**B**) Division into administrative regions of the Italian territory (VDA: Valle d'Aosta; PIE: Piemonte; LOM: Lombardia; TAA: Trentino-Alto Adige; VEN: Veneto; FVG: Friuli-Venezia Giulia; LIG: Liguria; EMR: Emilia-Romagna; TOS: Toscana; UMB: Umbria; MAR: Marche; LAZ: Lazio; ABR: Abruzzo; MOL: Molise; CAM: Campania; BAS: Basilicata; PUG: Puglia; CAL: Calabria; SIC: Sicilia; and SAR: Sardegna) with the indication of continental (regions in blue), peninsular (regions in black), and insular Italy (regions in red). The number under the abbreviated name of each region indicates its area in km$^2$. Regions for which we provide new floristic data on the basis of our study are highlighted in gray.

As is well known, Italy has an extraordinary physiographic, geological, pedological and land use variability. It is characterized by the presence of two large mountain ranges, namely the Alps and the Apennines (Figure 1A). The Alps, which represent the largest mountain range in Europe, cross most of continental Italy from the East to the West and include the highest peaks of the continent such as Monte Bianco (4810 m a.s.l.), while the Apennines extend for about 1200 km in the Italian Peninsula and have the highest elevation on Corno Grande (2912 m a.s.l.). Additionally, the active volcanic districts such as Etna in Sicilia (3350 m a.s.l.) and Vesuvio in Campania (1281 m a.s.l.) are noteworthy. The lowlands represent almost a quarter of the national territory and are almost entirely cultivated (e.g., Pianura Padana and Tavoliere Salentino). Overall, the coastline is about 7900 km in length. The largest urban areas are located around the main cities, namely Roma, Milano and Napoli. With about 59 million inhabitants [57], Italy is the third most populous member

state of the European Union, after Germany and France. According to the Bioclimatic map of Europe [58], Italy has two main temperate bioclimates (continental, oceanic) and one Mediterranean (pluvioseasonal oceanic).

### *2.2. Data Sources*

The floristic data are based on field investigations carried out from 2011 to 2021, herbaria surveys and bibliographic analysis. The collected or examined plant material is preserved in public herbaria registered (APP, BI, CAT, FI, HFLA, HLUC, IS, MJG-*Herb. Garganicum*, MS, MSNM, PI, PORUN-*Herb. Stinca*, REGGIO, RO-*HL*, SIENA) and not (*Herb. Magellense* of the Maiella National Park) in the Index Herbariorum [59], or private herbaria (*Herb. G. Mei*, *Herb. R.P. Wagensommer*). In the floristic list, taxa are arranged in alphabetical order. Nomenclature, taxa delimitation, and notes on the regional distribution follow the checklists of Italian vascular flora [33,34] and their updates [60–73] also available on the information system "FlorItaly—Portal to the Flora of Italy" (http://dryades.units.it/floritaly/index.php, accessed on 8 November 2021 [74]).

The collected or observed specimens were identified according to Flora Europaea [75–79], Flora d'Italia [28–31], Flora of North America [80], Flora of China [81], Flora do Brasil [82], and some monographic works cited in the species' notes in the floristic list. In these same notes the literature used for nomenclature and identification of taxa which are new for Italy are reported.

For each taxon the following information are provided:

- Accepted name;
- Plant family;
- Life form according to the categories of Flora d'Italia [28–31] and verified by on-field observations;
- Current chorology for indigenous plants or native range for exotic ones according to POWO [83];
- Period of introduction in Italy (i.e., archaeophyte or neophyte) for exotic plants;
- Data report in the study area;
- Only for exotic taxa, the current invasiveness status for each region, assessed by population monitoring over time according to the terminology of Pyšek et al. [84];
- Additional notes, including possible negative impacts of exotic taxa on habitats of interest to the European Community (Habitat Directive 92/43/EEC, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31992L0043, accessed on 10 November 2021).

Finally, sites of finds (i.e., exsiccata and observata) with details on the location (toponyms in Italian), growth environment(s), altitude, date, geo-coordinates E and N (datum WGS84, UTM); collector(s) (i.e., legit), author(s) of the identification (i.e., determinavit) are shown in Table S1.

Our new floristic data as well as those recently published in the series "Notulae to the Italian native vascular flora" [60–66] and "Notulae to the Italian alien vascular flora" [67–73], and related in the Supplementary Materials, were used to update the previous data of taxa in Italy and in each administrative region [33,34].

### *2.3. Data Analysis*

A multivariate analysis using XLSTAT software [85] was applied to test the degree of floristic similarity between regions. Data matrices, of taxa currently present in Italian regions (i.e., binary data: presence/absence), used for the analysis were: (i) only native taxa; (ii) only exotic taxa; (iii) total taxa. Taxa reported by mistake and as doubts, data deficient, extinct and were no longer recorded after 1950 were not considered for the analysis. The matrices were then processed by agglomerative hierarchical clustering (AHC, using Ward's method) and by principal component analysis (PCA, with the application of the Euclidean biplot) to the graphical exploration of the distances among Italian regions.

The floristic comparison between the regions was also carried out using the following indices:

- R*tn* = the richness of total native taxa (including cryptogenics) (n.);

- R*ta* = the richness of total alien taxa (including casual, naturalized, invasive and not assessed) (n.);
- FP = the degree of floristic pollution (i.e., total alien taxa/total flora × 100) (%);
- R*en* = the richness of exclusive native taxa (i.e., regional endemics + taxa with wider distribution but reported in only one Italian region) (n.; %);
- R*ea* = the richness of exclusive alien taxa (n.; %);
- R*ee* = the richness of exclusive endemics (i.e., regional endemics) (n.; %);
- D*tn* = the density of total native taxa (i.e., number of total native taxa/area) (taxa/km$^2$);
- D*ta* = the density of total alien taxa (i.e., number of total native taxa/area) (taxa/km$^2$);
- DN*tn* = the normalized density of total native taxa (i.e., natural logarithm of the number of total native taxa/natural logarithm of area) (taxa/km$^2$);
- DN*ta* = the normalized density of total alien taxa (i.e., natural logarithm of the number of total native taxa/natural logarithm of area) (taxa/km$^2$).

In addition, to better quantify the role of each regional flora on the national flora we propose a new index called the regional floristic index (RFI). RFI is the result of the ratio between the number of taxa occurring in the region and the average number of taxa present in all regions. It can be greater or less than 1 if the number of taxa occurring in the region is greater or less than the average number of taxa present in all regions, respectively. We calculated the value of this index considering only native taxa (RFI*n*), only alien taxa (RFI*a*) and the total taxa (RFI*t*) present in each Italian region.

## 3. Results

Below we report the list of the floristic notes that contribute to update the data on the Italian flora. Details on the floristic data collected (i.e., exsiccata and observata, n. 400) are reported in Table S1. A summary of our results is shown in Table 1.

**Table 1.** New floristic records for the Italian regions according to our field, herbarium and literature researches (CAL: Calabria; UMB: Umbria; TOS: Toscana; MAR: Marche; CAM: Campania; PUG: Puglia; LAZ: Lazio; BAS: Basilicata; SAR: Sardegna; ABR: Abruzzo; MOL: Molise; FVG: Friuli-Venezia Giulia; VEN: Veneto; and SIC: Sicilia).

| Italian Regions | First Records (n.) | Confirmations (n.) | Exclusions (n.) | Changes of Status (n.) | First Geolocalized Reports (n) | *Total (n.)* |
|---|---|---|---|---|---|---|
| **CAL** | 5 | 1 | 1 | 37 | | *44* |
| **UMB** | 10 | 1 | | 3 | | *14* |
| **TOS** | 4 | | | 8 | | *12* |
| **MAR** | 10 | | | 1 | | *11* |
| **CAM** | 9 | 1 | | 1 | 1 | *12* |
| **PUG** | 4 | 2 | | 2 | 2 | *10* |
| **LAZ** | 3 | | | 7 | | *10* |
| **BAS** | 4 | 1 | | 2 | | *7* |
| **SAR** | 4 | | | 1 | | *5* |
| **ABR** | 3 | 1 | | | | *4* |
| **MOL** | 1 | | | | 1 | *2* |
| **FVG** | 1 | | | | | *1* |
| **VEN** | 1 | | | | | *1* |
| **SIC** | | 1 | | | | *1* |
| ***Total (n.)*** | *59* | *8* | *1* | *62* | *4* | *134* |

### *3.1. Floristic List*

***Acanthus mollis* L. subsp. *mollis***
Acanthaceae—Hemicryptophyta scaposa—Mediterranean area (?)
*Change of status for Campania: from cryptogenic to invasive alien*

Notes—A very popular geophyte as an ornamental plant and in architecture since the Graeco-Roman era [30]: for this reason, its native range is difficult to define today. In Italy *Acanthus mollis* subsp. *mollis* is considered as a native plant only in some southern Italian regions and Sicilia, while in Campania it is classified as a cryptogenic species [33]. In this region, it is widespread in anthropogenic environments and disturbed forests [86–89] (see also our findings in Table S1), where it reproduces through abundant seed production. Its invasiveness is evident in the urban and peri-urban holm oak woods that can be attributed to the habitat 9340 (*Quercus ilex* and *Quercus rotundifolia* forests). In these plant communities *A. mollis* subsp. *mollis* competes with many native species such as *Asplenium onopteris* L., *Brachypodium sylvaticum* (Huds.) P.Beauv. subsp. *sylvaticum*, *Cyclamen hederifolium* Aiton subsp. *hederifolium*, *Drymochloa drymeja* (Mert. & W.D.J.Koch) Holub subsp. *exaltata* (C.Presl) Foggi & Signorini, *Limodorum abortivum* (L.) Sw., *Rubia peregrina* L., as well as with seedlings of *Fraxinus ornus* L. subsp. *ornus* and *Quercus ilex* L. subsp. *ilex*. Therefore, we propose this species as an invasive alien in Campania, in agreement with the other central-northern Italian regions and Sardegna.

***Actinidia deliciosa* (A.Chev.) C.F.Liang & A.R.Ferguson**
Actinidiaceae—Phanerophyta lianosa—China—Neophyte
*First record for Campania (casual alien)*

Notes—This species, native to China and often cultivated for fruits in Italy [29], was reported as casual in Piemonte, Lombardia, Trentino-Alto Adige, Veneto, Liguria, Emilia Romagna, Toscana and Lazio [34,69,71,73]. Therefore, our recent findings in Castellammare di Stabia (Napoli) (Figure 2A) are the first in Campania and concern a few plants spread by seed.

***Amaryllis belladonna* L.**
Amaryllidaceae—Geophyta bulbosa—South Africa—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—*Amaryllis belladonna* is a geophyte native to South Africa, often cultivated as an ornamental plant in Italy [28]. It is reported as a naturalized alien for Liguria, Campania and Sicilia, while it is considered a casual alien in Lombardia, Puglia and Calabria [34,69]. However, in the latter region it frequently grows on slopes where there are oak woods with *Quercus pubescens* Willd. subsp. *pubescens*, generally in the vicinity of villages and it blooms every year from its bulbs which remain in situ (i.e., Calanna, Reggio Calabria, and Santo Stefano in Aspromonte). Hence, the species can be considered naturalized for Calabria.

***Andrachne telephioides* L.**
Phyllanthaceae—Chamaephyta suffrutescentia—Mediterranean–South-East Asia
*New distribution data for Italian rare species in Lazio (native)*
*New distribution data for Italian rare species in Campania (native)*

Notes—*Andrachne telephioides* is a chamaephyte which has its current center of distribution from the Mediterranean to South-East Asia. In peninsular Italy it was reported as a native plant in many regions including Lazio and Campania, while it is considered a casual alien in Veneto and cryptogenic in Toscana [33,62,64]. According to the literature, this species was indicated in Lazio by Anzalone et al. [90] for the dry uncultivated and railway embankments of Roma, Bagni di Tivoli and Minturno. In Campania it was reported only in the South of the region for the train station of Sicignano degli Alburni by Salerno [91], and by De Natale [92] for the natural environments of Capo Palinuro in Centola municipality. Our discoveries of the species in and near the railway embankments of Roma (here also occurs in the parking area of the Engineering Department of the "Roma Tre" University), Bagni di Tivoli (i.e., two of the three localities reported by Anzalone et al. [90] and Caserta fuel doubts about its native status in these regions.

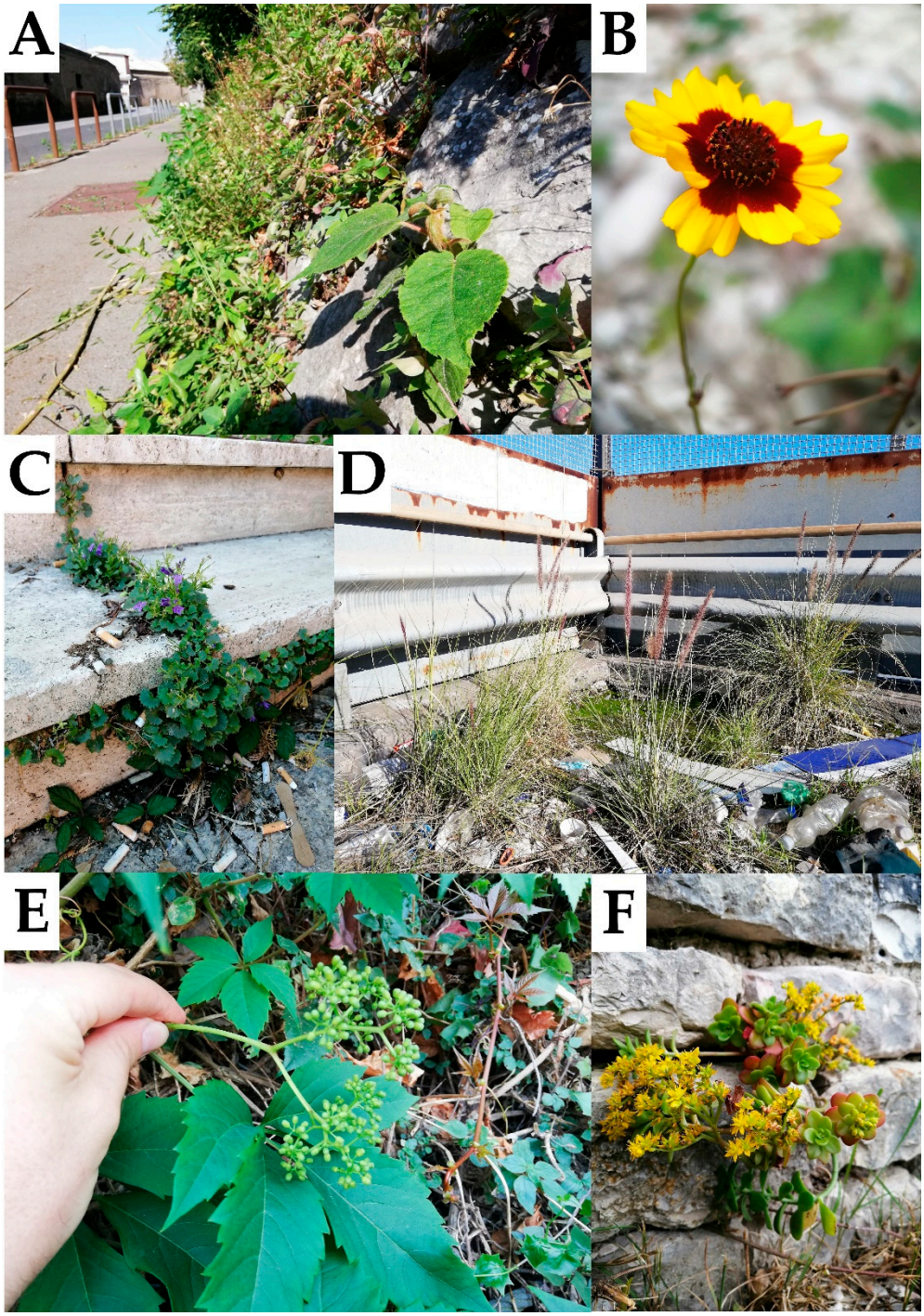



**Figure 2.** Some taxa reported as new for Italy and its regions. (**A**) *Actinidia deliciosa* (Campania, Castellammare di Stabia, 4 August 2019, photo: A. Stinca). (**B**) *Bidens tinctoria* (Marche, Cagli, 4 August 2021, photo: G. Mei). (**C**) *Campanula portenschlagiana* (Marche, Cagli, 30 August 2021, photo: G. Mei). (**D**) *Cenchrus setaceus* (Campania, Castellammare di Stabia, 1 January 2020, photo: A. Stinca). (**E**) *Parthenocissus inserta* (Campania, Castellammare di Stabia, 21 August 2021, photo: A. Stinca). (**F**) *Sedum spathulifolium* var. *spathulifolium* (Marche, Cagli, 4 May 2021, photo: G. Mei).

***Antirrhinum majus* L. subsp. *majus***
Plantaginaceae—Chamaephyta fruticosa—South-West Europe (?)—Archaeophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—This taxon was reported as naturalized for all Italian regions, except Valle d'Aosta and Calabria where it is considered as a casual alien [34]. However, we report here new records from four out five provinces of Calabria (i.e., Calanna, Decollatura, Oriolo, Motta San Giovanni, Reggio Calabria, and Vallelonga) where the species shows long established populations with several mature individuals that produce seeds. Hence, the species may be considered naturalized for Calabria.

***Araujia sericifera* Brot.**
Apocynaceae—Phanerophyta lianosa—South America—Neophyte
*Change of status for Lazio: from casual alien to naturalized alien*

Notes—*Araujia sericifera* is a liana native to central-eastern South America. According to the literature data [34,71,73], in Italy it was often reported as a casual or naturalized alien for many regions, except for Campania where it was indicated as invasive [93]. This neophyte was recorded for several localities in Lazio [94–96] and indicated as a casual alien by Galasso et al. [34]. However, based on the stabilized populations reproducing by seed and recently monitored in the municipality of Roma, we propose the status of naturalized in Lazio for this species. The naturalization of this species is worrying because it is generally a secondary host for viruses harmful to crops [97].

***Arctotheca calendula* (L.) Levyns**
Asteraceae—Therophyta scaposa—South Africa—Neophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—*Arctotheca calendula* is a therophyte native to South Africa, sometimes cultivated as an ornamental plant in Italy (A. Stinca, pers. comm.). It is reported as a casual alien for Trentino-Alto Adige and Sicilia, while it is considered a naturalized alien in Calabria and Sardegna [34]. Compared to the first report for the Italian Peninsula by Crisafulli et al. [98] from Calabria, in which only two reports were made for the same locality, the species has now expanded its range, having recently been found at new sites along the coast of Reggio Calabria province (i.e., Reggio Calabria, San Ferdinando, and Villa San Giovanni) where it was not present before. Here, it tends to invade the coastal dunes with habitats 2110 (embryonic shifting dunes) and 2120 (shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)). In these plant communities *A. calendula* competes with many native species such as *Cakile maritima* Scop. subsp. *maritima*, *Calamagrostis arenaria* (L.) Roth subsp. *arundinacea* (Husn.) Banfi, Galasso & Bartolucci, *Convolvulus soldanella* L., *Euphorbia peplis* L., *Medicago marina* L., *Pancratium maritimum* L. and *Polygonum maritimum* L. Therefore, we propose the status of invasive in Calabria for this neophyte.

***Artemisia campestris* L. subsp. *campestris***
Asteraceae—Chamaephyta suffrutescentia—Subcosmopolitan
*Confirmation for Abruzzo (native)*

Notes—The Italian distribution range of this taxon, includes all northern regions, Basilicata and Sicilia, while it is reported as doubtful for Abruzzo [33]. However, a review of the specimen conserved in the *Herb. Magellense* of the Maiella National Park using Tison and De Foucault [99] and Pignatti et al. [30] led to a correction of the previous attribution of the specimen to *Artemisia campestris* L. subsp. *glutinosa* (J.Gay ex Besser) Batt. The same correction has to be made in the phytosociological relevè of the *Loto cretici-Sixalicetum grandiflorae* Pirone, Ciaschetti, Di Martino, Frattaroli, Cianfaglione & Giallonardo published in Pirone et al. [100], while the records of *A. campestris* subsp. *glutinosa* in the *Echinophoro spinosae-Ammophiletum arundinaceae* (Br.-Bl. 1933) Géhu, Rivas-Martínez, Tüxen 1972 and *Junco maritimi-Spartinetum junceae* Biondi 1992 associations that can be found in the same paper require further investigations.

***Asparagus setaceus* (Kunth) Jessop**
Asparagaceae—Phanerophyta lianosa—East and South Africa—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—*Asparagus setaceus* is an African liana, sometimes cultivated as an ornamental plant in Italy [28]. It is reported as a naturalized alien for Campania and Sicilia, while it is considered as casual alien in Trentino-Alto Adige, Toscana, Lazio, Puglia, Calabria and Sardegna [34,69,72]. In Calabria, it was recently reported as casual for some localities in Reggio Calabria province [101]. Due to the new sites discovered for this same territory (i.e., Reggio Calabria and Villa San Giovanni) where adult mature individuals are forming stabilized populations, the species should be considered naturalized for the region.

***Astragalus penduliflorus* Lam.**
Fabaceae—Hemicryptophyta scaposa—European Orophyte
*New distribution data for Italian rare species in Lazio (native)*

Notes—*Astragalus penduliflorus* is a bushy perennial herb that occurs in grasslands of the montane and subalpine belt of some European mountains such as the Alps. Consequently, in Italy it occurs in the northern regions [33] and can be considered a rare species. An isolated population (a relict) was also discovered in the central Apennines by Lattanzi et al. [102]. These authors found only a few individuals near Colle del Vento (1500 m a.s.l.) on the Lazio side (Tyrrhenian side) of the Monti della Laga. However, in the following years the species was no longer found, so much so as to suggest that it was locally extinct (R. Di Pietro, pers. comm.). Fortunately, about thirty tufts were recently observed at Stazzo della Pacina in the municipality of Amatrice, once again on the Tyrrhenian side of the Monti della Laga. This important find confirms the presence of *A. penduliflorus* in the peninsular Italy.

***Bidens formosa* (Bonato) Sch.Bip.**
Asteraceae—Therophyta scaposa—North America—Neophyte
*First record for Lazio (casual alien)*

Notes—The North American *Bidens formosa* is a cultivated ornamental plant in Italy, where it also occurs as a casual alien in several regions [34,72]. In Lazio, in an anthropogenic site within Alatri municipality, we discovered a small population composed by few individuals spread by the seed of plants cultivated nearby. After the first find in October 2019, it was observed in the same site in autumn 2020.

***Bidens frondosa* L.**
Asteraceae—Therophyta scaposa—North America—Neophyte
*Change of status for Toscana: from naturalized alien to invasive alien*

Notes—This American herb is considered invasive in most of Italian regions [34]. In Toscana, where it was considered naturalized [34], we recorded it as abundant in riparian environments along the Fiume Arbia, where it often outcompetes the native *Bidens tripartita* L. We thus propose to change its status from naturalized to invasive in Toscana.

***Bidens subalternans* DC.**
Asteraceae—Therophyta scaposa—South America—Neophyte
*Change of status for Puglia: from naturalized alien to invasive alien*

Notes—*Bidens subalternans* is a South American therophyte introduced in Italy, but here often confused with similar species, such as *Bidens bipinnata* L. (A. Stinca, pers. comm.). This neophyte was recorded as a naturalized or invasive alien from many Italian regions except for Valle d'Aosta, Piemonte, Veneto, Calabria and Sardegna [34,69,72,73]. In Puglia, it is considered as a naturalized alien by Galasso et al. [34]. However, as observed in the Capurso, Carovigno, San Giovanni Rotondo, Manfredonia and Vico del Gargano municipalities in the same region, this species is rapidly colonizing many anthropogenic environments, such as roadsides and cultivated land. Therefore, we propose the status of invasive in Puglia for this neophyte.

***Bidens tinctoria* (Nutt.) Baill. ex Daydon**
Asteraceae—Therophyta scaposa—North and Central America—Neophyte
*First record for Marche (casual alien)*

Notes—This American species in Italy was reported as a casual escapee from cultivation in Lombardia and Veneto [34]. Recently, we discovered a new population on the banks of the Fiume Bosso in Cagli (Marche) (Figure 2B). Therefore, the new find extends its range to the South and is the first report for peninsular Italy.

***Boerhavia coccinea* Mill.**
Nyctaginaceae—Chamaephyta fruticosa—North, Central and South America—Neophyte
*First record for Campania (naturalized alien)*

Notes—Species native to the Neotropics, *Boerhavia coccinea* in Italy occurs as a naturalized alien in Calabria and Sicilia [34]. A large population was also discovered in southern Campania (Sapri), where it shows a noticeable propagation by seed in anthropogenic environments and appears stabilized. Therefore, the new discovery extends its Italian range to the North.

***Broussonetia papyrifera* (L.) Vent.**
Moraceae—Phanerophyta caespitosa—South and South-East Asia—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—In Calabria, this species was first reported by Pignatti [1], then confirmed as casual for the region by [71]. In the different populations reported herein (i.e., Cirò Marina, Fiumara, Melito di Porto Salvo, Montebello Jonico, and Motta San Giovanni), individuals were born in the vicinity of adult trees and created small populations with numerous plants, some of which are reproductive. Hence, the species can be considered naturalized for Calabria.

***Campanula portenschlagiana* Schult.**
Campanulaceae—Hemicryptophyta scaposa—Balkans—Neophyte
*First record for Marche (casual alien)*
*Change of status for Toscana: from casual alien to naturalized alien*

Notes—*Campanula portenschlagiana* is a hemycryptophyte native to the Balkan area. The species is sometimes cultivated as an ornamental plant in Italy. It was reported as a casual alien for Lombardia, Trentino-Alto Adige, Friuli-Venezia Giulia, Veneto, Liguria, Emilia-Romagna, Toscana, Umbria and Abruzzo [34,72,73,103]. In Cagli (Marche; Figure 2C), a small population was discovered consisting of a few individuals, probably spread by the seeds of nearby cultivated plants, which grow in the fractures of the floor and an external staircase of a disused building on the outskirts of the town. Instead, the population discovered in the urban center of Asciano in Toscana appears clearly stabilized, a region for which the status of naturalized is proposed for this neophyte.

***Canna indica* L.**
Cannaceae—Geophyta rhizomatosa—North, Central and South America—Neophyte
*First record for Umbria (casual alien)*

Notes—*Canna indica* is an American perennial often cultivated as an ornamental plant in Italy [28]. To date it occurs as a casual and naturalized alien in several Italian regions [34,71]. The individuals found in Umbria (Tuoro sul Trasimeno and Perugia) probably derive from vegetative parts present in the soil brought back.

***Cenchrus setaceus* (Forssk.) Morrone**
Poaceae—Hemicryptophyta caespitosa—North and East Africa and the Arabian Peninsula—Neophyte
*First record for Campania (naturalized alien)*

Notes—The hemycryptophyte *Cenchrus setaceus* was recorded in Italy as casual in Toscana and Lazio, naturalized in Puglia and invasive in Calabria, Sicilia and Sardegna [34,71,72]. Two populations were also discovered in Campania (Castellammare di Stabia and Nocera Inferiore; Figure 2D) in anthropogenic environments. In particular, in Castellammare di Stabia, it has shown a considerable propagation by seed and appears stabilized.

***Centaurium erythraea* Rafn subsp. *rhodense* (Boiss. & Reut.) Melderis**
Gentianaceae—Hemicryptophyta biennia—Steno-Mediterranean
*Confirmation for Basilicata (native)*

Notes—*Centaurium erythraea* subsp. *rhodense* was indicated in Liguria, Lazio, Puglia, Calabria, Sicilia and Sardegna, while it is reported as doubtful for Basilicata [33]. A specimen traced in HLUC collected at Lido di Metaponto (Bernalda) on May 1991, confirms the presence of this taxon in Basilicata, in geographical continuity with neighboring regions.

***Ceratochloa cathartica* (Vahl) Herter**
Poaceae—Hemicryptophyta caespitosa—South America—Neophyte
*First record for Basilicata (casual alien)*

Notes—*Ceratochloa cathartica*, a hemycryptophyte often cultivated in the lawns of Italian urban areas (A. Stinca, pers. comm.), was recorded as a casual or naturalized alien species for almost all Italian regions except for Molise and Basilicata [34]. In Basilicata, it was probably overlooked in the past; however, at present it must be considered as a casual species, based on a small population recently discovered in Potenza.

***Cerinthe retorta* Sm.**
Boraginaceae—Therophyta scaposa—East Steno-Mediterranean
*New distribution data for Italian rare species in Puglia (native)*

Notes—*Cerinthe retorta* is a therophyte having its current center of distribution in the southern Balkans and Turkey [104]. Wagensommer et al. [105] recorded it in the Gargano promontory (Valle dell'Inferno, in the municipality of San Giovanni Rotondo) in the Puglia region as a new taxon for Italy, based on a specimen collected in April 2013. Therefore, our discovery in the Gravina di Laterza (Laterza municipality), within the Regional Park of Terra delle Gravine, in May 2005 can be considered the first in Italy (but was misidentified until today) and represents the new southernmost limit of its Italian distribution. This species is very interesting from a phytogeographical point of view because it is a plant with eastern distribution that exhibits a disjunct Italian distribution, more or less restricted to Puglia, like other species such as *Bromus parvispiculatus* H.Scholz [106], *Carex phyllostachys* C.A.Mey. [107,108] and *Scrophularia lucida* L. [109].

***Chamaecyparis lawsoniana* (A.Murray) Parl.**
Cupressaceae—Phanerophyta scaposa—North America—Neophyte
*First record for Marche (casual alien)*
*First record for Umbria (casual alien)*

Notes—*Chamaecyparis lawsoniana*, native to North America, is sometimes cultivated for ornamental and reforestation purpose in Italy [28]. Here, it is recorded as casual in Lombardia, Trentino-Alto Adige, Veneto, Friuli-Venezia Giulia, Emilia-Romagna, Toscana, Abruzzo and Sardegna [34,70,73]. In Marche and Umbria, we discovered two small populations composed by young individuals spread by the seeds of this neophyte in reforestation areas of Cagli and Gualdo Tadino, respectively.

***Chasmanthe floribunda* (Salisb.) N.E.Br.**
Iridaceae—Geophyta bulbosa—South Africa—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—Reported as casual for Calabria by Galasso et al. [34], this species forms very numerous plant groups. The populations presented here (i.e., Palizzi and Reggio Calabria) were found in the indicated stations for several years and bloom every year. Therefore, the species can be considered naturalized for the region.

***Chimonanthus praecox* (L.) Link**
Calycanthaceae—Phanerophyta caespitosa—China—Neophyte
*First record for Marche (casual alien)*

Notes—*Chimonanthus praecox*, a popular ornamental tree in Italy (A. Stinca, pers. comm.), was previously recorded as casual only for Trentino-Alto Adige [34]. The discovery

of two small populations of this species in the Marche region (Cagli) is thus the second report for Italy and the first relating to peninsular Italy.

***Chlorophytum comosum* (Thunb.) Jacques**
Asparagaceae—Hemicryptophyta scaposa—Africa—Neophyte
*First record for Umbria (casual alien)*
*First record for Lazio (casual alien)*

Notes—*Chlorophytum comosum* is an evergreen perennial plant native to tropical and southern Africa. In Italy the species is present as an accidental escapee in Lombardia, Abruzzo, Calabria and Sardegna [34,72], while it is naturalized in Campania [89]. In Umbria (Terni) and Lazio (Orte) we discovered two small populations probably derived from vegetable waste from plants cultivated in nearby areas.

***Coleus scutellarioides* (L.) Benth.**
Lamiaceae—Hemicryptophyta scaposa—South-East Asia and Australia—Neophyte
*First record for Calabria (casual alien)*

Notes—Hemicryptophyte native to South-East Asia, *Coleus scutellarioides* in Italy is sometimes cultivated as an ornamental plant (A. Stinca, pers. comm.). It was indicated as casual only in Lombardia [34]. Recently, a small population of this neophyte, probably spread by seeds from plants nearby cultivated, were observed in anthropogenic environments in Verbicaro in Calabria. Therefore, the new discovery is the first for the Italian Peninsula.

***Cortaderia selloana* (Schult. & Schult.f.) Asch. & Graebn.**
Poaceae—Hemicryptophyta caespitosa—South America—Neophyte
*Change of status for Lazio: from casual alien to naturalized alien*

Notes—*Cortaderia selloana* was recorded for several localities in Lazio [96] and indicated as a casual alien by Galasso et al. [34]. However, based on the stabilized populations reproducing vegetatively and by seeds reported in the literature [96] or recently monitored (Ferentino), we propose the status of naturalized in Lazio for this species.

***Crassula muscosa* L.**
Crassulaceae—Chamaephyta suffrutescentia—South Africa—Neophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—A chamaephyte native to South Africa, in Italy it is reported as a casual escapee in Toscana, Marche, Campania and Sicilia, while it is naturalized in Liguria, Calabria and Sardegna [34,70]. However, in several localities in the province of Reggio Calabria (i.e., Campo Calabro, Reggio Calabria, and San Lorenzo), the species grows abundantly on the roofs of old abandoned houses and in dry stone walls, while some individuals are found in drainage ditches. We thus propose to change its status in Calabria from naturalized to invasive alien.

***Crepis sancta* (L.) Bornm. subsp. *nemausensis* (P.Fourn.) Babc.**
Asteraceae—Therophyta scaposa—East Mediterranean—Neophyte
*Change of status for Toscana: from naturalized alien to invasive alien*

Notes—This East Mediterranean taxon quickly spread across Italy during the last 150 years [30]. Nowadays, it is considered as naturalized in all the Italian regions but Sicilia (where its occurrence is doubtful), and it is invasive in Lombardia, Veneto, Marche and Campania [34]. In Toscana, this species is considered as naturalized, though it is widespread all over the region [110]. Based on this evidence and on abundant populations observed in Asciano (Siena), we propose to change its status in Toscana from naturalized to invasive alien. Moreover, in the aforementioned locality as well as in the olive groves (where it competes with *Aphanes australis* Rydb., *Medicago arabica* (L.) Huds., *Trifolium nigrescens* Viv. subsp. *nigrescens*, *Veronica arvensis* L., etc.), *Crepis sancta* subsp. *nemausensis* grows on the travertine walls with xerothermophile pioneer communities which can be attributed to the habitat 6110* (rupicolous calcareous or basophilic grasslands of the *Alysso-Sedion albi*). In these plant communities *C. sancta* subsp. *nemausensis* competes with some native species

such as *Arenaria leptoclados* (Rchb.) Guss. subsp. *leptoclados*, *Campanula erinus* L., *Petrosedum rupestre* (L.) P.V.Heath, *Poa bulbosa* L. subsp. *bulbosa* and *Saxifraga tridactylites* L.

***Cuscuta campestris* Yunck.**
Convolvulaceae—Therophyta parasitica—North, Central and South America—Neophyte
*Change of status for Umbria: from casual alien to naturalized alien*

Notes—*Cuscuta campestris* was reported as an invasive or naturalized alien for many Italian regions (but absent in Basilicata). Only in Umbria was it indicated as casual [34,73]. However, on the basis of a stabilized population recently monitored in the urbanized area of Spello, we propose the status of naturalized in Umbria for this species.

***Cyperus difformis* L.**
Cyperaceae—Therophyta caespitosa—Africa, Europa (?) and South Asia—Neophyte
*Change of status for Toscana: from casual alien to naturalized alien*

Notes—This species is a typical weed of rice fields [28] and occurs in many Italian regions [34]. We found it abundantly colonizing rice fields and adjacent channels South of Siena. We thus propose to change its status in Toscana from casual to naturalized alien.

***Cyperus rotundus* L.**
Cyperaceae—Geophyta rhizomatosa—Subcosmopolitan (?)
*Change of status for Calabria: from naturalized alien to cryptogenic*

Notes—*Cyperus rotundus* is a geophyte weed readily propagating vegetatively, with uncertain origin, and by now with a subcosmopolitan distribution [111]. In Italy, it grows in anthropogenic places including cultivated fields [28]. As its presence is related to human activities, its native range is difficult to define today. It is considered as alien in northern Italy and Calabria, while in other Italian regions it is classified as cryptogenic [33,66]. Pending further studies on the chorology of this species, in Calabria it should be considered as cryptogenic, consistent with neighboring regions. In this region, it is widespread in fields and anthropogenic environments, especially in coastal areas (e.g., Melia di Scilla and Reggio Calabria).

***Dactyloctenium aegyptium* (L.) Willd.**
Poaceae—Therophyta scaposa—Africa and South Asia—Neophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—The annual herb *Dactyloctenium aegyptium* in Italy is currently reported as casual for Campania (where it is known in just two sites [93]), and as naturalized for Lazio, Calabria, Sicilia and Sardegna [34]. However, based on our findings and observations carried out in Calabria (i.e., Brancaleone, Nocera Terinese, Reggio Calabria, Ricadi, and Sellia Marina), it forms true grass carpets on sandy and rocky beaches and grows along sidewalks and roadsides. It spreads very rapidly in such environments and should thus be considered invasive in the region. Particularly, it tends to invade the coastal dunes with habitats 2110 (embryonic shifting dunes), 2120 (shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)) and 2230 (*Malcolmietalia* dune grasslands). In these plant communities *D. aegyptium* competes with many native species such as *Cakile maritima* Scop. subsp. *maritima*, *Calamagrostis arenaria* (L.) Roth subsp. *arundinacea* (Husn.) Banfi, Galasso & Bartolucci, *Centaurea sphaerocephala* L. subsp. *sphaerocephala*, *Convolvulus soldanella* L., *Euphorbia peplis* L., *Matthiola tricuspidata* (L.) W.T.Aiton, *Medicago marina* L., *Pancratium maritimum* L. and *Polygonum maritimum* L.

***Datura inoxia* Mill.**
Solanaceae—Therophyta scaposa—North, Central and South America—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—*Datura inoxia* is an American therophyte, sometimes cultivated as an ornamental plant in Italy [30]. It was recorded often as casual from many Italian regions except for Valle d'Aosta, Trentino-Alto Adige, Liguria and Umbria [34]. The new findings here reported (i.e., Bova Marina, Condofuri, San Lorenzo, Sellia Marina, and Trebisacce), show

populations stabilized for many years and self-maintaining. Therefore, the species can be considered naturalized for the region.

***Datura stramonium* L.**
Solanaceae—Therophyta scaposa—North and Central America—Neophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—Native to North and Central America, *Datura stramonium* is widespread in all Italian regions and in many of these it is reported as invasive [34]. In Calabria (i.e., Melito di Porto Salvo, Reggio Calabria, San Lorenzo, San Roberto, and Scilla), this species occupies both urbanized and non-urbanized areas, and is increasingly expanding its range from year to year thanks to its abundant production of seeds. For this reason, *D. stramonium* should be considered invasive for the region.

***Delphinium hispanicum* Willk. ex Costa**
Ranunculaceae—Therophyta scaposa—Eurasian—Neophyte
*First geolocalized reports in Puglia (naturalized alien)*

Notes—*Delphinium hispanicum* was first reported from Puglia by Galasso et al. [34] sub *D. orientale* J.Gay based on our unpublished records. In Table S1, we provide full details concerning these discoveries (Mattinata and Monte Sant'Angelo).

***Deschampsia cespitosa* (L.) P.Beauv. subsp. *parviflora* (Thuill.) Dumort.**
Poaceae—Hemicryptophyta caespitosa—Eurasian
*First record for Abruzzo (native)*

Notes—*Deschampsia cespitosa* subsp. *parviflora* was previously reported in Italy only for Piemonte, Lombardia, Toscana and Calabria [33,62,63]. Like in UK [112], this taxon is probably under-recorded in Italy. In Abruzzo, a population with several tens of individuals, in an area of about two hectares whithin a mixed forest with *Quercus cerris* L. and *Fagus sylvatica* L. subsp. *sylvatica*, was recently found. Specimens were identified with Tison and De Foucault [99] and Pignatti et al. [28].

***Digitaria ciliaris* (Retz.) Koeler**
Poaceae—Therophyta scaposa—Africa and South Asia—Neophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—*Digitaria ciliaris*, an annual herb very similar to *Digitaria sanguinalis* (L.) Scop. [113], is reported as a naturalized or casual alien for all Italian regions, except Valle d'Aosta, Marche and Puglia [34,71]. Wilhalm [113] reported this species for Calabria and then Galasso et al. [71] updated its status as naturalized for this region. However, due to several new finds and observations for the region and according to its capacity to easily spread and invade new sites (i.e., Bagnara Calabra, Melia di Scilla, Montebello Jonico, Reggio Calabria, and San Lorenzo), this species should be considered invasive for the region.

***Drymochloa drymeja* (Mert. & W.D.J.Koch) Holub subsp. *exaltata* (C.Presl) Foggi & Signorini**
Poaceae—Geophyta rhizomatosa—Italian endemic
*New distribution data for Italian rare species in Lazio (native)*

Notes—Current distribution range of Italian endemic *Drymochloa drymeja* subsp. *exaltata* includes central-southern Italy and Sicilia [33]. Here, it is considered diagnostic for beech and ravine forests in southern Italy [114,115]. In Lazio *D. drymeja* subsp. *exaltata* was known for only two sites: Insugherata Nature Reserve (Monte Arsiccio) in the center of Rome, and the San Vittorino gorge on the outskirts of Roma in the municipality of Tivoli [90,116]. However, Foggi et al. [117] in a recent review on *Festuca* and allied genera have identified the specimens from San Vittorino and from Monte Arsiccio as *D. sylvatica* (Pollich) Holub, a species with central European distribution. The conclusions of these authors would suggest exclusion of this taxon from the regional flora. However, two specimens from the San Vittorino deposited in APP and HFLA respectively, were both recently confirmed by us as *D. drymeja* subsp. *exaltata*. Additionally, our recent discovery

on Monte Petrella, located within the Natural Park of Monti Aurunci in southern Lazio, confirms the presence of this endemic in the region. *Festuca* s.l. is a very complex group and obviously this situation of uncertainty in the location of the Lazio samples will require further analysis, especially because the northernmost limit of *D. drymeia* subsp. *exaltata* in the Italian Peninsula runs precisely between Lazio and Abruzzo. However, the reporting of this taxon for the Monti Aurunci is considered important because it covers a gap in the Tyrrhenian side of peninsular Italy where the northernmost stations before those of Lazio are located on the Piana Campana [118] and in the Bay of Napoli [88,89,119].

***Echinochloa hispidula* (Retz.) Nees**
Poaceae—Therophyta scaposa—Asia—Neophyte
*First record for Toscana (casual alien)*

Notes—This Asian species is naturalized across northern Italy [34], where it grows as a weed in rice fields [28]. In SIENA, we found an unpublished sample of this species collected in 1989 in crop fields near Carrara, and thus report this exotic as casual for Toscana for the first time.

***Elaeagnus* × *submacrophylla* Servett.**
Eleagnaceae—Nano-Phanerophyta—Japan and Korea—Neophyte
*First record for Toscana (casual alien)*

Notes—*Elaeagnus* × *submacrophylla*, a hybrid of *Elaeagnus macrophylla* Thunb. and *Elaeagnus pungens* Thunb. widely cultivated as an ornamental plant for hedges, was reported in Italy as casual for Piemonte, Abruzzo and Campania [34]. A few individuals, probably spread by seeds from plants cultivated nearby, were recently found in a riparian shrubland near the city centere of Monteroni d'Arbia in Toscana.

***Elaeodendron croceum* (Thunb.) DC.**
Celastraceae—Phanerophyta caespitosa—South Africa—Neophyte
*First record for Europe (casual alien)*
*First record for Sardegna (casual alien)*

Notes—*Elaeodendron croceum* is an evergreen tree native to South Africa, sometimes cultivated in Italy as an ornamental plant (A. Stinca, pers. comm.). A small population of this neophyte was observed in anthropogenic environments in Sardegna (Cagliari). These individuals had spread by seed from plants cultivated nearby. As far as we know, these are the first find in Europe. For the nomenclature, we followed POWO [120].

***Eleusine indica* (L.) Gaertn.**
Poaceae—Therophyta scaposa—Africa, South Asia and North Oceania—Neophyte
*Change of status for Toscana: from naturalized alien to invasive alien*

Notes—This synanthropic grass is considered invasive in several regions of Italy [34]. In Toscana, it was considered naturalized [34], though abundant and widespread in ruderal sites during summer. The species is present throughout the city of Siena, where it mainly colonizes sidewalks and urban pavements. We propose to change its status from naturalized to invasive in the region.

***Eruca vesicaria* (L.) Cav.**
Brassicaceae—Therophyta scaposa—Mediterranean (?) and Asian
*Change of status for Calabria: from naturalized alien to cryptogenic*

Notes—*Eruca vesicaria* is a therophyte with an uncertain area of origin, which in Italy is also cultivated as a vegetable [29]. It is considered as alien in some northern Italian regions and Calabria, while in other regions it is classified as cryptogenic [33]. Pending further studies on the chorology of this species, in Calabria it should be considered as cryptogenic, consistent with neighboring regions. In this region, it is widespread in fields and anthropogenic environments (i.e., Maierato, Montebello Jonico, and Reggio Calabria).

***Erythrostemon gilliesii* (Wall. ex Hook.) Klotzsch**
Fabaceae—Phanerophyta caespitosa—South America—Neophyte
*First record for Umbria (casual alien)*

Notes—Shrub native to South America, *Erythrostemon gilliesii* is sometimes cultivated as ornamental plant in Italy (A. Stinca, pers. comm.). It was recorded as casual for Toscana, Lazio, Calabria and Sardegna, while only in Sicilia was it indicated as naturalized [34,72]. Therefore, our recent discovery in Spello is the first in Umbria and concerns a few plants spread by seed.

***Euphorbia cuneifolia* Guss.**
Euphorbiaceae—Therophyta scaposa—West Mediterranean
*First geolocalized reports in Puglia (native)*

Notes—*Euphorbia cuneifolia* is an uncommon therophyte in Italy reported for Toscana, Lazio, Molise, Campania, Puglia, Calabria, Sicilia and Sardegna [33]. It was first indicated from Puglia by Bartolucci et al. [33] based on our unpublished record. In Table S1 we provide full details concerning this discovery (Monte Sant'Angelo).

***Euphorbia maculata* L.**
Euphorbiaceae—Therophyta scaposa—North and Central America—Neophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—*Euphorbia maculata* was reported as an invasive or naturalized alien for all Italian regions [34,73,121]. In Calabria, where it was considered naturalized, this species is very widespread in dry and nitrophilous environments (i.e., Melito Porto Salvo, Reggio Calabria, and Sellia Marina) and shows a high capacity to spread by seed. It should be considered invasive for the region, as in many other Italian regions.

***Euphorbia prostrata* Aiton**
Euphorbiaceae—Therophyta scaposa—North, Central and South America—Neophyte
*Change of status for Umbria: from casual alien to naturalized alien*

Notes—*Euphorbia prostrata* is reported as an invasive or naturalized alien for all Italian regions; only in Umbria was it indicated as casual [34,73,121]. However, based on two stabilized populations recently monitored in urbanized areas of Foligno and Spello, we propose the status of naturalized in Umbria for this species.

***Ficus microcarpa* L.f.**
Moraceae—Phanerophyta scaposa—South-East Asia and Australia—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—Musarella et al. [122] reported this species as casual for Calabria. However, since we recently observed that it is very widespread along roadsides and cracks of walls and maintaining its individuals for many years (i.e., Reggio Calabria and Villa San Giovanni), it can be considered naturalized for the region.

***Galium lucidum* All. subsp. *lucidum***
Rubiaceae—Hemicryptophyta scaposa—Euri-Mediterranean
*First record for Puglia (native)*

Notes—*Galium lucidum* subsp. *lucidum* is reported from all Italian regions except Lazio, Molise, Puglia, Basilicata and Sardegna [33]. Here, we provide the first records of this taxon for Puglia, all from the Gargano promontory, see also [123].

***Gladiolus italicus* Mill.**
Iridaceae—Geophyta bulbosa—Mediterranean area (?) and South-West Asian
*Change of status for Calabria: from naturalized alien to cryptogenic*

Notes—*Gladiolus italicus* is a geophyte sometimes confused with similar species, such as *Gladiolus byzantinus* Mill. (A. Stinca, pers. comm.). As its presence is related to human activities, its native range is difficult to define today. It is considered as alien in some northern Italian regions and Calabria, while in other regions it is classified as cryptogenic [33].

Pending further studies on the chorology of this species, in Calabria it should be considered as cryptogenic, consistent with neighboring regions. In accordance with Fanfarillo et al. [124], in Calabria it generally grows in cultivated fields (i.e., Brancaleone, Condofuri, Montebello Jonico, Reggio Calabria, and San Lorenzo).

***Hydrangea macrophylla* (Thunb.) Ser.**
Hydrangeaceae—Nano-Phanerophyta—Japan—Neophyte
*First record for Campania (casual alien)*

Notes—The Japanese *Hydrangea macrophylla* is a very common ornamental plant in Italy (A. Stinca, pers. comm.). Previously recorded as a casual alien from Piemonte, Trentino-Alto Adige, Veneto and Toscana, and as naturalized only in Toscana [34,73]. Therefore, our recent discovery in Vico Equense is the first in Campania and concerns a few plants spread by seed.

***Hypericum* × *inodorum* Mill.**
Hypericaceae—Nano-Phanerophyta—South and West European
*First record for Marche (native)*

Notes—This taxon is not reported in the checklist of the vascular flora native to Italy [33] because it is a hybrid between *Hypericum androsaemum* L. and *Hypericum hircinum* L. In Italy, it was indicated only for Campania in the Sorrento Peninsula [125]. Therefore, our recent discovery in Cagli is the first in Marche. For the nomenclature, we followed POWO [126].

***Impatiens balfourii* Hook.f.**
Balsaminaceae—Therophyta scaposa—South Asia—Neophyte
*Change of status for Lazio: from casual alien to naturalized alien*

Notes—This species was recorded for several localities in Lazio [96] and indicated as a casual alien by Galasso et al. [34]. In Alatri in Lazio where we collected it, the species has certainly been present since at least 2008 (see Google Street images https://www.google.it/maps/dir/Via+Campo+le+Fraschette,+03011+Alatri+FR/@41.7297813,13.3153171,64m/data=!3m1!1e3!4m9!4m8!1m0!1m5!1m1!1s0x132559a97f3e015d:0x46a9f6d11bfa41c8!2m2!1d13.3155165!2d41.7298483!3e3"\t"_blank"https://www.google.it/maps/dir//Via+Campo+le+Fraschette,+03011+Alatri+FR/@41.7297813,13.3153171,64m/data=!3m1!1e3!4m9!4m8!1m0!1m5!1m1!1s0x132559a97f3e015d:0x46a9f6d11bfa41c8!2m2!1d13.3155165!2d41.7298483!3e3, accessed on 15 September 2021). We thus propose to consider it as naturalized in the region.

***Ipomoea indica* (Burm.) Merr.**
Convolvulaceae—Geophyta rhizomatosa—North, Central and South America—Neophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—*Ipomoea indica* is an American geophyte, in Italy often cultivated as an ornamental plant (A. Stinca, pers. comm.). Galasso et al. [34] reported this neophyte as naturalized for Calabria. However, since this species is very widespread in anthropogenic environments (i.e., Calanna, Reggio Calabria, and Villa San Giovanni) and shows a high capacity to invade new sites, it should be considered invasive for the region.

***Ipomoea purpurea* (L.) Roth**
Convolvulaceae—Therophyta scaposa—North, Central and South America—Neophyte
*Change of status for Lazio: from casual alien to naturalized alien*
*Change of status for Basilicata: from invasive alien to naturalized alien*
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—Galasso et al. [34,69] reported this alien therophyte for all Italian regions, but only in Basilicata as invasive. Effectively, in this region *Ipomoea purpurea* was previously recorded as an invasive alien for Maratea [127]. The presence of this taxon in the region was also reported in the Forum Acta Plantarum (https://www.floraitaliae.actaplantarum.org/viewtopic.php?t=115754, accessed on 2 September 2021) for Pisticci, but not officially published. Our recent field investigations revealed the sporadic presence of this species in Basilicata, where it does not show invasive characteristics. Therefore, this species should be

considered naturalized in Basilicata. Additionally, in Lazio and Calabria this exotic shows stabilized populations and should be considered naturalized.

***Isatis tinctoria* L. subsp. *tinctoria***
Brassicaceae—Hemicryptophyta biennia—South-East Europe—Archaeophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—This taxon is reported as an invasive or naturalized alien for all Italian regions, except in Friuli-Venezia Giulia where is indicated as casual [34]. However, due to several records and observations in the field of this species (i.e., Bova, Cardeto, and Reggio Calabria), it should be considered invasive also in this region.

***Juglans nigra* L.**
Juglandaceae—Phanerophyta scaposa—North America—Neophyte
*First record for Toscana (casual alien)*

Notes—*Juglans nigra* is cultivated for economic purposes in Italy, and it is established in the wild in several regions as a casual to invasive alien [34,69,70]. In Toscana, we found some spontaneous young individuals growing in a riparian shrubland near a plantation along the Fiume Arbia at Castelnuovo di Berardenga, near Siena.

***Juglans regia* L.**
Juglandaceae—Phanerophyta scaposa—South-West Asia—Neophyte (cryptogenic?)
*First record for Puglia (casual alien)*
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—*Juglans regia* is a South-West Asian tree, in Italy often cultivated for its appreciated fruits [29]. Is it recorded as cryptogenic in Lombardia, Veneto and Sardegna, and as casual or naturalized from many Italian regions except for Puglia [33,65]. In this region, some small populations of young individuals spread by seed from plants cultivated nearby were observed in anthropogenic environments. In Calabria, although this species was considered casual by Laface et al. [101], recent field observations revealed that this exotic shows stabilized populations and should be considered as naturalized.

***Kalanchoë blossfeldiana* Poelln.**
Crassulaceae—Hemicryptophyta succulenta—Madagascar—Neophyte
*First record for Europe (casual alien)*
*First record for Sardegna (casual alien)*

Notes—*Kalanchoë blossfeldiana* is a perennial succulent native to Madagascar, very popular in Italy as an ornamental plant (A. Stinca, pers. comm.). A single individual of this neophyte, growing together with *Oxalis latifolia* Kunth, was observed in an anthropogenic environment in Sardegna (Cagliari). It probably originated from vegetative parts of plants cultivated in pots. As far as we know, this was the first finding in Europe.

***Kalanchoë daigremontiana* Raym.-Hamet & H.Perrier**
Crassulaceae—Chamaephyta succulenta—Madagascar—Neophyte
*Exclusion for Calabria (naturalized alien)*

Notes—The revision of the specimens preserved in FI concerning the only reports of *Kalanchoë daigremontiana* for Calabria (i.e., Caraffa del Bianco, Catanzaro, and Scalea [128]) led to the exclusion of this species from the regional flora, attributing the relative findings to *Kalanchoë* × *houghtonii* D.B.Ward. According to Stinca et al. [129] it is probable that many of the Italian reports of *K. daigremontiana* are erroneous and should be allocated to *K.* ×*houghtonii* (see below note).

***Kalanchoë delagoënsis* Eckl. & Zeyh.**
Crassulaceae—Chamaephyta succulenta—Madagascar—Neophyte
*First record for Campania (casual alien)*

Notes—*Kalanchoë delagoënsis*, endemic to Madagascar, is an uncommon ornamental plant in Italy (A. Stinca, pers. comm.). Here, it was recorded as casual in Lazio, Puglia,

Calabria, Sicilia and Sardegna [34,72]. In Campania, we discovered two small populations of this neophyte in the urban area of Caserta, undoubtedly spread by plantlets produced at the margins of leaves of nearby cultivated plants.

***Kalanchoë* × *houghtonii* D.B.Ward**
Crassulaceae—Chamaephyta succulenta—Artificial origin—Neophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—*Kalanchoë* × *houghtonii*, an artificial hybrid created in the 1930s in the USA by experimental crossings between *Kalanchoë daigremontiana* and *Kalanchoë delagoënsis*, is one of the most rapidly expanding invasive plants in recent times [130]. It was recently indicated as naturalized in Calabria by Stinca et al. [129]. Recent new field observations revealed that this exotic grows abundantly on the roofs of old abandoned houses, in dry stone walls, in drainage ditches and along roadsides (i.e., Reggio Calabria, Scilla, Sellia Marina, and Villa San Giovanni). Therefore, this species should be considered invasive for the region.

***Kalanchoë laxiflora* Baker**
Crassulaceae—Hemicryptophyta succulenta—Madagascar—Neophyte
*Confirmation for Europe (casual alien)*
*Confirmation for Italy (casual alien)*
*First record for Basilicata (casual alien)*

Notes—*Kalanchoë laxiflora* is a perennial succulent native to Madagascar, rarely cultivated in Italy (A. Stinca, pers. comm.). A small population of three young individuals of this neophyte was observed in anthropogenic environments in Basilicata (Maratea). These individuals are likely to have spread by seed from plants growing nearby. Until this record in Italy (i.e., Toscana and Sicilia), it was indicated as doubtful [34]. Therefore, our recent finding confirms the presence as a casual alien of this neophyte for Italian vascular flora. As far as we know, our finding confirms the presence of this species also in Europe.

***Lamarckia aurea* (L.) Moench**
Poaceae—Therophyta scaposa—Mediterranean-Turanian
*First geolocalized reports in Campania (native)*

Notes—*Lamarckia aurea* is an uncommon therophyte in Italy reported for Liguria, Toscana, Lazio, Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia and Sardegna [33]. It was historically reported from Campania only at Naples by Tenore (sub *Chrysurus cynosuroides* [131], sub *Chrysurus cynosuroides* [132], sub *Chrysurus aureus* [133]). Recently, only Bartolucci et al. [33] mentions this species as present in Campania without adding further details. Here, we provide the first geolocalized report of our discovery in June 2021 of a small population of this species that grows in the historic center of Naples, confirming Tenore's data.

***Lantana camara* L. subsp. *aculeata* (L.) R.W.Sanders**
Verbenaceae—Nano-Phanerophyta—North and Central America—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—This taxon was recently indicated as casual in Calabria by Stinca et al. [129] Recent new field observations revealed that this exotic plant forms numerous populations capable of reproducing and maintaining in the surrounding territories, preferring in particular roadsides and drainage channels (i.e., Bagnara Calabra, Montebello Jonico, Reggio Calabria, San Lorenzo, and Villa San Giovanni). Therefore, the species can be considered as naturalized for Calabria.

***Lepidium virginicum* L. subsp. *virginicum***
Brassicaceae—Therophyta scaposa—North and Central America—Neophyte
*Change of status for Umbria: from casual alien to naturalized alien*

Notes—*Lepidium virginicum* subsp. *virginicum* was reported as an invasive or naturalized alien for many Italian regions; only in Umbria and Puglia was it indicated as

casual [34]. However, based on stabilized populations recently monitored in urbanized areas of Spello, we propose the status of naturalized in Umbria for this species.

***Leucaena leucocephala* (Lam.) de Wit subsp. *glabrata* (Rose) Zárate**
Fabaceae—Phanerophyta scaposa—North and Central America—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—This taxon was first reported for Calabria as casual by Musarella et al. [122]. However, other new spreading sites have since been found (i.e., Reggio Calabria, Roccaforte del Greco, and Sellia Marina). The species prefers roadsides and sidewalks and easily germinates from the numerous dispersed seeds. Many adult individuals at different stages of growth, with inflorescences and ripe fruits, are found at new and old record sites, producing several seedlings. Therefore, the species can be considered naturalized for Calabria.

***Ligustrum lucidum* W.T.Aiton**
Oleaceae—Phanerophyta scaposa—South-East Asia—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—First reported as casual by Galasso et al. [134] for the province of Cosenza, in the northern part of Calabria, now *Ligustrum lucidum* was found in new stations in the southern part (i.e., Reggio Calabria, San Roberto, and Villa San Giovanni), growing along the roadsides and easily germinating from dispersed seeds. Some adult individuals at different stages of growth were found in the new site records, producing seedlings. Therefore, *L. lucidum* can be considered naturalized for Calabria.

***Melia azedarach* L.**
Meliaceae—Phanerophyta scaposa—South-East Asia and Australia—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—Reported for the first time for the region as casual for the provinces of Cosenza and Reggio Calabria [135], this species was found in new stations and, in the latter, growing along roadsides and sidewalks and easily germinating from dispersed seeds (i.e., Bagnara Calabra, Melito di Porto Salvo, and Reggio Calabria). Numerous adult individuals at different growth stages were found at the new collection sites, capable of producing new seedlings. Therefore, the species can be considered naturalized for Calabria.

***Morus nigra* L.**
Moraceae—Phanerophyta scaposa—South-West Asia—Archaeophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—*Morus nigra* is an Asian deciduous tree often cultivated in Italy for its sorosis [29]. According to Galasso et al. [34], in Italy it was reported as a casual alien for many regions, including Calabria. At present, in the different populations found (i.e., Reggio Calabria and Scilla), individuals were born in the vicinity of mature trees and created populations with adult plants, some of which reproduced. Therefore, the species can be considered naturalized in this region.

***Nephrolepis cordifolia* (L.) C.Presl**
Nephrolepidaceae—Geophyta rhizomatosa—South-East Asia and Australia—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—*Nephrolepis cordifolia* is a commonly cultivated fern in Italy (A. Stinca, pers. comm.), but reported as naturalized for Liguria, Toscana, Lazio and Campania, while in Marche, Abruzzo, Calabria, Sicilia and Sardegna it is indicated as casual [34,73]. However, based on a stabilized population recently monitored in an urbanized area of the old town of Verbicaro, we propose the status of naturalized in Calabria for this species.

***Nicotiana glauca* Graham**
Solanaceae—Nano-Phanerophyta—South America—Neophyte
*Change of status for Puglia: from invasive alien to naturalized alien*

Notes—The South American phanerophyte *Nicotiana glauca* is recorded from many Italian regions, but only in Puglia, Calabria, Sicilia and Sardegna is it reported as invasive [34,69]. However, in Puglia, although it is stabilized in some coastal areas from Barletta to Salento where it grows occasionally with a few individuals, it does not show invasive characteristics. Based on our field observations, we thus propose the status of naturalized in Puglia for this species.

***Nothoscordum gracile* (Aiton) Stearn**
Amaryllidaceae—Geophyta bulbosa—Central and South America—Neophyte
*Change of status for Sardegna: from casual alien to naturalized alien*

Notes—*Nothoscordum gracile* is reported as casual, naturalized, or invasive for some Italian regions [34,71,72]. In Sardegna, it occurs widely in different parts of the city of Cagliari and in apparent expansion, in the cracks of sidewalks, at the base of walls and along streets. It forms populations capable of reproducing through seeds even in the absence of plants cultivated nearby. Many of the reports for Sardinia of *Nothoscordum borbonicum* Kunth could be attributed to *N. gracile*.

***Ophrys dinarica* Kranjčev & P.Delforge**
Orchidaceae—Geophyta bulbosa—Amphi-Adriatic
*First geolocalized reports in Molise (native)*

Notes—Bartolucci et al. [33,66] report *Ophrys dinarica* from Valle d'Aosta, Piemonte and Lombardia to Molise region, the latter region being the southernmost limit of distribution of this taxon in Italy. However, the occurrence of this species in Molise is reported only generically in books [136] or as a general synthesis, without providing indications of collection sites or images of the plants collected [137]. Here, we provide the first geolocalized report of our discovery in June 2020 of a population of this species that grows in Capracotta.

***Opuntia dillenii* (Ker Gawl.) Haw.**
Cactaceae—Nano-Phanerophyta succulenta—North and Central America—Neophyte
*First record for Marche (naturalized alien)*

Notes—On Italian territory, *Opuntia dillenii* was recorded in Toscana, Lazio, Campania, Puglia, Calabria, Sicilia and Sardegna [34]. During fieldwork, we found two new populations also in Cagli in the Marche region. In the area of Acquaviva, the species was introduced for ornamental purposes in the early 1970s (G. Mei, pers. comm.). From the plant introduced initially, the species reproduced abundantly vegetatively, expanding until it became a problem for the owners themselves. Despite a series of interventions aimed at containing the species, these have nevertheless only managed to limit its expansion within the garden area while the species, albeit very slowly, continues to expand in the immediately adjacent areas. The population present in Ca' Giovanni, originating in all probability from the remains of shovels thrown on the ground, is located near the road at the beginning of the town where it characterizes an area of about 20 $m^2$ of vegetation typical of abandoned land, featuring *Prunus spinosa* L. subsp. *spinosa* and *Rubus ulmifolius* Schott. From a phytosociological point of view, both the find areas can be traced back to the *Pruno spinosae-Rubion ulmifolii* O.Bolòs 1954 alliance. It is also interesting to note that in the population present in Acquaviva, sunnier and less exposed to humidity, in the last two years the emergence of seedlings has been observed which do not survive the winter.

***Opuntia ficus-indica* (L.) Mill.**
Cactaceae—Phanerophyta succulenta—North America—Neophyte
*Change of status for Basilicata: from naturalized alien to invasive alien*

Notes—*Opuntia ficus-indica*, a phanerophyte native to North America, has been reported for almost all Italian regions except for Valle d'Aosta, Piemonte, Veneto and Friuli-Venezia Giulia [34]. Indicated as invasive throughout southern Italy, it is considered naturalized only in Basilicata. However, especially in the Matera municipality, this species is rapidly colonizing many of the rocky slopes of the Regional Park of Murgia Materana

and the Bradano gorge (Gravina del Bradano). Therefore, we propose the status of invasive in Basilicata for this neophyte.

***Oryza sativa* L. subsp. *sativa***
Poaceae—Therophyta scaposa—China—Archaeophyte
*Change of status for Toscana: from casual alien to naturalized alien*

Notes—This taxon occurs as a casual to invasive species in the northern Italian regions where it is cultivated as a crop [34]. In Toscana, where some rice fields are present in the South of the region, it was considered as a casual alien. In Murlo we found conspicuous populations growing in channels and pebbly shores around rice fields. Thus, we propose to change its status from casual to naturalized in Toscana.

***Oxalis brasiliensis* Lodd., G.Lodd. & W.Lodd. ex Drapiez**
Oxalidaceae—Geophyta bulbosa—South America—Neophyte
*First record for Europe (historical record for casual alien)*
*First record for Italy (historical record for casual alien)*
*First record for Toscana (historical record for casual alien)*

Notes—*Oxalis brasiliensis* is a geophyte native to Argentina, Uruguay and Brazil, and also reported as an alien in the state of Alabama in the USA [138]. Its presence as an alien species in Europe (Italy, Toscana) is only certified by specimens (sub *Oxalis macachin* Arechav.) traced in FI and collected by Rodolfo Pichi Sermolli on 1935 and 1936. Pichi Sermolli, in his handwritten notes, states that this species was also spontaneous at Poggio Imperiale in Firenze, in addition to Buggiano. Nowadays, this neophyte no longer seems to be present in nature in Italy despite our field research (A. Stinca and G. Ferretti, pers. comm.). Therefore, it should be added to the European and Italian vascular flora as a taxon not recently confirmed. The species was firstly described by Drapiez [139], who predates Hildebrand [140]; unlike what is reported by IPNI [141] and POWO [142], Drapiez's reference to Loddiges is to be referred to the whole Loddiges family, that is Conrad Loddiges and Sons, namely Lodd. (i.e., Joachim Conrad Loddiges), G.Lodd. (i.e., George Loddiges) and W.Lodd. (i.e., William Loddiges) [143].

***Oxalis debilis* Kunth**
Oxalidaceae—Geophyta bulbosa—Central and South America—Neophyte
*First record for Friuli-Venezia Giulia (casual alien)*
*First record for Umbria (casual alien)*

Notes—*Oxalis debilis* is recorded as a naturalized alien from Piemonte, Lombardia, Veneto, Liguria, Emilia-Romagna, Toscana, Abruzzo and Campania, while in Lazio, Calabria, Sicilia and Sardegna it is reported as a casual alien [34,69,71,73]. Furthermore, in Marche its invasion status is undefined, while it is doubtful in [34]. Therefore, our findings in Trieste and Assisi represent the first for Friuli-Venezia Giulia and Umbria, respectively.

***Oxalis dillenii* Jacq.**
Oxalidaceae—Hemicryptophyta/Therophyta scaposa—North America—Neophyte
*Confirmation for Campania (casual alien)*

Notes—*Oxalis dillenii* is a North American herb introduced in Italy, but here it is often confused with similar species, that is *Oxalis corniculata* L. and *Oxalis stricta* L. [144]. Due to identification difficulties, the data on its Italian distribution are still lacking. Since no pertinent samples were found in Italian herbaria (A. Stinca, pers. comm.), in Campania it was indicated as a doubtful [34]. Therefore, our recent find in the anthropogenic environments of Caserta and Salerno confirms its presence as a casual alien in the region.

***Oxalis latifolia* Kunth**
Oxalidaceae—Geophyta bulbosa—North, Central and South America—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—*Oxalis latifolia* is an American geophyte introduced into Italy, but here often confused with similar species, such as *Oxalis articulata* Savigny [144]. This neophyte is

recorded as a casual or naturalized alien from many Italian regions except for Valle d'Aosta, Molise; instead, in Friuli-Venezia Giulia and Marche its presence is doubtful [34,73]. In Calabria, *Oxalis latifolia* was recently recorded as a casual alien by Rosati et al. [41]. However, the indicated status is incorrect as this species is clearly naturalized in the region, as indicated by Rosati et al. [41] who define it as "abundantly naturalized".

***Oxalis pes-caprae* L.**
Oxalidaceae—Geophyta bulbosa—South Africa—Neophyte
*First record for Veneto (casual alien)*

Notes—*Oxalis pes-caprae*, a geophyte native to South Africa, after its introduction in the eighteenth century, has become one of the most widespread in the Mediterranean basin [144]. Indeed, it is recorded often as invasive by many Italian regions except for Valle d'Aosta, Veneto and Friuli-Venezia Giulia [34]. Therefore, our finding in Padova represents the first for Veneto.

***Papaver rhoeas* L. subsp. *rhoeas***
Papaveraceae—Therophyta scaposa—East-Mediterranean area (?)
*Change of status for Calabria: from naturalized alien to cryptogenic*

Notes—*Papaver rhoeas* subsp. *rhoeas* is an annual weed readily propagating by seeds, perhaps originally from the eastern Mediterranean, but by now with a subcosmopolitan distribution [145]. In Italy, it grows in anthropogenic places including cultivated fields [124]. As its presence is related to human activities, its native range is difficult to define today. It is considered as an alien in some northern Italian regions and in Calabria, while in other regions it is classified as cryptogenic [33]. Pending further studies on the chorology of this species, in Calabria it should be considered as cryptogenic, consistent with neighboring regions. In this region, it is widespread in fields and anthropogenic environments, especially in coastal areas (e.g., Melito di Porto Salvo, Montebello Jonico, Motta San Giovanni, Reggio Calabria, San Ferdinando, San Lorenzo, Serrastretta, and Villa San Giovanni).

***Parthenocissus inserta* (A.Kern.) Fritsch**
Vitaceae—Phanerophyta lianosa—North America—Neophyte
*First record for Umbria (naturalized alien)*
*First record for Calabria (casual alien)*
*First record for Campania (naturalized alien)*

Notes—*Parthenocissus inserta* is a liana native to North America often cultivated as an ornamental plant in Italy [29]. It is a doubtful taxon and very similar to *Parthenocissus quinquefolia* (L.) Planch. (in the past it was also considered a heterotypic synonym) from which it is mainly distinguished by the type of inflorescence (compound dichasium without distinct central axis vs. paniculate polychasium with a well-developed main axis) and tendrils (usually without adhesive discs vs. with adhesive discs) [146,147]. Due to identification difficulties, the data on its Italian distribution are still missing. Currently, in Italy it is reported as invasive in Lombardia and Veneto, as naturalized in Emilia-Romagna, and as casual in Toscana and Marche [34,72]. In Umbria, a large population was recently discovered along Fiume Topino in Foligno and it appears stabilized. The revision of the specimens preserved in PORUN-*Herb. Stinca* (linked to Stinca and Motti [89], Motti and Stinca [148] and Stinca et al. [149]) and PI (http://jacq.org/detail.php?ID=1737273, accessed on 6 August 2021), all previously identified as *Parthenocissus quinquefolia*, led the species *Parthenocissus inserta* to be added to the flora of Campania (Figure 2E) and Calabria.

***Parthenocissus tricuspidata* (Siebold & Zucc.) Planch.**
Vitaceae—Phanerophyta lianosa—South-East Asia—Neophyte
*First record for Calabria (casual alien)*

Notes—This species is native to South-East Asia and often cultivated in Italy as an ornamental plant [29]. It is recorded as a casual or naturalized alien in many Italian regions except Valle d'Aosta, Abruzzo, Molise, Calabria and Sardegna [34,69]. Therefore, our recent

find in Bova, Scilla and Villa San Giovanni are the first in Calabria and concern a few plants spread by seed.

***Paspalum notatum* Flüggé**
Poaceae—Hemicryptophyta caespitosa—South America—Neophyte
*First record for Campania (casual alien)*

Notes—A hemicryptophyte native to South America, *Paspalum notatum* was recently reported in Italy (Calabria) by Stinca et al. [150]. Later, it was also indicated in Basilicata [41] and Emilia-Romagna [73]. A new population was discovered by us also in the southern part of Campania in the Capaccio Paestum municipality. In accordance with Stinca et al. [150], also in Campania, this alien species was probably introduced via seeds to create lawns and thus subsequently spread. The new discovery extends its southern Italian distribution northward along the Tyrrhenian coast.

***Persicaria lapathifolia* (L.) Delarbre subsp. *lapathifolia***
Polygonaceae—Therophyta scaposa—Subcosmopolitan
*First record for Puglia (native)*

Notes—*Persicaria lapathifolia* subsp. *lapathifolia* is reported from most regions in northern and central Italy, whereas in southern Italy it is reported only from Molise and Campania [33,62,64]. Here, we provide the first two records of this taxon for Puglia, both from the Gargano promontory (see also [123]).

***Phyllostachys aurea* Carrière ex Rivière & C.Rivière**
Poaceae—Phanerophyta caespitosa—South-East Asia—Neophyte
*First record for Abruzzo (casual alien)*
*First record for Molise (naturalized alien)*

Notes—*Phyllostachys aurea* is recorded as a casual or naturalized alien in many Italian regions, while it shows a distribution gap in the eastern side of central Italy including Marche, Abruzzo and Molise [34,69,71,72]. However, we discovered some new populations in Abruzzo (Balsorano and Teramo) and Molise (Venafro). The population of Venafro has been monitored for more than ten years. Here, the species appears stabilized tending to invade the cultivated fields bordering the roads and the drainage channels in the plain, despite the continuous cutting-back by farmers.

***Phyllostachys edulis* (Carrière) J.Houz.**
Poaceae—Phanerophyta caespitosa—South-East Asia—Neophyte
*First record for Marche (naturalized alien)*

Notes—*Phyllostachys edulis* is found as a casual alien in various Italian regions [34]. In the Marche region, *P. edulis* grows wild near the Torrente Bisciugola and the Fiume Bosso (Cagli) where, starting from gardens where it was cultivated, the species spontaneously expanded along the banks areas and neighboring abandoned grasslands.

***Physalis philadelphica* Lam.**
Solanaceae—Therophyta scaposa—North and Central America—Neophyte
*First record for Campania (casual alien)*

Notes—This neophyte, native to North and Central America, was recently recorded as casual in Italy, based on a specimen collected in July 2018 in Lazio [69]. Therefore, our discovery in Torre del Greco in November 2017 can be considered the first for Campania but also the first discovery in Italy prior to the publication of Galasso et al. [69]. The few individuals observed in Campania were probably spread by the seeds of plants growing nearby.

***Phytolacca americana* L.**
Phytolaccaceae—Geophyta rhizomatosa—North America—Neophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—*Phytolacca americana* is a North American geophyte known as aninvasive or naturalized alien in all Italian regions, except in Puglia where it is reported as casual [34].

In Calabria, it shows a very aggressive capacity for invading sidewalks, roadsides, railway embankments, uncultivated lands and other nitrophilous environments, where it spreads easily by dispersal of its many ripe fruits dispersed (i.e., Cardinale, Palmi, Reggio Calabria, San Roberto, and Villa San Giovanni). It was also found in the *Rhamno catharticae-Prunetea spinosae* Rivas Goday and Borja ex Tüxen 1962 communities close to Lago dell'Aquila [151] where it was also observed in abandoned citrus groves. Therefore, the species should be considered invasive for Calabria, as in several other Italian regions. The invasion of this species is worrying because it is generally a secondary host for viruses harmful to crops [152].

***Platycladus orientalis* (L.) Franco**
Cupressaceae—Phanerophyta caespitosa—East and South-East Asia—Neophyte
*Change of status for Lazio: from casual alien to naturalized alien*

Notes—This species is recorded as a casual alien for the Lazio region by Galasso et al. [34]. In Guarcino, several individuals were found growing on a limestone cliff and on a roadside, not far from artificial conifer reforestations. Google Street images (https://www.google.it/maps/@41.8013644,13.3183157,54m/data=!3m1!1e3?hl=it&authuser=2, accessed on 15 September 2021) show the presence of the species on a cliff already in September 2008, supporting evidence of its naturalization.

***Potentilla indica* (Andrews) Th.Wolf**
Rosaceae—Hemicryptophyta rosulata—South and South-East Asia—Neophyte
*First record for Abruzzo (casual alien)*

Notes—*Potentilla indica* is reported often as a naturalized alien for many Italian regions, except for Abruzzo, Molise, Puglia, Basilicata, Calabria and Sicilia [34]. A small population about 10 $m^2$ of this neophyte was observed in anthropogenic environments at Raiano in Abruzzo. These individuals were accidentally introduced by nurseries as weeds on lawns.

***Prunus avium* (L.) L.**
Rosaceae—Phanerophyta scaposa—Europe, South-West Asia and North Africa (?)
*Change of status for Calabria: from naturalized alien to native*

Notes—*Prunus avium* is a tree mainly distributed in Europe, often also cultivated for its appreciated fruits [29]. It is considered an alien only in some central Italian regions (Umbria and Marche), and in Calabria, Sicilia and Sardegna, while in other regions it is classified as a native plant [33]. Pending further studies on the chorology of this species, in Calabria it should be considered indigenous, consistent with the neighboring southern Italian regions. In this region, it generally grows in anthropogenic environments and, albeit sporadically, in the natural deciduous forests (i.e., Longobardi, Marano Marchesato, Motta San Giovanni, Nardodipace, and San Roberto).

***Prunus laurocerasus* L.**
Rosaceae—Phanerophyta scaposa/caespitosa—South-West Asia—Neophyte
*First record for Basilicata (casual alien)*

Notes—*Prunus laurocerasus*, a species very frequently cultivated in the Italian gardens [29], is recorded as a casual, naturalized or invasive alien in many Italian regions, except for Molise, Basilicata, Sicilia and Sardegna [34,70,71]. In Basilicata (Potenza), we recently observed a single individual originating by seed in the herb layer of a peri-urban oak woodland.

***Rosa andegavensis* Bastard**
Rosaceae—Nano-Phanerophyta—Europe and North-West Africa
*First record for Calabria (native)*

Notes—According to the literature [33], the current Italian distribution of *Rosa andegavensis* includes all regions, except Veneto (only ancient data), Calabria and Sicilia. However, two small populations of this shrub were also found in Verbicaro in northern Calabria.

***Rudbeckia hirta* L.**
Asteraceae—Hemicryptophyta biennia—North America—Neophyte
*First record for Lazio (casual alien)*

Notes—*Rudbeckia hirta* is recorded as a casual or naturalized alien for all the regions of continental Italy, except for Valle d'Aosta where it is considered doubtful [34,73]. Some individuals were recently found in an anthropogenic environment at Fumone in Lazio, probably spread by the seeds of plants cultivated nearby. Therefore, our record is the first for Lazio and peninsular Italy.

***Rumex patientia* L. subsp. *patientia***
Polygonaceae—Hemicryptophyta scaposa—Asia (?)—Archaeophyte
*Confirmation for Umbria (casual alien)*

Notes—*Rumex patientia* subsp. *patientia*, probably native to Asia, is reported as a naturalized or casual alien for many Italian regions [34]. Since in Umbria it was indicated as doubtful [34], our recent find at Foligno of two small populations confirms the presence as a casual alien of this neophyte for the regional flora.

***Sedum palmeri* S.Watson**
Crassulaceae—Chamaephyta succulenta—Central America—Neophyte
*Change of status for Toscana: from casual alien to naturalized alien*

Notes—This species is often cultivated as an ornamental plant (A. Stinca, pers. comm.), and is recorded as casual or naturalized in several Italian regions [34,69–72]. In the historic center of Siena, it is established at several sites especially on roofs and gutters, and sometimes on walls. We propose to change its status from casual to naturalized alien in Toscana.

***Sedum spathulifolium* Hook. var. *spathulifolium***
Crassulaceae—Chamaephyta succulenta—North America—Neophyte
*First record for Europe (casual alien)*
*First record for Marche (casual alien)*
*First record for Umbria (casual alien)*

Notes—*Sedum spathulifolium* var. *spathulifolium* is a perennial herb native to North America, rarely cultivated in Italy (A. Stinca, pers. comm.). Three small populations of this neophyte were observed in anthropogenic environments in central Italy, two in the Marche region (i.e., Cagli and Falconara Marittima; Figure 2F) and one in the Umbria region (i.e., Scheggia e Pascelupo). These individuals appear to have spread from the seeds of plants cultivated nearby. However, it cannot be excluded that their propagation may be due to the involuntary dispersion of vegetative parts, perhaps by animals. As far as we know, these are the first find of this species in Europe. For the nomenclature and identification of the samples collected, we followed Ohba [153].

***Senecio angulatus* L.f.**
Asteraceae—Chamaephyta fruticosa—South Africa—Neophyte
*Change of the status for Calabria: from casual alien to naturalized alien*

Notes—Species considered as casual for Calabria by Galasso et al. [34]. However, in Reggio Calabria, we monitored a large population that occupies the entire valley floor for several hundred meters. In this site, *Senecio angulatus* has long been self-maintaining and flowers abundantly every year. For these reasons, the species can be considered naturalized for Calabria, like in other southern Italian regions and Sicily.

***Setaria italica* (L.) P.Beauv. subsp. *italica***
Poaceae—Therophyta scaposa—China—Archaeophyte
*Change of status for Calabria: from doubtful record to casual alien*

*Notes*—An annual herb native to China, *Setaria italica* subsp. *italica* is currently present as a casual alien in almost all Italy, while it is doubtful for Valle d'Aosta and Calabria [34]. However, a small population composed by few individuals spread by the seed was recently discovered by us also in the southern part of Calabria in the Reggio Calabria municipality.

***Setaria italica* (L.) P.Beauv. subsp. *pycnocoma* (Steud.) de Wet**
Poaceae—Therophyta scaposa—Asia (?)—Neophyte
*Change of status for Marche: from casual alien to naturalized alien*

Notes—*Setaria italica* subsp. *pycnocoma* is currently present in all regions of northern and central Italy (excluding Umbria and Lazio) and in Sardinia [34]. Its spread to the Marche region (i.e., Acqualagna, Ancona, Cagli, Cartoceto, Fano, Magliano di Tenna, and Serra San Quirico) and the increasing capacity to colonize grassland communities with even very different ecological characteristics to the detriment of other grassland species shows a behavior typical of invasive species.

***Solanum tuberosum* L.**
Solanaceae—Geophyta rhizomatosa—South America—Neophyte
*Confirmation for Sicilia (casual alien)*

Notes—*Solanum tuberosum*, a South American plant known as a casual alien in almost all Italian regions [34,72], was reported generically for Sicilia by Giardina et al. [154] as "commonly cultivated and subspontaneous near fields". However, this report was overlooked in the Italian alien checklist [34]. Therefore, we confirm its presence as a casual species escaped from cultivation in Sicilia (Catania).

***Solidago gigantea* Aiton**
Asteraceae—Hemicryptophyta scaposa—North America—Neophyte
*Change of status for Lazio: from casual alien to naturalized alien*

Notes—*Solidago gigantea* is a hemicryptophyte introduced from North America. It is reported for several Italian regions, but only in the North is it described as an invasive species [34]. In Lazio, this neophyte was observed, in recent years, in expansion along the Fiume Aniene (Marano Equo) in the absence of cultivated plants nearby. Therefore, we propose to change its status from casual to naturalized in Lazio.

***Stenotaphrum secundatum* (Walter) Kuntze**
Poaceae—Hemicryptophyta reptantia/Geophyta rhizomatosa—Tropical America and Africa—Neophyte
*First record for Basilicata (casual alien)*

Notes—*Stenotaphrum secundatum* is often cultivated for lawn grasses in thermo-temperate Italian coastal areas due to its aesthetic characteristics and its marked rusticity (A. Stinca, pers. comm.). It is recorded as a casual alien species in various Italian regions [34]. In Basilicata, some spontaneous individuals were observed in the road pavement cracks and at the edge of sidewalks near the beach of Maratea.

***Talinum paniculatum* (Jacq.) Gaertn.**
Talinaceae—Chamaephyta suffrutescentia—North, Central and South America—Neophyte
*First record for Campania (casual alien)*

Notes—*Talinum paniculatum*, native to Tropical America, is recorded as casual in Italy for Lazio, Sicilia and Sardegna [34,96]. The few individuals observed in Campania (Castellammare di Stabia) spread by seed from cultivated plants nearby. The species should be considered a casual alien in Campania because it does not form stable populations.

***Trachelium caeruleum* L. subsp. *caeruleum***
Campanulaceae—Chamaephyta suffrutescentia—West Mediterranean—Neophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—In the past, it was sometimes cultivated as an ornamental plant in Italy [30]; today, *Trachelium caeruleum* subsp. *caeruleum* is naturalized in many regions, especially on the Tyrrhenian side of the Italian Peninsula [34]. In some monitored sites in Calabria (i.e., Bagnara Calabra, Canolo Nuova, Grotteria, Platì, and Sant'Eufemia d'Aspromonte), this taxon spreads for several kilometers: for example, along the Torrente Pachina the species occupies the whole valley, as well as in the locality of Sant'Eufemia d'Aspromonte. Here,

it tends to invade the rocky environments of the humid gorges and competes with many native species such as *Adiantum capillus-veneris* L., *Geranium versicolor* L., *Mycelis muralis* (L.) Dumort. subsp. *muralis*, *Osmunda regalis* L., *Polystichum setiferum* (Forssk.) T.Moore ex Woyn. and *Woodwardia radicans* (L.) Sm. Therefore, the species should be considered invasive for Calabria.

***Trachelospermum jasminoides* (Lindl.) Lem.**
Apocynaceae—Phanerophyta lianosa—South-West Asia—Neophyte
*First record for Sardegna (casual alien)*

Notes—*Trachelospermum jasminoides* is an Asian liana and a very popular ornamental plant in Italy (A. Stinca, pers. comm.). It is recorded as a casual alien only for Lombardia [34]. Recently, a few individuals were observed in rocky crevices along an escarpment in Cagliari, probably originating from vegetative parts from nearby urban gardens. Therefore, our find is the first for insular Italy.

***Trachycarpus fortunei* (Hook.) H.Wendl.**
Arecaceae—Phanerophyta scaposa—South-East Asia—Neophyte
*Change of status for Toscana: from casual alien to naturalized alien*

Notes—This ornamental palm is considered an invasive species in some regions of northern Italy, and a casual alien in Toscana and Marche [34,67,69]. At two sites around the historical center of Siena, it was observed abundantly reproducing from seed in urban shrublands and ruderal site, with individuals even reaching medium sizes. We propose to change its status from casual to naturalized in Toscana.

***Tradescantia fluminensis* Vell.**
Commelinaceae—Hemicryptophyta reptantia/Geophyta rhizomatosa—South America—Neophyte
*Change of status for Calabria: from casual alien to naturalized alien*

Notes—The species was reported as casual for Calabria by Galasso et al. [34]. However, in the stations reported here (i.e., Reggio Calabria and San Roberto) some individuals were found to have vegetated for several years and to have produced some new individuals. Hence, *Tradescantia fluminensis* can be considered naturalized for Calabria. In southern Italy, this neophyte propagates mainly vegetatively, producing a large amount of biomass and, in this way, strongly competes with indigenous species [155].

***Tradescantia sillamontana* Matuda**
Commelinaceae—Hemicryptophyta reptantia/Geophyta rhizomatosa—North America—Neophyte
*First record for Sardegna (casual alien)*

Notes—Like the previous species, *Tradescantia sillamontana* is a hemicryptophyte or geophyte often cultivated as an ornamental plant in Italy (A. Stinca, pers. comm.). Based on a discovery in Campania by Stinca et al. [156], it was recorded as a casual alien for the first time in Europe. It was later reported for Calabria by Laface et al. [101] Therefore, according to current knowledge, this species is known only for these two regions [34,72]. However, some individuals were recently found in an anthropogenic environment at Cagliari in Sardegna, probably spread by the seeds of cultivated plants nearby. Therefore, our record is the first for insular Italy.

***Tropaeolum majus* L.**
Tropaeolaceae—Therophyta reptantia—South America—Neophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—*Tropaeolum majus* is a South American therophyte often cultivated as ornamental in Italy. It is reported as a naturalized alien in Calabria [34]. However, several individuals were found in the new sites (i.e., Bova Marina, Condofuri, Motta San Giovanni, and Reggio Calabria), showing a high capacity to spread rapidly and occupy ever larger surface areas. Therefore, the species should be considered invasive for Calabria.

***Ulmus pumila* L.**
Ulmaceae—Phanerophyta scaposa—Asia—Neophyte
*Change of status for Lazio: from casual alien to naturalized alien*

Notes—*Ulmus pumila*, often cultivated as an ornamental plant in Italy [29], was reported as casual, naturalized or invasive in several Italian regions [34,71,73]. In Lazio, based on some populations detected in Roma and Sabaudia [90,96], it is considered a casual species [34]. In Alatri, we found a new population with numerous individuals originating from seed from ornamental trees that were planted in the mid-1990s. They appear well-established and sexually reproducing in a range up to 200 m away from mother plants, with some individuals up to 5 m tall. We thus propose a status change for the species in Lazio, from casual to naturalized alien.

***Verbascum thapsus* L. subsp. *montanum* (Schrad.) Bonnier & Layens**
Scrophulariaceae—Hemicryptophyta biennia—South-East European Orophyte
*Confirmation for Puglia (native)*

Notes—The known Italian distribution of *Verbascum thapsus* subsp. *montanum* includes all continental regions, Toscana and Campania [33]. However, Curti et al. ([157] sub *Verbascum crassifolium*) reported this taxon also for Lesina in northern Puglia. Later, Forte et al. ([158] sub *Verbascum thapsus* subsp. *crassifolium*) mention it for the same locality but only according to the information provided by Curti et al. [157]. Fortunately, a specimen collected at Lesina on May 1978 and preserved in MJG-*Herb. Garganicum* allow us to confirm *Verbascum thapsus* subsp. *montanum* for the flora of Puglia.

***Veronica agrestis* L.**
Plantaginaceae—Therophyta scaposa—European
*Confirmation for Puglia (native)*

Notes—*Veronica agrestis* is a native weed, often present in Italy in the cultivated fields [124]. According to Bartolucci et al. [33] *Veronica agrestis* does not occur in Puglia. However, Curti et al. [157] reported this taxon for Lesina in northern part of the region. Later, Forte et al. [158] do not mention it for Lesina. Fortunately, a specimen from Vico del Gargano preserved in MJG-*Herb. Garganicum* allows *Veronica agrestis* to be confirmed for the flora of Puglia.

***Veronica cymbalaria* Bodard subsp. *cymbalaria***
Plantaginaceae—Therophyta scaposa—Euri-Mediterranean
*First record for Puglia (native)*

Notes—*Veronica cymbalaria* subsp. *cymbalaria* is reported as a native taxon from Lombardia, Liguria, Emilia-Romagna and from peninsular and insular Italy, except Puglia and Basilicata [33]. Here, we provide the first records of this taxon for Puglia, all from the Gargano promontory (see also [123]).

***Veronica persica* Poir.**
Plantaginaceae—Therophyta scaposa—South-West Asia—Neophyte
*Change of status for Calabria: from naturalized alien to invasive alien*

Notes—*Veronica persica* is an Asian annual weed easily propagated by seed. It is considered an invasive or naturalized alien in all Italian regions, and in particular, as naturalized in Calabria [34]. Recent field observations revealed that this exotic species grows abundantly in anthropogenic places including cultivated fields, especially in coastal areas. The seeds are likely to be transported by agricultural vehicles or by moving horticultural plants. Therefore, this species should be considered invasive for the region.

***Vitis* × *koberi* Ardenghi, Galasso, Banfi & Lastrucci**
Vitaceae—Phanerophyta lianosa—Artificial origin—Neophyte
*First record for Umbria (invasive alien)*

Notes—*Vitis* × *koberi*, an artificial hybrid of American grapevines, i.e., *Vitis berlandieri* Planch. and *Vitis riparia* Michx. [159], is recorded as an invasive or naturalized alien in

almost all Italian regions, except Umbria and Basilicata [34,69,160]. Recently, we discovered some large populations also at Foligno in Umbria, where it showed a noticeable vegetative propagation in anthropogenic environments. In addition to the above cited localities, we observed this taxon as being abundant along the SS 75 road from Foligno to Perugia and along the motorway junction up to the A1 motorway. Therefore, we propose this species as an invasive alien in Umbria.

***Vitis labrusca* L.**
Vitaceae—Phanerophyta lianosa—North America—Neophyte
*First record for Marche (casual alien)*

Notes—*Vitis labrusca* is a climbing shrub native to the eastern USA and belonging to the grouping of "American vines". Introduced as a table grape in Europe before the advent of phylloxera, its cultivation was later supplanted by species or varieties more resistant to this pathogen. Currently, the species is present in almost all Italian regions except for Valle d'Aosta, Trentino-Alto Adige, Marche, Umbria and Molise [34,69]. However, a new population was discovered in Marche near the banks of the Fiume Metauro (Peglio).

***Vitis rupestris* Scheele**
Vitaceae—Phanerophyta lianosa—North America—Neophyte
*First record for Umbria (casual alien)*

Notes—*Vitis rupestris* is reported as a casual alien in several Italian regions [34]. Recently, a single individual was observed in the urban area of Spello in Umbria.

***Zephyranthes candida* (Lindl.) Herb.**
Amaryllidaceae—Geophyta bulbosa—South America—Neophyte
*First record for Calabria (casual alien)*

Notes—*Zephyranthes candida* is a geophyte native to Central-East part of South America, sometimes cultivated as an ornamental plant in Italy (A. Stinca, pers. comm.). It is reported as a casual alien only for Toscana [34]. A small population was also observed also in Reggio Calabria, probably derived from vegetative parts present in the soil brought back. Therefore, our discovery extends its distribution range into southern Italy.

### *3.2. Current Floristic Knowledge in Italy*

Currently, without counting the taxa reported by mistake, that are doubtful, data deficient, extinct or no longer recorded after 1950, the Italian vascular flora comprises 9150 taxa of which 7547 are native (of which 1598 are Italian endemics; i.e., 21.17% of total native taxa) and 1603 are exotic at a national level. Therefore, related to the total current plant diversity, the contribution of exotic taxa is 17.52%. As for the alien flora, casual species number 761 (47.47% of total alien taxa), naturalized are 601 (37.49%), invasive taxa number 238 (14.85%), while the not assessed ones (i.e., without indication of the invasiveness status) are only three (0.19%). The Italian floristic density (i.e., number of taxa/area) is 0.025 taxa/km$^2$ for native units and 0.005 taxa/km$^2$ for alien ones.

At the regional scale (Table 2), the greatest richness of native species (including cryptogenics) is found in Toscana (R*tn* = 3202 taxa) followed by Piemonte (3028), Lombardia (2926) and Abruzzo (2920). Instead, the region with the greatest presence of the alien taxa (including alien at regional level) is Trentino-Alto Adige (R*ta* = 959) followed by Lombardia (955), Veneto (785) and Friuli-Venezia Giulia (641). With 118 taxa, Lombardia is the Italian region with the highest number of invasive alien plants. Friuli-Venezia Giulia results the region with the largest number of aliens without indication of the invasiveness status (77), while in Campania and Puglia this category of exotic plants is absent.

**Table 2.** Currently occurring floristic composition of Italian regions (ABR: Abruzzo; BAS: Basilicata; CAL: Calabria; CAM: Campania; EMR: Emilia-Romagna; FVG: Friuli-Venezia Giulia; LAZ: Lazio; LIG: Liguria; LOM: Lombardia; MAR: Marche; MOL: Molise; PIE: Piemonte; PUG: Puglia; SAR: Sardegna; SIC: Sicilia; TOS: Toscana; TAA: Trentino-Alto Adige; UMB: Umbria; VDA: Valle d'Aosta; and VEN: Veneto). Gradients of yellow, blue and green indicate the richness of native taxa (including certainly natives and cryptogenics), alien taxa (including casual, naturalized, invasive and not assessed aliens) and total taxa in each region, respectively. Taxa reported by mistake and as doubts, data deficient, extinct and no longer recorded after 1950 are not counted.

| Italian Regions | Natives (n.) | Cryptogenics (n.) | *TOTAL NATIVES* (R*tn*; n.) | Casual Aliens (n.) | Naturalized Aliens (n.) | Invasive Aliens (n.) | Aliens with No Indication of Invasiveness Status (n.) | *TOTAL ALIENS* (R*ta*; n.) | *TOTAL FLORA (TOT. NATIVES + TOT. ALIENS)* (n.) | Degree of Floristic Pollution (FP; %) | Exclusive Natives (Excluded the Species Reported as "Sensu Lato") (R*en*; n.) | Exclusive Aliens (Excluded the Species Reported as "Sensu Lato") (R*an*; n.) | Exclusive Endemics (R*ee*; n.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ABR** | 2900 | 20 | ***2920*** | 223 | 138 | 34 | 1 | ***396*** | ***3316*** | **11.94** | 91 | 0 | 71 |
| **BAS** | 2495 | 18 | ***2513*** | 142 | 80 | 21 | 4 | ***247*** | ***2760*** | **8.95** | 21 | 2 | 14 |
| **CAL** | 2496 | 18 | ***2514*** | 178 | 124 | 48 | 6 | ***356*** | ***2870*** | **12.40** | 86 | 7 | 65 |
| **CAM** | 2414 | 22 | ***2436*** | 237 | 149 | 49 | 0 | ***435*** | ***2871*** | **15.15** | 33 | 20 | 27 |
| **EMR** | 2582 | 22 | ***2604*** | 296 | 252 | 29 | 12 | ***589*** | ***3193*** | **18.45** | 16 | 17 | 4 |
| **FVG** | 2754 | 10 | ***2764*** | 288 | 239 | 37 | 77 | ***641*** | ***3405*** | **18.83** | 162 | 20 | 24 |
| **LAZ** | 2839 | 21 | ***2860*** | 318 | 166 | 41 | 1 | ***526*** | ***3386*** | **15.53** | 21 | 19 | 11 |
| **LIG** | 2631 | 16 | ***2647*** | 307 | 180 | 19 | 2 | ***508*** | ***3155*** | **16.10** | 64 | 41 | 10 |
| **LOM** | 2911 | 15 | ***2926*** | 548 | 288 | 118 | 1 | ***955*** | ***3881*** | **24.61** | 60 | 81 | 24 |
| **MAR** | 2326 | 19 | ***2345*** | 224 | 129 | 40 | 14 | ***407*** | ***2752*** | **14.79** | 23 | 6 | 19 |
| **MOL** | 2194 | 15 | ***2209*** | 95 | 85 | 26 | 5 | ***211*** | ***2420*** | **8.72** | 1 | 0 | 0 |
| **PIE** | 3004 | 24 | ***3028*** | 234 | 279 | 70 | 1 | ***584*** | ***3612*** | **16.17** | 213 | 26 | 46 |
| **PUG** | 2210 | 34 | ***2244*** | 240 | 126 | 21 | 0 | ***387*** | ***2631*** | **14.71** | 63 | 12 | 38 |
| **SAR** | 2223 | 32 | ***2255*** | 338 | 215 | 72 | 5 | ***630*** | ***2885*** | **21.84** | 357 | 43 | 259 |
| **SIC** | 2581 | 31 | ***2612*** | 221 | 221 | 18 | 10 | ***470*** | ***3082*** | **15.25** | 446 | 44 | 293 |
| **TAA** | 2757 | 21 | ***2778*** | 665 | 237 | 43 | 14 | ***959*** | ***3737*** | **25.66** | 201 | 72 | 75 |
| **TOS** | 3172 | 30 | ***3202*** | 311 | 242 | 65 | 6 | ***624*** | ***3826*** | **16.31** | 107 | 19 | 22 |
| **UMB** | 2073 | 17 | ***2090*** | 200 | 98 | 13 | 21 | ***332*** | ***2422*** | **13.71** | 4 | 1 | 2 |
| **VDA** | 1767 | 37 | ***1804*** | 85 | 73 | 21 | 1 | ***180*** | ***1984*** | **9.07** | 23 | 2 | 4 |
| **VEN** | 2808 | 14 | ***2822*** | 425 | 258 | 70 | 32 | ***785*** | ***3607*** | **21.76** | 43 | 18 | 18 |

Analyzing the degree of floristic pollution (FP) of each regional flora, we found that only in Molise, Basilicata and Valle d'Aosta do alien species currently present in these areas not exceed 10% of the total flora. At the other extreme, the regions in which alien taxa are about 25% of the total flora are Trentino-Alto Adige and Lombardia (Table 2).

The regions of insular Italy are clearly those with the highest number of exclusive native taxa (i.e., Italian endemics + taxa with wider distribution but reported in only one Italian region): Sicilia (R*en* = 446; i.e., 17.08% of total regional native taxa) and Sardinia (357; 15.83%). Conversely, Lombardia (R*ea* = 81; i.e., 8.48% of total regional alien taxa) and Trentino-Alto Adige (79; 7.51%) are the regions with the highest number of exclusive alien taxa (Table 2, Figure 3A,A'). It is interesting to note that Sicilia also results as the region with the highest percentage of exclusive alien taxa on the total of its exotic flora (9.36%) (Figure 3). As for the exclusive endemic taxa of a single Italian region (i.e., regional endemics; the complete list are available in Table S2), the islands of Sicilia (R*ee* = 293; i.e., 11.22% of total regional native taxa) and Sardegna (259; 11.49%) results the richest territories of Italy (Table 2, Table S3).

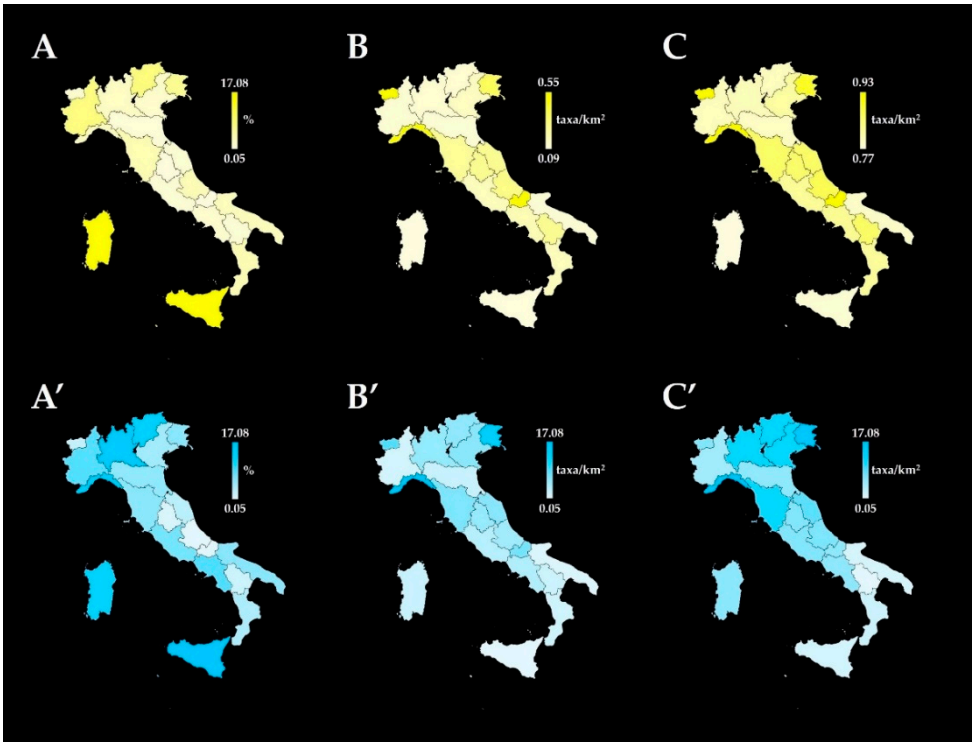



**Figure 3.** Current percentage of exclusive native (R*en*) (**A**) and alien (R*ea*) (**A'**) taxa of the Italian regions. Density of total native (D*tn*) (**B**) and alien (D*ta*) (**B'**), and normalized density of total native (DN*tn*) (**C**) and total alien (DN*ta*) (**C'**). Values of R*en*, R*ea*, D*tn*, D*ta*, DN*tn* and DN*ta* for each region are available in Table S3. Taxa reported by mistake and as doubts, data deficient, extinct and no longer recorded after 1950 are not counted.

Considering the floristic density at the regional level, Valle d'Aosta (D*tn* = 0.553 taxa/km$^2$; DN*tn* = 0.927 taxa/km$^2$), Molise (0.495; 0.916) and Liguria (0.489; 0.917) showed the highest values for native taxa (Figure 3B,C). Likewise, Liguria (D*ta* = 0.094; DN*tn* = 0.725) and Friuli-Venezia Giulia (0.081; 0.720) are the areas with the highest density of alien taxa (Figure 3B',C').

As presented in Figure 4, the regional floristic index applied only to native taxa (RFI*n*), which ranges from 1.242 in Toscana to 0.700 in Valle d'Aosta, shows values above 1 (i.e., average value) in the regions of continental Italy (except Valle d'Aosta), Toscana, Abruzzo, Lazio and Sicilia. Considering only the alien taxa, RFI*a* shows a greater gap between the maximum value (1.876 in Trentino-Alto Adige) and the minimum (0.352 in Valle d'Aosta). RFI*a* values are also higher for the northern Italian regions (except Liguria), Sardegna,

Toscana and Lazio. RFI calculated to total regional taxa (RFI*t*) confirms the trend shown by RTI*n* and is between 1.256 in Lombardia and 0.642 in Valle d'Aosta.

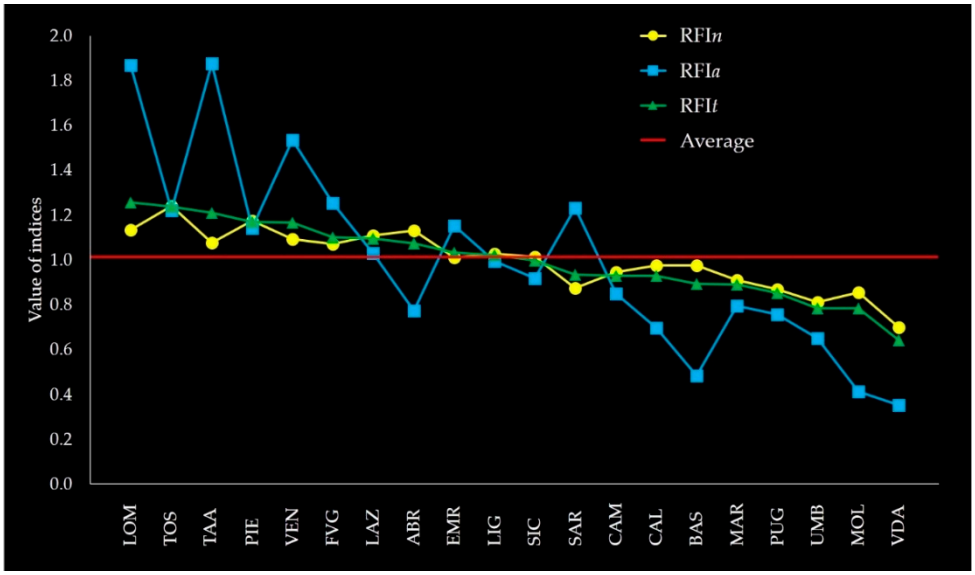



**Figure 4.** Trend of the regional floristic index applied only to only native taxa (RFI*n*, yellow curve), only alien taxa (RFI*a*, blue curve) and the total taxa (RFI*t*, green curve) currently present in each Italian region (ordered according to RFI*t* values: LOM: Lombardia; TOS: Toscana; TAA: Trentino-Alto Adige; PIE: Piemonte; VEN: Veneto; FVG: Friuli-Venezia Giulia; LAZ: Lazio; ABR: Abruzzo; EMR: Emilia-Romagna; LIG: Liguria; SIC: Sicilia; SAR: Sardegna; CAM: Campania; CAL: Calabria; BAS: Basilicata; MAR: Marche; PUG: Puglia; UMB: Umbria; MOL: Molise; and VDA: Valle d'Aosta). The red line represents the average number of only native, only alien and total taxa present in all regions (i.e., RFI = 1). Values of RFI*n*, RFI*a* and RFI*t* for each region are available in Table S4. Taxa reported by mistake and as doubts, data deficient, extinct and no longer recorded after 1950 are not counted.

The classification and ordination analysis of the flora of the Italian admistrative regions considering data matrices of only native taxa at the regional level (data matrix of 7697 taxa × 20 regions; taxa include species reported as "sensu lato"), only alien taxa at the regional level (2337 taxa × 20 regions) and the total taxa (9330 taxa × 20 regions) are depicted in Figure 5. The dendrogram resulting from the agglomerative hierarchical clustering of only native taxa currently present in the Italian regions show three clearly distinct groups (i.e., I, II and III; Figure 5A). Three main groups are characterized by exclusive native taxa (i.e., exclusively common to all regions of the group) which are respectively 159, 68 and 22 (Figure 5A', Table S5). Cluster I includes all Alpine regions divided into two subgroups according to a longitudinal gradient, i.e., Piemonte and Valle d'Aosta in subgroup I*a*, and Friuli-Venezia Giulia, Veneto, Lombardia and Trentino-Alto Adige in subgroup I*b*. Within group II, there are all southern regions of the Italian Peninsula (subgroup II*a*: Puglia, Calabria, Basilicata and Campania) and the regions of insular Italy (subgroup II*b*: Sardegna and Sicilia). The regions of central Italy (Marche, Umbria, Molise, Abruzzo and Lazio) are instead grouped in subgroup III*a*, with the exception of Toscana which clasterizes in subgroup III*b* together with Liguria and Emilia-Romagna. The cluster analysis performed on the matrix of only alien taxa show two distinct groups, although with a much lower value of dissimilarity than the main groups of only native taxa (ca. 500 vs. 1500) (Figure 5B). Indeed, two main groups are distinguished by only four exclusive alien taxa (Figure 5B', Table S5). Within group I there are all the regions of peninsular and insular Italy, as well as Valle d'Aosta and Liguria. The remaining continental regions are instead grouped in cluster II. As for the dendrogram obtained by total taxa, it shows two clearly distinct groups (Figure 5C). Group I's results are identical to those of only native taxa, while cluster II includes four subgroups which are II*a* (with Sardegna and Sicilia), II*b* (Liguria,

Emilia-Romagna and Toscana), II*c* (Marche, Umbria, Abruzzo and Lazio), and II*d* (Puglia, Basilicata, Calabria, Campania and Molise).

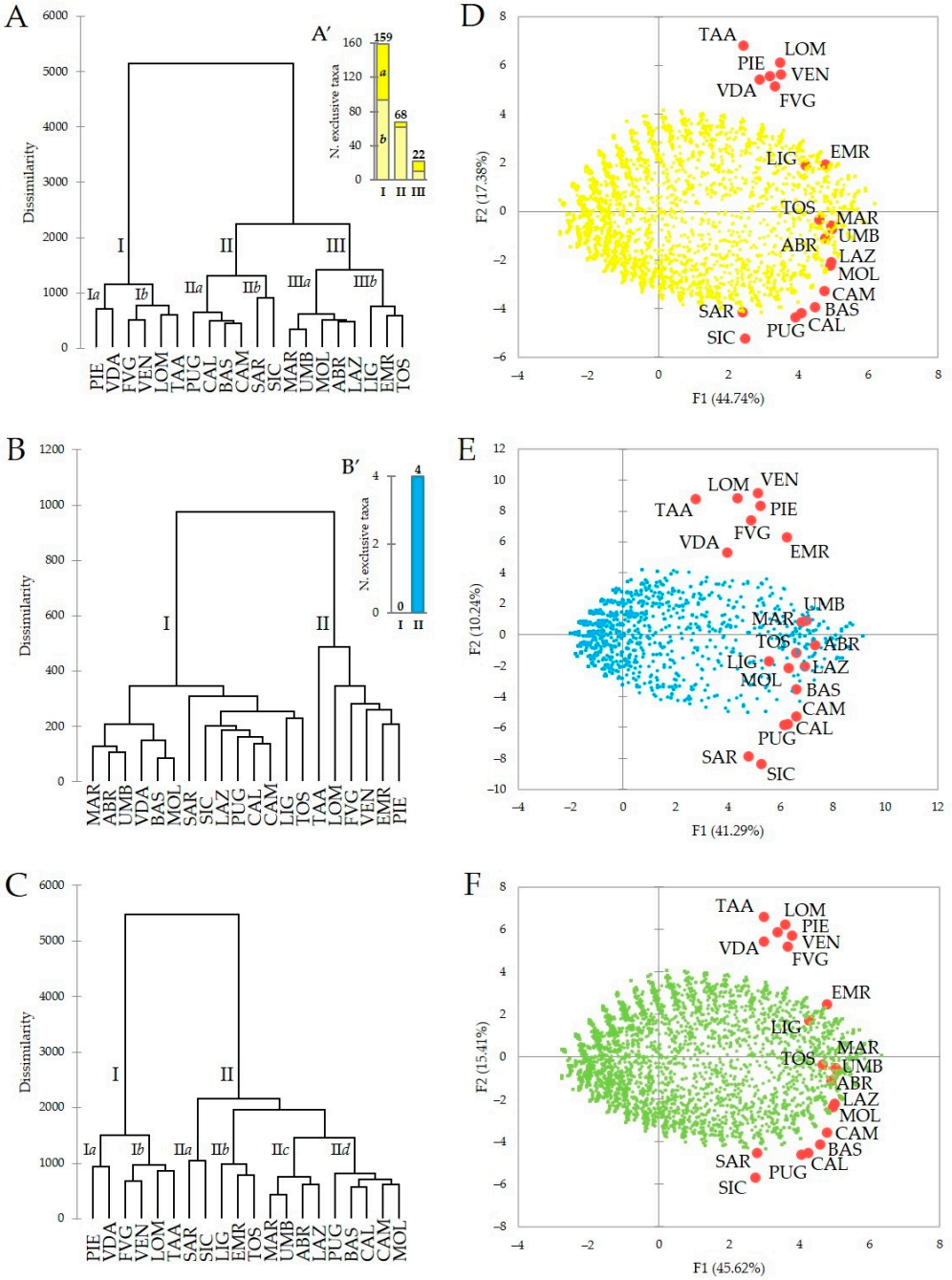



**Figure 5.** Dendrogram of the agglomerative hierarchical clustering (**A**–**C**, with an indication of the main groups and subgroups) and biplot of the principal component analysis in the first two principal components space (**D**–**F**) of current flora of the Italian administrative regions considering only native taxa (**A**,**D**), only alien taxa (**B**,**E**) and the total taxa (**C**,**F**). Histograms show the number of exclusive native (**A′**) and alien (**B′**) taxa of the main clusters (the complete list are available in Table S5). Taxa reported by mistake and as doubts, extinct and no longer recorded after 1950 are not counted (ABR: Abruzzo; BAS: Basilicata; CAL: Calabria; CAM: Campania; EMR: Emilia-Romagna; FVG: Friuli-Venezia Giulia; LAZ: Lazio; LIG: Liguria; LOM: Lombardia; MAR: Marche; MOL: Molise; PIE: Piemonte; PUG: Puglia; SAR: Sardegna; SIC: Sicilia; TOS: Toscana; TAA: Trentino-Alto Adige; UMB: Umbria; VDA: Valle d'Aosta; and VEN: Veneto).

In all biplots (Figure 5D–F), the clusters of regions are highlighted along the first axis (F1) which accounted for 44.74%, 41.29% and 45.62% of the variation considering native, alien and total flora, respectively (to improve readability species variables are not shown). However, the 20 regions showed a separation according to the second axis (F2), which accounted for 17.38% (native flora), 10.24% (alien flora) and 15.41% (total flora) of the remaining variation and clearly reflected their geographical location. With some exceptions concerning only the alien taxa (i.e., the position of Valle d'Aosta, Sicilia and Sardegna), the results shown by the biplots are consistent with those of the dendrograms.

## 4. Discussion

### *4.1. New Findings and Updates*

Our research concerned 125 taxa and allowed us to propose 134 floristic updates for Italy (Table 1), in addition to discoveries of new growth sites for four Italian rare species. Most of the taxa recorded (i.e., not considering *Kalanchoë daigremontiana*, since it was excluded from the flora of Calabria) belong to the Asteraceae (13.71%), are phanerophytes (29.03%), native to the Americas (37.90%) and neophytes 75.81%). Four taxa, all exotic, are reported for the first time in Italy. *Elaeodendron croceum* (native to South Africa), *Kalanchoë blossfeldiana* (Madagascar) and *Sedum spathulifolium* var. *spathulifolium* (North America) were recorded as casual aliens, while the historic presence of *Oxalis brasiliensis* (South America) was only certified by specimens stored in herbarium FI. On the basis of the available floristic literature all these taxa are to be considered new for the European flora. Likewise, *Kalanchoë laxiflora* from Madagascar can be considered as a confirmed alien species for Italy and Europe as a whole.

In all, our floristic updates covered 14 of the 20 Italian regions (Table 1). The region for which we proposed the largest number of updates was Calabria (44, of which 5 were first records), followed by Umbria and Toscana. Fifty-nine taxa were reported as new in one or more Italian regions. The largest number of first reports were recorded in Umbria (10 taxa, all exotic) and Marche (10 taxa, of which nine are alien). These data are not surprising since, with the exception of the information reported in the national checklist [34] and in its updates [67–73], detailed studies on alien flora have not recently been performed in these two regions. On the contrary, the high number of first reports from Campania (9 taxa, all alien), a region in which many studies on alien plants have been conducted in recent years [25,42,129,149,156,161], is mainly due to recent introductions. With the exception of the fern *Nephrolepis cordifolia* all the other floristic notes concern angiosperms and gymnosperms. These data were predictable, since new reports concerning ferns have been very rare in recent years in all European countries [162]. As for the discoveries of *Chimonanthus praecox* in Marche, *Coleus scutellarioides* in Calabria, *Echinochloa hispidula* in Toscana, and *Rudbeckia hirta* in Lazio, we point out that these are the first findings as casual alien plants in peninsular Italy. Likewise, *Tradescantia sillamontana* and *Trachelospermum jasminoides* found as casual in Sardegna were also recorded as new for insular Italy. Furthermore, the discovery in Campania of a naturalized population of *Cenchrus setaceus* was of particular interest because this neophyte is included in the list of invasive alien species of the European Union (Commission Implementing Regulation (EU) 2017/1263, https://eur-lex.europa.eu/legal-content/EN/TXT/?WT.mc_id=Twitter&uri=CELEX:32017R1263, accessed on 7 September 2021). It has ecophysiological traits that make her an aggressive invader in the arid and semi-arid environments of the tropics and subtropics [163], but also in the natural (e.g., perennial dry grasslands with *Hyparrhenia hirta* (L.) Stapf.) and anthropogenic environments (e.g., along the roads) of Calabria, Sicilia and Sardegna [101,164]. We believe that our reports can be useful to local authorities to plan the appropriate eradication actions in order to prevent ecological damage. We emphasize that the discovery sites are located not far from protected natural areas such as the Vesuvio National Park and the Regional Parks of Fiume Sarno, Monti Lattari, Partenio and Monti Picentini.

On a regional scale, based on plant population monitoring over time and on analysis of the literature, we assigned to some of the examined taxa a different invasiveness status

or a different indigenous status compared with the past assessment. The analysis also made it possible to update the invasiveness status at national level for 10 species as follows: from casual to naturalized (*Campanula portenschlagiana*, *Morus nigra*, *Phyllostachys edulis*), and from naturalized to invasive (*Arctotheca calendula*, *Crassula muscosa*, *Dactyloctenium aegyptium*, *Digitaria ciliaris*, *Kalanchoë* × *houghtonii*, *Trachelium caeruleum* subsp. *caeruleum*, *Tropaeolum majus*). Interestingly, most changes of the invasiveness status and indigenous status result from observations carried out in Calabria (Table 1). This data is undoubtedly due to the lack of knowledge on alien flora in this region. Indeed, only recently some studies focused their attention on exotic species at the regional level and in part have filled this knowledge gap [101,122,129,150]. For some invasive species we have also observed significant negative impacts on habitats of interest to the European Community (Habitat Directive 92/43/EEC, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31992L0043, accessed on 7 September 2021): *Acanthus mollis* subsp. *mollis* (on habitat 9340), *Arctotheca calendula* (2110 and 2120), *Crepis sancta* subsp. *nemausensis* (6110*) and *Dactyloctenium aegyptium* (2110, 2120 and 2230). With the exception of *A. calendula*, for all other exotic taxa these are the first evidence of impacts on EU habitat in Italy [165].

Most of the 59 taxa reported for the first time for the Italian regions are escapees from cultivation (e.g., *Actinidia deliciosa*, *Boerhavia coccinea*, *Campanula portenschlagiana* and *Elaeagnus* × *submacrophylla*). This is fully in agreement with other authors according to whom agricultural activities and artificial green areas (gardens, parks and cultivated fields) represent starting points for the process of invasion [93,166,167]. In addition to human activities, the large number of alien species reported as new for Italy and for its regions should be related to the recent greater attention of Italian botanists to this group of plants. In any event, our results are in line with the trend of increasing reports of alien species in Italy [46] and Europe [167].

The few new reports of indigenous plants at the regional level mostly concern taxa with wide ranges such as *Deschampsia cespitosa* subsp. *parviflora* (Eurasian, discovered in Abruzzo), *Rosa andegavensis* (Europe and North-West Africa, found in Calabria) and *Verbascum thapsus* subsp. *montanum* (South-East European Orophyte, recorded in Puglia). We point out that *Deschampsia cespitosa* subsp. *parviflora* is a taxon difficult to identify and probably underestimated in Italy. For this reason, it was categorized as DD (i.e., data deficient) in the IUCN Red List of the Italian Flora [168,169]. Of great interest was the discovery of new populations of two rare native species: *Astragalus penduliflorus* (in Lazio) and *Cerinthe retorta* (in Puglia). As for the latter species, it previously received the conservation status EN (i.e., endangered) in the IUCN Red List of the Italian Flora [168–170] and new site discovered by us in the Gravina di Laterza does not lead to a change of the IUCN category. Additionally, noteworthy was the discovery of a new population for the Monti Aurunci (Lazio) of the Italian endemic *Drymochloa drymeja* subsp. *exaltata*, a taxon listed in the IUCN Red List of the Italian Flora as LC (i.e., least concern) [47,168], common in southern Italian Peninsula but very rare in central Italy. Useful to clarify the current distribution in Italy were also the discoveries of new growth sites for *Andrachne telephioides* in Lazio and Campania. The occurrence of this species in Italian regions has been variously interpreted by the researchers [33] and, in our opinion, further investigations on its chorology are necessary in the Mediterranean basin.

The revision of the specimens preserved in FI, HLUC, PORUN-*Herb. Stinca*, PI, *Herb. Magellense*, MJG-*Herb. Garganicum* and SIENA led to a review or confirmation of some previous reports. In detail: (i) three samples were found in FI which testify to the presence of *Oxalis brasiliensis* in Italy in the 1930s; in HLUC, we traced and confirmed a single unpublished specimen of *Centaurium erythraea* subsp. *rhodense* from Basilicata; (ii) a revision of some exsiccata preserved in PORUN-*Herb. Stinca* and PI previously identified as *Parthenocissus quinquefolia* led to *Parthenocissus inserta* added to the flora of Campania and Calabria; (iii) in MJG-*Herb. Garganicum*, we traced and confirmed one unpublished specimen of *Verbascum thapsus* subsp. *montanum* from Puglia; (iv) the re-examination of a specimen of *Artemisia campestris* subsp. *glutinosa* conserved in the *Herb.*

*Magellense* led us to correct it to *Artemisia campestris* subsp. *campestris* which was therefore confirmed for the flora of Abruzzo; and (v) in SIENA, we traced and confirmed a single unpublished specimen of *Echinochloa hispidula* from Toscana. These examples confirm the essential role of herbaria in botanical researches [171,172].

As regards the current richness of the native vascular flora and endemics in Italy, in accordance with Bartolucci et al. [33,46], we confirm Italy's primacy compared to other European floras for which we have fairly update-to-date data; that is, France [173], Albania [174], Greece [175], Spain, Portugal [176] and the Czech Republic [177]. We emphasize that the number of native taxa occurring in Italy, like in other countries, is subject to continuous changes resulting from new discoveries, new descriptions and taxonomic revisions. The high richness of the Italian flora can be related by the marked environmental diversification of the territory. Indeed, four "biogeographical provinces", i.e., the Alpine, the Apennino-Balkan, the Italo-Tyrrhenian and the Adriatic, meet in Italy [58]. As regards the alien flora, although it does not have updated data for most of the European countries [178–182], Italy ranks among the first countries also for the number of exotic taxa currently reported.

### *4.2. Exploration of Floristic Similarities between Regions*

Our study was the first to statistically explore floristic similarities between Italian administrative regions using currently occurring native, alien and total taxa separately, as well as updated to 2021. Indeed, previously only Blasi et al. [183] merely used native floras for multivariate analyses. Other few studies analyzed the Italian floristic composition only in quantitative [46] and chorological terms [184], or using only Italian endemics [185] or only native woody genera [186]. Our multivariate analysis of updated floristic data on a regional scale is interesting from several points of view. As shown in the graphs of the Figure 5A,D regarding only native taxa, the regions are clearly distributed along the latitudinal gradient. Interestingly, in the biplot of Figure 5D, the regions are clearly divided into continental, peninsular and insular Italy. Only Liguria and Emilia-Romagna are placed in an intermediate position between the northern and the peninsular regions, but this reflects their natural geographical location and the environmental characteristics. Our data thus fully confirm the hypothesis regarding a different regional floristic composition along the North—South geographic gradient and are in full agreement with Blasi et al. [183]. The detection of six subclusters based on native and total taxa is consistent with the results by Abbate et al. [186], that highlighted how Italian regions cluster in six groups based on native woody genera; however, such groups are only partially consistent with ours in terms of included regions. Furthermore, our results do not confirm the strong phytogeographic isolation of Sardegna highlighted by Peruzzi et al. [185] and Abbate et al. [186], and the relative isolation of Puglia with respect to other southern Italian peninsular regions found by Peruzzi et al. [185]. This evidence suggest that the reliable evaluation of the floristic similarities between different areas (regions, countries, etc.) is only possible with complete data (i.e., all species and subspecies) on vascular flora.

We have found that only 310 taxa (4.11%) are common to all regions, while 2141 (28.37%) result exclusively present in a single administrative Italian region. Almost half of this 2141 native taxa (i.e., 1026 taxa) are classified as regional endemic [33] with a restricted range and therefore worthy of protection [47]. Notable examples are: *Armeria helodes* (Friuli-Venezia Giulia), *Astragalus siculus* (Sicilia), *Athamanta cortiana* (Toscana), *Campanula elatines* (Piemonte), *Campanula reatina* (Lazio), *Centaurea leucadea* (Puglia), *Genista tenorei* (Basilicata), *Hieracium semicanescens* (Emilia-Romagna), *Linaria tonzigii* (Lombardia), *Lonicera stabiana* (Campania), *Moehringia papulosa* (Marche), *Nigritella buschmanniae* (Trentino-Alto Adige), *Pilosella sciadogena* (Umbria), *Pinguicula lattanziae* (Liguria), *Poa magellensis* (Abruzzo), *Polygala sardoa* (Sardegna), *Ranunculus bovioi* (Valle d'Aosta), *Saxifraga berica* (Veneto) and *Soldanella calabrella* (Calabria). More generally, the northernmost regions are mostly characterized by Alpine endemics and Central or Orophyte European taxa such as *Alchemilla helvetica*, *Artemisia glacialis*, *Dianthus furcatus* subsp. *lereschii*, *Euphrasia alpina*

subsp. *christii*, *Hornungia alpina* subsp. *austroalpina*, *Jacobaea alpina*, *Pedicularis rosea* subsp. *allionii*, *Sabulina austriaca*, *Sempervivum glaucum*, *Soldanella minima*, *Taraxacum venustum*, *Trisetaria alpestris* and *Valeriana celtica* subsp. *celtica*. On the contrary, the native flora of the southern regions is more characterized by South Italian endemic taxa and with Mediterranean distribution such as *Carex panormitana*, *Crepis rubra*, *Genista etnensis*, *Lathyrus jordanii*, *Rumex scutatus* subsp. *glaucescens*, *Sabulina verna* subsp. *grandiflora*, *Saponaria sicula* and *Stipa austroitalica* subsp. *austroitalica* (Table S5).

As is known, latitude is not an ecological factor directly affecting plant diversity [187]. In accordance with Kessler et al. [188], numerous ecological factors (e.g., climatic and soil characteristics) that vary with latitude may be responsible for creating latitudinal diversity patterns in Italy. Our results at the regional level suggest that the higher values of richness and density of native taxa can be correlated to the environmental diversification of the same regions. Nowadays, it is mainly the wet areas and the presence of islands and mountain massifs that determine a greater plant diversity. Factors directly related to elevation (e.g., temperature, rainfall, light intensity, nitrogen availability) are indicated as the main factors that regulate the distribution and number of taxa [189,190]. Despite most of the studies on species richness variation along elevational gradients found either a monotonic decline with increasing elevation or a hump-shaped pattern with a mid-elevational peak [191–193], the presence of high mountains favors the processes of plant speciation. Indeed, in recent years, many species were discovered or described for mountain areas also in Italy [194–196].

Instead, analyzing the effect of the alien flora alone, the presence of two large groups of regions are highlighted both in the dendrogram (Figure 5B) and in the biblot (Figure 5E); one includes only the continental regions (except Valle d'Aosta and Liguria), and the other all the other regions. In other words, the alien taxa currently present in continental Italy are, at least in part, different from those found in the rest of Italy including the islands. Indeed, of the 1603 exotic reported at national level only 35 (2.18%) are reported in all Italian regions such as *Ailanthus altissima* (Mill.) Swingle, *Datura stramonium* L., *Erigeron sumatrensis* Retz., *Robinia pseudoacacia* L. and *Sorghum halepense* (L.) Pers. In addition, all northern regions (except Valle d'Aosta and Liguria) are distinguished from others by only four exclusive alien taxa that are *Bidens lanceolata*, *Elodea nuttallii*, *Spiraea salicifolia* and *Sporobolus neglectus* (Table S5). All these data also confirm our hypothesis regarding an increase in similarities between regions due to the introduction of non-native species. However, these results are surprising because one would expect a greater similarity between the alien floras of each region. In fact, it is known that non-native taxa can promote homogenization in living systems all over the world [197]. Fortunately, although some regions show a large rate of alien taxa (see Table 2 and Figure 3), the presence of exotics did not alter the ability to distinguish the regions on the basis of their total flora (Figure 5C,F). This pattern of plant distribution in the Italian regions would seem to indicate the presence of a strong phytoclimatic driver (e.g., greater extension and intensity of the Mediterranean climate in the southern regions), which influences the overall similarity between the regional floras, largely overcoming historical factors, and shaping the North—South clustering of regions along the Italian Peninsula.

Regarding the new regional floristic index (RFI) proposed by us here, we point out that its range (i.e., the difference between the maximum and minimum value) resulted significantly greater when applied to only regional alien taxa (FRI*a*) compared to only native taxa (FRI*n*) (i.e., 1.524 vs. 0.542). These results suggest that, at least in the richest (Trentino-Alto Adige for aliens and Toscana for natives) and poorest regions (Valle d'Aosta both for aliens and natives) of taxa, the alien component contributes more than the native one to sharpen the differences between regions. As new introductions of alien species are expected to increase in the coming years [198], this gap will likely widen.

## 5. Conclusions

As far as we know, Italy is the only country in the Mediterranean basin that has continuously updated floristic knowledge at the regional level. Our study represents a

step towards a better understanding of its floristic diversity. The data obtained confirm the important role of floristic investigations in the field and in herbaria, as well as the collaborative approach among botanists. Overall, we recorded or confirmed, for the first time in Italy and Europe, four alien vascular plant taxa, including *Oxalis brasiliensis* cited as historically present in Italy based on herbarium samples. On the contrary, no major native species (i.e., floristic novelties) for the Italian vascular flora were found by us in the field or in the herbaria consulted. Analysis of the data thus allowed us to update the number of plant taxa present in Italy today (which amount to 7547 native and 1603 exotic taxa) and to evaluate the degree of floristic similarity between administrative regions. We found that the regional floras have a clear distribution along the latitudinal gradient and this pattern is not affected by the introduction of alien species. On the basis of the available literature, this appears to be the first study that statistically analyzed the similarities between the Italian regions considering separately the native, alien and total vascular plants currently occurring in these areas.

The next step should be to improve the knowledge on the distribution of taxa through the georeferencing of occurrences. This information will be useful to better define the areas richest in taxa and to investigate the drivers related to the plant distribution patterns in Italy. However, we believe that several problems will have to be addressed by botanists in the coming years. Among these, there is certainly the need to standardize the methods for attributing invasive status to taxa found outside their original range. Additionally, given the taxonomic problems highlighted by many authors for several critical groups, further studies are required to properly assess the floristic composition of Italian vascular flora.

**Supplementary Materials:** The following are available online at https://www.mdpi.com/article/10.3390/d13110600/s1, Table S1: Details on the collected floristic data (i.e., exsiccata and observata), Table S2: Exclusive endemic taxa of a single Italian region, Table S3: Values of R*en*, R*ea*, D*tn*, D*ta*, DN*tn*, DN*ta* and R*ee* for each region, Table S4: Values of RFI*n*, RFI*a* and RFI*t* for each region, Table S5: List of the exclusive native and alien taxa of the main clusters groups in the dendrograms of the agglomerative hierarchical clustering.

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diversity

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*Article*

# New Chorological Data for the Italian Vascular Flora

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**Abstract:** Despite the importance for scientific and conservation purposes, the knowledge of the Italian territory is far from exhaustive. New chorological data for 87 vascular taxa regarding the central-southern part of Italy and its two main islands (Sicilia and Sardegna) are presented. Among these taxa, *Epilobium nummularifolium*, *Metrosideros excelsa*, and *Salvinia minima* are recorded as casual aliens for the first time in Europe (excluding Azores and Madeira for *M. excelsa*), while *Cyclamen balearicum* and *Polygala rupestris* are reported for the first time and confirmed for Italian native flora, respectively. Furthermore, several taxa are new or confirmed at regional level. Finally, *Lathyrus cirrhosus*, *Urginea fugax*, and *Linum tenuifolium* are excluded from Italy, continental and peninsular Italy, and Sardegna, respectively.

**Keywords:** alien species; endemic plants; checklist; new floristic records; plant diversity

## 1. Introduction

Over the past 20 years, floristic studies of the central-southern Italian Peninsula have greatly improved our knowledge of the flora of this region [1–15] and some syntheses at the national scale [16–22] have been made available.

However, despite the importance for scientific and conservation purposes, our knowledge of the Italian territory is far from exhaustive. In particular, in some regions of Italy, knowledge about the vascular flora remains inadequate usually because the geographic distributions of many species are poorly understood resulting in gaps in our knowledge of their actual extent [23]. This is the so-called "Wallacean shortfall," that is considered one of the crucial sources of uncertainty in biodiversity inventories, limiting both biosystematic and ecological analyses of these [24,25] and resulting in some exceptional discoveries when critical gaps are surveyed, such as finding of a new taxon of

*Gymnospermium* (Berberidaceae) in an unexplored mountain range between Basilicata and Campania [26,27]. Further biological invasions represent a major threat to biodiversity [28,29], particularly as new naturalizations of alien vascular plants are continuously happening and are usually poorly documented within regional flora treatments. This is particularly the case on Mediterranean islands [30]. As a consequence, it is important that frequent assessment of regional floras are undertaken, not only to monitor the established populations (indigenous and naturalized), but also to update the distribution data to enable early warning of declines in indigenous or endemic species, and to document new arrivals of invasive plants, as an aid to better manage the invasive ones, particularly those species included in the European list of EU concern [31].

In this paper we document new observations of plants for the central-southern Italian Peninsula and the two main insular regions (Figure 1). Our records include both native and alien non-cultivated species with a careful assessment of the status of naturalization for the latter. For each taxon, relevant information about ecology and distribution are also provided.

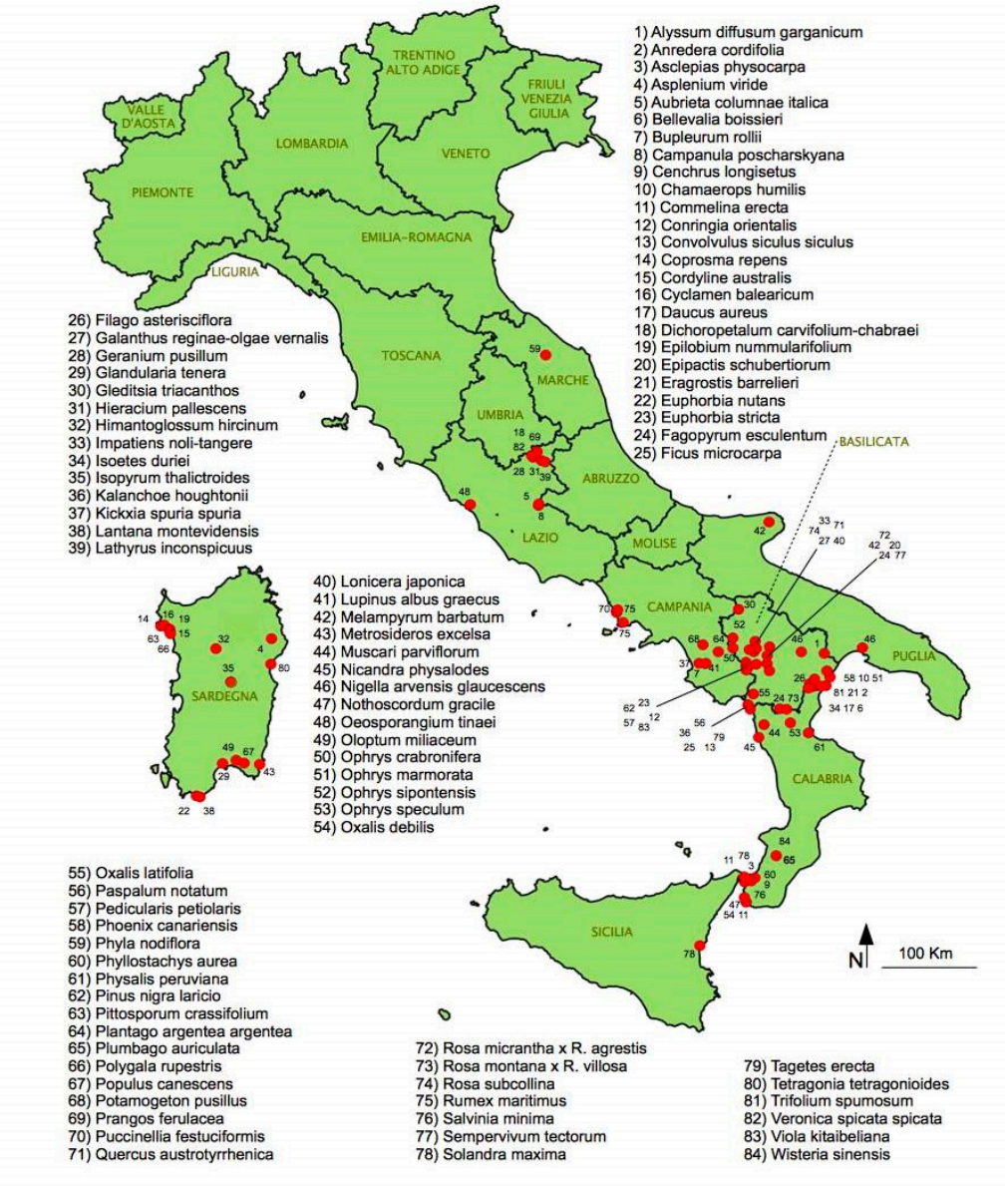



**Figure 1.** Research area with administrative Italian regions and locations of the new records of vascular plants reported in this study. We considered "continental Italy" the regions north to Toscana and Marche, "peninsular Italy" the other regions of Italian peninsula and "insular Italy" the Sardegna (Sardinia) and Sicilia (Sicily) regions.

## 2. Materials and Methods

The floristic data are based on field investigation carried out by the authors in the study area, as well as on herbaria and literature surveys. The collected or examined materials are preserved in public (ANC, AK, HLUC, PORUN-Herb. Stinca, REGGIO, SS; acronyms according to Thiers [32]) or private herbaria. In the floristic list (Appendix A), taxa are arranged in alphabetical order. Nomenclature, taxa delimitation, and notes on the regional distribution follow the recent checklists of the Italian vascular flora [16,17] and their updates [33–40]. Nomenclature of the species that had not been previously reported from Italy and of *Populus* ×*canescens* follows World Flora Online [41]. The taxa recorded in this paper were identified using Flora Europaea [42–46], Flora d'Italia [18–21,47], and some monographic works cited in the species' note listed in Appendix A.

For each species the following information is provided: basionym and most relevant synonyms; plant family; life form, attributed on the basis of field observations using the categories of Flora d'Italia [47]; native range; period of introduction (archaeophyte or neophyte); data report in the study area; current invasiveness status for each region, assessed by population monitoring over time according to the terminology of Pyšek et al. [48]; date and discovery localities with details on the location (municipality, administrative province), habitat, altitude, decimal degrees geographic coordinates (datum WGS84); collector(s) (*legit*), author(s) of the identification (*determinavit*) and, eventually, the identity confirmation (*confirmavit*); herbarium where specimen is kept; additional notes. Species not documented with a herbarium specimen are shown in Figure 2.




**Figure 2.** Species not documented by herbarium specimens in Appendix A: (**A**) *Ophrys crabronifera*, (**B**) *O. marmorata*, (**C**) *O. speculum*, (**D**) *O. sipontensis*.

## 3. Results

Two native and four alien species are recorded for the first time in Italy; among the aliens, three species deserve more attention since they are new for Europe. Overall, 87 taxa of floristic interest for the Italian flora are herein reported, 50 are native and 37 represent alien taxa. Among the native plants seven are endemic taxa of the Italian territory.

### *3.1. Native taxa*

*Cyclamen balearicum* and *Polygala rupestris* discovered in Sardegna are recorded for the first time in Italy, while *Euphorbia stricta* found in Basilicata is recorded as new for peninsular Italy (i.e., the regions south to Toscana and Marche, Sicilia and Sardegna excluded). *Lathyrus cirrhosus*, previously reported by [49], is here excluded from the Sardinian and Italian flora.

In the same way, *Linum tenuifolium* reported from Sardegna [50] and *Urginea fugax* from Basilicata [51] are not confirmed throughout this study. These species seem to have been recorded by mistake and are here excluded from the floras of these regions.

Thirty-four taxa are new for the regional floras of the study area: 6 were found in Lazio (*Dichoropetalum carvifolium-chabraei, Geranium pusillum*, *Hieracium pallescens s.l.*, *Lathyrus inconspicuus*, *Oeosporangium tinaei*, and *Veronica spicata* subsp. *spicata*), 6 in Campania (*Bupleurum rollii*, *Kickxia spuria* subsp. *spuria*, *Lupinus albus* subsp. *graecus*, *Plantago argentea* subsp. *argentea*, *Potamogeton pusillus*, and *Rumex maritimus*), 17 in Basilicata (*Alyssum diffusum* subsp. *garganicum*, *Bellevalia boissieri*, *Convolvulus siculus* subsp. *siculus*, *Daucus aureus*, *Epipactis schubertiorum*, *Eragrostis barrelieri* subsp. *barrelieri*, *Euphorbia stricta*, *Filago asterisciflora*, *Galanthus reginae-olgae* subsp. *vernalis*, *Isoetes duriei*, *Melampyrum barbatum* subsp. *carstiense*, *Nigella arvensis* subsp. *glaucescens, Ophrys crabronifera*, *Ophrys marmorata*, *Ophrys sipontensis*, *Quercus petraea* subsp. *austrotyrrhenica*, *Rosa subcollina*, and *Sempervivum tectorum*) and 4 in Sardegna (*Asplenium viride, Himantoglossum hircinum*, *Isopyrum thalictroides*, and *Oloptum miliaceum*).

In addition, two hybrids within the genus *Rosa* are reported in Basilicata for the first time (*R.* × *bishopii* and *R. montana* × *R. villosa*) and one (*Populus* ×*canescens*) in Sardegna. We also confirm 10 taxa as present in the regions covered by this paper: *Prangos ferulacea* in Lazio; *Pedicularis petiolaris, Potamogeton pusillus, Puccinellia festuciformis* subsp. f*estuciformis,* and *Viola kitaibeliana* in Campania; *Trifolium spumosum* in Basilicata; *Melampyrum barbatum* subsp. *carstiense* and *Nigella arvensis* subsp. *glaucescens* in Puglia, *Muscari parviflorum* and *Ophrys speculum* in Calabria region. Finally, for one species (*Impatiens noli-tangere*), reported for the first time in Basilicata in the recent checklist of the Italian vascular flora [16] on the basis of our unpublished data, full details about the record are provided.

### *3.2. Alien taxa*

Three alien species are recognized new for Europe (excluding Azores and Madeira for *M. excelsa*) and for Italy: *Epilobium nummularifolium, Metrosideros excelsa,* found in Sardegna, and *Salvinia minima,* found in Calabria. In the same regions, we found *Coprosma repens*, *Pittosporum crassifolium* (Sardegna) recorded for the first time in Italy, and *Commelina erecta,* recorded for the first time in Italy (Calabria) outside Sicilia. In addition to those species, 31 new alien vascular species are reported at regional level (two of these are present in two regions): 2 in Lazio (*Aubrieta columnae* subsp. *italica* and *Campanula poscharskyana*); 2 in Campania (*Conringia orientalis* and *Pinus nigra* subsp. *laricio*); 12 in Basilicata (*Anredera cordifolia, Chamaerops humilis, Euphorbia nutans, Fagopyrum esculentum, Ficus microcarpa, Gleditsia triacanthos, Kalanchoë* ×*houghtonii, Lonicera japonica, Paspalum notatum*, *Phoenix canariensis, Pinus nigra* subsp. *Laricio,* and *Tagetes erecta*); 12 in Calabria (*Asclepias physocarpa*, *Cenchrus longisetus*, *Commelina erecta*, *Nicandra physalodes*, *Nothoscordum gracile*, *Oxalis debilis*, *Oxalis latifolia*, *Phyllostachys aurea*, *Physalis peruviana, Plumbago auriculata, Solandra maxima,* and *Wisteria sinensis*); 1 in Sicilia (*Solandra maxima*); 4 in Sardegna (*Cordyline australis*, *Euphorbia nutans*, *Glandularia tenera,* and *Lantana montevidensis*). Furthermore, the presence of *Phyla nodiflora* in Marche, *Fagopyrum esculentum*

in Calabria (herein recorded as new also in Basilicata) and *Tetragonia tetragonoides* in Sardegna is confirmed.

## 4. Discussion

We reported 50 native taxa for the regions covered in this paper, including several endemic Italian taxa that are range extensions from their previous reported limits. The discovery in Sardegna of *Cyclamen balearicum* and *Polygala rupestris*, two species that had until now not been recorded for Italy, is particularly relevant because their presence provides additional support for the biogeographical link between Sardegna and the W-Mediterranean areas [52–54].

In the same way, the numerous neophytes reported for the first time in the regional floras once again confirm that alien species are continuously invading the environment. Although the majority of the recorded species have been evaluated with respect to their naturalization degrees as "casual," their monitoring over time is considered of primary importance in order to be able to effectively intervene if these species prove to be highly invasive. One especially noteworthy discovery is *Salvinia minima*, a species known to be invasive in most of the southern United States, where it is a significant threat to aquatic systems [55]. *Salvinia minima* is widely available for purchase for aquaria and water-gardens in Europe. Accordingly, we think that this species established in Italy from the aquatic plant trade, probably as an accidental introduction. The high number of floristic records of international and regional relevance provided, after a very short time from the publication of the latest Italian vascular flora checklist [16,17], even if not derived from a systematic sampling activity, testify of the importance to continuously implement our knowledge of plant diversity, especially for conservation purposes, studying and reviewing herbaria collections, coupled with frequent field surveys with special attention to achieve an early warning to monitor introduction and naturalization of alien taxa.

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**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

***Alyssum diffusum* Ten. subsp. *garganicum* Španiel, Marhold, N. G. Passal. and Lihová**
Brassicaceae Hemicryptophyte scapose Italian endemic
*First record for Basilicata*
Specimen: 8-4-2011, Difesa S. Biagio (Montescaglioso, Matera province), rocky outcrop within dry grassland, 155 m a.s.l., 40.5044° N-16.6876° E, *leg. et det* S. Fascetti (HLUC).
*Note:* This endemic taxon was until now recorded only for Puglia region [56]. It is noteworthy to underline the presence in Basilicata of two infraspecific taxa of *Alyssum diffusum*: the subspecies *calabricum* Španiel, Marhold, N. G. Passal. and Lihová in the Campano-Lucano Apennine, along the border with Campania and Calabria regions [16] and the subsp. *garganicum* in the easter part, along the border in Puglia region.

***Anredera cordifolia* (Ten.) Steenis** [≡ *Boussingaultia cordifolia* Ten.]
Basellaceae Phanerophyte climbing Neophyte, S-America
*First record for Basilicata* (casual)
Specimen: 15-6-2014, Lido di Policoro (Policoro, Matera province), roadside, 40.17361° N-16.70099° E, 3 m a.s.l., *leg*. G. Salerno *et* M.R. Lapenna, *det*. G. Salerno (Herb. Salerno).

*Note:* Casual or naturalized alien species in most of the peninsular and insular regions except for Umbria [17]. It is considered an invasive taxon in Toscana [17].

***Asclepias physocarpa* (E. Mey.) Schltr.** [≡ *Gomphocarpus physocarpus* E. Mey.]
Apocynaceae Phanerophyte caespitose Neophyte, S-Africa
*First record for Calabria* (casual)
Specimen: 1-7-2019, Campo Calabro (Reggio Calabria province), roadside, 38.20633° N-15.64897° E, *leg*. V.L.A. Laface, *det*. V.L.A. Laface *et* G. Spampinato (REGGIO).
*Note:* Five plants were recorded along the road, mixed with *Hyparrhenia hirta* (L.) Stapf. subsp. *hirta* and *Rubus ulmifolius* Schott. It was previously recorded as casual or naturalized alien species only in Toscana, Campania, and Sicilia regions [17].

***Asplenium viride* Huds.**
Aspleniaceae Hemicryptophyte rosulate Circumboreal
*First record for Sardegna*
Specimen: 14-5-2013, Monte Albo (Siniscola, Nuoro province), 40.54141° N-9.62394° E, sinkhole shaft in montane karstfield, 880 m a.s.l., *leg. et det*. P.J. de Lange (AK, SS).
*Note.* Recorded from all regions of Italy except for Puglia and doubtfully for Basilicata, but until now absent in the insular regions (Sardegna and Sicilia) [16]. However, *Asplenium viride* had been reported from Sardegna from a locality close to Fluminimaggiore (Iglesiente, South-western Sardegna) from where it has not since been seen [57]. Recently Ballero et al. [57] suggested its exclusion from the flora of Sardegna.
Image available at: https://inaturalist.nz/observations/4046536

***Aubrieta columnae* Guss. subsp. *italica* (Boiss.) Mattf.** [≡ *A. italica* Boiss.]
Brassicaceae Chamaephyte subshrubs Italian endemic
*First record for Lazio* (naturalized)
Specimen: 5-8-2019, Old town (Anticoli Corrado, Roma province), old walls, 500 m a.s.l., 42.00991° N-12.99103° E, *leg. et det.* L. Rosati (HLUC).
*Note:* A small population of this Italian endemic taxon, which grows in nature only in Puglia (Gargano peninsula) and doubtfully in Basilicata, was observed for over 10 years in anthropogenic habitat at Anticoli Corrado (Rosati, pers. observ.). These individuals have spread by seeds from a nearby cultivated plant in pots and urban gardens. Our specimens were identified using the key by [58].

***Bellevalia boissieri* Freyn** [≡ *Bellevalia dubia* (Guss.) Kunth subsp. *boissieri* (Freyn) Feinbrun]
Asparagaceae Geophyte bulbouse E-Mediterranean
*First record for Basilicata*
Specimen: 28-3-2018, Iazzo di Tucci (Rotondella, Matera province), olive groves, 40.17157° N-16.53832° E, 298 m a.s.l., *leg*. G. Salerno *et* G. Misano, *det*. G. Salerno (Herb. Salerno).
*Note:* Until these discoveries this species was known from Italy only from the Calabria region [16].

***Bupleurum rollii* (Montel.) Moraldo** [≡ *B. gracile* d'Urv. var. *rollii* Montel.]
Apiaceae Therophyte scapose Italian endemic
*First record for Campania*
Specimen: 8-9-2013, Monte Vesole (Roccadaspide, Salerno province), chestnuts, 580 m a.s.l., 40.41156° N-15.16761° E, *leg. et det.* G. Salerno (Herb. Salerno).
*Note.* This Italian endemic had previously been recorded from Lazio to Sicilia, but not from Campania [16].

***Campanula poscharskyana* Degen**
Campanulaceae Hemicryptophyte scap Neophyte, SE-European (Dinarides)
*First record for Lazio* (casual)
Specimen: 5-8-2019, Old town (Roviano, Roma province), calcareous rock crevices, 495 m a.s.l., 42.02565° N-12.99403° E, *leg. et det.* L. Rosati (HLUC).

*Note:* This alien species was reported as casual or naturalized only in Lombardia, Veneto, and Toscana [17].

***Cenchrus longisetus* M. C. Johnst.** [= *Pennisetum villosum* R. Br. ex Fresen.]
Poaceae Hemicryptophyte caespitose Neophyte, Paleotropical
*First record for Calabria* (casual)
Specimen: 16-6-2019, San Roberto (Reggio Calabria province), sidewalks, 280 m a.s.l., 38.21074° N-15.736° E, *leg*. V.L.A. Laface, *det*. V.L.A. Laface, C.M. Musarella *et* G. Spampinato (REGGIO).
*Note:* Collected from the margins of sidewalks where it was probably derived from a nearby flowerbed. This species has been recorded from Italian regions as casual or naturalized [17]; only in Sardegna is it considered invasive [17].

***Chamaerops humilis* L.**
Arecaceae Nano-phanerophyte Neophyte, W-Mediterranean
*First record for Basilicata* (casual)
Specimen: 14-12-2017, S. Basilio, Marina di Pisticci (Pisticci, Matera province), clearings in mediterranean maquis, 3 m a.s.l., 40.2998° N-16.78265° E, *leg. et det.* S. Fascetti (HLUC).
*Note:* Although this palm is indigenous to the neighboring regions of Campania and Calabria [16], it has not been recorded in the previous flora of Basilicata [51]. Therefore, as for the neighboring Puglia region [16], we consider it as introduced to this region. Plants probably spread from cultivation as the species was present in the nearby gardens, and only juvenile plants and seedlings were observed.

***Commelina erecta* L.**
Commelinaceae Terophyte crawling Archeophyte, C-America
*First records for Calabria and peninsular Italy* (casual)
Specimens: 23-6-2019, Lazzaro (Motta San Giovanni, Reggio Calabria province), crevices between road and sidewalks, 16 m a.s.l., 37.97394° N-15.66507° E, *leg. et det*. C. M. Musarella (REGGIO); 25-6-2019, Catona (Reggio Calabria, Reggio Calabria province), sidewalks, 22 m a.s.l., 38.17987° N-15.64811° E, *leg*. V.L.A. Laface, *det*. V.L.A. Laface, C.M. Musarella *et* G. Spampinato (REGGIO).
*Note:* Observed growing in crevices and on the edge of the roadside. Probably escaped from plants cultivated in pots placed on sidewalks. It was recently reported for the first time in Italy in Sicilia by [38].

***Conringia orientalis* (L.) Andrz. ex DC.** [≡ *Brassica orientalis* L.; ≡ *Gorinkia orientalis* (L.) J. Presl and C. Presl]
Brassicaceae Therophyte scapose Neophyte, W-Asia
*First record for Campania*(casual)
Specimen: 15-5-2018, Campitello, Monti della Maddalena (Padula, Salerno province), forest edges, along a track, 1270 m a.s.l., 40.3452° N-15.68886° E, *leg*. S. Fascetti, *det* S. Fascetti *et* L. Rosati (HLUC).
*Note:* It is considered an archaeophyte associated with cereal crops, as stated for example in a previous record for Basilicata [59]. However, our finding of *C. orientalis* was in a silvo-pastoral habitat, quite far from cultivated areas.

***Convolvulus siculus* L. subsp. *siculus***
Convolvulaceae Therophyte scapose S-Mediterranean
*First record for Basilicata*
Specimen: 12-3-2012, Torre Caina (Maratea, Potenza province), clearings in mediterranean maquis, 39.94319° N-15.73534° E, 880 m a.s.l., *leg. et det*. G. Salerno (Herb. Salerno).
*Note:* It was previously recorded in Liguria, Toscana, Lazio, Campania, Puglia, Sicilia, and Sardegna regions [16].

***Coprosma repens* A. Rich.**
Rubiaceae Nano-phanerophyte Neophyte, New Zealand

*First record in Italy* (casual)
Specimen: 10-03-2013, Torre Nuova, Porto Conte (Alghero, Sassari Province), occasional shrubs growing by old Spanish tower near beach, 2 m a.s.l., 40.593647° N-8.20430° E, *leg. et det*. P.J. de Lange (AK).
*Note:* Growing among *Myoporum laetum* G. Forst., *M. aff. insulare* R. Br., *M. laetum* × *M. aff. insulare*. Plants with flower buds, seedlings present. In Europe, although it has been recorded only from Great Britain [60], this species was commonly seen by PdL along the coastline of southern France (1999, 2013), and northern Spain (Catalonia) (2013). It seems surprising it has not naturalized further as under the vernacular "mirror bush" it is recorded as an aggressive invasive species throughout much of the world [61].

***Cordyline australis* (G. Forst.) Endl.** [≡ *Dracaena australis* G. Forst.]
Asparagaceae Phanerophyte scapose Neophyte, New Zealand
*First record for Sardegna* (casual)
Specimen: 12-3-2012, Via Tarragona (Alghero, Sassari province), courtyard garden 30 m a.s.l., 40.55422° N-8.32475° E, *leg. et det*. P.J. de Lange (AK, SS).
*Note:* Seedling collected from rank grassland within inner courtyard garden. Growing close to planted adult fruiting trees. Although this species is a very commonly cultivated tree in Sardegna, so far, only sparingly naturalizing. This may be because mostly only one clone is grown, and the species is self-incompatible [62]. Outside Sardegna this species has been reported as a casual alien only in Marche, Abruzzo, and Campania [17].

***Cyclamen balearicum* Willk.** [≡ *C. repandum* Sm. subsp. *balearicum* (Willk.) O. Schwarz]
Primulaceae Geophyte bulbouse NW-Mediterranean
*First record for Italy (Sardegna)*
Specimen: 20-4-2008, Monte Doglia (Alghero, Sassari province), evergreen woodlands of *Prasio majoris-Quercetum ilicis chamaeropetosum humilis,* 40.60742° N-8.24683° E, 190 m a.s.l., *leg. et det.* E. Farris (SS).
*Note: Cyclamen balearicum* differs from *C. repandum* in having leaves usually adaxially speckled with white and flowers that are either fully white or with a white-veined pale pink corolla [42]. Recent research [63,64] highlighted the presence of a hybrid zone between *Cyclamen repandum* and *C. balearicum* in NW Sardegna, where hybrid plants displaying bi-colored flowers prevail, and pure *C. balearicum* plants were scarce. However, based on the original observations, at Mt. Doglia plants with small white flowers and non-exerted stigma are dominant, though only occasional individuals have the diagnostic leaf ornamentation of *C. balearicum s.s.* The nearest known localities of this species according to Flora Gallica and Flora Iberica are in Corsica (France), Provence (S-France), and Balearic Islands (Spain).

***Daucus aureus* Desf.**
Apiaceae Therophyte scapose S-Mediterranean
*First record for Basilicata*
Specimen: 1-5-2019, Serra delle Grotte (Rotondella, Matera province), fallows on clay soils, 120 m a.s.l., 40.19691° N-16.49405° E, *leg*. G. Salerno *et* G. Misano, *det*. G. Salerno (Herb. Salerno).
*Note:* At present known only from Calabria and Sicilia [16]. There are historical doubtful records of this species from Liguria and Campania, respectively [16].

***Dichoropetalum carvifolium-chabraei* (Crantz) Soldano, Galasso and Banfi** [≡ *Selinum carvifolium-chabraei* Crantz; – *Holandrea carvifolia* Reduron, Charpin and Pimenov; = *Peucedanum carvifolium-chabraei* (Crantz) Soldano]
Apiaceae Hemicryptophyte scapose European-Caucasian
*First record for Lazio*

Specimen: 16-7-2015, Monte Tilia, Fondo del Laghetto (Leonessa, Rieti province), secondary grassland with *Brachypodium genuense*, marly-calcareous slopes, 1400 m a.s.l., 42.55842° N-12.95441° E, *leg. et det.* E. Del Vico (Herb. Del Vico).
*Note:* In Italy it is reported in many northern and central regions and in Sicilia [16].

***Epilobium nummularifolium* R. Cunn. ex A. Cunn.**
Onagraceae Hemicryptophyte crawling Neophyte, New Zealand
*First record for Italy* (casual)
Specimen: 24-04 2013, via Castelsardo (Alghero, Sassari province), damp ground on side of road adjacent pasture used for hay making, 6 m a.s.l., 40.57221° N-8.32010° E, *leg. et det.* P.J. de Lange (AK, SS).
*Note:* Image of *Epilobium nummularifolium* at this locality available at: https://inaturalist.nz/observations/4437892.

*Epilobium nummularifolium* is apparently not known wild elsewhere in greater Europe [65]. However, this species has a superficial similarity to *E. brunnescens* (Cockayne) Raven et Engelhorn subsp. *brunnescens*, which is abundantly naturalized in the British Isles, and reported from the Guernesy Islands, so it is possible that it has been confused with that species, and so overlooked [65]. *E. nummularifolium*, a New Zealand endemic, is well-known for its aggressive, weedy nature. Raven and Raven [65] argue that this species was once a narrow range endemic of northern New Zealand, which has spread throughout that archipelago as a garden plant pot contaminant. We suspect that this is how it has reached Sardegna, i.e., as a possible soil/garden plant contaminant, introduced alongside anyone of the many New Zealand indigenous/endemic plants seen there in cultivation. This species should be looked for elsewhere in Europe. *Epilobium nummularifolium* is distinguished from both *E. brunnescens* and *E. komarovianum* H. Lev, which is also naturalized in Europe [65] by the yellow-green, serrulate leaves, purple-blue stems, and grey-strigulose capsules [65–68] (Table A1, Figure A1). These species are keyed out as follows:

***1.*** Adaxial leaf surface deeply rugose-impressed..... *E. komarovianum*
***1.*** Adaxial leaf surface smooth, not rugose-impressed..... .. *2*
***2.*** Leaves yellow-green, with red margins, serrulate bearing 2-11 pairs of teeth either side of midrib; stems purple-blue, capsules grey-strigulose..... *E. nummularifolium*
***2***. Leaves dark green, tinged red or brown, entire or with 1-4 pairs of indistinct teeth either side of midrib, capsules glabrate, rarely very sparsely hairy..... .....*E. brunnescens*

**Table A1.** Distinguishing characters between three New Zealand creeping *Epilobium* species naturalized in Europe/British Isles.

| | ***E. brunnescens* subsp. *brunnescens*** | ***E. komarovianum*** | ***E. nummularifolium*** |
|---|---|---|---|
| **Growth habit** | Densely matted, creeping herb forming patches up to 1 m diameter | Matted, creeping herb forming patches of tightly appressed stems and leaves up to 1 m diameter (usually less) | Loosely matted, creeping herb patches up to 1 m diameter |
| **Stems** | Light brown | Yellow-green | Purple-blue |
| **Leaves** | Dull green often with a red or brown-tinge, bearing 0–1(–2) obscure lateral veins either side of midrib; lamina 1.5–13.0 × 1.5–12.0 mm ovate to broadly ovate, apex rounded to obtuse, base obtuse to truncate, entire, rarely with 1–2(–4) weakly | Dull reddish-green to coppery, adaxially rugose-impressed, bearing 1–4 lateral veins on each side of the midrib; lamina 2.0–12.0 × 1.5–9.0 mm, usually orbicular, but occasionally oblong or ovate (sometimes with all forms on the same plant), apices subacute to obtuse, base attenuate to obtuse, | Yellowish-green, usually with red margins and 1–3(–4) inconspicuous lateral veins on either side of the midrib; lamina 3.0-13.0 × 3-11.0 mm, broadly ovate to oblate, obtuse or rounded at apex, rounded to truncate at base, |

| | | | |
|---|---|---|---|
| | developed teeth on each margin | entire or occasionally with 1–3 remote, weak teeth on each side of leaf | margins remotely and shallowly serrulate with 2–11 teeth on either side |
| **Flowers** | Flowers nodding, falling before full pedicel elongation is achieved | Flowers falling before full pedicel elongation is achieved | flowers falling when pedicel elongation is complete |
| **Capsules** | Capsule glabrate or sparsely hairy, indumentum of appressed glandular or erect glandular or glandular hairs running along lines of dehiscence, 12–60 mm long, borne on a glabrous pedicel (16–)35-80(–120) mm long | Capsule subglabrous or sparsely furnished with hairs, 4–30 mm long, borne on a pedicel 3–93(–135) mm long | Capsule densely grey-strigulose, (10-)15–40 mm long, borne on a strigulose pedicel 23–130 mm long |




**Figure 1.** Comparison images of three New Zealand creeping *Epilobium* species naturalized in Europe/British Isles: (**A**) *Epilobium brunnescens* subsp. *brunnescens* fruiting plant showing growth habit, Mt Te Aroha, North Island, New Zealand, image: P.J. de Lange; (**B**) *E. komarovianum*, flowering plant with immature capsules, showing distinctive rugose-impressed leaves, Long Point, Otago, South Island, New Zealand, image: J.W. Barkla; (**C**) *E. nummularifolium*, vegetative material showing growth habit, note stem and leaf color and toothed leaf margins; Alghero, Sardegna, image: P. J. de Lange; (**D**) *E. nummularifolium* flowering and fruiting plant (note greyish color of capsules); Centre Road, Otago Peninsula, South Island, New Zealand image: D. Lyttle.

***Epipactis schubertiorum* Bartolo, Pulv. and Robatsch** [≡ *Epipactis helleborine* (L.) Crantz subsp. *schubertiorum* (Bartolo, Pulv. and Robatsch) Kreutz]
Orchidaceae Geophyte rhizomatous Italian endemic
*First record for Basilicata*

Observatum: 25-7-2017, Abetina di Laurenzana (Viggiano, Potenza province), *Abies alba* and *Quercus cerris* forest, 1130 m a.s.l., 40.40708° N-15.95478° E, *leg*. *et det.* V.A. Romano (HLUC).
*Note:* This Italian endemic species had previously been recorded only from Puglia and Calabria [16].

***Eragrostis barrelieri* Daveau subsp. *barrelieri***
Poaceae Therophyte scapose S-Mediterranean
*First record for Basilicata*
Specimen: 16-6-2014, Concio, Sinni river (Policoro, Matera province), roadside, 40.17126° N-16.64227° E, 10 m a.s.l., *leg. et det.* G. Salerno (Herb. Salerno).
*Note:* In Italy it is recorded for some northern and central regions, Sicilia and Sardegna [16].

***Euphorbia nutans* Lag.** [≡ *Chamaesyce nutans* (Lag.) Small]
Euphorbiaceae Therophyte scapose. Neophyte, N-America
*First record for Basilicata* (casual) *and Sardegna* (casual)
Specimens: 3-8-2017, Porto (Maratea, Potenza province), roadside, 15 m a.s.l., 39.98978° N-15.70888° E, *leg.* A. Stinca *et* M. Eviano, *det*. A. Stinca (PORUN-Herb. Stinca); 20-8-2017, along SS18 road, close by loc. La Torre (Maratea, Potenza province), roadside, 60 m a.s.l., 40.03127° N-15.67405° E, *leg*. A. Stinca *et* M. Ravo, *det*. A. Stinca (PORUN-Herb. Stinca); 29-9-2019, Tuerredda (Teulada, Cagliari province), pots and paths along the dune, 2 m a.s.l., 38.89686° N-8.81394° E, *leg*. *et det*. L. Rosati *et* M. Marignani (HLUC).
*Note: Euphorbia nutans* was recorded as casual or naturalized alien in most of the Italian regions [17]. It is considered invasive in Lombardia and Veneto [17].

***Euphorbia stricta* L.** [= *Euphorbia serrulata* Thuill.]
Euphorbiaceae Therophyte scapose European-Caucasian
*First record for Basilicata and confirmation for peninsular Italy*
Specimen: 12-6-2018, Vascarano, Pergola (Marsico Nuovo, Potenza province), traditional arable land, 915 m a.s.l., 40.42385° N-15.68713° E, *leg. et det.* L. Rosati (HLUC).
*Note:* Previously, and reliably reported only from the northern Italian regions [16]; this record provides the first verified evidence of its presence in peninsular Italy. Previously it was considered as doubtfully present in Lazio [16], while it has not been recently recorded from Abruzzo and Calabria [16], and was apparently recorded by mistake from Sicilia [16].

***Fagopyrum esculentum* Moench**
Polygonaceae Therophyte scapose Neophyte, Asia
*First record for Basilicata* (casual) *and confirmation for Calabria* (casual)
Specimens: 7-9-2011, Diga Masseria Nicodemo, Lago di Cogliandrino (Lauria, Potenza province), fallows, mesic grasslands, 670 m a.s.l., 40.08151° N-15.93680° E, *leg. et det.* S. Fascetti (HLUC); 30-8-2017, Contrada Schiena La Torre (Verbicaro, Cosenza province), vegetable garden, 575 m a.s.l., 39.76166° N-15.89780° E, *leg. et det.* S. Fascetti (HLUC).
*Note:* This species is known with certainty only from the northern Italian regions [17]; otherwise considered doubtfully present in Lazio, and not recently confirmed from Abruzzo and Calabria (after 1950) [17]. In Basilicata it was observed escaping from small cultivated fields of buckwheat. In the Calabria region it was observed for some years as a weed of vegetable gardens and along arable land edges.

***Ficus microcarpa* L. f.** [– *Ficus retusa* auct. p.p., non L.]
Moraceae Phanerophyte scapose Neophyte, E-Asia
*First record for Basilicata* (casual)
Specimen: 3-8-2017, Porto (Maratea, Potenza province), walls and crevices in the road pavements, 5 m a.s.l., 39.98949° N-15.70868° E, *leg*. A. Stinca *et* M. Eviano, *det*. A. Stinca (PORUN-Herb. Stinca).
*Note:* Treated as a casual alien in Sardegna, Campania, and Puglia; naturalized in Sicilia [17]. Recently recorded in southern Italy for Calabria [14].

***Filago asterisciflora* (Lam.) Sweet** [≡ *Gnaphalium asterisciflorum* Lam.; ≡ *Evax asterisciflora* (Lam.) Pers.]
Asteraceae Therophyte crawling Steno-Mediterranean

*First record for Basilicata*
Specimen: 2-5-2019, Bosco Finocchio (Rotondella, Matera province), roadside, 40.15282° N-16.47588° E, 600 m a.s.l., *leg*. G. Salerno *et* G. Misano *det*. G. Salerno (Herb. Salerno).
*Note:* Previously *Filago asterisciflora* has been recorded from Toscana, Lazio, Campania, Puglia, Calabria, Sicilia, and Sardegna [16].

***Galanthus reginae-olgae* Orph. subsp. *vernalis* Kamari**
Amaryllidaceae Geophyte bulbouse European-Caucasian
*First record for Basilicata*
Specimen: 20-2-2014, Sellata (Pignola, Potenza province), beech forest, 1270 m a.s.l., 40.53127° N-15.78871° E, *leg. et det*. S. Fascetti (HLUC).
*Note:* Several plants observed in a large population extending for approximately 200 m$^2$. Previously reported from the Calabria and Sicilia regions [16].

***Geranium pusillum* L.**
Geraniaceae Therophyte scapose Eurasian
*First record for Lazio*
Specimen: 4-6-2015, Colle Pietrolone (Poggio Bustone, Rieti province), secondary grassland with *Bromus hordeaceus, Poa trivialis* and *Poa sylvicola*, gently marly slopes, 1070 m a.s.l., 42.50015° N-12.90332° E, *leg.* E. Del Vico *et* L. Facioni, *det*. E. Del Vico (Herb. Del Vico).
*Note:* It was previously recorded in all Italian regions except for Lazio and Sicilia [16].

***Glandularia tenera* (Spreng.) Cabrera** [≡ *Verbena tenera* Spreng.; ≡ *Shuttleworthia tenera* (Spreng.) Walp.]
Verbenaceae Chamaephyte subshrubs Neophyte, S-America
*First record for Sardegna* (casual)
Specimen: 27-4-2019, Colle S. Michele (Cagliari, Cagliari province), grassland, 95 m a.s.l., 39.24345° N-9.11095° E, *leg. et det.* L. Rosati *et* M. Marignani (HLUC).
*Note:* It was previously recorded only for Lazio as casual [17]. Plant samples were identified using the diagnostic characters and keys of [69–71].

***Gleditsia triacanthos* L.**
Fabaceae Phanerophyte scapose, Neophyte, N-America
*First record for Basilicata* (casual)
Specimen: 25-5-2017, M. Vulture, Foggianello (Rionero in Vulture, Potenza province), forest edges and road side, 570 m a.s.l., 40.96473° N-15.59563° E, *leg. et det.* E. Fanfarillo *et* L. Rosati (HLUC)
*Note:* Previously reported from all Italian regions except for Molise and Basilicata [17].

***Hieracium pallescens* Waldst. and Kit. *s.l.***
Asteraceae Hemicryptophyte scapose SE-European
*First record for Lazio*
Specimen: 29-7-2015, Rifugio Sebastiani, Monte Terminillo (Rieti province), pastured grassland dominated by *Bromopsis erecta* with *Helictochloa praetutiana*, *Brachypodium genuense*, *Carex kitaibeliana,* and *Festuca violacea* subsp. *italica*, limestone, 1870 m a.s.l., 13.01343° N-42.46902° E, *leg*. E. Del Vico *et* L. Facioni, *det*. G. Gottsclich (Herb. Del Vico).
*Note:* This species is present in all the northern regions of Italy except for Liguria [16]. In peninsular Italy it was recorded only from Abruzzo, Campania, Basilicata, and Calabria [16]. About twenty subspecies of *H. pallescens* are present in Italy; however, our specimen does not allow to ascertained the subspecific level. Further on filed investigations should be performed to fix this gap.

***Himantoglossum hircinum* (L.) Spreng.** [≡ *Satyrium hircinum* L.]
Orchidaceae Geophyte bulbouse Mediterranean-Atlantic
*First record for Sardegna*
Specimen: 22-5-2013, Illorai forest (Illorai, Sassari province), within a small clearing in otherwise dense *Quercus ilex* and *Q. pubescens* forest, 40.40494° N-8.92588° E, photo *et det*. P. J. de Lange.

*Note:* This species is present in Italy in the north-western (Piemonte, Liguria, Toscana and Emilia-Romagna) and in the southern regions with a clear gap in central Italy [16]. Although it is a very showy orchid it was never seen before in Sardegna, probably because of its rarity.
Images available at: https://inaturalist.nz/observations/4060025

***Impatiens noli-tangere* L.**
*Distribution clarification for Basilicata*
Balsaminaceae Therophyte scapose Eurasian
Specimen: 31-7-2015, Fossa Cupa (Sasso di Castalda, Potenza province), *Fagus sylvatica* forest, 40.50972° N-15.73002° E, *leg*. V.A. Romano, *det*. L. Rosati (HLUC).
*Note:* This species was reported first from Basilicata by Bartolucci et al. [16] based on our unpublished record above. Here we provide full details of the discovery.

***Isoëtes durieui* Bory**
Isoëtaceae Geophyte bulbouse W-Steno-Mediterranean
*First record for Basilicata*
Specimen: 2-5-2019, Bosco Finocchio (Rotondella, Matera province), ponds within *Quercus cerris* forest, 600 m a.s.l., 40.15282° N-16.47588° E, *leg*. G. Salerno *et* G. Misano, *det*. G. Salerno (Herb. Salerno).
*Note:* It was previously recorded for all western Italian regions though considered doubtfully in Molise [16].

***Isopyrum thalictroides* L.**
Ranunculaceae Geophyte rhizomatous Eurasian
*First record for Sardegna*
Specimen: 15-6-2014, Fontana Is Bidileddos (Desulo, Nuoro province), riparian forest of *Glechomo sardoae-Alnetum glutinosae*, 1660 m a.s.l., 40.01029° N-9.309394° E, *leg. et det*. E. Farris (SS).
*Note:* Locally common on the Fonni mountain side, exclusively in *Alnus glutinosa* forests above 1500 m a.s.l. (see https://inaturalist.nz/observations/4112222). This taxon is present throughout Italy, in most of the central-northern regions of Italy and though absent south of Toscana [16]. Our finding is the first for Mediterranean islands. This is noteworthy as it is believed to be absent from Corsica [72].

***Kalanchoë ×houghtonii* D. B. Ward** [≡ *Bryophyllum ×houghtonii* (D. B. Ward) P. I. Forst.; *Kalanchoë daigremontiana* Raym. -Hamet and H. Perrier × *Kalanchoë delagoensis* Eckl. and Zeyh.]
Crassulaceae Ch succ Neophyte, horticultural origin
*First record for Basilicata* (naturalized)
Specimen: 3-8-2017, Porto (Maratea, Potenza province), calcareous sea cliffs, 6 m a.s.l., 39.98835° N-15.70995° E, *leg*. A. Stinca *et* M. Eviano. *det*. A. Stinca (PORUN-Herb. Stinca).
*Note:* At Maratea *Kalanchoë ×houghtonii* seems to form populations capable of self-sustaining reproduction. Indeed, because of the viviparous nature, whereby the leaf lamina produces myriad plantlets this species has the potential to be highly invasive. It is recorded as naturalized from Liguria, Toscana, Lazio, and Calabria; it is present as casual in Campania, Puglia, Sardegna, and Sicilia [17].

***Kickxia spuria* (L.) Dumort. subsp. *spuria*** [≡ *Antirrhinum spurium* L. subsp. *spurium*]
Plantaginaceae Therophyte scapose Eurasian
*First record for Campania*
Specimen: 29-7-2014, near Vallone Serra Melito (Capaccio Paestum, Salerno province), arable land, 40.41596° N-15.08801° E, *leg. et det*. A. Stinca (PORUN-Herb. Stinca).
*Note:* This is the first record for the Southern Italian peninsula [16].

***Lantana montevidensis* (Spreng.) Briq.** [≡ *Lippia montevidensis* Spreng.]
Verbenaceae Nano-phanerophyte Neophyte, S-America
*First record for Sardegna* (casual)
Specimen: 30-8-2018, Su Giudeu (Domus de Maria, Cagliari province), crevices in the walls, 5 m a.s.l., 38.88749° N-8.85886° E, *leg. et det*. L. Rosati *et* M. Marignani (HLUC).
*Note:* Previously reported as a casual alien only from Liguria and Calabria regions [17]. In Sardegna

this species is widely grown in urban green areas, pots, and Mediterranean gardens (pers. observ.) so further naturalizations are likely.

***Lathyrus cirrhosus* Ser.**
Fabaceae Hemicryptophyte NW-Steno-Mediterranean
*Exclusion for Italy (Sardegna)*
*Note:* This taxon was reported only once at Monte Arviganu and Monte S. Giuliano, near Alghero, Sardegna by Schmid [49]. Pignatti [19,47] and Arrigoni [73] stated that the presence of *L. cirrhosus* in Sardegna is doubtful because of the probable confusion with *L. heterophyllus* L. Nevertheless, it was considered present in Sardegna in the Italian Flora checklists of vascular plants [16,74]. We have unsuccessfully searched for this species in the two sites during the last decade, and in the absence of verified herbarium evidence of its historic presence we recommend that *L. cirrhosus* be excluded from the flora of Sardegna and Italy.

***Lathyrus inconspicuus* L.**
Fabaceae Therophyte scapose Euri-Mediterranean
*First records for Lazio*
Specimens: 11-6-2015, Monte Porillo (Micigliano, Rieti province), secondary grassland with *Bromopsis erecta* and *Brachypodium rupestre*, gently marly slopes, 1000 m a.s.l., 42.45552° N-13.06439° E, *leg*. E. Del Vico *et* L. Facioni, *det*. E. Del Vico (Herb. Del Vico); 28-6-2016, Micigliano (Rieti province), secondary grassland with *Bromopsis erecta* and *Brachypodium rupestre*, gently marly slopes, 1130 m a.s.l., 42.46011° N-13.06226° E, *leg. et det*. E. Del Vico (Herb. Del Vico); 8-6-2016, Monte Porillo (Micigliano, Rieti province), secondary grassland with *Bromopsis erecta* and *Brachypodium rupestre*, gently marly slopes, 1130 m a.s.l., 42.46301° N-13.05907° E, *leg*. E. Del Vico *et* S. Bonacquisti, *det*. E. Del Vico (Herb. Del Vico); 20-7-2016, Monte Porillo (Micigliano, Rieti province), secondary grassland with *Cynosurus cristatus*, 1110 m a.s.l., 42.46596° N-13.06396° E, *leg. et det*. E. Del Vico (Herb. Del Vico); 20-7-2016, Erta (Micigliano, Rieti province), secondary grassland with *Brachypodium rupestre*, marly substratum, 1110 m a.s.l., 42.46428° N-42.46428° E, *leg. et det*. E. Del Vico (Herb. Del Vico).
*Note:* In peninsular Italy *L. incospicuus* was previously recorded from Toscana, Marche, Abruzzo, and Puglia; indeed, in Umbria and Campania its presence is doubtful [16]. It is absent in the southern and insular regions [16].

***Linum tenuifolium* L.**
Linaceae Chamaephyte subshrubs Steno-Mediterranean-Euxinian
*Exclusion for Sardegna*
*Note:* The presence of this taxon in Sardegna was reported by Mossa et al. [50] and so accepted in the Italian checklist of vascular flora [16,74]. Nevertheless, the species is excluded by [75] who considers its presence a mistake, because of the confusion with *L. bienne*. Our surveys in the site from where *Linum tenuifolium* was reported by Mossa et al. [50] found only *L. bienne.* Therefore, *L. tenuifolium* has to be excluded from Sardegna. It was also reported by mistake in Sicilia region [16].

***Lonicera japonica* Thunb.**
Caprifoliaceae Phanerophyte climbing Neophyte, E-Asia
*First record for Basilicata* (casual)
Specimen: 14-6-2019, Macchia Romana, Campus of University of Basilicata (Potenza), crevices in road pavements close to the walls, 40.68829° N-15.80848° E, 735 m a.s.l, *leg*. *et det*. L. Rosati (HLUC).
*Note: Lonicera japonica* has been recorded from all Italian regions except for Molise and Basilicata [17]. It is considered invasive in several regions of Northern Italy [17].

***Lupinus albus* L. subsp. *graecus* (Boiss. and Spruner) Franco and P. Silva** [≡ *L. graecus* Boiss. and Spruner]
Fabaceae Therophyte scapose E-Steno-Mediterranean
*First record for Campania*
Specimen: 22-4-2011, M. Vesole (Roccadaspide, Salerno province), chestnuts, 40.41538° N-15.17548° E, 500 m a.s.l., *leg. et det*. G. Salerno (Herb. Salerno).

*Note:* Previously reported from the Italian Peninsula for all of the regions, except Abruzzo, Molise, and Campania [16].

***Melampyrum barbatum* Waldst. and Kit. subsp. *carstiense* Ronniger**
Orobanchaceae Therophyte scapose SE-European
*First record for Basilicata and confirmation for Puglia*
Specimens: 9-6-1981, Trivigno (Potenza), oak forests, 500 m a.s.l., 40.58074° N-15.98965° E, *legit et det.* F. Cremonini (HLUC); 6-6-2018, V.ne Mariano (Laurenzana, Potenza province), edge of *Quercus pubescens* woods, siliceous substratum, 40.48337° N-15.96811° E, *leg*. L. Rosati *et* G. Potenza, *det*. L. Rosati (HLUC); 20-7-2014, Foresta Umbra (Vico del Gargano, Foggia province), roadside of forest road and edge of forest clearing, 560 m a.s.l, 41.854115° N-16.001818° E, *leg. et det.* G. Mei (ANC, Herb. Mei).
*Note:* In Southern Italy previously known only from doubtful historic records [16].

***Metrosideros excelsa* Sol. ex Gaertn.** [= *M. tomentosa* A. Rich.; = *Nania tomentosa* (A. Rich.) Kuntze]
Myrtaceae Phanerophyte caespitose Neophyte, New Zealand
*First record for Europe (Azores and Madeira excluded)* (casual)
Specimen: 31-5-2013, Costa Rei, Monte Nai (Muravera, Cagliari province), urban areas, 20 m a.s.l., 39.2565° N-9.575611° E, *leg. et det*. P.J. de Lange (AK, SS).
*Note:* A few seedlings, and saplings growing in the vicinity of the planted adult trees; this species is common in many coastal towns and resorts around Sardegna (see for example https://inaturalist.nz/observations/1715168). *Metrosideros excelsa*, commonly known as "New Zealand Christmas tree," is a coastal evergreen tree that produces a brilliant display of red flowers. It has been recently added to the list of host plants referred to in Article 1(b) of Commission Implementing Decision (EU) 2015 2417 of 17 December 2015, which have been found to be susceptible to *Xylella fastidiosa* in the European Union territory.
Until this record *Metrosideros excelsa* had been recorded in Europe as a naturalized plant only from the Azores and Madeira (Portugal) by [76]. Thus, our finding represents the first record for Europe (Azores and Madeira excluded).

***Muscari parviflorum* Desf.**
Asparagaceae Geophyte bulbouse Central-E-Mediterranean
*Confirmation for Calabria*
Specimen: 10-10-2011, Orsomarso (Cosenza), fallows, 488 m a.s.l., 39.78545° N-15.90759° E, *leg. et det* S. Fascetti (HLUC).
*Note:* Previous records of this species from Calabria had been considered doubtful [16].

***Nicandra physalodes* (L.) Gaertn.** [≡ *Atropa physalodes* L.]
Solanaceae Therophyte scapose Neophyte, S-American
*First record for Calabria* (casual)
Specimen: 3-6-2019, S. Litterata (Belvedere Marittimo, Cosenza province), fallows, 35 m a.s.l., 39.65594° N-15.83856° E, *leg*. *et det*. A. Capano (HLUC).
*Note:* This species was recorded in Italy from several regions; it is present in almost all of the central and northern regions as a casual alien; in Piemonte, Trentino-Alto Adige, and Friuli-Venezia Giulia it is considered naturalized [17]. It is absent in most of the southern regions, except for Sicilia [17].

***Nigella arvensis* L. subsp. *glaucescens* (Guss.) Greuter and Burdet** [≡ *N. arvensis* L. var. *glaucescens* Guss.]
Ranunculaceae Therophyte scapose Euri-Mediterranean
*First record for Basilicata and confirmation for Puglia*
Specimens: 15-4-2019, Padula (Ferrandina, Matera province), fallows, 40.5237° N-16.39444° E, *leg*. G. Marsilio, *det*. L. Rosati (HLUC); 15-4-2019, Accetta Grande (Statte, Taranto province), herbaceous fallows, 500 m a.s.l., 40.55389° N-17.17667° E, *leg*. G. Santoro, *det*. G. Santoro *et* L. Rosati (HLUC).
*Note: Previously* it was only recorded from Calabria, Sicilia, and Sardegna; no recent records are found from Puglia [16]. The presence of this taxon in Basilicata (Matera and Potenza Province) was also

reported in the Forum Acta Plantarum ("*Nigella arvensis* subsp. *glaucescens* (Guss.) Greuter and Burdet—Scheda IPFI, Acta Plantarum." Available on line (access date: 02-10-2019): http:\\www.actaplantarum.org\flora\flora_info.php?id=5297).

***Nothoscordum gracile* (Aiton) Stearn** [≡ *Allium gracile* Aiton]
Amaryllidaceae Geophyte bulbouse Neophyte, S-America
*First record for Calabria* (casual)
Specimen: 3-5-2019, Lazzaro (Motta San Giovanni, Reggio Calabria province), crevices in the sidewalks, 17 m a.s.l., 37.97408° N-15.66485° E, *leg. et det*. C.M. Musarella (REGGIO).
*Note:* Probably escaped from cultivated plants growing in pots placed on the sidewalks from where it had spread into crevices and the edge of the roadside. It was recorded as naturalized in Toscana, Campania, and Puglia [17] and as casual alien in Piemonte, Liguria, and Sardegna [17].

***Oeosporangium tinaei* (Tod.) Fraser-Jenk.** [≡ *Cheilanthes tinaei* Tod.; = *C. corsica* Reichst. and Vida]
Pteridaceae Hemicryptophyte rosulate Steno-Mediterranean-Macaronesian
*First record for Lazio*
Specimen: 23-5-2012, Cerveteri (Roma province), trachytes steep slope, 60 m a.s.l., 42.00000° N-12.10000° E, *leg. et det.* E. Del Vico *et* L. Facioni (HRO).
*Note:* Although new to the Lazio region this West steno-Mediterranean species has been recorded in all Italian peri-Thyrrhenian regions, except for Campania [16].

***Oloptum miliaceum* (L.) Röser and H. R. Hamasha** [≡ *Agrostis miliaceum* L.; ≡ *Oryzopsis miliacea* (L.) Asch. and Schweinf.; ≡ *Piptatherum miliaceum* (L.) Coss.]
oaceae Hemicryptophyte caespitose Mediterranean-Turanian
*First records for Sardegna*
Specimens: 2-6-2018, Sirigragiu, Corongiu (Maracalagonis, Cagliari province), reforestation with *Eucaliptus*, 84 m a.s.l., 9.2791° E-39.28434° N, *leg. et det*. E. Lallai (Herb. E. Lallai); 7-6-2018, C. D'Aquila, Stagno di Quartu (Quartu Sant'Elena, Cagliari province), olive grove, 3 m a.s.l., 9.17736° E-39.22613° N, *leg. et det*. E. Lallai (Herb. E. Lallai); 14-6-2018, Corti de Perda (Quartucciu, Cagliari province), reforestation with *Eucaliptus* and *Pinus* spp., 135 m a.s.l., 9.32868° E-39.24517° N, *leg. et det*. E. Lallai (Herb. E. Lallai).
*Note:* In the recent checklist of Italian vascular flora only *O. thomasii* and not *O. miliaceum* has been reported from Sardegna [16]. However, *O. miliaceum* is the only species that has ever been considered present in the flora treatments of Sardegna e.g., [47,74,75]. In addition, several authors consider questionable the distinction between these two taxa and include *O. thomasii* in *O. milaceum*. Our observations confirm the presence of *O. miliaceum,* accordingly this name has to be re-added to the checklist of vascular flora of Sardegna. *O. miliaceum* is present in almost all Italian regions except Valle d'Aosta, Piemonte e Molise [16].

***Ophrys crabronifera* Mauri** [≡ *O. argolica* H. Fleischm. ex Vierh. subsp. *crabronifera* (Mauri) Faurh.; = *O. exaltata* Ten. subsp. *sundermannii* Soó; = *O. fuciflora* (F. W. Schmidt) Moench subsp. *sundermannii* Soó]
Orchidaceae Geophyte bulbouse Italian endemic
*First record for Basilicata*
Observation: 15-4-2015; 30-4-2019, along the road SP 12 Vietrese (Vietri di Potenza, Potenza province), roadside on calcareous substratum, 371 m a.s.l., 40.57086° N-15.52102° E, photo *et det*. V.A. Romano (Figure 2).
*Note:* This species was previously recorded in almost all the peninsular regions except for Puglia, Calabria, and Basilicata. This observation extends southward the range of this endemic taxon in Italy [16]. It is absent in the insular regions [16].

***Ophrys marmorata* G. Foelsche and W. Foelsche** [≡ *Ophrys fusca* Link subsp. *marmorata* (G. Foelsche and W. Foelsche) Kreutz]
Orchidaceae Geophyte bulbouse Italian endemic
*First record for Basilicata*

Observation: 14-2-2015, Lido di Scanzano Jonico (Scanzano Jonico, Matera province), *Pinus halepensis* forest, 10 m a.s.l., 40.26114° N-16.75518° E, photo *et det*. S. Fascetti *et* V.A. Romano (Figure 2).
*Note:* Since 2005, a few isolated flowering plants have been observed at this site flowering between February and March. The new findings extend southward the range of this endemic taxon in Italy; previously it had only been recorded from Toscana [16].

***Ophrys sipontensis* (Gumpr.) O. Danesch and E. Danesch** [≡ *O. sphegodes* Mill. subsp. *sipontensis* Gumpr.; ≡ *O. garganica* O. Danesch and E. Danesch subsp. *sipontensis* (Gumpr.) Del Prete]
Orchidaceae G bulbouse Italian endemic
*First record for Basilicata*
Observation: 25-4-2015, Balvano (Potenza province), shrublands with *Spartium junceum*, 726 m a.s.l., 40.67352° N-15.52065° E, photo *et det*. S. Fascetti *et* V.A. Romano (Figure 2).
*Note:* Since 2002, at this location only a few isolated flowering plants have been observed flowering between April and May. Hitherto this endemic orchid has only been recorded from Campania and Puglia regions [16].

***Ophrys speculum* Link** [= *O. ciliata* Biv.]
Orchidaceae G bulbouse W-Steno-Mediterranean
*Confirmation for Calabria*
Observation: 15-4-2010, Frascineto (Cosenza province), roadside, 39.801091° N-16.241693° E, 420 m a.s.l., photo H. Presser, *det*. V.A. Romano (Figure 2).
*Note:* Previously reported from southern Italy only from Campania and Molise, it had otherwise been regarded as doubtfully present in Calabria [16].

***Oxalis debilis* Kunth** [= *O. corymbosa* DC.]
Oxalidaceae G. bulbouse Neophyte, S-America
*First record for Calabria* (casual)
Specimens: 3-5-2019, Lazzaro (Motta San Giovanni, Reggio Calabria province), crevices in the road pavements, 17 m a.s.l., 37.97405° N-15.66492° E, *leg. et det.* C.M. Musarella, *conf*. A. Stinca (PORUN-Herb. Stinca, REGGIO); 25-09-2019, Catona (Reggio Calabria, Reggio Calabria province), along the roadside, 15 m a.s.l., 38,189334° N- 15,643462° E, *leg*. V.L.A. Laface, *det*. V.L.A. Laface *et* C.M. Musarella *conf*. A. Stinca (PORUN-Herb. Stinca, REGGIO).
*Note:* At these locations only a few plants were recorded growing in the crevices and at the edge of the roadside; these probably escaped from plants cultivated in pots on the sidewalks. It is reported for several regions of Italy as a naturalized or casual alien [17]; it is considered doubtfully present in Lazio, Basilicata, and Puglia [17].

***Oxalis latifolia* Kunth**
Oxalidaceae Geophyte bulbouse Neophyte, America
*First record for Calabria* (casual)
Specimens: 10-5-2018, Tortora Marina (Tortora, Cosenza province), fallows close to a plant nursery, 12 m a.s.l., 39.92276° N-15.76723° E, *leg. et det.* S. Fascetti (HLUC); 29-7-2019, Catona (Reggio Calabria, Reggio Calabria province), sidewalks, 15 m a.s.l., 38.187390° N-15.643697° E, *leg*. V.L.A. Laface, *det*. V.L.A. Laface, C.M. Musarella *et* G. Spampinato (REGGIO); 29-7-2019, Porelli di Bagnara SS18 (Bagnara Calabra, Reggio Calabria province), along the roadside, 142 m a.s.l., 38.286887° N-15.810304° E, *leg*. V.L.A. Laface, *det*. V.L.A. Laface, C.M. Musarella *et* G. Spampinato *conf*. A. Stinca (PORUN-Herb. Stinca, REGGIO); 25-9-2019, Ferrito SS. 18 (Villa San Giovanni, Reggio Calabria province), along the roadside, 38 m a.s.l., 38.233512° N-15.660117° E, *leg*. V.L.A. Laface, *det*. V.L.A. Laface, C.M. Musarella, G. Spampinato (REGGIO); 27.07.2019, Catona (Reggio Calabria, Reggio Calabria province), sidewalks, 10 m a.s.l., 38.188338° N-15.641358° E, *leg*. V.L.A. Laface, *det*. V.L.A. Laface, C.M. Musarella *et* G. Spampinato *conf*. A. Stinca (PORUN-Herb. Stinca, REGGIO); 25.09.2019, Melia di Scilla (Melia di Scilla, Reggio Calabria province), 653 m a.s.l., 38.228695° N-15.757547° E, *leg*. V.L.A. Laface, *det*. V.L.A. Laface, C.M. Musarella (REGGIO); 28.09.2019, Pietrastorta (Reggio Calabria, Reggio Calabria province), along the roadside, 317 m a.s.l., 38.113405° N-15.684027° E, *leg. et det*.

V.L.A. Laface (REGGIO); 21.10.2019, Molochio (Molochio, Reggio Calabria province), along the sidewalks, 316 m a.s.l., 38.310638° N-16.029284° E, *leg. et det.* V.L.A. Laface (REGGIO).
*Note:* Abundantly naturalized. In some stations of Calabria, it probably escaped from plants grown in pots cultivated on the sidewalks as plants were seen in nearby crevices and on the nearby roadside. It was previously reported for almost all the Italian regions except for Molise, Basilicata, and Calabria in southern Italy [17]. In Basilicata region it is reported in the forum Acta Plantarum (2007 on—"*Oxalis latifolia* Kunth—Scheda IPFI, Acta Plantarum." Available on line (access date: 16/10/2019): http://www.actaplantarum.org/flora/flora_info.php?id=502806).

***Paspalum notatum* Flüggé** [= *P. saurae* (Parodi) Parodi]
Poaceae Hemicryptophyte caespitose Neophyte, Central - S-America
*First record for Basilicata* (casual)
Specimen: 3-8-2017, Porto (Maratea, Potenza province), shores, 1 m a.s.l., 39.98927° N-15.70905° E, *leg*. A. Stinca *et* M. Eviano. *det*. A. Stinca (PORUN-Herb. Stinca).
*Note:* Hitherto reported for Italy from the Calabria region as a casual alien at Scalea [77].

***Pedicularis petiolaris* Ten.**
Orobanchaceae Hemicryptophyte scapose E-Mediterranean
*Confirmation for Campania*
Specimen: 27-5-2014, Mandranello (Padula, Salerno province), carbonatic dry grasslands, 1100 m a.s.l., 40.38762° N-15.68548° E, *leg. et det*. L. Rosati (HLUC).
*Note:* In Italy it was previously reported only for Abruzzo, Basilicata, and Calabria regions [16]. In Campania it had previously only been considered doubtful present [16].

***Pittosporum crassifolium* Banks and Sol. ex A. Cunn.**
Pittosporaceae Nano-phanerophyte Neophyte, New Zealand
*First record for Italy* (casual)
Specimen: 11-03-2013, Sardegna, Lungomare Valencia (Alghero, Sassari province), at back of disco bar near former castle, 9 m a.s.l., 40.55058° N-8.31974° E, *leg. et det*. P.J. de Lange (AK)
*Note:* Associated with the superficially similar *Pittosporum tobira* (by far the most commonly grown and naturalized *Pittosporum* species in Sardegna). *Pittosporum crassifolium* was only seen here and at Torre Nuova (Alghero). Seedlings occasional, these appear to be pure *Pittosporum crassifolium*. In Europe it has previously recorded only from Great Britain [60].

***Phoenix canariensis* H. Wildpret**
Arecaceae Phanerophyte scapose Neophyte, Macaronesia
*First record for Basilicata* (casual)
Specimens: 14-12-2017, S. Basilio, Marina di Pisticci (Pisticci, Matera province), roadside along *Pinus halepensis* forests, 5 m a.s.l., 40.29815° N-16.77887° E, *leg. et det.* S. Fascetti (HLUC); 25-08-2019, Pisticci (Matera province), road escarpment of SS Jonica 106, 21 m a.s.l., 40.325447° N-16.746782° E, *leg*. *et det*. C.M. Musarella (REGGIO).
*Note:* In loc. S. Basilio a few juvenile plants were observed probably spread from nearby gardens. In loc. Pisticci two mature individuals, away from each other about 50 m, were recorded at the edge of a drainage channel along the SS Jonica 106, outside of a lay-by. *Phoenix canariensis* is reported as casual or naturalized for almost all coastal regions of peninsular Italy [17].

***Phyla nodiflora* (L.) Greene** [≡ *Lippia nodiflora* (L.) Michx.; ≡ *Verbena nodiflora* L.]
Verbenaceae Neophyte, Tropical America, Africa and Asia
*Confirmation for Marche* (casual)
Specimen: 3-8-2019, Osteria (Serra de' Conti, Ancona province), lawn borders and slopes of agricultural ditches for rainwater runoff, 135 m a.s.l., 43.541875° N-13.020947° E, *leg. et det.* G. Mei (ANC, Herb. Mei).
*Note:* Previously *P. nodiflora* was reported as naturalized from almost all the peninsular regions but it was considered as doubtfully present in Marche [17].

***Phyllostachys aurea* Carrière ex Rivière and C. Rivière**

Poaceae Phanerophyte caespitose Neophyte, E-Asia
*First record for Calabria* (casual)
Specimens: 2-7-2019, Pellaro, Torrente Fiumarella (Reggio Calabria, Reggio Calabria province), dry riverbed, 6 m a.s.l., 38.02138° N-15.64416° E, *leg. et det*. C.M. Musarella (REGGIO); 2-9-2019, C. da Monacelli, (Melicucco, Reggio Calabria province), roadside, 118 m a.s.l., 38.44528° N-16.04166° E, *leg. et det.* C.M. Musarella (REGGIO); 9-8-2019, C. da Sant'Angelo (Melia di San Roberto, Reggio Calabria province), road escarpment, 749 m a.s.l., 38.22281° N-15.77548° E, *leg*. V.L.A. Laface, *det*. V.L.A. Laface *et* G. Spampinato (REGGIO); 19.10.2019, Fiumara di S. Lorenzo (S. Lorenzo, Reggio Calabria province), bedriver, 6 m a.s.l., 37.920494° N-15.839534° E, *leg. et det*. V.L.A. Laface (REGGIO).
*Note:* In southern Italy it was previously recorded only for Campania (naturalized) and Sicilia (casual) [17].

***Physalis peruviana* L.**
Solanaceae Hemicryptophyte scapose Neophyte, S-America
*First record for Calabria* (casual)
Specimen: 23-8-2019, Thurio (Corigliano Calabro, Cosenza province), fallows, 8 m a.s.l., 39.69515° N-16.46777, *leg*. P. Nicoletti, *det*. L. Rosati (HLUC).
*Note:* In southern Italy recorded previously only from Puglia and Sicilia regions [17].

***Pinus nigra* J. F. Arnold subsp. *laricio* Palib. ex Maire** [= *P. laricio* Poir. subsp. *calabrica* (Loud.) Cesca and Peruzzi]
Pinaceae Phanerophyte scapose Italo-Corsican Endemic
*First record for Basilicata* (casual) *and Campania* (casual)
Specimens: 15-05-18, Mandrano, Monti della Maddalena (Paterno, Potenza province), pastures and roadsides, 1110 m a.s.l., 40.36917° N-15.71119° E, *leg. et det*. L. Rosati (HLUC); 15-05-18, Mandrano, Monti della Maddalena (Padula, Salerno), pastures and roadsides 1075 m a.s.l., 40.36901° N-15.70758° E, *leg. et det.* L. Rosati (HLUC).
*Note:* Several young trees from the nearby reforestation areas where this species had been deliberately planted were observed. It was recorded as alien taxa in others Italian regions (Sardegna, Fruli-Venezia Giulia, Toscana), whereas it is considered native only in Calabria and Sicilia [16].

***Plantago argentea* Chaix subsp. *argentea***
Plantaginaceae Hemicryptophyte rosulate S-European-S-Siberian
*First record for Campania*
Specimen: 20-7-2014, M. Alburno under M. Panormo (Sicignano degli Alburni, Salerno province), rocky slopes, 1402 m a.s.l., 40.53226° N-15.33386° E, *leg*. A. Stinca *et* M. Ravo, *det*. A. Stinca (PORUN-Heb. Stinca).
*Note: Plantago argentea* was previously indicated in sensu lato in Campania, thus, here we report the presence of the nominal subspecies [16].

***Plumbago auriculata* Lam.** [= *Plumbago capensis* Thunb.]
Plumbaginaceae Nano-phanerophyte Neophyte, S-Africa
*First record for Calabria* (casual)
Specimen: 02-09-2019, C. da Monacelli (Melicucco, Reggio Calabria), roadside, 117 m a.s.l., 38.445020° N-16.042060° E, *leg. et det*. C. M. Musarella (REGGIO).
*Note.* In Calabria, we observed a few individuals growing along the roadside; these had probably escaped from a nearby garden. It is reported as casual alien from almost all the regions of Italian peninsula, except for Umbria, Molise, and Basilicata; in Sardegna it is considered naturalized [17].

***Polygala rupestris* Pourr.**
Polygalaceae Chamaephyte subshrubs W-Mediterranean
*First record for Sardegna and confirmation for Italy*
Specimens: 02-11-2005; 14-05-2014; 08-04-2016, Ca
nale Oma Molt (Alghero, Sassari province), garrigues with *Rosmarinus officinalis* and *Viola arborescens*, 33 m a.s.l., 40.52452° N-8.33371° E, *leg. et det.* E. Farris (SS).

*Note:* In the recent checklist of the Italian vascular flora the presence of this species was considered doubtful in Italy [16]. We found this species in Sardegna along the coast South of Alghero, where it was usually present, though at low densities in the calcareous coastal garrigues. The nearest known localities of this species, according to Flora Gallica and Flora Iberica are in Provence (S-France) and Balearic Islands (Spain).

***Populus ×canescens* (Aiton) Sm.** [≡ *P. alba* L. var. *canescens* Aiton]
Salicaceae Phanerophyte scapose S-European
*First record for Sardegna*
Specimens: 21-6-2016, Settefratelli, along the road from Codoleddu to the giant's tombstone (Maracalagonis, Cagliari province), near the creek, 465 m a.s.l., 39.26022° N-9.37907° E, *leg. et det*. L. Rosati (HLUC); 13-5-1981, Mandas (Mandas, Cagliari province), uscita dal paese verso Sorgono, 30 m a.s.l., 39.65376° N-9.12843° E, *leg. et det*. I. Camarda (SS); 23-5-1975, Piana di Posada (Nuoro province), 5 m a.s.l., 40.635480° N-9.72371° E, *leg.* S. Vanelli *et* B. Corrias (SS); 01-06-2018, Sedda Brandanu, Corongiu (Maracalagonis, Cagliari province), remnants of riparian forest, 140 m a.s.l., 39.29282° N-9.29236° E, *leg. et det*. E. Lallai (Herb. E. Lallai).
*Note:* In North Sardegna this species was also reported in a vegetation survey from the Cala Regina (Isola dell'Asinara, Sassari province) by [78]. In Italy it is widespread and known from all regions except for Liguria. This hybrid was reported for Sardegna by Camarda and Valsecchi [79] and Arrigoni [80] but not subsequently considered (by mistake?) in the recent checklist of vascular flora [74,16]. In the last checklist of the Italian vascular flora [16] it is not indicated as a hybrid (i.e. *P. canescens* (Aiton) Sm).

***Potamogeton pusillus* L.**
Potamogetonaceae Idrophyte rooted Subcosmopolitan
*Confirmation for Campania*
Specimen: 16-7-2016, Sele river, Oasi Persano (Serre, Salerno province), lotic freshwaters, 40.60488° N-15.13717° E, *leg. et det*. L. Rosati *et* G. Salerno, *rev*. L. Lastrucci (HLUC).
*Note:* Outside Campania this species is not known from the southern Italian Peninsula [16]; it was recently confirmed from Basilicata [39].

***Prangos ferulacea* (L.) Lindl.** [≡ *Laserpitium ferulaceum* L.; ≡ *Cachrys ferulacea* (L.) Calest.]
Apiaceae Hemicryptophyte scapose Mediterranean-Turanian
*Confirmation for Lazio*
Specimen: 16-7-2015, Monte Tilia, Fondo del Laghetto (Leonessa, Rieti province), secondary grasslands with *Brachypodium genuense*, marly slopes, 1400 m a.s.l., 42.55842° N-12.95441° E, *leg. et det*. E. Del Vico (Herb. Del Vico).
*Note:* Doubtfully reported from Lazio on the basis of a historic record (1914) from Terminillo of Cavara and Grande which had not been confirmed by recent surveys [81]. On the basis of the record above *Prangos ferulacea* is now verified from the Lazio region. This species is, with the exception of Molise, otherwise known from the other regions of the Italian Peninsula [16].

***Puccinellia festuciformis* (Host) Parl. subsp. *festuciformis*** [≡ *Poa festuciformis* Host]
Poaceae Hemicryptophyte caespitose Steno-Mediterranean
*Confirmation for Campania*
Specimen: 12-6-2014, Patria lake, close to the dewatering pump (Giugliano in Campania, Napoli province), temporary flooded grasslands, 0 m a.s.l. 40.94181° N-14.0235° E, *leg. et det*. A. Stinca *et* G. Salerno (PORUN-Herb. Stinca).
*Note:* Until this discovery the presence of this grass in Campania had been considered doubtful [16]. Outside Campania this *Puccinellia* had been reported from several regions of the Italian Peninsula and considered as extinct in Abruzzo [16].

***Quercus petraea* (Matt.) Liebl. subsp. *austrotyrrhenica* Brullo, Guarino and Siracusa**
Fagaceae Phanerophyte scapose Italian endemic
*First record for Basilicata*

Specimens: 15-6-2015, M.te Serranetta (Abriola, Potenza province), oak forests, 1300 m a.s.l., 40.56351° N-15.81886° E, *leg. et det*. S. Fascetti (HLUC); 15-8-2002, Serra di Calvello (Calvello, Potenza province), oak forests, 1300 m a.s.l., 40,45683° N-15,77855° E, *leg. et det*. M.R. Lapenna (HLUC).
*Note:* This Italian endemic is uncommon in Basilicata, where it is generally found in mixed forests with *Quercus cerris*, in relatively xeric habitats on mountain ridges, exclusively on subacid substrata (e.g. Flysch Galestrino). Previously it was recorded only from Calabria and Sicilia regions [16].

***Rosa ×bishopii* Wolley-Dod** [= *Rosa micrantha* Borrer ex Sm. × *R. agrestis* Savi]
Rosaceae Nano-phanerophyte
*First record for Basilicata*
Specimen: 3-6-2011, Fiumara di Laurenzana (Laurenzana, Potenza province), shurbland in dry riverbed, 577 m s.l.m., 40.49004° N-15.9583° E, *leg. et det* S. Fascetti, *conf*. E. Lattanzi (HLUC).
*Note*: Several hybrids into the wild dog roses group have been reported mainly in north-central Europe [82]; on the other hand, in southern Europe, knowledge concerning existence and distribution of these hybrids is very scarce. As a consequence, chorology for this taxon is not defined.

***Rosa montana* Chaix × *R. villosa* L.**
Rosaceae Nano-phanerophyte
*First record for Basilicata*
Specimen: 25-6-2016, Piano Jannace (San Severino Lucano, Potenza province), pastures, 1679 m a.s.l., 39.93977° N-16.19668° E, *leg. et det* S. Fascetti, *conf*. E. Lattanzi (HLUC).
*Note: Rosa villosa* is one of the species of sect. *Caninae* DC. that can easily hybridize with other sympatric dog roses [83]. According to some authors, it is probably the most common hybridogenic species among the dog roses [84]. To the best of our knowledge, a binomial name for this hybrid does not exist yet. As a consequence, chorology for this taxon is not defined.

***Rosa subcollina* (Christ) Vuk.** [≡ *R. coriifolia* Fr. f. *subcollina* Christ]
Rosaceae Nano-phanerophyte European-W-Asian
*First record for Basilicata*
Specimen: 16-6-2011, Fossa Cupa (Pignola, Potenza province), shrublands, 1000 m a.s.l., 40.55197° N-15.73003° E, *leg. et det*. S. Fascetti, *rev*. E. Lattanzi (HLUC).
*Note:* It is recorded from most of the Italian Peninsula regions.

***Rumex maritimus* L.**
Polygonaceae Therophyte scapose Eurasian
*First records for Campania*
Specimens: 23-5-2014, near the harbour (Pozzuoli, Napoli province), sea sands, 0 m a.s.l., 40.82935° N-14.11412° E, *leg. et det*. A. Stinca (PORUN-Herb. Stinca); 2-6-2014, Ponte del Diavolo on the banks of the Patria lake (Castel Volturno, Napoli province), artificial river bank, 1 m a.s.l., 40.92918° N-14.0287° E, *leg*. A. Stinca *et* G. Salerno, *det*. A. Stinca (PORUN-Herb. Stinca); 3-6-2014, along the Canale Vico Patri close by Masseria De Chiara (Villa Literno, Napoli province), artificial river bank, 3 m a.s.l, .40.95818° N-14.04141° E, *leg*. A. Stinca *et* G. Salerno, *det*. A. Stinca (PORUN-Herb. Stinca).
*Note:* Previously recorded only from Calabria in southern Italy [16].

***Salvinia minima* Baker**
Salviniaceae Idrophyte floating Neophyte Central-S-America
*First record for Europe* (casual)
Specimen: 1-7-2019, Petile di Calanna (Calanna, Reggio Calabria province), impluvium, 38.19045° N-15.73117° E, *leg*. V.L.A. Laface, *det*. V.L.A. Laface *et* C. M. Musarella (REGGIO).
*Note: Salvinia minima* is a non-rooted aquatic fern native to South and Central America. Madeira et al. [85] report this species as locally introduced for Spain, citing Lawarlee in Flora Europaea [42]. However, *S. minima* is not considered in Flora Europaea, neither in Flora Iberica [86]. For this reason, it may be that this record for Calabria is not the first for Italy but also for Europe. In this context, a case of accidentally introduction of *Salvinia minima* in Europe has been only documented in the botanical garden greenhouses in Jibou, Romania [87]. Detailed images of plants collected in Calabria

are shown in Figure A2. The collected plants were identified using [88–91]; diacritical characters useful to distinguish *S. minima* with respect to the most similar taxa are shown in Table A2.

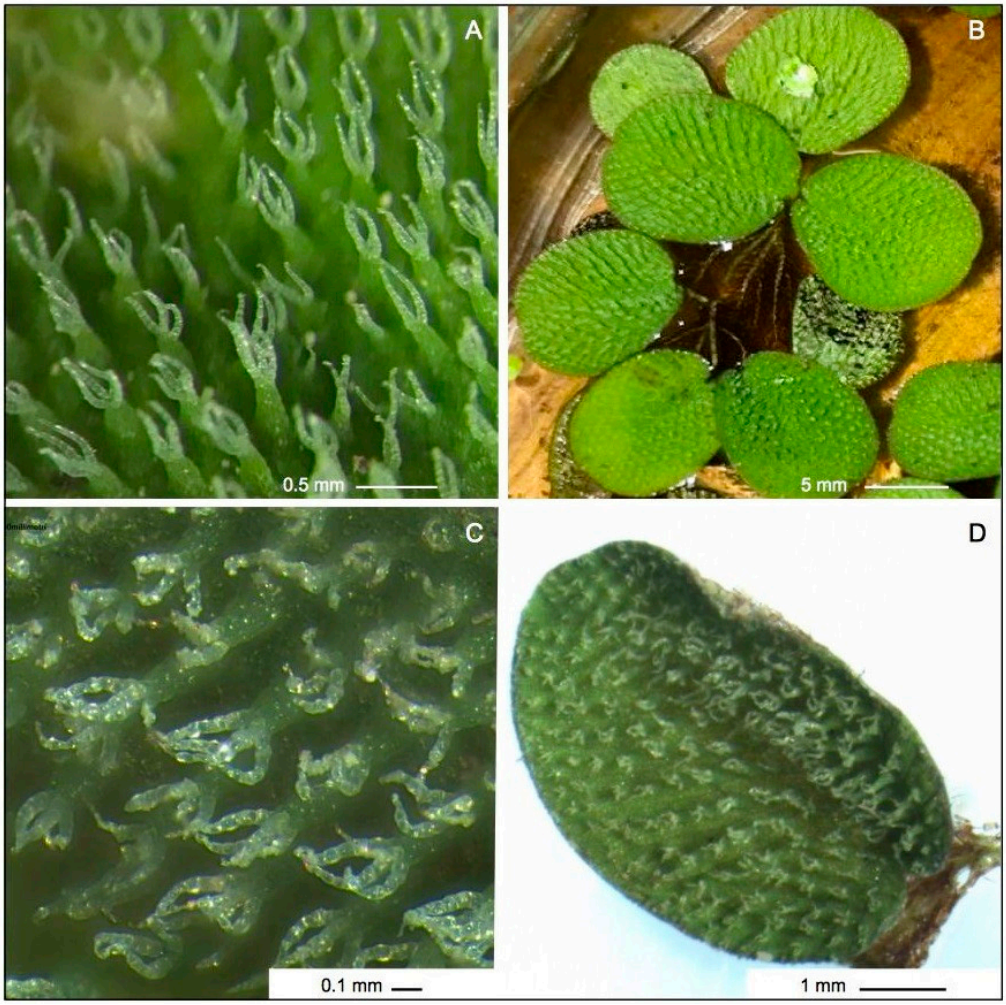



**Figure A2.** *Salvinia minima* plants collected in Calabria and photographed in laboratory at the University of Reggio Calabria: (**A**, **C**, **D**) upper side leaf hairs at different magnification, note distinctive hairs not joined at their tips (**B**) entire plants with the typical rounded leaves shape.

**Table A2.** Distinguishing characters between *Salvinia minima* and the most similar species (data retrieved from [91] including measures taken on our samples collected in Calabria.

| | Floating Blade Length (mm) | Hairs on Papillae | Length/Width Ratio | Papillae on Upper Face (mm) |
|---|---|---|---|---|
| *S. adnata* Desv. (= *S. molesta* D. S. Mitch.) | 15–25 | Joined into dark knot at tips | <1.5 | ≤ 1 |
| *S. oblongifolia* Mart. | 25–45 | Not joined at their tips | 2–3 | <0.1 |
| *S. minima* Baker | 5–10 (15) | Not joined at their tips | <1.5 | ≤1 |
| | 6–9 | Not joined at their tips | <1.5 | ≤1 |

***Sempervivum tectorum* L.**
Crassulaceae Chamaephyte S-European
*First record for Basilicata*
Specimen: 15-6-2019, M. Volturino (Marsico Vetere, Potenza province), siliceous rocks and cliffs, 1500 m a.s.l., 40.4026° N-15.81642° E, *leg*. L. Rosati *et* G. Potenza, *det*. L. Rosati (HLUC).

*Note:* Present in central and northern regions of Italy but in southern regions, records of it from Puglia, Basilicata, and Calabria have been treated as mistakes [16]. Therefore, the discovery of Mt. Volturino reported here now confirms its presence in the southern Apennine.

***Solandra maxima* (Sessé and Moc.) P. S. Green** [≡ *Datura maxima* Sessé and Moc.]
Solanaceae Phanerophyte climbing Neophyte, Central America
*First record for Calabria* (casual) *and Sicilia* (casual)
Specimen: 9-8-2019, Ferrito (Villa San Giovanni, Reggio Calabria province), roadside, 34 m a.s.l., 38.23229° N-15.64493° E, *leg*. V.L.A. Laface, *det*. V.L.A. Laface, C.M. Musarella *et* G. Spampinato (REGGIO); 5-7-2019, Canalicchio (Catania), road escarpment, 91 m a.s.l., 37.53119° N-15.09410° E, *leg.* C.M. Musarella, *det*. C.M. Musarella *et* G. Spampinato (REGGIO).
*Note: Solandra maxima* was recorded for the first time in Europe from the Campania region [92]. Our two records are therefore the second for the Italian peninsula and the first for Calabria and Sicilia respectively.

***Tagetes erecta* L.** [= *T. patula* L.]
Asteraceae Therophyte scapose Neophyte, Central American
*First record for Basilicata* (casual)
Specimen: 3-8-2017, Porto (Maratea, Potenza province), crevices in road pavements, 16 m a.s.l., 39.98889° N-15.70958° E, *leg*. A. Stinca *et* M. Eviano. *det*. A. Stinca (PORUN-Herb. Stinca).
*Note:* This species has been recorded as casual alien from many Italian regions [17].

***Tetragonia tetragonoides* (Pall.) Kuntze** [≡ *Demidovia tetragonoides* Pall.]
Aizoaceae Therophyte scapose Neophyte, Australia and New Zealand
*Confirmation for Sardegna* (casual)
Specimen: 19-05-2013, Golfo di Orosei, Cala Gonone (Orosei, Nuoro province), cobble beach, 1 m a.s.l., 40.28270° N-9.63620° E, *leg. et det*. P.J. de Lange (AK).
*Note:* Flowering and fruiting plants have been observed (see https://inaturalist.nz/observations/1509928). In Italy it was previously reported in Friuli Venezia Giulia, Trentino-Alto Adige, Lombardia, Toscana, Lazio, Campania, and Sicilia regions [17]. Prior to this record this species was known from Sardegna on the basis of old reports that required confirmation [17].

***Trifolium spumosum* L.**
Fabaceae Therophyte scapose E-Steno-Mediterranean
*Confirmation for Basilicata*
Specimen: 16-6-2014, Anglona Sanctuary (Tursi, Matera province), dry grassland, 262 m a.s.l., 40.2449° N-16.55653° E, *leg*. G. Salerno *et* M.R. Lapenna, *det*. G. Salerno (Herb. Salerno).
*Note:* The presence of this species in Italy was ascertained only from Sardegna, Sicilia, Calabria, and Lazio [16]. In recent times this species has not been recorded from most of the Italian peninsular regions [16]. Our discovery from Basilicata confirms its continued presence from at least part of that region.

***Urginea fugax* (Moris) Steinh.** [≡ *Anthericum fugax* Moris]
Asparagaceae Geophyte bulbouse W-Mediterranean
*Exclusion for continental and peninsular Italy (Basilicata)*
*Note:* In Italy, we can only confirm this species as present in Sardegna [16], which is consistent with its W-Mediterranean distribution. Accordingly, we regard past records of the species from Basilicata and neighboring regions as erroneous. Although Gavioli [51] reported the species from Basilicata in 1915 the samples he noted had been lost, so the record cannot be verified. In absence of further specimens of this distinctive plant from the Italian Peninsula we suggest that *U. fugax* had probably been reported by mistake, because of the confusion with a similar species (likely small size

individuals of *Urginea maritima* auct. Fl. Ital.). Therefore, we recommend that this species is excluded from the flora of Basilicata.

***Veronica spicata* L. subsp. *fischeri* (Trávn.) Albach** [≡ *Pseudolysimachion spicatum* (L.) Opiz subsp. *fischeri* Trávn]
Plantaginaceae Hemicryptophyte crawling Eurasian
*First records for Lazio*
Specimens: 2-7-2015, Monte Rosato (Poggio Bustone, Rieti province), secondary grassland with *Bromopsis erecta*, *Carex humilis* and *Plantago argentea*, calcareous slopes, 1300 m a.s.l., 42.51662° N-12.88791° E, *leg. et det*. E. Del Vico (Herb. Del Vico); 10-7-2016, Monte Rosato (Poggio Bustone, Rieti province), secondary grassland with *Bromopsis erecta*, calcareous slopes, 1350 m a.s.l., 42.51387° N-12.88557° E, *leg*. E. Del Vico *et* L. Facioni *det*. E. Del Vico (Herb. Del Vico).
*Note:* In Italy this taxon has a northern (Lombardia, Trentino-Alto Adige, Veneto) and central (Marche, Umbria, Abruzzo) disjunct distribution [16]. In Piemonte it is recorded by mistake [16]. Subspecies identification of our samples was based on the key reported in [20]; however, in our view the subspecies delimitation of *V. spicata* as stated in [20] is unclear and needs further study.

***Viola kitaibeliana* Schult.**
Violaceae Therophyte scapose European-Caucasian
*Confirmation for Campania*
Specimen: 1-3-2016, Campitello, M. della Maddalena (Padula, Salerno province), pastures on siliceous schistous substrate, 1300 m a.s.l., 40.34573° N-15.69029° E, *leg. et det*. L. Rosati (HLUC).
*Note: Viola kitaibeliana* is recorded from most of the peninsular regions, except for Emilia-Romagna, Molise, and Puglia; it was previously considered as doubtfully present in Campania [16]. Our discovery now fills this gap along the Apennine chain.

***Wisteria sinensis* (Sims) Sweet** [≡ *Glycine sinensis* Sims]
Fabaceae Phanerophyte climbing Neophyte, E-Asia
*First record for Calabria* (casual)
Specimen: 2-9-2019, C. da Monacelli (Melicucco, Reggio Calabria province), roadside, 118 m a.s.l., 38.44528° N-16.04166° E, *leg. et det.* C.M. Musarella (REGGIO).
*Note:* A few individuals of *Wisteria sinensis* were noted growing together with *Phyllostachys aurea* and *Plumbago auriculata* along the roadside, probably escaped from a nearby garden. Previously *Wisteria sinensis* was recorded as casual alien from almost all of the Italian regions but only from Campania in the southern ones [17]. In Sardegna it is considered naturalized [17].

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# NEW DATA ON THE ALIEN VASCULAR FLORA OF CALABRIA (SOUTHERN ITALY)

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Abstract – New data concerning the distribution of 21 non-native vascular species for Calabria (southern Italy) are presented. *Agave filifera* is reported for the first time in Europe (Canary Islands excluded), while *Leucaena leucocephala* subsp. *glabrata* and *Senna corymbosa* are founded for the first time in continental Italy. *Saccharum biflorum* is confirmed in Italian Peninsula, while *Physalis angulata* is a new exotic plant for southern Italy. Moreover sixteen other species are reported for the first time, confirmed or indicated with an updated naturalization status in Calabria.

Keywords - Biodiversity, Exotic plant, Herbarium speciments, Invasiveness

## Introduction

As the globalization has triggered a massive spread of plant species to areas outside their native distribution ranges (van Kleunen et al., 2015), the first step to counter their spread in new environments is a rapid eradication action. This action plan must include a rapid alert system based on field surveys to identify new species and their invasive trends. Invasive alien species can change the native biodiversity by competing for water and nutrients or inducing allelopathic interference. For this reason, they produce a considerable reduction of native species (Cano-Ortiz et al., 2015, 2018), as well as ecological and landscape modifications (Stinca et al., 2015). Many of these plants grow in sciaphilo-subnitrophilous annual communities of natural and semi-natural habitats, mostly belonging to the order *Geranio-Cardaminetalia* (Brullo et al., 2007). In the last twenty years in Calabria (southern Italy) many botanic studies were performed (Brullo et al., 2001; Musarella & Tripodi, 2004; Crisafulli et al., 2010; Bernardo et al., 2011, 2012; Signorino et al., 2011; Spampinato, 2014; Cano et al., 2017; Galasso et al., 2016a, 2016b, 2017, 2018a, 2018b; Stinca et al., 2016a; Spampinato et al., 2017, 2018, 2019; Musarella et al., 2018, 2019a; Panuccio et al., 2018; Maruca et al., 2019). Recently, Galasso et al. (2018c) recorded for this region 247 non-native species and subspecies (3 undefined status, likely casual aliens; 110 casual; 105 naturalized; 29 invasive). These surprising data allow Calabria as the fourth region with the lowest presence of exotic plants. Similarly to the other regions of southern Italy, probably this is due to lack of knowledge of the vascular flora in the most anthropized areas where alien plants are frequently found in greater numbers

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(e.g. Stinca & Motti, 2013; Stinca et al., 2016b), as well as in disturbed forest environments (Stinca & Motti, 2017; Bonanomi et al., 2018). Indeed, the number of alien species is steadily increasing in all southern regions, especially in environments with low level of naturalness (e.g. Motti et al., 2018; Stinca et al., 2018, 2019; Galasso et al., 2018b, 2019; Stinca, 2019; Stinca & Mei, 2019; Musarella, 2020; Rosati et al., 2020). Therefore, the aim of this paper is to report new data concerning the non-native flora of Calabria.

## Materials And Methods

This research was based on fieldwork carried out from 2010 to 2019, as well as on herbaria and literature surveys. The collected or examined plant material was stored in REGGIO, PORUN-Herb. Stinca, CLU and MS herbaria (acronyms according to Thiers, 2019).

In the floristic list, the species are arranged in alphabetical order. The nomenclature follows Galasso et al. (2018c). The collected specimens were identified by means of the standard literature (e.g. Tutin et al., 1964-1980, 1993; Pignatti, 1982; Pignatti et al., 2017-2019; Flora of North America Editorial Committee, 1993-2016).

For each species the following information are provided: 1) accepted name; 2) basionym and most relevant synonyms; 3) family; 4) life form according to Pignatti et al. (2017-2019) and verified by observations *in situ*; 5) native range; 6) period of introduction (archaeophyte or neophyte); 7) data report and current invasiveness status in Calabria, assessed by population monitoring over time according to the terminology of Pyšek et al. (2004); 8) discovery localities (*exsiccata* and *observata*) with details on the location (in Italian, according to the information on the specimen label data), growth environments, altitude, date, coordinates E and N (datum WGS84, UTM ), *legit* and *determinavit*; 9) distribution and/or ecological notes.

## Results

***Acacia saligna* (Labill.) H.L.Wendl.** [≡ *Mimosa saligna* Labill.]

Fabaceae – P scap – Australia – Neophyte.

First geolocalized reports in Calabria (provinces of Catanzaro and Reggio Calabria). Invasive.

*Exsiccatum.* Cropani presso la foce del Fiume Trocchio (Catanzaro), shrubland, 3 m a.s.l., 24.07.2018, 657722-4308474, *leg. et det*. A. Stinca (PORUN-Herb. Stinca).

*Observata.* Squillace all'Oasi Scolacium (Catanzaro), sandy dunes, 4 m a.s.l., 28.06.2018, 638004-4294839, *obs. et det.* C.M. Musarella *et* G. Spampinato; Reggio Calabria lungo il Torrente Calopinace (Reggio Calabria), river bank, 47 m a.s.l., 09.01.2014, 557160-4217238, *obs. et det*. C.M. Musarella; Reggio Calabria lungo il Raccordo Autostradale 4 di Reggio Calabria in località Modena (Reggio Calabria), roadside, 77 m a.s.l., 09.12.2018, 557995-4215949, *obs. et det.* C.M. Musarella; Reggio Calabria lungo la SS 106 Jonica in corrispondenza di località San Gregorio (Reggio Calabria), roadside, 32 m a.s.l., 22.12.2018, 557997-4212553, *obs. et det*. C.M. Musarella.

*Notes. A. saligna* was reported for Calabria by Conti et al. (2005) and after by Bernardo et al. (2009) and Galasso et al. (2018c) as invasive. In the past, this neophyte has been widely used to stabilize coastal sandy dunes and as ornamental plant. Afterwards, its spread was mainly due to the abundant seeds production. This invasive species was included by the Europaean Union in the "Union list" (Regulation EU No 1114/2014).

***Aeonium haworthii* Webb & Berthel.** [≡ *Sempervivum haworthii* (Webb & Berthel.) Salm-Dick ex Christ]

Crassulaceae – Ch suffr (succ) – Canary Islands – Neophyte.

New distribution data for the province of Reggio Calabria. Change of status for Calabria: from casual to naturalized.

*Exsiccatum.* Melito di Porto Salvo a Pentedattilo (Reggio Calabria), ruins, 265 m a.s.l., 566936-4200919, 07.01.2001, *leg. et det.* C.M. Musarella (MS).

*Observatum.* Melito di Porto Salvo a Pentedattilo (Reggio Calabria), ruins, 265 m a.s.l., 566936-4200919, 03.05.2019, *obs. et det.* C.M. Musarella.

*Notes. A. haworthii* is a popular ornamental plant in Italy reported as casual in Toscana, Puglia, Calabria, Sicilia and Sardegna, and as naturalized in Liguria and Campania (Galasso et al., 2018c). In Calabria, only Musarella & Tripodi (2004) reported it on the walls of the ruined houses and into the rocks cracks (see *exsiccatum*) for the abandoned village of Pentedattilo (Melito di Porto Salvo). After several surveys in the same place since the first time it was observed, the species continues to be present and to produce new individuals. For this reason, we propose a change of its status from casual to naturalized in Calabria.

***Agave filifera* Salm-Dyck** [= *Agave filamentosa* Salm-Dyck ≡ *Bonapartea filamentosa* (Salm-Dyck) Boucen.]

Asparagaceae – H succ – North America (Mexico) – Neophyte.

First report for Europe (Canary Islands excluded). Casual.

*Exsiccatum.* Reggio Calabria lungo Via Veglia salendo dallo svincolo di Via Lia (Reggio Calabria), roadside, 102 m a.s.l., 01.02.2019, 558097-4220132, *leg. et det*. C.M. Musarella (REGGIO).

*Notes*. *A. filifera* is an exotic plant native to central Mexico, from Querétaro to Mexico State. In the Euro-Mediterrenean area, it was recorded for the first time in Algeria (Zeddam et al., 2018) and Canary Islands (Verloove et al., 2019). Therefore, our find is the first one for Europe (Canary Islands excluded) and it is referred to a little group of plants living with *Aloë vera* (see below) along the edge of a road, probably abandoned as garbage.

***Aloë vera* (L.) Burm.f.** [≡ *Aloë perfoliata* L. var. *vera* L. = *Aloe barbadensis* Mill. = *Aloe vulgaris* Lam.]
Asphodelaceae – NP – Arabian Peninsula and East Africa – Archeophyte.
New distribution data for the province of Reggio Calabria. Change of status for Calabria: from casual to naturalized.
*Exsiccata.* Motta San Giovanni lungo la SS 106 Jonica in corrispondenza di Capo dell'Armi (Reggio Calabria), rocks, 30 m a.s.l., 23.01.2019, 559709-4200916, *leg. et det.* C.M. Musarella (REGGIO); Melito di Porto Salvo a Pentedattilo (Reggio Calabria), rocks, 303 m a.s.l., 11.04.2017, 566940-4200991, *leg. et det.* C.M. Musarella (REGGIO); Reggio Calabria lungo Via Veglia salendo dallo svincolo di Via Lia (Reggio Calabria), roadside, 102 m a.s.l., 01.02.2019, 558097-4220132, *leg. et det*. C.M. Musarella (REGGIO).
*Observatum.* Melito di Porto Salvo a Pentedattilo (Reggio Calabria), rocks, 303 m a.s.l., 28.02.1998, 566940-4200991, *obs. et det.* C.M. Musarella.
*Notes.* For Calabria, Fiori (1923, sub *A. vera* "L."), Pignatti (1982, sub *Aloe barbadensis* Miller) and Pignatti et al. (2017-2019, sub *Aloe vera* (L.) Burm. fil.) reported *A. vera* as cultivated and "naturalized", while Bernardo et al. (2009, sub *Aloe vera* "L.") indicated generically it for the region. Bernardo et al. (2011, sub *Aloe vera* "L.") reported this species for the Crati Valley (northern Calabria), but this record is an erroneous interpretation of Passalacqua et al. (2007), which refers this plant only as cultivated for ethnobotanical purposes. After the first finding in Pentedattilo by Musarella in 1998 (see *observatum*), a lot of surveys in the same place confirmed its presence in several points of this abandoned village, living in the rocks cracks and producing new individuals.

***Anredera cordifolia* (Ten.) Steenis** [≡ *Boussingaultia cordifolia* Ten.]
Basellaceae – P lian – South America – Neophyte.
First geolocalized reports in Calabria (province of Reggio Calabria). Naturalized.
*Exsiccata.* Reggio Calabria al quartiere Santa Caterina (Reggio Calabria), roadside, 74 m a.s.l., 09.01.2019, 557814-4220147, *leg. et det.* C.M. Musarella (REGGIO); Reggio Calabria all'incrocio tra Via Borrace Alla Caserma e Via del Torrione (Reggio Calabria), near a wall, 52 m a.s.l., 14.01.2019, 557829-4219349, *leg. et det.* C.M. Musarella (REGGIO); Reggio Calabria al quartiere Santa Caterina (Reggio Calabria), ruin, 32 m a.s.l., 14.01.2019, 557552-4220010, *leg. et det.* C.M. Musarella (REGGIO); Reggio Calabria presso località Catona (Reggio Calabria), near a wall, 21 m a.s.l., 20.03.2019, 556642-4226899, *leg. et det.* C.M. Musarella, G. Spampinato *et* V.L.A. Laface (REGGIO).
*Notes.* Based on our literature research, *Anredera cordifolia* was recorded for the first time in Calabria by Bernardo et al. (2009) as casual alien. Recently, Pasta et al. (2016) states that this exotic taxon appears quite naturalized and rather generically widespread along the Tyrrhenian coast of Reggio Calabria and Cosenza. We confirm these data for the province of Reggio Calabria.

***Araujia sericifera* Brot.** [= *Araujia albens* (Mart.) G.Don]
Apocynaceae – P lian – South America – Neophyte.
Confirmation for Calabria (province of Reggio Calabria). Casual.
*Exsiccatum*. Reggio Calabria presso località Catona (Reggio Calabria), uncultivated field, 22.11.2014, unspecified coordinates, *leg. et det.* G. Arena (REGGIO).
*Notes.* In Calabria *A. sericifera* was indicated as "recently not confirmed" by Galasso et al. (2018c). Therefore, we can confirm its presence in this region as casual. In Italy this is an invasive exotic plant (Galasso et al., 2018c) and a secondary host for viruses harmful to crops (Parrella et al., 2013).

***Cardamine occulta* Hornem.** [= *Cardamine flexuosa* With. subsp. *debilis* O.E.Schulz ≡ *Cardamine hamiltonii* G.Don]
Brassicaceae – T scap – South-East Asia – Neophyte.
First reports for Calabria (province of Cosenza). Casual.
*Exsiccata.* Rossano presso l'Agriturismo Malena (Cosenza), flowerbed, 109 m a.s.l., 16.08.2018, 644030-4381590, *leg. et det*. A. Stinca (PORUN-Herb. Stinca); Santa Maria del Cedro a Marina di Santa Maria del Cedro (Cosenza), flowerbed, 4 m a.s.l., 18.08.2017, 568501-4401666, *leg.* A. Stinca *et* M. Ravo, *det.* A. Stinca (PORUN-Herb. Stinca).
*Notes.* In Italy this species was reported in Piemonte, Lombardia, Trentino-Alto Adige, Friuli-Venezia Giulia, Veneto, Emilia Romagna, Toscana, Marche, Umbria, Lazio, Campania and Sardegna (Galasso et al., 2018a, 2018b, 2018c). As observed in other populations in southern Italy (Stinca et al., 2017), also in Calabria *C. occulta* has been largely widespread by nurseries and soil transportation.

***Cenchrus setaceus* (Forssk.) Morrone** [≡ *Phalaris setacea* Forssk. ≡ *Pennisetum setaceum* (Forssk.) Chiov.]
Poaceae – H caesp – North-East Africa – Neophyte.
New distribution data for the province of Catanzaro, Cosenza and Reggio Calabria. Change of status for Calabria: from casual to naturalized.
*Exsiccata.* Gioia Tauro nel parcheggio della stazione ferroviaria (Reggio Calabria), sidewalk, 35 m s.l.m., 08.04.2018, 578442-

4253264, *leg*. S. Cannavò, *det*. S. Cannavò, C.M. Musarella *et* G. Spampinato (REGGIO); Reggio Calabria in località Armo (Reggio Calabria), scarp ex uncultivated olive grove, 321 m s.l.m., 19.11.2018, 562475-4214103, *leg*. V.L.A. Laface, *det*. C.M. Musarella, G. Spampinato *et* V.L.A. Laface (REGGIO); Bova Marina lungo la SP Bova Marina-Bova (Reggio Calabria), roadside and uncultivated field, 143 m s.l.m., 20.11.2018, 582549-4199250, *leg*. V.L.A. Laface, *det*. C.M. Musarella, G. Spampinato *et* V.L.A. Laface (REGGIO); Villa San Giovanni lungo l'Autostrada A2 del Mediterraneo all'area di servizio Villa San Giovanni est (Reggio Calabria), flowerbed, 100 m s.l.m., 08.01.2019, 556551-4231223, *leg. et det.* C.M. Musarella (REGGIO); Reggio Calabria lungo la SS 106 Jonica presso località Ravagnese (Reggio Calabria), roadside, 38 m s.l.m., 19.11.2018, 558138-4213357, *leg. et det.* C.M. Musarella (REGGIO); Reggio Calabria presso località Catona (Reggio Calabria), anthropized places, 2 m s.l.m., 09.02.2019, 556079-4226281, *leg. et det.* V.L.A. Laface (REGGIO); Reggio Calabria presso località Marinella di Catona (Reggio Calabria), roadside, 2 m s.l.m., 06.04.2019, 555559-4227374, *leg. et det.* G. Spampinato *et* V.L.A. Laface (REGGIO); Montebello Jonico tra località Saline e Pantano (Reggio Calabria), railway, 8 m s.l.m., 07.04.2019, 562790-4198976, *leg. et det.* G. Spampinato *et* V.L.A. Laface (REGGIO).

*Observata.* Reggio Calabria lungo il Raccordo Autostradale 4 di Reggio Calabria in località Modena (Reggio Calabria), roadside, 90 m s.l.m., 09.12.2018, 557874-4216191, *obs. et det.* C.M. Musarella; Reggio Calabria lungo Raccordo Autostradale 4 di Reggio Calabria prima della galleria Spirito Santo in direzione Sud (Reggio Calabria), roadside, 93 m s.l.m., 21.11.2018, 557933-4218164, *obs. et det.* V.L.A. Laface *et* C.M. Musarella; Gizzeria presso località C. Stocco al confine con Falerna (Catanzaro), sandy dunes, 3 m s.l.m., 24.11.2017, 599823-4313321, *obs. et det.* C. Gangale, D. Puntillo *et* D. Uzunov.

*Notes.* Castellano & Marino (2007) make the first find of *C. setaceus* (sub *Pennisetum setaceum*) in Calabria. They reported the presence of this species in the provinces of Reggio Calabria (along the A2 motorway between Rosarno and Gioia Tauro) and Catanzaro (along the highway SS 106 Jonica near Cropani Marina). Successively Bernardo et al. (2011) generically recorded it for "Medio Tirreno" on the basis of three *exsiccata* collected at Fiumefreddo Bruzio and Capo Suvero and stored in CLU [Fiumefreddo Bruzio lungo la SS 18 (Cosenza), 50 m a.s.l., 13.09.1998, WD 91.42, *leg. et det.* D. Puntillo; Fiumefreddo Bruzio lungo la SS 18 (Cosenza), 50 m a.s.l., 01.11.1999, WD 91.42, *leg. et det.* L. Bernardo; Capo Suvero (Cosenza), 5 m a.s.l., 10.10.2008, XD 00.11, *leg. et det.* L. Bernardo]. As a result, Galasso et al. (2018c) indicated this exotic species as casual for the flora of Calabria. *C. setaceus* probably came from Sicily, where it is very widespread (Pasta et al., 2010). Our data highlights the active spreading process of this species via seeds along the southern Italian coastal strip, favored by the road network and vehicular traffic. In all these sites *C. setaceus* seems to form populations capable of self-sustaining reproduction. We therefore propose the status change from casual to naturalized in Calabria. This species was included by the Europaean Union in the "Union list" (Regulation EU No 1114/2014).

***Cyperus alternifolius* L. subsp. *flabelliformis* Kük.** [= *Cyperus involucratus* Rottb.]

Cyperaceae – H rhiz – East Africa – Neophyte.

First reports for Calabria (province of Reggio Calabria). Casual.

*Exsiccata.* Villa San Giovanni in località Santa Trada, lungo la strada che porta dallo svincolo autostradale alla SS 18 (Reggio Calabria), water drainage channel, 50 m a.s.l., 09.01.2019, 559299-4232631, *leg. et det*. C.M. Musarella (REGGIO); Villa San Giovanni lungo la Fiumara Santa Trada, lungo il corso d'acqua (Reggio Calabria), in the bed of the river, 24 m a.s.l., 25.04.2019, 559025-4232687, *leg. et det*. C.M. Musarella (REGGIO).

*Observatum.* Reggio Calabria lungo l'Autostrada A2 in corrispondenza di località Baglio Giunta (Reggio Calabria), roadside, 62 m a.s.l., 09.03.2019, 558497-4223134, *obs. et det.* V.L.A. Laface.

*Notes.* In Italy it was reported for many regions, except Valle d'Aosta, Piemonte, Trentino-Alto Adige, Friuli-Venezia Giulia, Molise, Basilicata and Calabria (Galasso et al., 2018c).

***Euphorbia hypericifolia* L.** [≡ *Anisophyllum hypericifolium* (L.) Haw. ≡ *Chamaesyce hypericifolia* (L.) Millsp.]

Euphorbiaceae – T scap – America – Neophyte.

First reports for Calabria (provinces of Catanzaro and Reggio Calabria). Casual.

*Exsiccata.* Motta San Giovanni in località Lazzaro Vecchio (Reggio Calabria), sandy dunes, 3 m a.s.l., 08.07.2011, 558090-4202970, *leg. et det*. C.M. Musarella (REGGIO); Reggio Calabria in via Fiumarella (Reggio Calabria), uncultivated field, 11 m a.s.l., 06.10.2018, 556516-4208229, *leg.* C.M. Musarella, *det*. C.M. Musarella *et* G. Spampinato (REGGIO); Girifalco presso località Curcio (Catanzaro), uncultivated field, 396 m a.s.l., 10.09.2018, 624611-4298764, *leg. et det.* R. Petrilli (REGGIO).

*Notes.* Sciandrello et al. (2016) recorded *E. hypericifolia* for the first time in Italy in two coastal areas close to the town of Taormina (eastern Sicilia). Later, Lazzeri (2017) and Spadaro & Raimondo (2017) report this species for Toscana and other locations of western Sicilia, respectively. Finally, Galasso et al. (2018b) states that a previous record by Buono et al. (2017) of *Euphorbia hyssopifolia* L. for Puglia should be referred to *E. hypericifolia*. Therefore, in Italy this species has been recorded only in Toscana, Puglia and Sicilia, whereas it was reported by mistake in Lombardia (Galasso et al., 2018c). With these new records, *E. hypericifolia* can be considered as new for the vascular flora of Calabria.

***Ficus microcarpa* L.f.** [– *Ficus retusa* auct. p.p., non L.]
Moraceae – P scap – Asia and North Australia – Neophyte.
First reports for Calabria (provinces of Cosenza and Reggio Calabria). Casual.
*Exsiccata.* Scalea in centro (Cosenza), wall, 7 m a.s.l., 20.08.2017, 567723-4407273, *leg.* A. Stinca *et* M. Ravo, *det.* A. Stinca (PORUN-Herb. Stinca); Reggio Calabria lungo il Torrente Calopinace (Reggio Calabria), wall, 13 m a.s.l., 09.01.2019, 555796-4217193, *leg. et det*. C.M. Musarella (REGGIO); Reggio Calabria lungo il Torrente Calopinace, wall, 15 m a.s.l., 09.01.2019, 555894-4217194, *leg. et det*. C.M. Musarella (REGGIO); Reggio Calabria lungo il Torrente Calopinace, wall, 22 m a.s.l., 09.01.2019, 556210-4217227, *leg. et det*. C.M. Musarella (REGGIO).
*Notes.* Only recently this exotic plant was recorded in southern Italy for Campania (Stinca et al., 2017). In Calabria the observed individuals have been originated by the seeds of nearby cultivated plants.

***Leucaena leucocephala* (Lam.) de Wit subsp. *glabrata* (Rose) Zárate** [≡ *Leucaena glabrata* Rose]
Fabaceae – P scap – Tropical America – Neophyte.
First reports for Calabria (province of Reggio Calabria) and continental Italy. Casual.
*Exsiccata.* San Lorenzo in località Marina di S. Lorenzo (Reggio Calabria), uncultivated field, unspecified altitude, 15.12.2014, unspecified coordinates, *leg. et det*. F. Lugarà (REGGIO); Reggio Calabria lungo la SS 106 Jonica in corrispondenza di località San Leo (Reggio Calabria), roadside, 17 m a.s.l., 22.12.2018, 557564-4211119, *leg. et det*. C.M. Musarella (REGGIO); Reggio Calabria lungo la SS 106 Jonica in corrispondenza di località San Gregorio (Reggio Calabria), roadside, 32 m a.s.l., 22.12.2018, 557997-4212553, *leg. et det*. C.M. Musarella (REGGIO); Villa San Giovanni lungo l'Autostrada A2 del Mediterraneo allo svincolo di Villa San Giovanni (Reggio Calabria), roadside, 86 m a.s.l., 08.01.2019, 556678-4230515, *leg. et det.* C.M. Musarella (REGGIO); Reggio Calabria in località Pellaro nei pressi della stazione ferroviaria (Reggio Calabria), flowerbed, 8 m a.s.l., 11.01.2019, 557073-4208726, *leg. et det*. C.M. Musarella (REGGIO); Reggio Calabria lungo la strada per Gallina presso località C. delle Rose (Reggio Calabria), roadside, 173 m a.s.l., 19.02.2019, 558962-4215774, *leg. et det.* V.L.A. Laface (REGGIO); Melito di Porto Salvo lungo la SS 183 presso contrada Caderia, (Reggio Calabria), roadside, 91 m a.s.l., 16.02.2019, 569415-4200195, *leg. et det.* V.L.A. Laface (REGGIO); Villa San Giovanni lungo SS 18 tra località Porticello e il castello di Altafiumara (Reggio Calabria), roadside, 20 m a.s.l., 17.02.2019, 559128-4232894, *leg. et det*. V.L.A. Laface (REGGIO).
*Observata.* Condofuri presso località Straci (Reggio Calabria), roadside, 15 m a.s.l., 16.02.2019, 574187-4197656, *obs. et det.* V.L.A. Laface; Reggio Calabria lungo SS 106 Jonica in località Occhio di Pellaro (Reggio Calabria), roadside, 15 m a.s.l., 16.02.2019, 557763-4209823, *obs. et det*. V.L.A. Laface.
*Notes.* In Italy *L. leucocephala* subsp. *glabrata* was recorded only in Sicily as naturalized alien near Agrigento, Campofelice di Roccella and Cefalù (Raimondo & Domina, 2007; Galasso et al., 2018c). Therefore, our finding is the first for continental Italy. Probably the individuals gathered in Calabria developed from seeds dispersed by plants nearby cultivated plants.

***Narcissus papyraceus* Ker Gawl.** [= *Narcissus barlae* Parl. = *Narcissus niveus* Loisel. = *Narcissus polyanthos* Loisel.]
Amaryllidaceae – G bulb – West Mediterranean (Iberian Peninsula, France, Algeria, Morocco [?]) – Archeophyte.
First reports for Calabria (province of Reggio Calabria). Casual.
*Exsiccata.* Reggio Calabria presso località Cerasi (Reggio Calabria), uncultivated field, 660 m a.s.l., 23.11.2018, 565730-4223710, *leg.* V.L.A. Laface, *det.* C.M. Musarella, G. Spampinato *et* V.L.A. Laface (REGGIO); Reggio Calabria presso località Cerasi (Reggio Calabria), uncultivated olive grove, 655 m a.s.l., 23.11.2018, 565877-4223618, *leg.* V.L.A. Laface, *det.* C.M. Musarella, G. Spampinato *et* V.L.A. Laface (REGGIO); Reggio Calabria in località Ortì Inferiore (Reggio Calabria), uncultivated field, 670 m a.s.l., 12.01.2018, 562400-4222398, *leg.* V.L.A Laface, *det.* C.M. Musarella, G. Spampinato *et* V.L.A. Laface (REGGIO); Calanna tra località Caria e Rocche (Reggio Calabria), uncultivated field, 568 m a.s.l., 12.01.2019, 563196-4227555, *leg.* V.L.A. Laface, *det.* C.M. Musarella, G. Spampinato *et* V.L.A. Laface (REGGIO); Santo Stefano in Aspromonte lungo la SS 184 (Reggio Calabria), uncultivated field, 797 m a.s.l., 12.01.2018, 568352-4224570, *leg.* V.L.A. Laface, *det.* C.M. Musarella, G. Spampinato *et* V.L.A. Laface (REGGIO).
*Notes.* In Italy this species was reported in Lombardia, Liguria, Toscana, Marche, Campania, Puglia, Sicilia, and Sardegna (Galasso et al., 2018c). Therefore, our findings are the first for Calabria.

***Petroselinum crispum* (Mill.) Fuss** [≡ *Apium crispum* Mill.]
Apiaceae – H bienn – Mediterranean (Europe and Asia) – Archeophyte.
First report for Calabria (province of Cosenza). Casual.
*Exsiccatum.* Scalea in centro (Cosenza), between floor cracks, 7 m a.s.l., 22.08.2016, 567636-4407438, *leg. et det.* A. Stinca (PORUN-Herb. Stinca).
*Notes. P. crispum* was recorded as casual in all Italian regions, except Valle d'Aosta, Friuli-Venezia Giulia, Calabria and Sicilia (Galasso et al., 2018c). The individuals observed in Calabria have spread by the seeds of nearby cultivated plants.

***Phoenix canariensis* H.Wildpret**
Arecaceae – P scap – Macaronesia – Neophyte.

First geolocalized report in Calabria (province of Catanzaro). Change of status for Calabria: from naturalized to casual.
*Observatum.* Staletti alle Vasche di Cassiodoro (Catanzaro), sea rocks, 5 m a.s.l., 28.06.2018, 636509-4291446, *obs. et det.* C.M. Musarella *et* G. Spampinato.
*Notes.* This species was reported generically for Calabria by Bernardo et al. (2009, 2011), and recently by Galasso et al. (2018c) as naturalized. However, *P. canariensis* in this region not form self-replacing populations, unlike other southern Italian regions (e.g. Campania: Stinca et al., 2012). It was observed during a monitoring action of habitats in the sea rocks of the SIC "Scogliere di Staletti" and it clearly came from some mature individuals in a villa overlooking the cliff below.

***Physalis angulata* L.** [≡ *Boberella angulata* (L.) E.H.L.Krause]
Solanaceae – T scap – America – Neophyte.
First report for Calabria (province of Reggio Calabria) and southern Italy. Casual.
*Exsiccatum.* Laureana di Borrello al lago L'Aquila (Reggio Calabria), near the lake shore, 36 m a.s.l., 12.09.2013, 589615-4263017, *leg. et det.* S. Cannavò, C.M. Musarella *et* G. Spampinato (REGGIO).
*Notes.* Casual alien species with Italian distribution range including only in Lombardia, Veneto and Lazio (Galasso et al., 2018c).

***Prunus laurocerasus* L.**
Rosaceae – P scap – South-East Europe, West Asia and Caucasus – Neophyte.
Change of status for Calabria: from naturalized to casual.
*Exsiccatum.* Decollatura al SIC "Boschi di Decollatura" (Catanzaro), old chestnut grove, 911 m a.s.l., 22.06.2018, 615668-4323267, *leg.* C.M. Musarella, A. Morabito, G. Settineri *et* M. Prigoliti, *det.* C.M. Musarella (REGGIO).
*Notes.* This species was reported recently for Calabria by Musarella et al. (2019b) as naturalized at Decollatura. However, *P. laurocerasus* in this locality, as well as in all the region, not form self-replacing populations. It was reported in many Italian regions, except Friuli-Venezia Giulia, Molise, Basilicata, Calabria, Sicilia and Sardinia (Galasso et al., 2018c).

***Saccharum biflorum* Forssk.** [= *Saccharum aegyptiacum* Willd. – *Saccharum spontaneum* auct., non L.]
Poaceae – H caesp – Palaeotropical – Neophyte.
First reports for Calabria (province of Reggio Calabria) and confirmation for continental Italy. Naturalized.
*Exsiccata.* Reggio Calabria località Sopra Lume in corrispondenza dell'incrocio con via Pantano (Reggio Calabria), roadside, 40 m a.s.l., 23.12.2018, 557467-4208236, *leg. et det*. C.M. Musarella (REGGIO); Reggio Calabria presso località Bocale (Reggio Calabria), vineyard margins, 28 m a.s.l., 23.12.2018, 556506-4206133, *leg. et det*. C.M. Musarella (REGGIO); Reggio Calabria lungo la SS 106 Jonica presso località Bocale (Reggio Calabria), roadside, 23 m a.s.l., 23.12.2018, 556483-4205948, *leg. et det*. C.M. Musarella (REGGIO); Reggio Calabria lungo la SS 106 Jonica presso località Pellaro (Reggio Calabria), roadside, 14 m a.s.l., 23.12.2018, 557486-4209007, *leg. et det*. C.M. Musarella (REGGIO).
*Notes.* Naturalized alien plant in Sicily, occurring with an undefined invasion status in Sardegna and no longer recorded in Puglia (Galasso et al., 2018c). Since about 10 years, this species grows in several uncultivated fields and along the roads of Reggio Calabria. Because of its ancient presence with fructifying mature clumps, we record here the new report for this species for continental Italy.

***Sedum palmeri* S.Watson** [= *Sedum compressum* Rose]
Crassulaceae – Ch suffr (succ) – North America (Mexico) – Neophyte.
First report for Calabria (province of Crotone). Casual.
*Exsiccatum.* Casabona in località Zinga (Crotone), humid wall, 354 m a.s.l., 12.10.2018, 665270 -4347473, *leg. et det*. A. Stinca (PORUN-Herb. Stinca).
*Notes*. The Italian distribution range of this neophyte includes Lombardia, Veneto, Liguria, Emilia-Romagna, Lazio, Campania and Sardegna (Galasso et al., 2018c). As observed in other populations in southern Italy (Stinca et al., 2017), also the individuals recorded in Calabria have spread almost surely by seeds.

***Senna corymbosa* (Lam.) H.S.Irwin & Barneby** [≡ *Cassia corymbosa* Lam.]
Fabaceae – NP – South America – Neophyte.
First report for Calabria (province of Reggio Calabria) and continental Italy. Casual.
*Exsiccata.* Reggio Calabria presso località San Gregorio, in una traversa di Via Mortara di Ravagnese (Reggio Calabria), land with abandoned waste, 26 m a.s.l., 05.10.2018, 557287-4213012, *leg. et det.* C.M. Musarella (REGGIO); Reggio Calabria presso località San Gregorio, in una traversa di Via Mortara di Ravagnese (Reggio Calabria), land with abandoned waste, 26 m a.s.l., 03.12.2018, 557287-4213012, *leg. et det.* C.M. Musarella (REGGIO).
*Notes.* Only one individual was found in an abandoned area, among waste and nitrophilous vegetation. A first observation was made in October 2018 on the flowering plant, a second one in December on the same plant with fruits. In Italy, this species has been recorded only in Sardinia as casual alien in Camassi (Lazzeri et al., 2013; Galasso et al., 2018c). Therefore, our finding is the first for continental Italy.

***Tagetes erecta* L.** [= *Tagetes patula* L.]
Asteraceae – T scap – North America – Neophyte.
First report for Calabria (province of Crotone). Casual.

*Observatum*. Caccuri in località La Conicella (Crotone), road edge, 515 m a.s.l., 11.10.2018, 654331-4344348, *obs. et det.* A. Stinca.
*Notes*. Casual alien species with Italian distribution range including Piemonte, Lombardia, Trentino-Alto Adige, Friuli-Venezia Giulia, Veneto, Liguria, Emilia Romagna, Toscana, Lazio, Abruzzo, Molise, Campania, Sicilia and Sardegna (Galasso et al., 2018c).

## Discussion

In this work new data concerning the distribution of 21 non-native vascular species for Calabria are presented. *Agave filifera* is reported for the first time in Europe (Canary Islands excluded), while *Leucaena leucocephala* subsp. *glabrata* and *Senna corymbosa* are indicated for the first time in continental Italy. *Physalis angulata* is a new exotic taxon for southern Italy, while *Cardamine occulta*, *Cyperus alternifolius* subsp. *flabelliformis*, *Euphorbia hypericifolia*, *Ficus microcarpa*, *Narcissus papyraceus*, *Petroselinum crispum*, *Prunus laurocerasus*, *Sedum palmeri* and *Tagetes erecta* are reported for the first time in Calabria. In addition, *Saccharum biflorum* is collected for the first time for this region and it is a confirmation of its presence in Italian Peninsula. The presence of *Araujia sericifera* for the region is also confirmed. New distribution data regarding 14 species are first finds for some provinces of Calabria. Most of these new reports concern the province of Reggio Calabria (n. 10 taxa), while no alien plants were recorded in Vibo Valentia province (Tab. 1).
Moreover, the discovery of new sites and their population monitoring, along with a critical analysis of the literature, allowed us to update the alien status in Calabria for *Aeonium haworthii* (from casual to naturalized), *Aloë vera* (from casual to naturalized), *Cenchrus setaceus* (from casual to naturalized), *Phoenix canariensis* (from naturalized to casual) and *Prunus laurocerasus* (from naturalized to casual).

## Conclusions

Due to the importance of managing alien species from a region scale up to level of each habitat, it is very important to know their presence and distribution. In addition, the monitoring of non-native plant populations is fundamental to outline needful measures according to the guidelines of the conservation biogeography (Richardson, 2012; Cano-Ortiz et al., 2016). The results obtained in this research confirm the importance of field investigations to detect the presence of alien species in Calabria, as well as some aspect of their biology invasion. However, further researches aimed to increase the knowledge of the exotic flora of this region will be more necessary in the future.

**Table 1.** New reports of alien taxa for the provinces of Calabria (CS: Cosenza; CZ: Catanzaro; KR: Crotone; RC: Reggio Calabria; VV: Vibo Valentia).

| Taxon | Provinces | | | | |
|---|---|---|---|---|---|
| | CS | CZ | KR | RC | VV |
| *Agave filifera* | | | | • | |
| *Araujia sericifera* | | | | • | |
| *Cardamine occulta* | • | | | | |
| *Cyperus alternifolius* subsp. *flabelliformis* | | | | • | |
| *Euphorbia hypericifolia* | | • | | • | |
| *Ficus microcarpa* | • | | | • | |
| *Leucaena leucocephala* subsp. *glabrata* | | | | • | |
| *Narcissus papyraceus* | | | | • | |
| *Petroselinum crispum* | • | | | | |
| *Physalis angulata* | | | | • | |
| *Saccharum biflorum* | | | | • | |
| *Sedum palmeri* | | | • | | |
| *Senna corymbosa* | | | | • | |
| *Tagetes erecta* | | | • | | |
| Total reports | 3 | 1 | 2 | 10 | 0 |

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# Nuove segnalazioni floristiche italiane 9. Flora vascolare (67–78)

V.L.A. Laface, C.M. Musarella, G. Spampinato, D. Iamonico, A. Noor Hussain, P. Fortini, L. Peruzzi, M. Giardini, D. Angeloni, E. Meneguzzo, A. Meneguzzo, E. Banfi, G. Busnardo, G. Galasso, M. Kleih, B. Wallnöfer, L. Bernardo, F. Roma-Marzio, M. Brentan, R. Marcucci

67. ***Acacia dealbata*** Link subsp. ***dealbata*** (Fabaceae)
(NAT) **CAL**: Ortì (Reggio Calabria), località San Nicola (WGS84: 38.152752 N, 15.695745 E), bordo strada, 552 m s.l.m., 26 gennaio 2020, *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella et G. Spampinato* (REGGIO); Diminniti di Sambatello (Reggio Calabria), località Malupassu (WGS84: 38.159496 N, 15.720715 E), bordo strada, 588 m s.l.m., 26 gennaio 2020, *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella et G. Spampinato* (REGGIO); Reggio Calabria, Passo della Serra, S.P. Ortì-Gambarie (WGS84: 38.144852 N, 15.771749 E), bordo strada, 948 m s.l.m., 1 dicembre 2019, *V.L.A. Laface*, det. V.*L.A. Laface, C.M. Musarella et G. Spampinato* (REGGIO, FI); Reggio Calabria, Passo della Serra, S.P. Ortì-Gambarie, (WGS84:38.147149 N, 15.774518 E), bordo strada, 946 m s.l.m., 1 dicembre 2019, *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella et G. Spampinato* (REGGIO); Decollatura (Catanzaro), C.da Calollo, SP 159 Lamezia Terme-Decollatura, in un querceto a bordo strada (WGS84: 38.983048 N, 16.331100 E), 422 m s.l.m.,19 dicembre 2019, *V.L.A. Laface, C.M. Musarella et G. Spampinato* (REGGIO, FI). – Specie esotica naturalizzata di nuova segnalazione per le province di Catanzaro e Reggio Calabria.
*Acacia dealbata* è una specie originaria dell'Australia, coltivata nel nostro Paese esclusivamente a fini ornamentali (CABI 2020). Tende a spontaneizzarsi facilmente formando piccoli boschi che dipingono di giallo le colline in febbraio/marzo. È diffusa in molte regioni d'Italia come specie esotica casuale (Basilicata, Campania, Friuli Venezia Giulia, Lombardia, Piemonte), naturalizzata (Lazio, Sardegna) o invasiva (Toscana, Liguria) (Galasso et al. 2018). Recen-temente è stata segnalata come naturalizzata in Calabria per la provincia di Cosenza (Galasso et al. 2020). Le stazioni qui segnalate rappresentano le prime segnalazioni per le province di Reggio Calabria e Catanzaro.

Valentina Lucia Astrid Laface, Carmelo Maria Musarella, Giovanni Spampinato

68**.** ***Amaranthus tuberculatus*** (Moq.) J.D.Sauer (Amaranthaceae)
(NAT) **MAR**: Falconara marittima (Ancona), località Fiumesino (WGS84: 43.637329 N, 13.369258 E), incolti adiacenti Via del Fiume, 5 m s.l.m., 15 settembre 2020, *D. Iamonico, A. Ansadi, N. Hofmann* (FI, HFLA, IS, PESA); Falconara marittima (Ancona), località Fiumesino (WGS84: 43.638872 N, 13.368423 E), greto del fiume Esino non distante dal ponte pedonale, 5 m s.l.m., 15 settembre 2020, *D. Iamonico, A. Ansadi, N. Hofmann* (FI, HFLA, IS, PESA). – Specie esotica naturalizzata di nuova segnalazione per la provincia di Ancona.
*Amaranthus tuberculatus* è una specie nativa del Nord America (Iamonico 2015), segnalata in Italia come invasiva in Lombardia, Veneto, Emilia-Romagna e Marche, naturalizzata in Piemonte e casuale in Trentino-Alto Adige, Friuli Venezia Giulia e Toscana (Galasso et al. 2018). Nelle Marche la specie risulta indicata per la provincia di Pesaro e Urbino dove è stata segnalata per la prima volta da Gubellini, Pinzi (2008) lungo le sponde del fiume Metauro. Nel corso di recenti indagini floristiche sul genere *Amaranthus*, abbiamo rinvenuto due popolazioni di *A. tuberculatus* in località Fiumesino (Provincia di Ancona). La popolazione presente nell'incolto lungo la Via del Fiume è rappresentata da 2-3 individui e non sembra rappresentare una minaccia per la flora e vegetazione circostante (casuale). Al contrario, la popolazione lungo le sponde del fiume è ricca in individui e si estende per diverse decine di metri quadrati nella vegetazione spontanea (naturalizzata). Oltre ad essere le prime stazioni di *A. tuberculatus* per la Provincia di Ancona, esse rappresentano le più meridionali per l'Italia.

Duilio Iamonico, Amara Noor Hussain, Paola Fortini

69. ***Athamanta ramosissima*** Port. (Apiaceae)
**CAL**: Frascineto (Cosenza), rupi a nord-ovest di Timpone del Corvo (WGS84: 39.84539 N, 16.26263 E), 725-800 m, 11 agosto 2020, *L. Peruzzi* (FI). – Nuova stazione di specie rara.
La specie è stata osservata anche a Frascineto (Cosenza), rupi sopra Eianina (WGS84: 39.83821 N, 16.27503 E), 650-700 m s.l.m.; Civita (Cosenza), rupi sotto al Ponte del Diavolo (WGS: 39.82904 N, 16.31838 E), 250 m s.l.m.; San Lorenzo Bellizzi (Cosenza), rupi e massi erratici in loc. Scala di Barile (WGS84: 39.89024 N, 16.31530 E), 570-625 m s.l.m. Si tratta di una specie austroitalico-liburnica (Peruzzi, Gargano 2004a), presente in Italia in una ristretta fascia dalla Campania meridionale alla Calabria settentrionale. Le località calabresi, tutte ricadenti

nel Parco Nazionale del Pollino, dalla letteratura erano sinora 8 (Peruzzi, Gargano 2004a, Di Marco et al. 2013). Interessante notare che le aree di Frascineto ed Eianina non risultassero tra quelle potenzialmente vocate a questa specie nel modello distributivo pubblicato da Peruzzi, Gargano (2004a). Al contrario, sulle rupi a monte di Frascineto e Eianina si contano centinaia di individui, alcune decine dei quali in fruttificazione (anche la fioritura è riportata come un fenomeno sporadico).

Lorenzo Peruzzi

70. ***Campanula bononiensis*** L. (Campanulaceae)
**LAZ**: Poggio Moiano (Rieti), al margine di strada sterrata e campi coltivati (WGS84: 42.196525 N, 12.884877 E), 425 m s.l.m., 27 giugno 2020, *M. Giardini et D. Angeloni* (FI, RO, *Herb. Giardini*). – Nuova stazione di entità rarissima nel Lazio e nuovo limite altitudinale per la regione.
In Italia la specie è presente in tutte le regioni settentrionali e centrali, giungendo verso sud fino al Lazio e al Molise, mentre in Campania non è più segnalata da molto tempo (Bartolucci et al. 2018). Per quanto riguarda il Lazio sono noti campioni d'erbario per due sole località del reatino: Rivodutri e Borgorose (Anzalone et al. 2010). Il campione di Rivodutri risale al 1988 (Lattanzi, Scoppola 1990), mentre quelli di Borgorose (Trabalza) al 1911 e 1930 (Lucchese 2018). La specie è stata inoltre segnalata da Abbate et al. (1995; sulla base di rilievi fitosociologici effettuati nel 1988) per due altre località, sempre del reatino: lungo la strada tra Leonessa e Rieti (vicino a Leonessa) e nella Valle del Salto presso Casette. Non sono pertanto noti campioni e/o segnalazioni più recenti del 1988. La specie è inclusa da Lucchese (2018) tra quelle di maggiore interesse conservazionistico del Lazio e indicata come vulnerabile (VU) in Anzalone et al. (2010). La popolazione di *C. bononiensis* di Poggio Moiano è costituita da oltre quaranta esemplari distribuiti in sei piccole stazioni lungo il sentiero 309 del Parco Naturale Regionale dei Monti Lucretili, tutte costituite da pochissimi individui (circa 30 in una sola stazione, da 1 a 6 es. nelle altre) osservabili a quote comprese tra 425 e 1000 m s.l.m. Nel Lazio il range altitudinale indicato per questa specie va da 500 a 900 m s.l.m. (Anzalone et al. 2010, Lucchese 2018). La presente segnalazione estende pertanto il limite altitudinale della specie di 75 m verso il basso e di 100 m verso l'alto.

Marco Giardini, Daniele Angeloni

71. ***Carex vulpina*** L. (Cyperaceae)
**LOM**: Sesto Calende (Varese), loc. La Piana (WGS84: 45.747238 N, 8.638349 E), prati da sfalcio parzialmente umidi solcati da fossi e canalette acquitrinose, localmente inondati dopo forti o prolungate piogge, 245 m s.l.m., 18 maggio 2020, *E. Meneguzzo, A. Meneguzzo* (FI, W, *Herb. E. Meneguzzo*); Taino (Varese) (WGS84: 45.757648 N, 8.634465 E), prato da sfalcio umido, inondato dopo forti o prolungate piogge, 258 m s.l.m., 23 maggio 2020, *E. Meneguzzo* (FI, W, *Herb. E. Meneguzzo*). – Terza segnalazione di specie rara per la Lombardia.
*Carex vulpina* è una specie eurosiberiana, rara in Italia (Pignatti et al. 2017, Bartolucci et al. 2018), presente in Lombardia nelle provincie di Brescia (Martini et al. 2012) e Varese (Roma-Marzio et al. 2019). Queste due nuove stazioni varesine sono situate, rispettivamente, a circa 1 e 2 km di distanza e a quota leggermente inferiore da quella precedentemente segnalata da Roma-Marzio et al. (2019). Nella prima stazione (Sesto Calende), dove è abbondante anche *Carex leporina* L., su una superficie di ca. 0,12 km$^2$ sono presenti nove nuclei nei quali si contano da una decina a centinaia di cauli fioriti. Nella seconda (Taino) si contano oltre cento cauli fioriti su una superficie di ca. 5.000 m$^2$.

Enzo Meneguzzo, Andrea Meneguzzo, Enrico Banfi,Giuseppe Busnardo,
Gabriele Galasso, Michael Kleih, Bruno Wallnöfer

72. ***Cenchrus setaceus*** (Forssk.) Morrone (Poaceae)
(INV) **CAL**: Crotone, Contrada Passovecchio (WGS84: 39.113499 N, 17.091962 E), bordo strada, 12 m s.l.m., 29 luglio 2020, *V.L.A. Laface, C.M. Musarella et G. Spampinato* (FI, REGGIO). – Specie esotica naturalizzata di nuova segnalazione per la provincia di Crotone.
In Calabria la specie era già nota per le province di Reggio Calabria, Catanzaro e Cosenza (Musarella et al. 2020). La presente segnalazione rappresenta la prima per la provincia di Crotone, confermando lo status di specie invasiva in Calabria, così come proposto recentemente da Laface et al. (2020).

Valentina Lucia Astrid Laface, Carmelo Maria Musarella, Giovanni Spampinato

73. ***Cuscuta epithymum*** (L.) L. subsp. ***kotschyi*** (Des Moul.) Arcang.
**CAL**: Papasidero (Cosenza), Monte Ciagola, 1250 m s.l.m., 11 agosto 2008, *F. Di Marco* (PI 035055). – Sottospecie di nuova segnalazione per Papasidero.
*Cuscuta epithymum* subsp. *kotschyi* è stata segnalata per la prima volta in Calabria da Peruzzi, Gargano (2004b) presso il Parco Nazionale del Pollino e successivamente da Crisafulli et al (2006) per la zona delle Serre Calabre. La specie, senza indicazione della sottospecie, era già stata segnalata per l'area in questione da Di Marco et al. (2013).

Liliana Bernardo, Francesco Roma-Marzio

74. ***Melampyrum barbatum*** L. subsp. ***carstiense*** Ronniger (Orobanchaceae)
**LAZ**: Poggio Moiano (Rieti), lungo il sentiero che da Fonte Castello porta a Cima Casarene, Monti Lucretili (WGS84: 42.179800 N, 12.897100 E), 760 m s.l.m., 6 giugno 2020, *M. Giardini et D. Angeloni* (FI, RO, *Herb. Giardini*). – Nuova stazione di entità rarissima nel Lazio e nuovo limite altitudinale per la regione.
In Italia la specie è presente in Friuli Venezia Giulia, Veneto, Emilia-Romagna, Marche, Lazio, Abruzzo e Molise, mentre in Campania non è segnalata da molto tempo (Bartolucci et al. 2018). Recentemente è stata confermata anche la sua presenza in Basilicata ed è stata segnalata per la prima volta in Puglia (Rosati et al. 2020). Per quanto riguarda il Lazio, Anzalone et al. (2010) segnalano la sua presenza in due località dei Monti Lucretili (Monteflavio e Montorio Romano) e nei pressi del Lago del Turano. Lucchese (2018), oltre a quelli delle località citate, segnala l'esistenza di un altro campione raccolto da Anzalone nel 1981 ad Ascrea, sempre nei pressi del Lago del Turano. La specie risulta infine segnalata per il Monte Navegna (Bartolucci 2006). È inclusa da Lucchese (2018) tra quelle di maggiore interesse conservazionistico del Lazio e indicata come vulnerabile (VU) da Anzalone et al. (2010). Lungo il sentiero per Cima Casarene, all'interno del Parco Naturale Regionale dei Monti Lucretili, la specie si osserva con una certa frequenza. Il range altitudinale indicato per il Lazio è 400–700 m s.l.m. (Anzalone et al. 2010, Lucchese 2018). A Poggio Moiano la specie compare invece intorno ai 750 m giungendo fino a 1060 m s.l.m., innalzando così il limite altitudinale di 360 m.

Marco Giardini, Daniele Angeloni

75. ***Phacelia tanacetifolia*** Benth. (Boraginaceae)
**VEN**: Casacorba di Vedelago, sorgenti del Sile (Treviso) (WGS84: 45.646627 N, 12.045099 E), bordo di coltivi, sporadica, 29 m s.l.m., 20 giugno 2020, M. *Brentan et R. Marcucci* (FI, PAD). – Specie esotica casuale di nuova segnalazione per la provincia di Treviso.
Introdotta in Italia come pianta mellifera, è una specie originaria degli Stati Uniti occidentali e del Messico nord-orientale. In Veneto era già nota per le province di Vicenza, Padova e Rovigo (Tasinazzo 2007, Masin, Scortegagna 2011, Scortegagna et al. 2016, Argenti et al. 2019). La piccola popolazione rinvenuta lungo il corso del fiume Sile permette di estendere la sua presenza anche per la provincia di Treviso oltre che indicare il nuovo limite distributivo settentrionale nella regione.

Mariano Brentan, Rossella Marcucci

76. ***Prunus dulcis*** (Mill.) D.A.Webb (Rosaceae)
**CAL**: Tarsia (Cosenza), loc. Acqua Canale (WGS84: 39.626975 N, 16.244744 E), 230 m s.l.m., 20 agosto 2020, *L. Peruzzi* (FI). – Specie esotica casuale di nuova segnalazione per la provincia di Cosenza.
La specie è stata recentissimamente segnalata come esotica casuale per la Calabria da Laface et al. (2020), per svariate località in provincia di Reggio Calabria. *Prunus dulcis* è ampiamente coltivato nell'area di Tarsia ed è stata osservata in 33 località. In almeno 8 di queste località, tra cui quella oggetto di segnalazione, la specie mostra chiaramente una tendenza alla spontaneizzazione.

Lorenzo Peruzzi

77. ***Sempervivum riccii*** Iberite & Anzal. (Crassulaceae)
**LAZ**: Scandriglia (Rieti), rocce calcaree carsicizzate e assolate nei pressi della vetta di Cima Casarene, Monti Lucretili (WGS84: 42.168200 N, 12.905000 E), 1190 m s.l.m., 11 luglio 2020, *D. Angeloni et M. Giardini* (FI). – Nuovo limite altitudinale per il Lazio.

Specie endemica dell'Italia centrale, è presente in tre sole regioni: Lazio, Abruzzo e Molise, mentre è incerta la sua presenza nelle Marche (Bartolucci et al 2018). Nel Lazio la specie è poco comune e indicata come a basso rischio (LR) da Anzalone et al. (2010), che la riportano per i Monti della Duchessa, Monti Simbruini, Monte Scalambra, Monti Ernici, Lepini, Aurunci, Monte Cairo e Mainarde. Altre località vengono aggiunte da Lucchese (2018): Monti Carseolani, Reatini meridionali, Monti del Cicolano, Valle del Tronto e Monti della Laga, Cantari, Marsicani occidentali e Monti di Arpino. La specie è inclusa da Lucchese (2018) tra quelle di maggiore interesse conservazionistico del Lazio e indicata come a minor rischio (LR) in Anzalone et al. (2010). Il range altitudinale riportato sia da Anzalone et al. (2010) sia da Lucchese (2018) è 1500–2000 m s.l.m. La stazione di Cima Casarene, posta all'interno del Parco Naturale Regionale dei Monti Lucretili, estende pertanto di oltre 300 m verso il basso il limite altitudinale di questa specie nella regione.

Daniele Angeloni, Marco Giardini

78. ***Veronica barrelieri*** H. Schott ex Roem. & Schult. subsp. ***barrelieri*** (Plantaginaceae)
**LAZ**: Poggio Moiano (Rieti), lungo il sentiero che da Fonte Castello porta a Cima Casarene, Monti Lucretili (WGS84: 42.1749000 N, 12.902800 E), 1020 m s.l.m., 11 luglio 2020, *D. Angeloni et M. Giardini* (FI, RO, *Herb. Giardini*). – Nuova stazione di entità molto rara nel Lazio.
In Italia la specie è presente in Lombardia, Veneto, Friuli Venezia Giulia, Emilia-Romagna, Toscana, Umbria, Lazio, Abruzzo, Molise e Campania (Bartolucci et al. 2018). Secondo Anzalone et al. (2010) questo *taxon*, indicato come a minor rischio (LR) (sub *Pseudolysimachion barrelieri* (Schott. ex Roem. et Schult) Holub subsp. *barrelieri*), risulta presente nell'Alto Viterbese (Monte Rufeno), Monti della Laga (Piana di Accumoli), Monti Simbruini (Altopiani di Arcinazzo) e Monti Aurunci (Monte Faggeto e Monte Altino). Nella stazione di Cima Casarene, all'interno del Parco Naturale Regionale dei Monti Lucretili, *V. barrelieri* subsp. *barrelieri* si osserva comunemente a partire da circa 1020 m s.l.m. fino alla vetta (1191 m).

Daniele Angeloni, Marco Giardini

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RESEARCH ARTICLE

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# Global and Regional IUCN Red List Assessments: 9

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**Abstract**

In this contribution, the conservation status assessment of three vascular plants according to IUCN categories and criteria are presented. It includes the assessment of *Soldanella calabrella* Kress at global level, and the regional assessment of *Luzula pindica* (Hausskn.) Chrtek & Křísa and *Romulea variicolor* Mifsud (Italy).

**Keywords**

conservation, extinction risk, IUCN protocol, threats

## How to contribute

The text of the global and regional assessments should be submitted electronically to Simone Orsenigo (simone.orsenigo@unipv.it) or to Giuseppe Fenu (gfenu@unica.it); the text, up to 8000 characters in length (spaces included), must include a distribution map and a picture of the assessed species.

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## Red List assessments

*Luzula pindica* (Hausskn.) Chrtek & Křísa

Regional assessment (Italy)
**Taxonomy and nomenclature**
*Order:* Poales *Family:* Juncaceae

*Luzula pindica* (Hausskn.) Chrtek & Křísa Webbia 19: 6 (1964) ≡ *Luzula spicata* (L.) DC. var. *pindica* Hausskn., Mitth. Thüring. Bot. Vereins, n.f., 13–14: 33 (1899)

**Common name***:* Erba lucciola del M. Pindo (It), Pindus woodrush (En).

**Geographic distribution range:** The main range of *Luzula pindica* (Fig. 1) includes the mountain areas of the Balkan region, but this species reaches its western distribution limit in southern Italy (Chrtek and Křísa 1980). In the context of the species' range, the Italian populations define a striking disjunction. Accordingly, this plant represents one of the most remarkable examples of Amphi-Adriatic taxa within the Italian vascular flora. As found for other taxa with a similar geographical pattern (e.g., *Gentianella crispata* (Vis.) Holub: Gargano et al. 2009), in Italy *L. pindica* is confined to a small area at the southern extreme of the Apennine chain. Indeed, some historical records (from the beginning of the 20$^{th}$ century or earlier) reporting the presence of this species on Mt. Volturino and the Sila mountains (Chrte and Křísa 1964) were not later confirmed. Therefore, the ascertained Italian range of *L. pindica* currently includes just a few localities in a restricted area of the massif of Mt. Pollino (Fig. 2) that falls within the Administrative Regions of Basilicata and Calabria (Bernardo et al. 2014).

**Distribution:** Countries of occurrence: Albania, Bulgaria, Greece, Italy, and North Macedonia.

**Biology:** *Plant growth form:* perennial (caespitose hemicryptophyte).

**Flowering time:** From June to July.

**Reproduction:** *Luzula* is mostly wind-pollinated, while seed dispersal generally relies on myrmecochory (e.g., Oostermeijer 1989).

**Habitat and ecology:** *Luzula pindica* grows on limestone, within high-mountain grasslands established close or above the treeline. Accordingly, this species is associated to the *Ranunculo-Nardion* vegetation (Tomaselli et al. 2003), which includes the mesophilous grasslands and the fragments of snowbed vegetation of the S-Apennines (Gargano et al. 2010).

**Population information:** Since 2016, this species is included in a monitoring program focused on the oro-Mediterranean herbaceous communities of the Pollino National Park. The demographical data obtained from permanent sampling areas indicate that flowering rates of *L. pindica* range from 19.7 to 2.7 flowering stalks/m$^2$. To date, it is difficult to deduce a clear demographic trend. However, data related to different periods of the blooming seasons show that the species is subjected to intense grazing; indeed, during the four years of observation, the percent of grazed flowering stalks ranged from 87.5 to 100%.



**Figure 1.** *Luzula pindica* at Piani di Pollino (Terranova di Pollino, Potenza, Basilicata), a locality included in the Pollino National Park. Photograph by Liliana Bernardo.

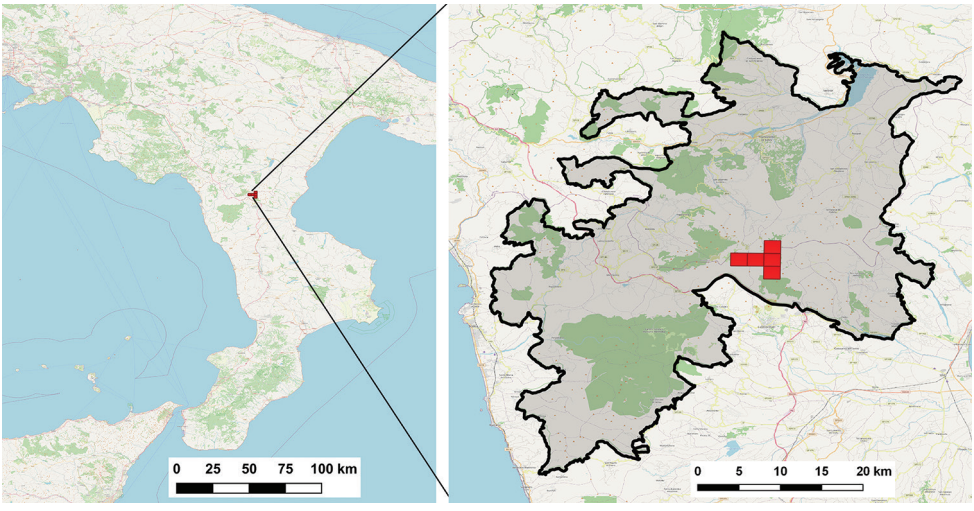



**Figure 2.** Left side: area of occupancy of *Luzula pindica* in the southern Italian peninsula; right side: location of the AOO cells with respect to the boundaries of the Pollino National Park (light shaded area).

**Threats:** *2.3. Livestock and farming and ranching:* the grasslands hosting this species are subjected to over-grazing pressure during the flowering season. Trampling due to nomadic domestic animals reduces the soil quality by promoting erosion and nitrification; the excessive grazing rate represents a severe limitation to sexual recruitment in all known populations of *L. pindica*.

**CRITERIA APPLIED**:
*Criterion B*: **EOO:** 20 km$^2$.
**AOO:** 20 km$^2$ calculated with a 2 × 2 km fixed cell grid (Gargano 2011).
a) Number of locations: all the populations occur in a restricted area; the growth contexts are highly homogeneous and show a comparable regime of over-grazing. For these reasons, *L. pindica* is believed to occupy a unique location in Italy.
b) Due to over-grazing, the habitat quality (iii) is declining in many sites, as well as the number of mature individuals (v). Since the plant was no longer observed in some historical sites of its regional range, a reduction of EOO and AOO may have also affected the species in Italy, but this is difficult to prove and quantify.

**Red List category and Criteria (Regional Assessment)**

| | | |
|---|---|---|
| **CR** | **Critically Endangered** | **B1ab(iii,v)** |

**Rationale for the assessment:** In Italy, *L. pindica* is confined to a few sites within a small mountain area of the peninsula. The current regional distribution accounts for an EOO and AOO of only 20 km$^2$. This species is threatened by excessive grazing pressure, which can alter the quality of the habitat and reduce the rate of reproductive success. Due to the contiguity of the inhabited sites, and their homogeneous sensitivity to the prevalent threat, *L. pindica* occurs in a single location. The absence of recent records for some historical sites suggests a historical reduction of the regional range. Currently, due to the marked geographical rarity, the occurrence in a single location, and the effect of over-grazing on habitat quality and on the population's reproductive processes, this taxon qualifies as Critically Endangered (CR) at the regional level. Because geographical isolation makes any contribution of the populations occurring in Eastern Europe to the conservation status of the Italian ones unlikely, there is no reason for up- or down-grading the risk category resulting from this assessment procedure.

**Previous assessment:** This taxon is Not Evaluated (NE) at the global level (IUCN 2020), while it is as Endangered (EN) in the Red List of the Italian vascular flora (Orsenigo et al. 2020).

**Conservation actions**: All known Italian populations of *L. pindica* occur within the Pollino National Park.

**Conservation actions needed**: It is necessary to improve the site management in order to reduce the impact of grazing on this species during the flowering period. This would allow to enhance the quality of the growth context and to improve the rates of

sexual recruitment. Seed banking would be also an effective way to preserve the species' genetic resources and support future reinforcement trials.

Domenico Gargano, Nicodemo G. Passalacqua, Liliana Bernardo

### *Romulea variicolor* Mifsud

Regional assessment (Italy)
**Taxonomy and nomenclature**
*Order*: Asparagales *Family*: Iridaceae

*Romulea variicolor* Mifsud, Webbia 70: 257 (2015) – *Romulea melitensis* auct. Fl. Ital. et Malta

**Common name**: Zafferanetto maltese, Romulea maltese (It); Maltese Sand Crocus (En).

**Geographic distribution range:** *Romulea variicolor* (Fig. 3) is native to Malta and Sicily (Italy). Previously, it was reported by some authors (Haslam et al. 1977; Frignani and Iiriti 2001) as *Romulea melitensis* Béguinot. However, Mifsud (2015) suggested that this taxonomic treatment should be considered as ambiguous, describing the new name *R. variicolor*. This species was reported for the first time in Sicily by Brullo et al. (2009) and later confirmed by Mifsud (2015). Its Italian distribution is restricted to a small coastal stretch between Cava d'Aliga and Marina di Modica (Ragusa, Sicily) (Fig. 4).

**Distribution:** *Countries of occurrence:* Italy (Sicily), Malta.

**Biology:** *Plant growth form:* perennial (bulbous geophyte).

**Flowering and fruiting time:** Flowering from February to March and fruiting from March to April.

**Reproduction:** No detailed information is available on the pollination system and seed dispersal mechanism.

**Habitat and ecology:** *Romulea variicolor* grows on sandstones and Miocene limestones (0–100 m a.s.l.), within the lower upper semiarid thermomediterranean bioclimatic belt (Bazan et al. 2015). From a phytosociological point of view, in the Maltese Islands this plant was considered by Brullo et al. (2020) as a differential species of the *Romuleo melitensis-Ranunculetum bullati*, an association framed within the *Leontondonto tuberosi-Bellidion sylvestris* Biondi, Filigheddu and Farris 2001 (*Lygeo sparti-Stipetea tenacissimae* Rivas-Martinez 1978). In Sicily, it shows similar ecological requirements, colonizing small flat surfaces among the low shrubs of coastal garrigues or halophilous communities with *Limonium hyblaeum* Brullo (Brullo et al. 2009). From a biogeographical perspective, the population of *Romulea variicolor* falls within the Camarino-Pachinense district (Brullo et al. 1995).

**Population information:** In Sicily, *R. variicolor* is represented by few groups of individuals circumscribed to the south-eastern coast of the island, in the province of Ra-



**Figure 3.** *Romulea variicolor* in the rocky coast near Sampieri (Ragusa, Sicily). Photograph by S. Cambria.

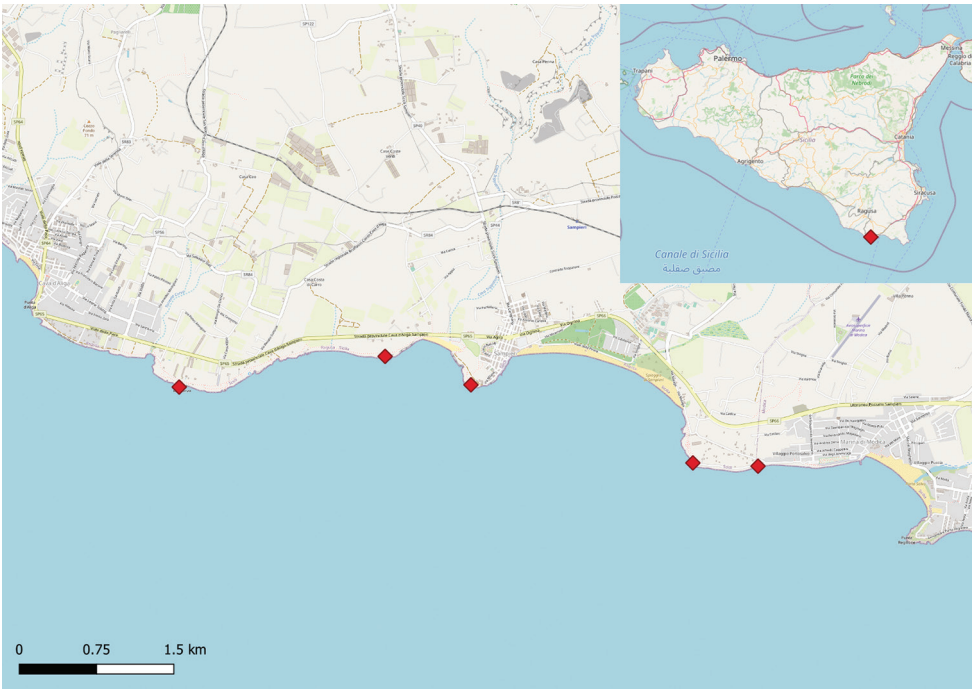



**Figure 4.** Geographical range and distribution map of *Romulea variicolor* Mifsud in Sicily.

gusa. This species shows an extremely scattered distribution with few isolated patches, where it is sometimes locally abundant for an estimated total number of a few hundred individuals. Mifsud (2018) reported a stable population trend, while direct observations of the Sicilian population indicate a slight regression and thus its progressive decline.

**Threats:** *1.1 Housing & Urban Areas:* the modifications of urban areas impact on the habitat of this species.

*8.1 Invasive Non-Native/Alien Species/Diseases:* the species' range can be reduced by invasive alien plants, such as *Carpobrotus edulis* (L.) N.E.Br.

*1.3 Tourism & Recreation Areas:* the coastal area is strongly subject to tourist activities during the summer season.

*7.3. Other ecosystems modifications:* many of the stands are subject to coastal erosion.

**CRITERIA APPLIED**

*Criterion B:* **AOO**: 16 km$^2$ calculated with GeoCAT (Geospatial Conservation Assessment Tool) software (Bachman et al. 2011).

a) Number of locations: we identified five locations based on urbanization that represents the main threat affecting the species.

b) Decline observed in (iii) area, extent and/or quality of habitat; (v) number of mature individuals.

**Red List category and Criteria (Global Assessment)**

| | | |
|---|---|---|
| **EN** | **Endangered** | **B2ab(iii,v)** |

**Rationale for the assessment:** *Romulea variicolor* is a geophyte endemic of the Maltese islands and south-eastern Sicily. In Italy, this species shows a localized distribution in Sicily, being limited to a small coastal area strongly affected mainly by urbanization, tourism and other risk factors. Populations are represented by scattered groups with few individuals, clearly subject to a decline, particularly for locations closest to urban centers and tourist sites. The regional distribution range consists in an AOO of 16 km$^2$. Considering the exiguous number of stands and the presence of several threats, this taxon can be classified as Endangered (EN).

**Previous assessment**: *Romulea variicolor* was evaluated as Least Concern (LC) at a global level (Mifsud 2018) and, more recently, as Data Deficient (DD) in Italy (Orsenigo et al. 2020).

**Conservation actions:** *Romulea variicolor* is unprotected by international, national and regional specific laws. The Sicilian population partly falls within the SAC ITA080008 'Contrada Religione'. Moreover, the area at issue has been identified as an Important Plant Area (IPA), essential for the conservation of plant biodiversity, indicated as "Costa di Sampieri (SIC 16)".

**Conservation actions needed:** Research activities (e.g., demographic, eco-physiological, etc.) are advisable and an improved quality of the habitat is necessary for *in situ* conservation.

Salvatore Cambria, Gianmarco Tavilla

### *Soldanella calabrella* Kress

Global Assessment
**Taxonomy and nomenclature**
*Order*: Ericales *Family*: Primulaceae

*Soldanella calabrella* Kress, Primulac.-Stud. 8: 24 (1988) – *Soldanella hungarica* auct. Fl. Ital.

**Common name:** Soldanella calabrese (It), Calabrian Soldanella (En).

**Geographic distribution range:** *Soldanella calabrella* Kress (Fig. 5) is endemic to Calabria (Fig. 6), and its distribution consists of two disjunct populations in Sila and Aspromonte. Cristofolini and Pignatti (1962) attributed the Calabrian populations to *S. hungarica* Simonk., underlining their significant disjunction concerning the main distribution area. Later, Pignatti (1982) reported for Sila and Apromonte the presence of *S. hungarica*, stating in a note that the Calabrian *Soldanella* could represent an as yet unreported species. Finally, Kress (1988) classified the Calabrian plants as *Soldanella calabrella*. Zhang et al. (2001), in their review of the genus *Soldanella* L., confirmed the autonomy of this species.

**Distribution:** Country of occurrence: Italy.

**Biology:** *Plant growth form:* Perennial (hemicryptophyte)

**Flowering and fruiting time:** Flowering from May to June and fruiting from June to August.

**Reproduction:** *Soldanella calabrella* is an insect-pollinated species. Dispersal mechanisms are barochory and hydrochory (for long-distance dissemination). No information on seed germination is available.

**Habitat and ecology:** *Soldanella calabrella* grows near springs or on shady and damp walls subject to dripping along the mountain streams with permanent, weakly flowing and well-oxygenated waters. This habitat is located within deciduous mesophilous forests of *Fagus sylvatica* L. often associated with *Abies alba* Mill. on acid crystalline rocks of the mountain belt. The altitude range falls between 1,200 and 1,900 m a.s.l., in upper supratemperate or lower orotemperate bioclimate (Brullo et al. 2001). *Soldanella calabrella* is a characteristic species of the *Adenostylo-Soldanelletum calabrellae* Signorello 1986 *corr.* Brullo, Scelsi and Spampinato 2001, an association of the *Caricion remotae* Kästner 1941 alliance (Brullo et al. 2001).

**Population information:** this species shows a highly fragmented and disjunct distribution, with two macro distribution areas, the Sila mountains (where it is further fragmented into two sub-areas: Sila Grande and Sila Piccola) and the Aspromonte massif. A total of 25 localities was confirmed in 2019 (10 in Aspromonte, 7 in Sila Grande, and 8 in Sila Piccola). Four of the past sites of occurrence documented in the literature (Brullo et al. 2001, Spampinato et al. 2008) were not confirmed by recent surveys carried out in 2019. Due to ecological factors and habitat threats, populations range from several hundred up to a few individuals limited to very small areas.



**Figure 5.** *Soldanella calabrella* Kress, at Materazzelli (Cosoleto, Reggio Calabria). Photograph by V.L.A. Laface.

**Threats:** *2.3.1 Nomadic grazing*: many grazing animals, in particular, cows (*Bos taurus*) and wild boar (*Sus scrofa*), drink in the streams and springs where the species grows, damaging the habitat.

*5.3 Logging & wood harvesting*: the localities at lower altitudes are located in areas subject to forestry uses that severely modify the habitat. The threat is still present, therefore a further drop in the number of individuals and habitat quality can be expected.

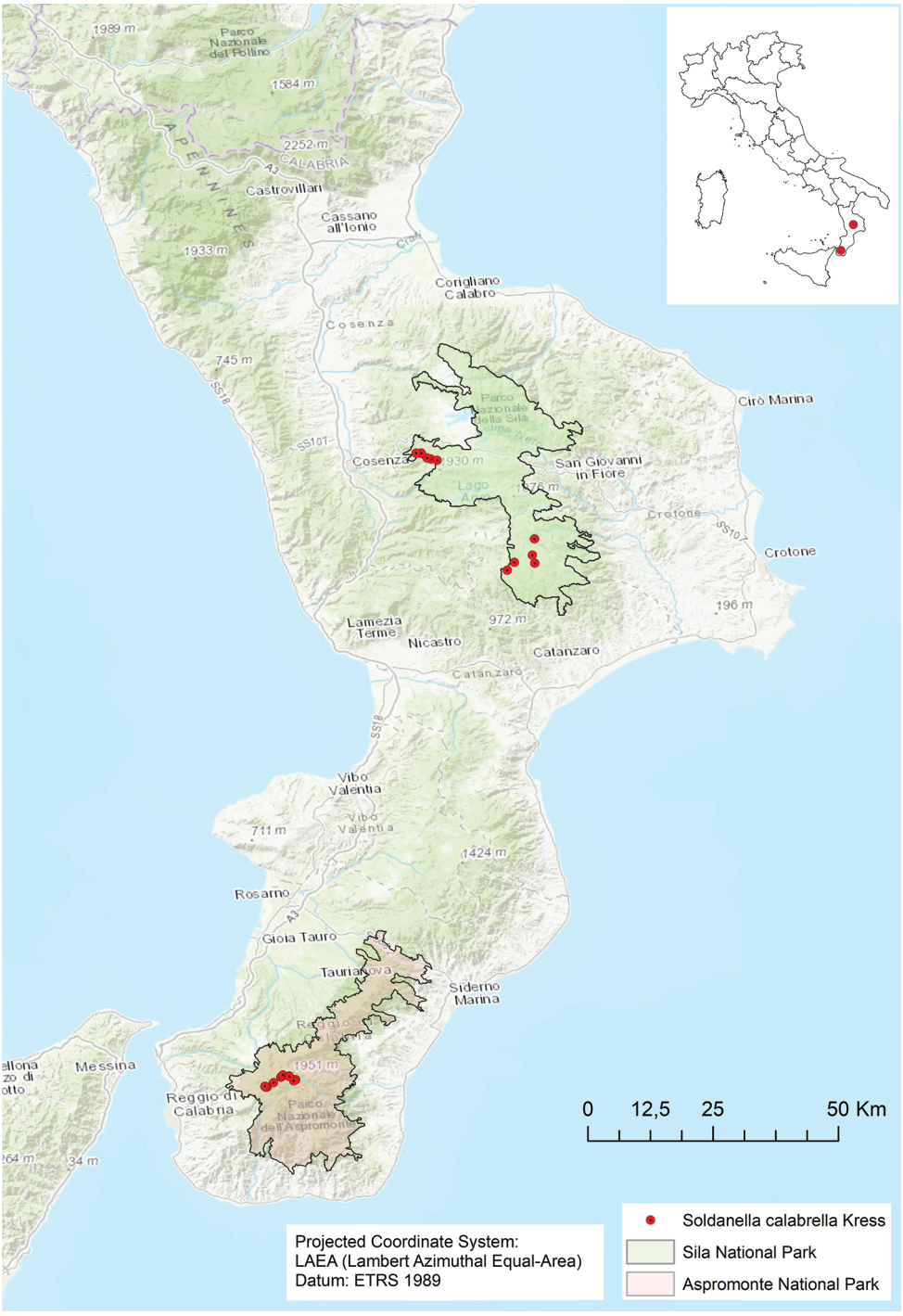



**Figure 6.** Geographical range and distribution map of *Soldanella calabrella* Kress.

*11.1 Habitat shifting & alteration:* field surveys show that the lower-altitude stations are the most threatened by the natural evolution of habitats due to climate change. This species is restricted to the microclimate occurring in streams and springs of the mountain belt.

*11.2 Drought*: the survival of *S. calabrella* is tied to peculiar wet habitats; drought, therefore, causes the rapid disappearance of the species.

*11.4 Storms and floods*: they cause landslides, collapses, erosion or sediment deposition, causing the loss of suitable species habitat.

**CRITERIA APPLIED:**

*Criterion B:* **EOO:** 2,203 km$^2$ calculated with minimum convex hull polygon using ArcMap10.4.

**AOO:** 44 km$^2$ calculated with 2 × 2 km cell fixed grid in the ArcMap10.4.

a) number of locations >5

b) Habitat extent and quality (iii) are declining, as well as the number of mature individuals (v). A reduction of AOO (ii) is likely to have affected the species.

*Criterion A2:* reduction in the estimated population as a function of an AOO reduction >30% in 10 years, which continues today due to declining habitat quality and habitat destruction.

c) documented decline in AOO and habitat quality, according to threats 11.1, 11.2,11.4, and 2.3.1

**Red List category and Criteria (Global Assessment)**

| | | |
|---|---|---|
| **VU** | **Vulnerable** | **A2c + B1ab(ii,iii,v) + 2ab(ii,iii.v)** |

**Rationale for the assessment:** The populations are scattered as a consequence of its peculiar habitat: shady and damp walls subject to dripping near springs or along the perennial streams of the mountain belt. A decline in population size is documented by a continuous and significant reduction in AOO. The AOO decreased from 64 km$^2$ to 44 km$^2$ in the last 10 years, due to the fore-mentioned threats that affect the extent and quality of the habitat. The individuals located at lower altitudes are the most threatened by the anthropic impact (logging, water abstraction, and grazing) and by climate change, which have already led to the extinction of some populations in the last decades. Based on new data that document a decline in AOO, quality of habitat, and number of mature individuals, *S. calabrella* can be considered "Vulnerable (VU)" at global level according to IUCN criteria (IUCN 2012).

**Previous assessment:** the species was previously assessed as "Endagered (EN)" at global level (Orsenigo et al. 2018).

**Conservation actions:** *Soldanella calabrella* is unprotected by regional, national or international laws. The current localities of this species fall within the Aspromonte and Sila National Park.

**Conservation actions needed:** Monitoring and research activities are needed to evaluate population dynamics and trends. Specific control and protection measures must be taken to preserve the habitat and the species.

Valentina Lucia Astrid Laface, Carmelo Maria Musarella, Giovanni Spampinato

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RESEARCH ARTICLE

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# Notulae to the Italian native vascular flora: 11

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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, exclusions, and status changes to the Italian administrative regions. A new combination in the genus *Pilosella* is proposed. 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 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 (typifications only for accepted names), status changes, exclusions, and confirmations should be submitted electronically to: Fabrizio Bartolucci (fabrizio.bartolucci@gmail.com). Each text should be within 1,000 characters (spaces included).

## Floristic records

***Aconitum anthora* L. (Ranunculaceae)**

+ **TOS**: Villa Collemandina (Lucca), Pania di Corfino (WGS84: 44.197804N, 10.383953E), lungo la cresta rocciosa sopra la località "La Bandita", 1550 m s.l.m., 17 August 2020, *E. Cheli* (FI). – Species new for the flora of Toscana.

E. Cheli, G. Bedini

***Ajuga genevensis* L. (Lamiaceae)**

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

According to Bartolucci et al. (2018), this species has not been recently found in Campania and Abruzzo. For both these administrative regions, Tenore (1831) indicated *Ajuga reptans* L. var. *montana* Ten., and, on this basis, Casali (1901) reported *A. genevensis* for Montevergine (Pignatti et al. 2018). However, Tenore's combination is a synonym of *A. reptans* (Grande 1923).

E. Del Guacchio

***Arabis caerulea* All. (Brassicaceae)**

– **LIG**. – Species to be excluded from the flora of Liguria.

This species was reported for Liguria by Penzig (1897), but at the time the administrative region included part of the Maritime Alps, which are currently located in France or in Piemonte. Furthermore, in Liguria the suitable habitats for this species (wet gravels above 1,900 m a.s.l.; Pignatti et al. 2017) are extremely reduced. No herbarium specimens were found in FI, GE, GDOR, and TO.

G. Barberis, S. Peccenini

***Bolboschoenus glaucus* (Lam.) S.G. Sm. (Cyperaceae)**

+ **MAR**: Porto Recanati (Macerata), loc. Scossicci, stagni artificiali ad uso venatorio ("guazzi") presso la foce del Fiume Musone (WGS84: 43.467787N, 13.632456E), c. 3 m, 13 October 2020, *L. Gubellini, N. Hofmann, S. Tonelli* (FI, PESA); dintorni di Fano, luoghi acquitrinosi nell'alveo del Metauro presso la foce, suolo prevalentemente argilloso, 18 September 1963, leg. et det. A.*J.B. Brilli-Cattarini* (PESA, under

the name *Scirpus maritimus* L. β *macrostachys* W.). – Species confirmed for the flora of Marche.

According to Bartolucci et al. (2018) and Di Natale et al. (2020), *B. glaucus* was known so far for Marche only as historical record.

L. Gubellini, N. Hofmann, S. Tonelli

***Bolboschoenus maritimus* (L.) Palla (Cyperaceae)**

+ **UMB**: Tuoro sul Trasimeno (Perugia), Punta Navaccia, tra i massi dell'argine del lago nei pressi del Campo del Sole (WGS84: 43.194102N, 12.079322E), ca. 255 m, 5 October 2020, *N.Hofmann* (FI; PESA). – Species confirmed for the flora of Umbria.

This species was recorded by Bartolucci et al. (2018) as doubtfully occurring in Umbria, and has been recently reported for this administrative region by Di Natale et al. (2020) based on old herbarium specimens.

L. Gubellini, N. Hofmann

***Bupleurum stellatum* L. (Apiaceae)**

– **LIG**. – Species to be excluded from the flora of Liguria.

This species was reported for Liguria by Penzig (1897) and Gismondi (1950) and, based on these records, also by Bartolucci et al. (2018) and Pignatti et al. (2018). Burnat (1906) provided only a few localities for the Maritime Alps, which currently fall in France. The habitat of this species (rocks and siliceous stony ground) is very rare in the Ligurian Alps. We were unable to trace any herbarium specimens in FI, GE, GDOR, and TO.

G. Barberis, S. Peccenini

***Bromus arvensis* L. subsp. *arvensis* (Poaceae)**

+ **TOS**: Piazzano (Empoli), lungo il Rio Camerata in loc. Villa Somelli (WGS84: 43.69403N, 10.966135E), margine di campi coltivati, 45 m, 2 August 2020, F. Roma-Marzio, L. Peruzzi (FI). – Subspecies new for the flora of Toscana.

F. Roma-Marzio, L. Peruzzi

***Carex elata* All. subsp. *elata* (Cyperaceae)**

+ **LIG**: Luni (La Spezia), "IT1345101 Piana del Magra", campi abbandonati a N di Luni Mare (WGS84: 44.063945N, 10.009447E), magnocariceto, 0 m, 1 April 2019, *I. Briozzo, D. Dagnino, C. Turcato* (GE No. 450). – Species confirmed for the flora of Liguria.

According to Bartolucci et al. (2018), *C. elata* subsp. *elata* is no longer recorded in Liguria. Barberis et al. (2019) cited three old herbarium specimens housed in GDOR.

I. Briozzo, D. Dagnino, C. Turcato

***Centaurea arrigonii* Greuter (Asteraceae)**

+ **LAZ**: Accumoli (Rieti), Forca Canapine, towards Pantani di Accumoli (WGS84: 42.72319183N, 13.20861419E), 1550–1600 m, arid subalpine meadows, 10 July 1957, leg. *V. Marchesoni*, rev. *S. Ballelli, D. Lucarini* (CAME, FI). – Species new for the flora of Lazio.

This specimen was previously referred to *C. ambigua* Guss. s.l. (Ballelli et al. 2005).

S. Ballelli, R. Pennesi, D. Lucarini†

***Chenopodium betaceum* Andrz. (Amaranthaceae)**

+ **UMB**: Perugia, isola Polvese (lago Trasimeno), dintorni della Villa S. Giuliano, il Poggio, Punta del Macerone (WGS84: 43.122316N, 12.130543E), incolti erbosi, 262–295 m, 23 October 2007, leg. *S. Ballelli, D. Lucarini*, det. *S. Ballelli*, conf. *D. Iamonico* (CAME); Perugia, isola Polvese (lago Trasimeno), dal molo Canoa Club alla Punta del Macerone (rive del viale nord) (WGS84: 43.118573N, 12.144589E), battigia, incolti, limiti boschivi, 262–270 m, 23 October 2007, leg. *S. Ballelli, D. Lucarini*, det. *S. Ballelli*, conf. *D. Iamonico* (HFLA). – Species confirmed for the flora of Umbria.

*Chenopodium betaceum* has been reported in Italy for the northern administrative regions (except Liguria), Marche, Lazio (central Italy) and as doubtful in Umbria (Bartolucci et al. 2018). This species is represented on the Polvese Island by two populations, both consisting of few individuals.

D. Iamonico, R. Pennesi, S. Ballelli

***Chenopodium pedunculare* Bertol. (Amaranthaceae)**

+ **VEN**: San Martino Buon Albergo (Verona), loc. Cà dell'Aglio, margine di strada sterrata nei pressi di una stalla (WGS84: 45.405564N, 11.105253E), 37 m, 30 November 2019, *F. Menini, M. Trenchi* (FI); Erbè (Verona), loc. Oltre Tione, prato incolto con accumulo di stallatico (WGS84: 45.240611N, 10.964377E), 13 m, 7 October 2020, *S. Andreatta* (VER No. SA525) – Species confirmed for the flora of Veneto.

*Chenopodium pedunculare* was only recently re-established (Iamonico and Mosyakin 2018), and has been poorly known from Veneto: its presence was witnessed by Bertoloni, who found it in Brondolo (Chioggia, Verona) and mentioned it at "*Fossa Clodia ad viam della Madonna a Prof. Naccario*". Other than there, the author also described this species only in Sarzana (La Spezia; Bertoloni, 1837). Several specimens have been found in San Martino Buon Albergo (Verona), by the side of a country lane near a big barn, on nitrophilic soil.

F. Menini, M. Trenchi, S. Andreatta

***Crucianella angustifolia* L. (Rubiaceae)**

+ **PIE**: Bussoleno (Torino), Val di Susa, fraz. Case Trucco (WGS84: 43.149152N, 7.125142E), prateria xerica, 650 m, 16 June 2014, *G. Nota, A. Mainetti, S. Ravetto*

*Enri* (FI); Giaglione (Torino), Val di Susa, Borgata Clarea (WGS84: 45.134872N, 6.993274E), radura xerica all'interno di boschi misti di latifoglie e pino silvestre, 882 m, 26 August 2020, *M. Pittarello, D. Barberis, M. Lonati* (FI). – Species confirmed for the flora of Piemonte.

*Crucianella angustifolia* was reported for Piemonte by Braun-Blanquet (1961), for a site close to the first site here recorded. Since then, this species had never been observed again in Piemonte.

S. Ravetto Enri, M. Pittarello, D. Barberis, M. Lonati

***Eleocharis caduca* (Delile) Schult. (Cyperaceae)**

0 **PUG**: Otranto (Lecce), Laghi Alimini ("*In paludosis ad lacum Alimini, prope Hydrantum*") (WGS84: 40.201063N, 18.445781E), August 1875, leg. et det. *H. Groves*, rev. *L. Lastrucci* (FI barcode FI054915, under the name *Heleocharis ovata* R. Br.). – Species not recently confirmed for the flora of Puglia.

In Italy, this species was reported as native only for Toscana, Sicilia, and Sardegna by Bartolucci et al. (2018).

L. Lastrucci, D. Viciani

***Gentiana lutea* L. subsp. *symphyandra* (Murb.) Hayek (Gentianaceae)**

+ **TOS**: Villa Collemandina (Lucca), Monte Vecchio (WGS84: 44.230882N, 10.414822E), lungo il versante roccioso che alterna ripidi canali ad ampi macereti terminanti al limite della faggeta, esposizione S, stazione compresa tra 1620 e 1750 m s.l.m., 5 August 2020, *E. Cheli* (FI). – Subspecies new for the flora of Toscana.

E. Cheli, G. Bedini

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

+ **BAS**: Scanzano Jonico (Matera), SS 106, svincolo rotatoria di Scanzano Jonico (WGS84: 40.235278N, 16.692500E), bordo strada, 11 May 2018, leg. *C.M. Musarella*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO). – Species new for the flora of Basilicata.

This species was recently re-evaluated based on morphological and ecological features (Cano et al. 2017). *Glebionis discolor* was recently reported also for Puglia (Manni 2020).

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

***Helleborus viridis* L. subsp. *abruzzicus* (M.Thomsen, McLewin & B.Mathew) Bartolucci, F.Conti & Peruzzi (Ranunculaceae)**

**+ MAR**: Sefro (Macerata), Forca di Bara (WGS84: 43.12632052N, 12.87509678E), 1160 m, edge of beech forest, no exp., 3 July 1962, leg. *V. Marchesoni* rev. *D. Lucarini* (CAME); Sarnano (Macerata), Monti Sibillini National Park, Pizzo di Meta-Punta

di Ragnolo (WGS84: 43.02522031N, 13.20534272E), 1560 m, meadows, 12 July 1962, leg. *V. Marchesoni*, rev. *D. Lucarini* (CAME). – Subspecies confirmed for the flora of Marche.

These specimens were previously referred to *H. viridis* subsp. *bocconei*, and then (2007) revised as *H. viridis* L. subsp. *abruzzicus*.

R. Pennesi, D. Lucarini†, S. Ballelli

***Hieracium amplexicaule* L. subsp. *chenevardianum* Zahn (Asteraceae)**

+ **VDA**: Brusson (Aosta), Castello di Graines (WGS84: 45.73843N, 7.75398E), mura interne, 1362 m s.l.m., exp. Est, 16 June 2020, leg. *S. Orsenigo*, det. *G. Gottschlich* (PAV). – Subspecies confirmed for the flora of Valle d'Aosta.

According to Bovio (2014) and Bartolucci et al. (2018), this subspecies was known, only historically, for Valle d'Aosta. Vaccari (1904–1911) reported its presence for several localities: between Bard and Champorcher, Valsavarenche, Èntrèves, Valgrisenche, between Aosta and Valpelline, and between Bionaz and Prarayer).

S. Orsenigo, G. Gottschlich

***Hieracium cydoniifolium* Vill. subsp. *parcepilosum* (Arv.-Touv.) Zahn (Asteraceae)**

+ **VEN**: Rocca Pietore (Belluno) sopra Passo Fedaia verso il Rifugio Padon (WGS84: 46.456420N, 11.888447E) cespugli in pascolo, su silice, 2100 m, 25 July 2020, leg. *C. Argenti*, det. *G. Gottschlich* (FI, *Herb. Argenti*). – Subspecies new for the flora of Veneto.

G. Gottschlich, C. Argenti

***Hieracium gombense* Lagger ex Christener subsp. *weitfeldense* (Murr) Zahn**

+ **VEN**: Livinallongo del Col di Lana (Belluno), in loc. Spiz de Jou, Altopiano di Cherz (WGS84: 46.508808N, 11.891936E), pascolo, su silice, 2095 m, 15 August 2020, leg. *C. Argenti*, det. *G. Gottschlich* (FI, *Herb. Argenti*). – Species new for the flora of Veneto.

G. Gottschlich, C. Argenti

***Hieracium lachenalii* Suter subsp. *amaurochlorum* (Zahn ex Heimerl) Zahn**

+ **VEN**: Ponte nelle Alpi (Belluno), in loc. La Secca (WGS84: 46.129080N, 12.317921E), rupe calcarea, 390 m, 26 May 2020, leg. *C. Argenti*, det. *G. Gottschlich* (FI, *Herb. Argenti*). – Subspecies new for the flora of Veneto.

G. Gottschlich, C. Argenti

***Hieracium levicaule* Jord. subsp. *perscissiforme* Benz & Zahn**

+ **ITALIA** (**VEN**): Agordo (Belluno), in loc. La Campona (WGS84: 46.302955N, 12.053582E), margine bosco a *Picea abies*, 1200 m, 26 June 2020, leg. *C. Argenti*, det. *G. Gottschlich* (FI, Herb. Argenti). – Subspecies new for the flora of Italy (Veneto).

This subspecies was hitherto only known from Austria and Slovenia (Zahn 1922–38).

G. Gottschlich, C. Argenti

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

+ **LOM**: Stagno Lombardo (Cremona), destra idrografica del Fiume Po, ca. 1 Km a SE di Cascina Isolone (WGS84: 45.070042N, 10.040859E), carrareccia tra un giovane pioppeto e una boscaglia ripariale con *Salix alba*, *Humulus japonicus*, *Sicyos angulatus* e *Artemisia verlotiorum*, 35 m, 24 June 2020, leg. *P. Marenzi*, det. *F. Bonali*, conf. *E. Banfi* (FI, MSNM, *Herb. F. Bonali*). – Species new for the flora of Lombardia.

The population here reported consists of about eighty individuals.

F. Bonali, P. Marenzi, E. Banfi, G. Galasso

***Hyparrhenia sinaica* (Delile) Llauradó ex G.López (Poaceae)**

+ **LAZ**: Alvito (Frosinone), Fossa Maiura (WGS84: 41.715940N, 13.721343E), garriga sul versante esposto a sud di una grande dolina, 771 m, 26 May 2020, *L. Cancellieri*, *L. Carotenuto* (FI). – Species new for the flora of Lazio.

*Hyparrhenia sinaica* is a SW-Steno-Mediterranean species, reported in peninsular Italy for Toscana, Puglia, Calabria, and for Sicilia and Sardegna (Bartolucci et al. 2018); it was also recently reported also for Umbria (Bartolucci et al. 2019). A population of about 1 $m^2$ was found on the steep, south-facing slope of the Maiura doline on a loose and coarse substrate, apparently poor in organic matter.

L. Cancellieri, L. Carotenuto

***Laburnum alpinum* (Mill.) Bercht. & J.Presl (Fabaceae)**

+ **LAZ**: Settefrati (Frosinone), Val Canneto tra Rifugio Acquanera e Casone Bartolomucci (WGS84: 41.713656N, 13.901975E ± 100 m), margine di faggeta, 1330 m, 4 September 2020, *L. Cancellieri*, *G. Filibeck* (UTV). – Species confirmed for the flora of Lazio.

This species was reported as doubtful for Lazio by Bartolucci et al. (2018) and as an "almost certainly wrong record" by Anzalone et al. (2010); however, Conti (1995), following Grande (1924), referred to this taxon in an old record by Tenore and Gussone (1842) (sub *Cytisus laburnum*) from Val Canneto, where we have rediscovered it.

L. Cancellieri, G. Filibeck

***Laurus nobilis* L. (Lauraceae)**

+ **SAR**: Status change from naturalized alien to native for the flora of Sardegna.

*Laurus nobilis* is reported by Bartolucci et al. (2018) as casual or naturalized alien in five Italian administrative regions, including Sardegna, whereas in all other regions it is considered as a native species. However, several previous works (Desole 1947, 1949; Arrigoni 2006; Filibeck 2006) highlighted the native status of this species in Sardegna.

Indeed, Mediterranean Italy is probably an area of glacial refugia for this frost-sensitive species (Alessi et al. 2019 and references therein). In Sardegna, old individuals grow in gorges and along streams (Filibeck 2006; Bacchetta et al. 2007).

E. Farris, L. Rosati, G. Filibeck

***Leucopoa spectabilis* (Bertol.) H.Scholz & Foggi subsp. *spectabilis* (Poaceae)**

**+ TOS**: Zeri (Massa-Carrara), tra Bergugliara e Patigno, lungo la SP 37 (WGS84: 44.34857N, 9.75561E), macereti lungo la strada, su serpentino, 655 m s.l.m. 28 August 2020, *B. Foggi, A. Gabellini* (FI). – Subspecies confirmed for the flora of Toscana.

The first record for Toscana can be found in Caruel (1866) in the Monte Pisano area, where the subspecies has never been found again (Del Prete et al. 1990; Pierini et al. 2009; Pierini and Peruzzi 2014). A large population was found in an area between Bergugliara and Patigno in a serpentine outcrop.

B. Foggi, A. Gabellini, G. Ferretti

***Narcissus tazetta* L. subsp. *italicus* (Ker Gawl.) Baker (Amaryllidaceae)**

+ **CAL**: Reggio Calabria (Reggio Calabria), Podargoni (WGS84: 38.165488N, 15.780366E), noceto incolto, 542 m, 18 January 2020, leg. *V.L.A. Laface*, det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO). – Subspecies new for the flora of Calabria.

First observed in 2007 in an uncultivated field with *Juglans regia* L., nowadays the subspecies is much more widespread in the nearby areas.

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

***Phelipanche nana* (Reut.) Soják (Orobanchaceae)**

+ **MAR**: Cagli (Pesaro e Urbino) (WGS84: 43.541627N, 12.652022E), vegetazione di recupero di coltivi abbandonati 280 m, 16 May2020, leg. *G. Mei*, det. *G. Mei, A. Stinca, G. Domina (FI, Herb. Mei*). – Species new for the flora of Marche.

This species, whose range is restricted to the Mediterranean area (Domina et al. 2011), is an annual parasite of the root systems mainly of *Urtica dioica* L., *Oxalis pes-caprae* L., *Asteraceae* and *Fabaceae*, both spontaneous and cultivated (Domina 2018).

G. Mei, A. Stinca, G. Domina

***Phlomis fruticosa* L. (Lamiaceae)**

**+ SAR**: Status change from doubtful alien to native for the flora of Sardegna.

*Phlomis fruticosa* is a northern Mediterranean calcicolous species typical of cliffs and garrigues, whose original areal extent is difficult to establish (Pignatti et al. 2018). In Sardegna, this taxon was first reported by Moris (1827, 1859). Later it was reported as native by Pignatti (1982) and Corrias and Diana-Corrias (1983). It was then

reported as doubtful casual alien by Arrigoni (2013), Bartolucci et al. (2018) and as native of doubtful occurrence by Pignatti et al. (2018). The population found in Taccu (WSG84: 39.513194N, 09.325653E) near S. Nicolò Gerrei (Sud Sardegna) confirms its presence in Sardegna, and certainly it has to be considered native, due to its presence in natural, inaccessible, and rocky contexts.

G. Bacchetta, G. Campus, L. Podda

***Pilosella cymosa* (L.) F.W.Schultz & Sch.Bip. subsp. *vaillantii* (Tausch) S.Bräut. & Greuter**

+ **VEN**: Canale d'Agordo (Belluno), nell'abitato di Gares (WGS84: 46.312934N, 11.882061E), prato, 1375 m, 28 June 2020, leg. *C. Argenti*, det. *G. Gottschlich* (FI). – Subspecies new for the flora of Veneto.

G. Gottschlich, C. Argenti

***Pilosella paragogiformis* (Zahn & Besse ex Käser) Soják (Asteraceae)**

+ **ITALIA** (**VDA**): Champorcher (Aosta), Valle di Champorcher, scendendo dal Creton, sopra il Ponte delle Maddalene (WGS84: 45.614538N, 7.578559E), bordo strada, 1820 m s.l.m., 9 July 2013, leg. *M. Bovio et al.*, det. *G. Gottschlich* (AO, *Herb. Gottschlich 60034*); *ibidem*, 1814 m s.l.m., 4 July 2020, *C. Ganz, M. Broglio, M. Bovio* (FI, *Herb. Gottschlich 75989, Herb. Ganz*). – Species new for the flora of Italy (Valle d'Aosta).

*Pilosella paragogiformis* was published as *Hieracium paragogiforme* by Käser (1903), who cited a handwritten description sent to him by Zahn. Our collection from 2013 was first identified as *P. arida* (Freyn) Soják, however the second collection from 2020 shows that the broad white margins of the phyllaries do not fit with this species.

G. Gottschlich, M. Bovio

***Quercus coccifera* L. (Fagaceae)**

+ (CAS) **ABR**: Pineto (Teramo), Area Marina Protetta Torre del Cerrano (WSG84: 42.58842N, 14.08589E), in pineta retrodunale a dominanza di *Pinus pinea* L. con *Pinus halepensis* Mill. subsp. *halepensis*, 0 m, 14 November 2020, *J. Lupoletti, A. Pica* (FI). – Casual regional alien species new for the flora of Abruzzo.

It is very likely these plants derive from three adult and fertile planted specimens of *Q. coccifera* growing into the Mediterranean garden of the Marine Protected Area, 300 m from the discovery site.

J. Lupoletti, A. Pica

***Ranunculus rionii* Lagger (Ranunculaceae)**

**+ SIC**: Godrano (Palermo), Gorgo Lungo (WGS84: 37.900907N, 13.408385E), 1 June 2018, *L. Lastrucci, R. Bolpagni, L. Gianguzzi, O. Caldarella* (FI barcode

FI055169); Castronovo di Sicilia (Palermo), Gorgo di Carcaci (WGS84: 37.700990N, 13.540453E), 2 June 2018, *L. Lastrucci, R. Bolpagni, L. Gianguzzi* (FI barcode FI055170). – Species new for the flora of Sicilia.

*Ranunculus rionii* Lagger is a species distributed in Europe, North Africa, and central-western Asia (Wiegleb et al. 2017). In Italy, it is considered very rare (Pignatti et al. 2017), and is, so far, known with certainty only for Trentino-Alto Adige (Bartolucci et al. 2018), Lombardia, and Toscana (Bartolucci et al. 2019).

L. Lastrucci, R. Bolpagni, L. Gianguzzi, O. Caldarella

***Salix repens* L. subsp. *repens* (Salicaceae)**

– **ITALIA** (**LOM**, **VEN**). Species to be excluded from the flora of Italy (Lombardia, Veneto).

Many old records of *S. repens* for Lombardia and Veneto are unreliable, lacking habitats suitable for this species. No herbarium specimens attest to its presence in these administrative regions. Furthermore, the recent report (Frattini 1997) for Lombardia (Piana del Gaver, Tonale) is not confirmed. Most records of *S. repens* are to be referred to *Salix rosmarinifolia* L. or *S. helvetica* Vill., so that the species is to be excluded from Italy.

M. Merli, E. Banfi, G. Galasso

***Senecio doronicum* (L.) L. subsp. *orientalis* J.Calvo (Asteraceae)**

+ **TOS**: Val Serenaia (Lucca), Sentiero CAI 180, sopra il Rif. Donegani (WGS84: 44.130927N, 10.199348E), 1200 m, 7 July 2020, leg. *L. Pinzani*, det. L. Peruzzi, L. Pinzani (FI); Monte Orsaro (Massa-Carrara), (44.408214N, 9.990470E), 1800 m, 25 July 2020, leg. *L. Pinzani* det *L. Peruzzi, L. Pinzani* (PI); Monte Gomito (Pistoia), versante SE (44.123341N, 10.642118E), 1800 m, 21 July 2020, leg. *L. Pinzani*, det *L. Peruzzi*, *L. Pinzani* (PI). – Subspecies new for the flora of Toscana.

+ **LIG**: Pratorotondo (Genova) (WGS84: 44.427253N, 8.589218E), 1100 m, 26 June 2020, leg. *L. Pinzani*, det. *L. Peruzzi, L. Pinzani* (FI). – Subspecies new for the flora of Liguria.

In Toscana, *Senecio doronicum* subsp. *doronicum* has been reported by several authors along the northern Apennines (Raffaelli and Rizzotto 1991; Tomaselli et al. 2019; Marchetti 2020). According to Calvo et al. (2015), *S. doronicum* subsp. *doronicum* shows scattered arachnoid trichomes above the leaves and involucre weakly arachnoid to floccose. Our specimens, on the contrary, are glabrescent on both leaves and involucres, in agreement with the morphological features typical of *S. doronicum* subsp. *orientalis*. In Italy, *S. doronicum* subsp. *orientalis* occurs in many regions of the peninsula and on the eastern Alps (Bartolucci et al. 2018). In some localities, *S. doronicum* subsp. *orientalis* overlaps with *S. doronicum* subsp. *doronicum*, e.g., as in Monte Baldo (Veneto, Italy) (Calvo et al. 2015).

L. Pinzani, L. Peruzzi

***Senecio doronicum* (L.) L. subsp. *doronicum* (Asteraceae)**

–**TOS**. – Subspecies to be excluded from the flora of Toscana.

L. Pinzani, L. Peruzzi

***Stellaria ruderalis* M.Lepší, P.Lepší, Z.Kaplan & P.Koutecký (Caryophyllaceae)**

+ **LOM**: Milano (Milano), Monte Stella (WGS84: 45.490153N, 9.134815E ± 300 m), margine erboso, 130–180 m, 6 May 2020, leg. *M. Martignoni*, det. *G. Galasso* (FI, MSNM Nos 50831, 50832, 50833). – Species new for the flora of Lombardia.

This recently described species has been already reported for Italy (Lepší et al. 2019). The presence in Italy of this species is presumably much greater than currently documented, given its high morphological similarity with *Stellaria media* (L.) Vill.

M. Martignoni, E. Banfi, G. Galasso

***Ulmus laevis* Pall. (Ulmaceae)**

+ C **CAL**: Corigliano-Rossano (Cosenza), Foce del Fiume Crati (WGS84: 39.717472N, 16.524165E), bosco planiziale igrofilo, 5 m, 22 August 2019, *A. Brusco, R. Marchianò*, *G. Piovesan* (FI). – Cryptogenic species new for the flora of Calabria.

This species is cultivated in Italy as an ornamental tree (Mittempergher et al. 1993), and it has been regarded as non-native for the whole country (Banfi and Galasso 2010). However, genetic data (Pepori et al. 2013) suggest a native status for some populations in NW Italy. Bartolucci et al. (2018) consider the species as cryptogenic in Piemonte; it was not recorded for Calabria. We found two large individuals in an area of well-preserved riparian vegetation. We think that *U. laevis* in Calabria should provisionally have the status of cryptogenic.

G. Filibeck, A. Brusco, R. Marchianò, G. Piovesan

## Nomenclatural novelties

***Pilosella piloselloides* (Vill.) Soják subsp. *litoralis* (Nägeli & Peter) Gottschl., comb. nov.**

urn:lsid:ipni.org:names:77217192-1

≡ *Hieracium florentinum* subsp. *litorale* Nägeli & Peter, Hierac. Mitt.-Eur., 540 (1885) ≡ *Hieracium piloselloides* subsp. *litorale* (Nägeli & Peter) Zahn, Syn. Mitteleur. Fl. [Ascherson & Graebner] 12/1: 315 (1929).

The combination *Pilosella piloselloides* subsp. *litorale* (Nägeli & Peter) Zahn reported by Bartolucci et al. (2018) was never published.

G. Gottschlich

## Nomenclatural and distribution updates from other literature sources, and corrigenda

Nomenclatural and distribution updates, and corrigenda to Bartolucci et al. (2018) 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

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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# Notulae to the Italian native vascular flora: 12

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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, exclusions, and status changes to the Italian administrative regions. 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 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 (typifications only for accepted names), status changes, exclusions, and confirmations 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

### *Acanthus spinosus* L. (Acanthaceae)

+ **CAL**: Cirò (Crotone), loc. Favare, 550 m a sud della centrale (WGS84: 39.37787N, 17.04018E), boscaglia mediterranea, argilloso, 280 m, 13 October 2019, *G. De Fine* (CLU). – Species new for the flora of Calabria.

N.G. Passalacqua, G. De Fine

### *Alchemilla exigua* L. (Rosaceae)

+ **LAZ**: Settefrati (Frosinone), Santuario di Canneto (WGS84: 41.713970N, 13.902108E), pascolo in loc. Casale Bartolomucci, suolo calcareo, 1327 m, 22 July 2020, *G. Tondi*, *F. Minutillo* (FI, *Herb. Tondi*). – Species confirmed for the flora of Lazio.

This population represents the first record outside of Monti della Laga in the central Apennines (Di Pietro et al. 2015; Ballelli and Allegrezza 2016).

F. Minutillo, G. Tondi

### *Alchemilla fissa* Günther & Schummel (Rosaceae)

+ **LAZ**: Accumoli (Rieti), Agro Nero (WGS84: 42.701884N, 13.323876E), sponde rocciose di ruscello, in radura nella faggeta di Pannicaro, presso Lago Secco, suolo marnoso-arenaceo, 1590 m, 30 May 1999, *G. Tondi* (FI). – Species new for the flora of Lazio.

F. Minutillo, G. Tondi

***Alchemilla subglobosa* C.G.Westerl. (Rosaceae)**

+ **MAR**: Monte Cavallo (Macerata), Monte Cetrognola (Riserva Statale Montagna di Torricchio) (WGS84: 42.96099269N, 13.00418242E), sotto nuclei di faggio e pascoli pingui adiacenti, substrato calcareo, 1350 m, 4 June 1987, *S. Ballelli* (FI; *Herb*. *Ballelli*; *Herb*. *Tondi*). – Species new for the flora of Marche.

This species shows its centre of distribution in northern and central Europe up to the Alps (Kurrto 2009). In Italy it is very rare and known only for few sites of the south Tyrolean and Trentino Alps (Pignatti et al. 2018; F. Festi pers. comm.).

S. Ballelli, G. Tondi

***Anemone apennina* L. (Ranunculaceae)**

– **PIE**. – Species to be excluded from the flora of Piemonte.

This species was first reported for Piemonte by Bellone et al. (2014) in two different localities in the Ligurian Alps: Limone Piemonte (Cuneo) and Frabosa Sottana (Cuneo). Recently, Bellone (2020) attributed the record from Limone Piemonte to *Anemone blanda* Schott & Kotschy, an allochthonous taxon originating from the Balkan peninsula, used for ornamental purposes. The specimen from Frabosa Sottana in TO must also be referred (revision by A. Selvaggi, 31 March 2021) to *A. blanda*, in accord with the keys proposed by Ziman et al. (2011) and Verloove (2017).

A. Selvaggi

***Apium graveolens* L. (Apiaceae)**

+ **SAR**: Status change from casual alien to native for the flora of Sardegna.

*Apium graveolens* is a Mediterranean species, whose presence is well documented in Sardegna (e.g., Moris 1840–1843; Milia and Mossa 1977; De Martis et al. 1984; De Martis and Loi 1989). It is common in moist places, swamps and riverbanks (Arrigoni 2013). Different horticultural varieties of this species are also widely cultivated as a vegetable . We speculate that the evaluation of its status as a casual alien may be derived from the interpretation of rarely occurring sub-spontaneous plants (Bacchetta 2006; Bacchetta et al. 2009). At any rate, its status is to be re-evaluated as a native to Sardegna.

M. Fois, L. Podda, G. Bacchetta

***Aristolochia pallida* Willd. (Aristolochiaceae)**

+ **PUG**: Gravina in Puglia (Bari), "Bosco Difesa Grande", nei pressi di Lago Splendore in bosco a *Quercus cerris* e *Q. frainetto* (WGS84: 40.765021N, 16.381718E), 462 m s.l.m., 25 April 2018, campione coltivato in Orto Botanico sino a 28 May 2021, leg. *G. Pazienza*, *L. Forte,* det. *G. Pazienza, L. Forte, V. Cavallaro* (FI; BI Nos 42445, 42448, 42449, 42450, 42451, 42452). – Species new for the flora of Puglia.

*Aristolochia pallida* is considered as erroneously recorded in Puglia by Bartolucci et al. (2018), where it was formerly reported by Pasquale and Licopoli (1873) for the

Gargano promontory at Sannicandro and by Palanza (1900) *"Nell'erboso sassoso del Pulicchio alle Murge di Gravina"*. The ecological conditions of this locality are similar to those reported for this species in Basilicata (Forte 2001; Pignatti et al. 2017).

G. Pazienza, L. Forte, V. Cavallaro

***Bromus chrysopogon* Viv. (Poaceae)**

+ **ITALIA** (**BAS**): Maratea (Potenza), litorale presso il porto (WGS84: ca. 39.989508N, 15.705615E), incolto litoraneo, ca. 10 m, no exp., 19 April 1990, leg. *E. Banfi*, det. *E. Banfi* 15 February 2021 (FI, MSNM sub *B. scoparius* No. 24034). – Species new for the flora of Italy (Basilicata).

+ **CAL**: Praia a Mare (Cosenza), spiaggia in faccia all'Isola di Dino (WGS84: ca. 39.873902N, 15.783107E), dune, ca. 2 m, no exp., 20 April 1990, leg. *E. Banfi*, det. *G. Osti & C. Acedo* June 2018 (FI, MSNM sub *B. scoparius* Nos. 24031, 24032, 24033, 24035). – Species new for the flora of Calabria.

*Bromus chrysopogon* is a southeastern-Mediterraean species described from Libya, absent in Morocco, Spain, France and the former-Yugoslavia (Clayton et al. 2006+; Valdés and Scholz 2009+), possibly native to Italy. Initially confused with *B. scoparius* L. with which it shares a compact ovoid to flabellate synflorescence, it stands out (Sherif and Siddiqi 1988) for the spikelets 20–25 mm long (vs. 8–20 mm), the lemmas 9.0–11.5 × 3.0–4.0 mm (vs. 7.0–8.0(–10.0) × 1.0–2.5 mm), the awn up to 15 mm (vs. 9(–12) mm), and the brownish-golden, never anthocyanic panicle.

E. Banfi, G. Galasso

***Bromus lepidus* Holmb. (Poaceae)**

+ C **LOM**: Magenta (Milano), Parco del Ticino, riserva "La Fagiana" (WGS84: 45.433122N, 8.829445E ± 400 m), margine di sentiero, ca. 100 m, no exp., 20 May 1993, leg. *G. Galasso*, det. *G. Osti & C. Acedo* June 2018 (MSNM sub *B. hordeaceus* No. 33852). – Cryptogenic species new for the flora of Lombardia.

*Bromus lepidus* is easy to identify for major lemmas shorter than 6.5 mm with a wide hyaline margin folded to an acute angle, and palea shorter than the caryopsis (Tison and de Foucault 2014). It had been reported for Italy (Piemonte and Lombardia) by Pignatti (1982), but without confirmation, and later excluded by the same author (Pignatti et al. 2017). It is impossible to evaluate if the species is native or alien to Lombardia, although in Trentino-Alto Adige it is considered a casual alien (Bartolucci et al. 2018).

E. Banfi, G. Galasso

***Carex buekii* Wimm. (Cyperaceae)**

+ **TOS**: Firenze (Firenze), Fiume Arno (WGS84: 43.765973N, 11.286693E), riva destra del fiume vicino all'Hotel "Ville sull'Arno", 10 May 2021, *L. Lastrucci* (FI). – New species for the flora of Toscana.

*Carex buekii* was reported as occurring only in Piemonte and doubtfully in Friuli Venezia Giulia (Bartolucci et al. 2018), where it has delimitation problems with the closely related *C. randalpina* B.Walln. (Koopman et al. 2018). This record represents the southernmost finding for Italy and the absolute southwestern limit for the range of this species (Koopman et al. 2018). In the collection site the species grows temporarily submerged.

L. Lastrucci, P. Jiménez-Mejías

***Carex strigosa* Huds. (Cyperaceae)**

+ **ABR**: Rocca S. Maria (Teramo), F.so Valle Castellana (WGS84: 42.701884N, 13.323876E), schiarita umida in faggeta mista, loc. La Piana, sotto Colle Romicito; suolo marnoso-arenaceo, 1550 m, 15 September 2017, *G. Tondi*, *F. Minutillo* (FI, *Herb*. *Tondi*). – Species new for the flora of Abruzzo.

F. Minutillo, G. Tondi

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

+ **LIG**: Bergeggi (Savona), "IT1323202 Isola Bergeggi - Punta Predani" presso Punta del Maiolo (WGS84: 44.2374N, 8.442402E), macchia mediterranea, substrato calcareo, 16 m, 15 May 2020, *D. Dagnino, L. Minuto* (GE No. 2408); Portovenere (La Spezia), "IT1345005 Portovenere - Riomaggiore - San Benedetto" Castello di Portovenere, (WGS84: 44.050324N, 9.832397E), gariga a *Euphorbia dendroides* (Habitat Natura 2000 cod.5330), 21 m, 8 May 2020, *D. Dagnino, C. Turcato* (GE No. 5055); Portovenere (La Spezia), "IT1345005 Portovenere - Riomaggiore - San Benedetto" Castello di Portovenere, (WGS84: 44.048553N, 9.833048E), tasca sabbiosa sulla scogliera calcarea, 2 m, 8 May 2020, *D. Dagnino, C. Turcato* (GE No. 5075). – Species confirmed for the flora of Liguria.

Several old records of *C. pauciflorum* for Liguria are known from Brullo et al. (2003), Ottone Penzig's handwritten notes found on a copy of De Notaris (1844) stored in the library of the University of Genova, and the GDOR herbarium (Barberis et al. 2019).

D. Dagnino, L. Minuto, C. Turcato

***Cistus albidus* L. (Cistaceae)**

+ **TOS**: Monte Argentario (Grosseto), fra Punta Avoltore e Punta di Torre Ciana, (WGS84: 42.370900N, 11.167933E), nella gariga bassa a erica multiflora e rosmarino, su breccia calcarea, 88 m, 27 December 2019 (sterile), *F. Selvi 4035* (FI); *ibidem*, 23 May 2020 (fruit), *F. Selvi* e *I. Bettarini 4036* (FI); *ibidem*, 6 April 2021 (flower), *F. Selvi* e *I. Bettarini 4044* (FI). – Species new for the flora of Toscana.

The native presence in Toscana was recently excluded (Bartolucci et al. 2016). In this new locality, *C. albidus* forms a very small population in a low garrigue with

*Erica multiflora* L. and *Salvia rosmarinus* Spenn., on a warm, dry slope facing to the south, on rocky-gravelly calcareous soil. This is the typical habitat of this species. It is not known as a cultivated ornamental in the area, supporting its native status in this locality. Searches in the surrounding area, however, were not successful. The population is in urgent need of protection, as plants are close to a dirt road and subject to a high risk of being collected or extirpated.

F. Selvi

***Cladanthus mixtus* (L.) Chevall. (Asteraceae)**

+ **LIG**: Vado Ligure (Savona), sulla sponda destra del Quiliano (WGS84: 44.280714N, 8.444769E), 0 m, 07 April 2021, *M. Callegari, B. Ciocia* (GE ). – Species confirmed for the flora of Liguria.

Some historical herbarium specimens conserved in GDOR (Barberis et al. 2019) document the presence of the species in three localities: Voltri, Lagaccio, and Sarzana. Bibliographic data (Bertoloni 1853–1854; Ariello 1957) report the historical presence of this species in five other localities in the surroundings of La Spezia: Punta Mesco, Monterosso al Mare, Riomaggiore, Corniglia, and Canale Turì. The population consists of about ten individuals and some seedlings.

M. Callegari, B. Ciocia, G. Casazza, L. Minuto

***Convallaria majalis* L. (Asparagaceae)**

+ **UMB**: Costacciaro (Perugia), Monte Cucco, in Loc. Pignola (WGS84 43.366110N, 12.732120E), bosco misto su versante acclive con esposizione W, substrato carbonatico, c. 1050 m s.l.m., 30 May 2021, *A. Di Filippo, A. Scoppola* (UTV No. 38780). – Species confirmed for the flora of Umbria.

The species is reported as "doubtfully occurring" for Umbria (Bartolucci et al. 2018), although its presence was already reported for Monte Cucco in the sites Fosso di Musolea and Campo la Croce (Salerno and Puletti 1994, 1996), close to the site recorded here. This population is made up of clusters of a few dozen individuals, which 200–300 m upstream cover larger areas in the understory of a beech forest.

A. Di Filippo, A. Scoppola

***Crucianella angustifolia* L. (Rubiaceae)**

+ **VDA**: Quart (Aosta), tra l'oratorio Beato Emerico, Duclos e Porsod (WGS84: 45.757630N, 7.406327E), praterie xerotermiche, 950–1180 m s.l.m., 7 June 2021, *M. Lonati, A. Mainetti, S. Ravetto Enri* (FI). – Species confirmed for the flora of Valle d'Aosta.

This species was recorded by Braun-Blanquet (1961) based on specimens in MPU collected in the localities of Veynes/Sorreley (Saint-Christophe) in 1956. It has not been recently recorded for Valle d'Aosta, where it is actually considered as cryptogenic (Bovio 2014; Bartolucci et al. 2018). Dozens of individuals were sparsely distributed

over an area of about 10 hectares. Due to the species' abundance and distribution across the semi-natural xero-thermic grasslands of Quart, we believe it most appropriate to consider this species as native.

M. Lonati, A. Mainetti, S. Ravetto Enri

***Fedia graciliflora* Fisch. & C.A.Mey. (Caprifoliaceae)**

+ **LAZ**: Roma (Roma), Parco Petroselli (Talenti) (WGS84: 41.938009N, 12.557930E), pratello ai margini di un uliveto, lungo la rete di confine, suolo tufaceo, 37 m, 19 April 2019, *G. Tondi, G. Pellegrino* (FI, *Herb. Tondi*). – Species new for the flora of Lazio.

F. Minutillo, G. Tondi

***Helianthemum salicifolium* (L.) Mill. (Cistaceae)**

+ **LIG**: Diano San Pietro (Imperia), "IT1315602 Pizzo di Evigno" M. Lago (WGS84: 43.96365N, 8.06141E), prateria arida su substrato calcareo (Habitat Natura 2000 cod.6210*), facies densamente arbustata, 625 m, 25 May 2020, *D. Dagnino, M. Mariotti* (GE No. 2989). – Species confirmed for the flora of Liguria.

Some old records (De Notaris 1844; Bertoloni 1842–1844) and herbarium specimens housed in GDOR (Barberis et al. 2019) document the presence of this species in localities in the province of Savona (Albenga, Ceriale) and near Genova. According to Ottone Penzig's handwritten notes found on a copy of De Notaris (1844), stored in the library of the University of Genova, this species was also present at Capo Berta, an area close to the site of the current discovery.

D. Dagnino, M. Mariotti, I. Briozzo

***Hieracium pilosum* Schleich. ex Froel. subsp. *villosifolium* (Nägeli & Peter) Greuter (Asteraceae)**

+ **EMR**: Corniglio (Parma), tra il Lago Santo e La Sella del Marmagna (WGS84: 44.395387N, 10.000874E), prateria subalpina, 1700 m, 25 July 2020, leg. *L. Pinzani,* det. *G. Gottschlich* (FI). – Subspecies new for the flora of Emilia-Romagna.

L. Pinzani, G. Gottschlich

***Juncus ranarius* Songeon & E.P. Perrier (Juncaceae)**

+ **VEN**: Sopra Ruaz - Livinallongo (Belluno) (WSG84 46.496466N, 11.919887E), margine strada statale, 1400 m s.l.m., 4 August 2008, *S. e C. Argenti* (FI barcode FI064007, *Herb. Argenti* No. 16801). – New species for the flora of Veneto.

The distribution of *Juncus ranarius* in Italy was recently updated (Lastrucci et al. 2022), highlighting a certain ecological amplitude for this species. This record confirms the ability of *J. ranarius* to originate populations even in non-halophilic habitats.

L. Lastrucci, C. Argenti

***Lamium galeobdolon* (L.) L. subsp. *galeobdolon* (Lamiaceae)**

+ **LAZ**: Acquafondata (Frosinone) (WGS84: 41.514925N, 13.961504E), bosco di *Ostrya carpinifolia*, substrato calcareo, 990 m, 14 May 2016, *F. Minutillo* (FI, *Herb*. Minutillo, *Herb*. *Tondi*). – Subspecies new for the flora of Lazio.

F. Minutillo, G. Tondi

***Lolium arundinaceum* (Schreb.) Darbysh. subsp. *corsicum* (Hack.) J.-M.Tison (Poaceae)**

+ **SAR**: Perdu Locci, Pula (Sud Sardegna), prati umidi (WGS84: 38.995073N, 9.012160E), 1 m, 18 June 2021, *M. Fois, G. Bacchetta* (FI, CAG); Sa Giaga, Tula (Sassari), sponde sabbiose lacustri (WGS84: 40.762810N, 9.010656E), 164–165 m s.l.m., 16 June 2013, *G. Calvia* (*Herb. Calvia*). – Subspecies new for the flora of Sardegna.

*Lolium arundinaceum* subsp. *corsicum* is a perennial herb endemic to Corsica and Toscana (Bartolucci et al. 2018). This subspecies was doubtfully recorded for Sardegna, based on the synonymy with *Festuca arundinacea* var. *insularis* Gennari proposed by Banfi et al. (2017). We confirm its presence in several sub-halophilous wet meadows near the coast and inland plains of southern Sardegna, as well as in sandy and wet places of northern Sardegna.

M. Fois, G. Calvia, G. Bacchetta

***Ononis spinosa* L. subsp. *procurrens* (Wallr.) Briq. (Fabaceae)**

+ **LAZ**: Ostia Antica (Roma), scavi di Ostia Antica (WGS84: 41.753792N, 12.288327E), tra i ruderi, sul travertino, 5 m, 24 September 2019, *G. Tondi* (FI, *Herb*. *Tondi*). – Subspecies new for the flora of Lazio.

F. Minutillo, G. Tondi

***Pilosella fusca* (Vill.) Arv.-Touv. (Asteraceae)**

+ **LOM**: Sondalo (Sondrio), sentiero in Valle di Rezzalo, presso la chiesa di San Bernardo (WGS84: 46.35728N, 10.41861E), prateria alpina aperta di fondovalle, ca. 1850 m, 10 July 2005, leg. *S. Perego*, det. *G. Gottschlich* 2021 (MSNM No. 44104 sub *Hieracium aurantiacum*). – Species confirmed for the flora of Lombardia.

G. Gottschlich, G. Galasso

***Plantago atrata* Hoppe subsp. *fuscescens* (Jord.) Pilg. (Plantaginaceae)**

+ **TOS**: Coreglia Antelminelli (Lucca), M.te Rondinaio, sella sul crinale ad Est della vetta (WGS84: 44.114656N, 10.595474E), prateria altomontana, 1800 m, 8 July 2021, *L. Pinzani,* (FI, *Herb. Pinzani*). – Subspecies new for the flora of Toscana.

L. Pinzani

***Poa palustris* L. subsp. *palustris* (Poaceae)**

+ **LAZ**: Alvito (Frosinone), Valle di Rio, Font.na Lepore (WGS84: 41.745481N, 13.729308E), canale di scolo del fontanile, 847 m, 13 May 2021, *L. Cancellieri, G. Filibeck* (FI, *Herb. Cancellieri*); Vallerotonda (Frosinone), Valle Verrecchia, sotto Sorgente di Collelungo (WGS84: 41.624519N, 13.980796E), canale di scolo di fontanile, 1340 m, 4 June 2021, *G. Filibeck, G. Cangelmi* (*Herb. Cancellieri*); San Biagio Saracinisco (Frosinone), Valle Monacesca, Le Fontane (WGS84: 41.642979N, 13.960188E), torbiera, 1775 m, 20 July 2021, *L. Cancellieri, G. Cangelmi* (*Herb. Cancellieri*); Vallerotonda (Frosinone), ecotoni sopra loc. La Selva - Lago di Cardito (WGS84: 41.607930N, 13.989928E), boscaglia igrofila, suolo alluvionale a matrice calcarea, 1030 m, 22 June 2013, *G. Tondi, F. Minutillo* (FI, *Herb*. *Tondi*). – Species new for the flora of Lazio.

This species, previously overlooked, is quite common in wet habitats across a wide elevational range in SE-Lazio (Val Comino, Meta and Mainarde districts).

L. Cancellieri, G. Cangelmi, G. Filibeck, F. Minutillo, G. Tondi

+ **MOL**: Scapoli (Isernia), Colle Rotondo (WGS84: 41.617687N, 14.013347E), canale di scolo di fontanile, 1160 m, 8 July 2021, *L. Cancellieri, G. Cangelmi, G. Filibeck* (UTV). – Species confirmed for the flora of Molise.

L. Cancellieri, G. Cangelmi, G. Filibeck

***Polypogon monspeliensis* (L.) Desf. (Poaceae)**

+ **UMB**: Magione (Perugia), loc. Sant'Arcangelo sul Trasimeno (WGS84: 43.087983N, 12.156851E), vegetazione sinantropica delle canaline di scolo a bordo strada, 258 m, 16 June 2021, leg. *G. Mei*, det. *G. Mei*, *A. Stinca* (FI). – Species confirmed for the flora of Umbria.

G. Mei, A. Stinca

***Potamogeton coloratus* Hornem. (Potamogetonaceae)**

+ **LIG**: Genova (Genova), laghetti di Nervi (WGS84: 44.394861N, 9.045050E), pozza di torrente, 67 m, 26 January 2017, leg. *M. Calbi*, det. *G. Barberis, M. Calbi, D. Dagnino* (GE No. 5136); *ibidem*, 17 September 2020, leg. *V. Del Nero*, det. *G. Barberis, V. Del Nero, D. Dagnino* (GE No. 5185). – Species confirmed for the flora of Liguria.

De Notaris (1844, under the name *P. plantagineus* Du Croz ex Roem. & Schult.) quoted this species "in paludibus et in fossis secus litora Liguriae totius frequentissime", but in the 20th century almost all coastal wetlands disappeared.

G. Barberis, M. Calbi, V. Del Nero

***Pyrus nivalis* Jacq. (Rosaceae)**

+ **EMR**: Canossa (Reggio Emilia), ZSC "IT4030014 Rupe di Capotrera, Rossena", strada SP54 tra Ciano d'Enza e Rossena, dopo la curva al Km 2 (WGS84: 44.591183N,

10.417198E), boscaglia con *Quercus pubescens*, *Fraxinus ornus*, *Ulmus minor* e *Spartium junceum*, 347 m, NNE, 10 October 2020, leg. *G. Riva*, det. *E. Banfi* (FI, MSNM Nos. 50930, 50931, 50932). – Species new for the flora of Emilia-Romagna.

We found numerous 2–3 m tall shrubs of this species.

G. Riva, E. Banfi, G. Galasso

***Ranunculus baldensis* Dunkel (Ranunculaceae)**

+ **VEN**: Lusiana-Conco (Vicenza), loc. sopra Piazza Campana (WGS84: 45.793816N, 11.552451E), compluvio a margine boscaglia, 915 m, 4 May 2021, *leg. F. Fratolin*, *det. F.G. Dunkel* (FI, *Herb. Dunkel*, *Herb. Argenti*); *idem*, loc. presso Buso della Sperlonga (WGS84: 45.799687N, 11.550342E), margine ceduo, 1105 m, 4 Mai 2021, *leg. D. Campoccia, C. Argenti*, *det. F.G. Dunkel* (FI, *Herb. Dunkel*, *Herb. Argenti*); *idem*, loc. Ristoro (WGS84: 45.797986N, 11.545593E), compluvio a margine bosco, 1100 m, 4 Mai 2021, *leg. D. Campoccia, C. Argenti*, det. *F.G. Dunkel* (FI, *Herb. Dunkel*, *Herb. Argenti*). – Species confirmed for the flora of Veneto.

*Ranunculus baldensis* belongs to the *R. auricomus* L. complex and was described from Mt. Baldo in Trentino-Alto Adige. It was reported as probably extinct for Veneto (Dunkel 2010) based on a historical specimen kept at FI collected on M. Grappa by L. Vaccari in "Collalti, selve umide cedue di San Michele".

F.G. Dunkel, D. Campoccia, C. Argenti, F. Fratolin

***Ranunculus pedrottii* Spinosi ex Dunkel (Ranunculaceae)**

+ **LAZ:** Amatrice (Rieti), Fosso Cerruglia (WGS84: 42.588509N, 13.336007E), prati umidi, 1290 m, 8 May 2013, *F. Bartolucci, F. Conti* (APP Nos 52604, 52605, 52621–52624, 57186, 57195–57200); *ibidem*, 15 June 2012, *F. Bartolucci, F. Conti* (APP Nos 52645, 52648, 52649, 52651–52653); *ibidem*, 18 June 2016, *F. Conti* (APP Nos 57188–57190, 60271–60282); *ibidem*, 23 July 1997, *G. Tondi* (APP); *ibidem*, 14 June 1998, *G. Tondi* (APP). – Species new for the flora of Lazio.

The species was considered so far endemic to the high karstic plateaux around Castelluccio (Pian Grande di Castelluccio di Norcia and Pian Perduto) between Marche and Umbria (Dunkel 2011).

F. Conti, F. Bartolucci, F.G. Dunkel, G. Tondi

***Ranunculus rionii* Lagger (Ranunculaceae)**

**+ EMR**: Collecchio (Parma), quarry lake close to the Chiesuole Naturalistic Area (WGS84: 44.787751N, 10.208318E), 22 June 2021, leg. *R. Bolpagni, A. Dalla Vecchia,* det. *L. Lastrucci et R. Bolpagni* n. FI064048 (FI barcode FI064048). – Species new for the flora of Emilia-Romagna.

*Ranunculus rionii* grows along the shores of an abandoned quarry lake.

R. Bolpagni, A. Dalla Vecchia, L. Lastrucci

***Romulea columnae* Sebast. & Mauri (Iridaceae)**

+ **EMR**: San Leo (Rimini), propaggini occidentali di Monte Gregorio (WGS84: 43.912870N, 12.354773E), prato arido su substrato calcareo affiorante, 505 m s.l.m., 25 February 2021, *T. Bruschi, F. Santi* (FI); Cervia (Ravenna), radura prativa nella pineta (punto soggetto a calpestio), 27 March 1983, *F. Semprini* (*Herb. Semprini*). – Species new for the flora of Emilia-Romagna.

About 15 flowered individuals were observed in San Leo. This species was not recorded by Bruschi and Polverelli (2020), that studied the flora of this area.

T. Bruschi, F. Santi

***Rorippa sylvestris* (L.) Besser subsp. *sylvestris* (Brassicaceae)**

+ **CAL**: Sant'Eufemia d'Aspromonte (Reggio Calabria), Contrada San Bartolo (WGS84: 38.260484N, 15.843146E), lungo un'antica "saja" usata per irrigare i campi, 498 m, 8 July 2020, leg. *A. Crisafulli*; det. *A. Crisafulli, V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO). – Species and subspecies confirmed for the flora of Calabria.

*Rorippa sylvestris* subsp. *sylvestris* is reported throughout Italy, with the exception of Calabria where, according to Bartolucci et al. (2018), the taxon is of doubtful occurrence. The collected individuals grow in large numbers along an old "saja" used to irrigate the nearby fields.

C.M. Musarella, V.L.A. Laface, G. Spampinato, A. Crisafulli

***Rosa rubiginosa* L. (Rosaceae)**

+ **MAR**: Bolognola (Macerata), siepi e radure nel vers. N-NW del M. Castel Manardo (WGS84: 42.979389N, 13.242039E), ca. 1430 m., 26 June 2021, *L. Gubellini* (FI, PESA). – Species new for the flora of Marche.

The species grows in hedges, clearings and wood edges at mountain altitudes.

L. Gubellini, N. Hofmann

***Sedum caeruleum* L. (Crassulaceae)**

+ **CAL**: Montebello Jonico (Reggio Calabria), Rocche di Prastarà (WGS84: 37.952121N, 15.745786E), rocce, 325 m, 2 May 2021, leg. *V.L.A. Laface*; det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (FI, REGGIO); Montebello Jonico (Reggio Calabria), Prastarà (WGS84: 37.951119N, 15.744581E), muro a secco, 292 m, 16 May 2021, leg. *V.L.A. Laface*; det. V.L.A. *Laface, C.M. Musarella, G. Spampinato* (REGGIO); Montebello Jonico (Reggio Calabria), Borgata Caracciolino (WGS84: 37.945481N, 15.749657E), bordo strada, 182 m, 16 May 2021, leg. *V.L.A. Laface*; det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); Montebello Joni-

co (Reggio Calabria), SS 106 (WGS84: 37.933378N, 15.735161E), bordo strada, 31 m, 16 May 2021, leg. *V.L.A. Laface*; det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO); Montebello Jonico (Reggio Calabria), Contrada Tigani (WGS84: 37.934654N, 15.739465E), bordo strada, 63 m, 16 May 2021, leg. *V.L.A. Laface*; det. *V.L.A. Laface, C.M. Musarella, G. Spampinato* (REGGIO). – Species new for the flora of Calabria and for peninsular Italy.

The species grows abundantly on dry stone walls and along roadsides, and can also be found with numerous individuals in rocky plant communities occupied by *Lomelosia cretica* (L.) Greuter & Burdet. In Italy it was recorded so far only for Sicilia and Sardegna (Bartolucci et al. 2018).

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

***Sedum dasyphyllum* L. subsp. *glanduliferum* (Guss.) Nyman (Crassulaceae)**

+ **UMB**: Spoleto (Perugia), Colle Sant'Elia, pareti rocciose sottostanti la Rocca Albornoziana (WGS84: 42.733744N, 12.742815E), affioramenti di natura carbonatica, 418 m s.l.m. , 7 May 2021, leg. et det. *F. Bonini*. – Subspecies new for the flora of Umbria.

Unlike other Italian administrative Regions, no information was available until now on the occurrence of *Sedum dasyphyllum* subspecies in Umbria (Bartolucci et al. 2018).

F. Bonini, D. Gigante

***Stellaria ruderalis* M.Lepší, P.Lepší, Z.Kaplan & P.Koutecký (Caryophyllaceae)**

+ **PIE**: San Pietro Val Lemina (Torino), lungo il greto del Torrente Lemina (WGS84: 44.897584N, 7.315345E), suolo prevalentemente sabbioso, 411 m, 16 July 2021, *S. Carfagno, M. Lonati* (FI). – Species new for the flora of Piemonte.

This recently described species has been already reported for Sardegna, Toscana, and Veneto (Lepší et al. 2019), and recently recorded also in Lombardia (Bartolucci et al. 2021).

S. Carfagno, M. Lonati

+ **TAA**: Tenno (Trento), alla base di un muro presso Ville del Monte, parcheggio all'inizio della strada per Canale di Tenno (WGS84: 45.930205N, 10.824805E), 560 m a.s.l., 23 March 2021, leg. *F. Prosser, G. Tomasi* (FI; ROV No. 76947); Via Dós Trento (Trento), a bordo strada (WGS84: 46.0728136N, 11.1096564E), 300 m a.s.l., 24 March 2021, leg. *G. Bonari, L. Sottovia* (ROV No. 80104); Bolzano (Bolzano), centro storico, Via A. Hofer, cortile del Museo di Scienze dell'Alto Adige (WGS84: 46.50114N, 11.357272E), 270 m a.s.l., 12 April 2021, leg. *T. Wilhalm* (BOZ). – Species new for the flora of Trentino-Alto Adige.

G. Tomasi, F. Prosser, T. Wilhalm, G. Bonari

***Trifolium michelianum* Savi (Fabaceae)**

+ **PUG**: Gravina in Puglia (Bari), Bosco Difesa Grande, Lago d'Olmo (WGS84: 40.755172N, 16.385009E), prati umidi su suoli periodicamente inondati, 450 m, 14 June 2019, *V. Tomaselli* (FI, BI Nos 42443, 42444, 42446 e 42447). – Species new for the flora of Puglia.

*Trifolium michelianum* is a Mediterranean-Atlantic species with isolated locations in North Africa, the Balkan Peninsula, and Asia Minor (Caldarella et al. 2013). In the localities of Puglia, it forms small populations, growing in wet and periodically flooded meadows.

V. Tomaselli, F. Carruggio, L. Forte

***Veronica cymbalaria* Bodard subsp. *cymbalaria* (Plantaginaceae)**

+ **PIE**: Alto (Cuneo), Valle Pennavaire (WGS84: 44.112460N, 7.996134E), ambiente ruderale nei pressi di una costruzione, 770 m, 23 April 2021, *M. Pittarello, G. Nota, D. Barberis* (FI). – Species confirmed for the flora of Piemonte.

*Veronica cymbalaria* was reported by Bertolani Marchetti (1955) for Valsesia, but recently was indicated as reported by mistake in Bartolucci et al. (2018).

M. Pittarello, G. Nota, D. Barberis

## Floristic records of regional alien taxa

***Antirrhinum tortuosum* Bosc. ex Lam. (Plantaginaceae)**

+ (NAT) **LOM**: Bergamo (Bergamo), Via San Vigilio (WGS84: 45.710450N, 9.648429E), muro in pietra, 456 m, SW, 16 July 2021, *E. Banfi* (FI, MSNM No. 51025). – Naturalized regional alien species new for the flora of Lombardia.

This species was confused so far with *A. majus* L., also occasionally present on the walls of "Città Alta".

E. Banfi, G. Galasso

***Centranthus calcitrapae* (L.) Dufr. subsp. *calcitrapae* (Valerianaceae)**

+ (NAT) **VEN**: Domegliara (Verona), nello scalo merci della stazione ferroviaria (WGS84: 45.525713N, 10.821137E), massicciata, 117 m, 21 April 2021, *A. Bertolli, F. Prosser* (FI, ROV No. 80106); *ibidem*, 9 June 2021, *F. Prosser, G. Tomasi* (ROV No. 80108); Verona, nello scalo merci della stazione ferroviaria di Verona Porta Nuova (WGS84: 45.4251109N, 10.9813051E), massicciata, 63 m, 9 June 2021, *F. Prosser, G. Tomasi* (ROV No. 80109). – Naturalized regional alien species new for the flora of Veneto.

As far as northern Italy is concerned, this taxon was, so far, known only for Liguria and Lombardia (Bartolucci et al. 2020).

A. Bertolli, F. Festi, F. Prosser, G. Tomasi

***Crepis bursifolia* L. (Asteraceae)**

+ (NAT) **SAR**: Sassari (Sassari), Viale Italia, lungo la via principale e nelle vie traverse, in aiuole e bordi stradali (WGS84: 40.716621N, 8.554115E) 205 m, 7 June 2021, *G. Brundu, V. Lozano, S. Cherchi* (FI, *Herb. UniSS Agraria*). – Naturalized regional alien species new for the flora of Sardegna.

*Crepis bursifolia* is a perennial herb and a ruderal plant. In 2021, it was found to be abundant along the streets of the city center of Sassari. The record for Limbara by Veri and Bruno (1974) has been questioned by Calvia and Ruggero (2020).

V. Lozano, G. Brundu, S. Cherchi

***Euphorbia taurinensis* All. (Euphorbiaceae)**

+ (NAT) **TAA**: Mezzocorona (Trento), nella stazione ferroviaria (WGS84: 46.208705N, 11.129098E), massicciata, 210 m, 31 October 1999, leg. *F. Prosser,* det. *F. Prosser 11 May 2021* (ROV No. 32604, sterile plants); *ibidem*, 4 May 2021, leg. *F. Festi, M. Tognetti*, det. *F. Prosser 10 May 2021* (FI, ROV No. 80105, fertile plants). – Naturalized regional alien species new for the flora of Trentino-Alto Adige.

*Euphorbia taurinensis* was indicated as native in Piemonte and Liguria by Bartolucci et al. (2018). The species was also reported as alien for Veneto (Argenti and Lasen 2001), where it was observed in Feltre railway station between the 1970s and 1996.

A. Bertolli, F. Festi, F. Prosser, G. Tomasi

***Phalaris aquatica* L. (Poaceae)**

+ (NAT) **PIE**: Tortona (Alessandria), scarpata stradale della nuova tangenziale di Tortona (WGS84: 44.918263N, 8.886254E), 100 m, no exp., 22 June 2020, *S. Orsenigo* (PAV); *ibidem*, 21 May 2021, leg. *S. Orsenigo*, det. *S. Orsenigo* e *M. Pallanza* (FI, PAV). – Naturalized regional alien species new for the flora of Piemonte.

We have found about ten individuals, observed for four years, forming big tufts along the road margin, close to the railway.

S. Orsenigo, M. Pallanza

***Sedum caespitosum* (Cav.) DC. (Crassulaceae)**

+ (NAT) **VEN**: Sommacampagna (Verona), nell'Aeroporto Catullo (WGS84: 45.400643N, 10.891048E]), sede di stradina asfaltata dismessa, 75 m, 14 April 2021, *A. Bertolli, F. Prosser, G. Tomasi* (FI, ROV No. 80107). – Naturalized regional alien species new for the flora of Veneto.

This is a stenomediterranean species, known for southern and central Italy (Bartolucci et al. 2018), recently recorded for Emilia-Romagna (Alessandrini and Montanari 2020).

A. Bertolli, F. Festi, F. Prosser, G. Tomasi

## Nomenclatural and distribution updates from other literature sources, and corrigenda

Nomenclatural and distribution updates, and corrigenda to Bartolucci et al. (2018) 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

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

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# Notulae to the Italian native vascular flora: 14

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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 status changes to the Italian administrative regions. 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 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 (typifications only for accepted names), exclusions, and confirmations 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

***Arabis auriculata* Lam. (Brassicaceae)**

+ **EMR**: Montecopiolo (Rimini), versante SE del Monte San Marco (WGS84: 43.848287°N, 12.347453°E), prati con roccia calcarea affiorante, 1100 m s.l.m., 30 April 2022, *T. Bruschi, M. Magrini, L. Menghi, L. Polverelli* (FI). – Species new for the flora of Emilia-Romagna.

M. Magrini, L. Menghi, L. Polverelli

***Cytisus infestus* (C.Presl) Guss. subsp. *infestus* (Fabaceae)**

+ **PIE**: Alto (Cuneo), sotto Strada Provinciale 216, arbusteti misti a roverella e ginestrella (WGS84: 44.110861°N, 7.994028°E), 730 m, 19 September 2021, *M. Lonati, G. Nota, D. Barberis* (FI). Species new for the flora of Piemonte.

Some fully developed individuals were found in a scrubland dominated by Mediterranean species, mainly *Osyris alba* L., recently reported for the same study area (Bartolucci et al. 2020).

M. Lonati, G. Nota, D. Barberis

***Dracunculus vulgaris* Schott (Araceae)**

+ **UMB**: Perugia (Perugia), Monte di Lacugnano, esposizione SW (WGS84: 43.098312°N, 12.331790°E), ambiente aperto e cespugliato della macchia mediterranea con affioramenti rocciosi, substrato calcareo, 440 m s.l.m., 25 May 2021, *C. Longo, S. Vitale, P. Salerno* (UTV No. 38891). – Species confirmed for the flora of Umbria.

This species, recorded in the past in Umbria at Colle della Trinità (Batelli 1888) and at Isola Maggiore, Lake Trasimeno (Cicioni 1895), is currently considered as doubtfully occurring in Umbria (Bartolucci et al. 2018). The population identified at Parco di Monte Lacugnano, consists of about ten plants distributed on a surface of approximately 4,000 $m^2$.

C. Longo, S. Vitale, P. Salerno

***Elatine hexandra* (Lapierre) DC. (Elatinaceae)**

+ C **SAR**: Vena Limbara, Calangianus (Sassari), (WGS84: 40.862781°N, 9.262080°E), margini dei laghetti di cava e zone umide limitrofe, 500 m, 26 August 2022, *G. Calvia, A. Lallai* (FI, CAG). – Cryptogenic species new for the flora of Sardegna.

*Elatine hexandra* is a holarctic species, typical of temporarily flooded sites, which is widespread in western and north-western Europe, but becomes rare eastwards, in southern and eastern European countries (Popiela et al. 2011). In Italy, this species is recorded as cryptogenic for Piemonte, Lombardia, Veneto, and Emilia-Romagna (Bartolucci et al. 2018). In the Mediterranean islands, this species was previously recorded only for Corsica, where it has been considered native (Fichot et al. 2015; Delage and Hugot 2020). We report its presence in an area of northern Sardinia where it colonises the shores of several semi-natural lakes formed after the abandonment of granite quarries.

G. Calvia, A. Lallai

***Erodium alnifolium* Guss. (Geraniaceae)**

+ **MAR**: Monte Grimano Terme (Pesaro e Urbino), loc. Seriole (WGS84: 43.872045°N, 12.463668°E), sentiero sterrato, 587 m, 16 June 2022, *F. Santi* (FI). – Species new for the flora of Marche.

F. Santi

***Erodium salzmannii* Delile (Geraniaceae)**

+ **TOS**: Scarlino (Grosseto), Podere il Bersagliere (WGS84: 42.871241°N, 10.997414°E), pratelli aridi, 45 m, 30 April 2022, leg. *L. Pinzani*, det. *L. Peruzzi*, *L. Pinzani* (FI, *Herb. Pinzani*). – Species confirmed for the flora of Toscana.

*Erodium salzmannii* was ascertained so far only for Sardegna, while it has been doubtfully reported for Toscana (Bartolucci et al. 2018) based on a single record for the island of Elba (Carta et al. 2018 and literature cited therein). Our finding represents the first record for peninsular Italy.

L. Pinzani, L. Peruzzi

***Euphorbia segetalis* L. (Euphorbiaceae)**

+ **EMR**: Lugo (Ravenna) (WGS84: 44.410317°N, 11.931492°E), ambienti ruderali, 12 m s.l.m., 23 January 2022, leg. *T. Fiaschi*, det. *T. Fiaschi, E. Fanfarillo* (FI, SIENA). – Species new for the flora of Emilia-Romagna.

*Euphorbia segetalis* is a Mediterranean species considered native in many administrative regions of peninsular Italy and in Liguria, while it is recorded as a regional alien in Friuli Venezia-Giulia and Lombardia (Bartolucci et al. 2018). Given its synanthropic character as a weed of crops and ruderal sites (Fanfarillo et al. 2020), we consider it native in Emilia-Romagna.

T. Fiaschi, E. Fanfarillo, C. Angiolini

***Ferulago galbanifera* (Mill.) W.D.J.Koch (Apiaceae)**

+ **PUG**: Gravina in Puglia (Bari), Parco Nazionale dell'Alta Murgia loc. Pulicchio di Gravina, pratelli steppici su rupi calcaree (WGS84: 40.905522°N, 16.424333°E),

553 m, 12 May 2018, leg. *G. Buccomino*, det. *G. Buccomino, R.P. Wagensommer* (FI); *ibidem*, 4 July 2022 (fruit), leg. *G. Buccomino*, det. *G. Buccomino, R.P. Wagensommer* (FI); Candela (Foggia) loc. Pietra Longa sperone roccioso in prossimità della Strada Provinciale 99 (WGS84: 41.121125°N, 15.496817°E), 354 m, 6 July 2022, leg. *G. Buccomino*, det. *G. Buccomino, R.P. Wagensommer* (FI). – Species confirmed for the flora of Puglia.

*Ferulago galbanifera* was reported as no longer recorded by Bartolucci et al. (2018) based on the records of Palanza (1900) and Bianco (1962) in Pulicchio di Gravina. We hereby confirm the occurrence of this species with few individuals, growing together with *Athamanta sicula* L. and *Anisantha rubens* (L.) Nevski. In Puglia it is also present and very abundant on the rocky spur of Pietra Longa (Candela).

G. Buccomino, R.P. Wagensommer

***Hypecoum imberbe* Sm. (Papaveraceae)**

+ **BAS**: Matera (Matera), Piano di Trasano - Conca d'Aglio, margini di campo di cereali (WGS84: 40.65247312°N, 16.65746037°E), 500 m, 3 May 2022, *A. Selvaggi, G. Salerno* (FI, *Herb. Selvaggi*). – Species new for the flora of Basilicata.

G. Salerno, A. Selvaggi

***Ipomoea imperati* (Vahl) Griseb. (Convolvulaceae)**

+ **CAM**: Bacoli (Napoli), spiaggia in corrispondenza del Lago Fusaro (WGS84: 40.829972°N, 14.048093°E), dune embrionali, 0 m, 16 October 2018, *M. De Matteis Tortora et S. Gaudino* (NAP barcode NAP0000611); Bacoli (Napoli), Lido "Papel Beach" (WGS84: 40.830894°N, 14.0408081°E), 0 m, limite della zona afitoica a ridosso dello stabilimento balneare, 14 September 2022, *E. Del Guacchio, M. De Matteis Tortora, B. Menale, M. Spena* (*Herb. Del Guacchio*); Pozzuoli (Napoli), spiaggia in corrispondenza del Monte di Cuma, arenile (WGS84: 40.849032°N, 14.047468°E), 1 m, 26 September 2018, *M. De Matteis Tortora, L. Pellegrini, S. Gaudino* (NAP barcode NAP0000612); *ibidem*, 14 September 2022, *E. Del Guacchio* et *M. De Matteis Tortora* (*Herb. Del Guacchio*). – Status change and species confirmed for the flora of Campania.

This species is widespread along the tropical and subtropical coasts of the world (WCSP 2022), and it is usually regarded as native to Europe and Italy (e.g., POWO 2022). Data from Cennamo et al. (2013) strongly support its native status in Italy. In addition, this species was first described for the surroundings of Naples since the end of the 16$^{th}$ century, where it later became extinct (Migliorato 1896). The other localities discovered by M. Tenore and G. Gussone in Ischia Island disappeared in the 1970s, and an ancient indication for the island of Capri is doubtful (Ricciardi 1998). The new localities are the northernmost of the range; sadly, the first listed site has been destroyed, whereas the other two are constituted by a single or few individuals.

M. De Matteis Tortora, E. Del Guacchio, P. Caputo

***Lagurus ovatus* L. subsp. *nanus* (Guss.) Messeri (Poaceae)**

+ **SAR**: La Maddalena (Sassari), Abbatoggia (WGS84: 41.247864°N, 9.401394°E), 2 m, 13 June 2022, *M. Fois, A. Cuena-Lombraña, G. Bacchetta* (FI, CAG); Budoni (Nuoro), Pineta Sant'Anna (WGS84: 40.698212°N, 9.723101°E), 1 m s.l.m., 14 June 2022, *M. Fois, G. Bacchetta* (CAG). – Subspecies new for the flora of Sardegna.

M. Fois, A. Cuena-Lombraña, G. Bacchetta

***Maresia nana* (DC.) Batt. (Brassicaceae)**

+ **ABR**: Marina di Vasto (Chieti), Lido del Sole 57 (WGS84: 42.342290°N, 13.429072°E), margine stradale e terreno sabbioso, 3 m, 31 March 2022, leg. *D. C. Palermo*, det. *D. C. Palermo, D. Longo*, *F. Bartolucci, F. Conti* (APP No. 66131, FI). – Species confirmed for the flora of Abruzzo.

This species was reported by Zodda (1954) for Pineto and never confirmed thereafter.

D.C. Palermo, D. Longo, F. Bartolucci, F. Conti

***Mentha microphylla* K.Koch (Lamiaceae)**

+ **CAL**: Condofuri (Reggio Calabria), Amendolea (WGS84: 37.986869°N, 15.896327°E), bordo strada vicino a una fonte, 158 m, 21 August 2022, leg. *F. D'Aleo*, det. *F. D'Aleo*, *V.L.A. Laface*, *C.M. Musarella, G. Spampinato* (REGGIO, FI). – Species confirmed for the flora of Calabria.

This species was first reported in Calabria by Pignatti (1982) and recently regarded as no longer recorded by Bartolucci et al. (2018).

F. D'Aleo, V.L.A. Laface, C.M. Musarella

***Ornithogalum kochii* Parl. subsp. *monticola* (Jord. & Fourr.) Peruzzi (Asparagaceae)**

+ **EMR**: Monte Bosco della Torre (Parma), prato arido di cresta (WGS84: 44.778404°N, 9.902368°E), 525 m, 2 May 2017, leg. *M. Adorni*, det. *L. Peruzzi* (FI). – Subspecies new for the flora of Emilia-Romagna.

M. Adorni

***Orobanche pubescens* d'Urv. (Orobanchaceae)**

+ **CAL**: Cirò (Crotone), località Favare (WGS84: 4360737°N, 675456.00°E), 300 m a ovest della centrale su *Trifolium repens*, 361 m, 26 April 2022, leg. *G. De Fine*, det. *N.G. Passalacqua et G. Domina* (FI). – Species confirmed for the flora of Calabria.

This species was reported by Domina and Peruzzi (2010) based on a specimen housed in FI collected by Fiori (08 July 1899) on Monti di Paola (Cosenza).

N.G. Passalacqua, G. De Fine, G. Domina

***Prunus avium* (L.) L. (Rosaceae)**

+ **MAR**. – Status change from naturalized to native for the flora of Marche.

+ **UMB**. – Status change from naturalized to native for the flora of Umbria.

In Italy, this species is generally considered as a native plant, except for Marche, Umbria, Sicily, and Sardinia where it was reported as alien (Bartolucci et al. 2018; Stinca et al. 2021). The status of naturalized alien for populations in Umbria and Marche is not sustainable. In fact, there are no natural, geographical, or environmental barriers nor geo-pedological discontinuities allowing to consider these populations differently from those of the surrounding regions.

G. Mei, A. Stinca

***Ranunculus rionii* Lagger (Ranunculaceae)**

+ **FVG**: Staranzano (Gorizia), zona deltizia del fiume Isonzo (WGS84: 74.5067862°N, 16.383342°E) (OGU 10247/1), pozze temporanee fungenti da morfologie di impluvio, incluse in lembi di prateria sortumosa in contatto con gli ambienti acquitrinosi subsalsi della foce fluviale, 0 m s.l.m., 5 May 2021, *G. Bertani* (FI). – Species new for the flora Friuli Venezia-Giulia.

G. Bertani

***Scorzonera laciniata* L. subsp. *laciniata* (Asteraceae)**

+ **PUG**: Agro di Gravina in Puglia (Bari), substrato limoso-argilloso del vulcanello di Gravina in Puglia (WGS84: 40.702918°N, 16.428803°E), 210 m s.l.m, 27 Aptil 2022, *M. Terzi, F.S. D'Amico* (FI). – Subspecies confirmed for the flora of Puglia.

This taxon was recorded for Puglia by Béguinot (1910 sub *S. laciniata* subsp. *tenorei*) and Fiori (1928 sub *S. laciniata* var. *tenorei*) and later regarded as doubtfully occurring in this administrative region by Bartolucci et al. (2018).

M. Terzi, F.S. D'Amico

***Securigera cretica* (L.) Lassen (Fabaceae)**

+ **TOS**: Massarosa (Lucca) prima della Chiesa di Pieve a Elici, salendo (WGS84: 43.885224°N, 10.334922°E), uliveti, 130–150 m circa, 20 April 2022, *B. Pierini* (FI); San Casciano in Val di Pesa (Firenze), tra Villa il Poggiale e Castellaccio (WGS84: 43.664830°N, 11.162710°E), oliveto, 275 m, 25 April 2022, *L. Pinzani* (FI, *Herb. Pinzani*); Empoli (Firenze) antico meandro dell'Arno tra Arnovecchio e Fibbiana (WGS84: 43.729975°N, 10.985395°E), prati mesofili, 20 m, 15 May 2022, *L. Peruzzi* (FI). – Species new for the flora of Toscana.

B. Pierini, L. Pinzani, L. Peruzzi

***Sedum caespitosum* (Cav.) DC. (Crassulaceae)**

+ **CAM**: Padula (Salerno), presso Volta Cammino (WGS84: 43.304500°N, 15.639680°E), strada sterrata, 480 m, 23 Apr 2022, *L. Pinzani* (FI). – Species confirmed for the flora of Campania.

To the best of our knowledge, *S. caespitosum* was reported for Naples by De Rosa (1906). The species forms a small population along a country road.

L. Pinzani, A. Stinca

***Sporobolus virginicus* (L.) Kunth (Poaceae)**

+ **LIG**: Pietra Ligure (Savona), lungomare a valle della ferrovia (WGS84: 44.143735°N, 8.274991°E), margine erboso, 5 m, no exp., 29 August 2022, *G. Galasso* (FI, MSNM barcode MSNM52009). – Species confirmed for the flora of Liguria.

G. Galasso

***Tofieldia calyculata* (L.) Wahlenb. (Tofieldiaceae)**

+ **LAZ**: Amatrice (Rieti), Monti della Laga, Loc. Fosso Pelone (WGS84: 42.635833°N, 13.394444°E), within a system of temporary flooded ponds along a stream bank NNW, 1650 m a.s.l., 22 July 2022, *F. Di Pietro, R. Di Pietro* (FI, HFLA). – Species new for the flora of Lazio.

F. Di Pietro, R. Di Pietro

***Ulmus laevis* Pallas (Ulmaceae)**

+ **VDA**: Châtillon (Aosta), destra idrografica Dora Baltea, area alluvionale, sotto Ussel (WGS84: 45.74430834°N, 7.63023532°E), 432 m, 24 July 2022, *A. Selvaggi* (FI, AO); Saint-Vincent (Aosta), fraz. Tensoz, sx idrografica della Dora Baltea, bosco alluvionale (WGS84: 45.74347847°N, 7.64188723°E), 424 m, 6 August 2022, *A. Selvaggi* (FI, *Herb. Selvaggi*); Saint-Vincent (Aosta), fraz. Toux, sx idrografica della Dora Baltea, a monte ponte autostrada, bosco alluvionale (WGS84: 45.74406°N, 7.63454°E), 425 m, 6 August 2022, *A. Selvaggi* (FI, *Herb. Selvaggi*). – Species new for the flora of Valle d'Aosta.

*Ulmus laevis* is considered by Bartolucci et al. (2018) as a cryptogenic species in Piemonte and as naturalized alien elsewhere in Italy. As recently proposed by Torre et al. (2022), the native and relictual presence of the species in Piemonte and Lombardia has been definitely proven. The presence of *U. laevis* in alluvial woods along the Dora Baltea river is documented in Piemonte (R. Benetti and A. Selvaggi, pers. obs.). For this reason, its presence in Valle d'Aosta in alluvial woody areas along the Dora Baltea, consistent with the natural habitat of the species, should be considered native and relictual, too.

A. Selvaggi

***Valerianella echinata* (L.) DC. (Valerianaceae)**

+ **BAS**: Matera (Matera), Piano di Trasano - Conca d'Aglio, margini di campo di cereali (WGS84: 40.65247312°N, 16.65746037°E), 500 m, 3 May 2022, *A. Selvaggi, G. Salerno* (FI, *Herb. Selvaggi*). – Species new for the flora of Basilicata.

A. Selvaggi, G. Salerno

***Viola canina* L. subsp. *canina* (Violaceae)**

+ **CAL**: Serra S. Bruno (Vibo Valentia), contrada Chiusa della Madonna (WGS84: 38.56782°N, 16.32388°E), incolto erboso, ai bordi di un orto, terreno leggermente acido Ph 6, derivante dal disfacimento dei graniti, 820 m, 22 May 2022, leg. *G. Pisani*, det. *G. Pisani, F. Conti* (APP Nos 66134, 66135, FI). – Species confirmed for the flora of Calabria.

This record is new to southern Italy and represents the southernmost finding in Italy.

G. Pisani, F. Conti

## Floristic records of regional alien taxa

***Allium schoenoprasum* L. subsp. *schoenoprasum* (Amaryllidaceae)**

+ (CAS) **CAM**: Altavilla Silentina (Salerno), loc. Cerrelli, base di un muretto in cemento lungo la SP 174 (WGS84: 40.52963°N, 15.10561°E), 55 m, 19 June 2022, *E. Del Guacchio et E. Del Guacchio* (FI, *Herb. Del Guacchio*). – Casual alien species new for the flora of Campania.

The collected specimens derived from a single large clump, doubtless originated by seed dispersion.

E. Del Guacchio

***Barbarea verna* (Mill.) Asch. (Brassicaceae)**

+ (CAS) **VEN**: San Giovanni Lupatoto (Verona): località Fossa Contarina, Pontoncello, lungo la sponda sx del fiume Adige (WGS84: 45.38077973°N, 11.06688125°E), depositi ghiaioso/sabbiosi del fiume, un solo esemplare, 33 m, 2 May 2022, leg. *F. Menini*, det. *F. Menini, F. Prosser* (FI). – Casual regional species new for the flora of Veneto.

F. Menini, F. Prosser, S. Andreatta

***Bellevalia romana* (L.) Sweet (Asparagaceae)**

+ (CAS) **TAA**: Levico Terme (Trento), scarpata incolta lungo la strada S.P. 11 di Levico Terme per Vetriolo (WGS84: 46.021434°N, 11.301593°E), 759 m a.s.l., esposizione S, 10 April 2022, *F. Valentini* (FI). – Casual regional species new for the flora of Trentino-Alto Adige.

F. Valentini, F. Prosser, G. Bonari

***Buxus sempervirens* L. (Buxaceae)**

+ (CAS) **PUG**: Bitonto (Bari), Bosco Marinelli, nei pressi di Palombaio, Bosco a *Quercus pubescens* (WGS84: 41.076209°N, 16.581418°E), 200 m, 07 May 2022, leg. *G. Pazienza*, det. *L. Forte, G. Pazienza, V. Cavallaro* (FI, BI Nos. 56937, 56938, 56939). – Casual regional alien species new for the flora of Puglia.

*Buxus sempervirens* is confirmed for southern Italy only in Campania, while is reported as doubtfully occurring in Basilicata (Bartolucci et al 2018). It was introduced at Bosco Marinelli in the 19th century, as testified by a specimen in BI [Bitonto (Bari), 28 March 1898, *A. Palanza* (BI No. 46639)] and by Sallustio (1950). This species currently occurs, scattered in a *Q. pubescens* wood, also with young individuals clearly born from seed.

G. Pazienza, L. Forte, V. Cavallaro

***Capparis sicula* Veill. (Capparaceae)**

+ (CAS) **LOM**: Milano (Milano), Parco del Ticinello, Cascina Campazzo, muro esterno sul lato S (WGS84: 45.426468°N, 9.181718°E), muro, 109 m, SSE, 15 June 2022, *G. Galasso* (FI); *ibidem*, 3 July 2022, *G. Galasso* (MSNM barcodes MSNM51987, MSNM51988). – Casual regional alien species confirmed for the flora of Lombardia.

*Capparis sicula* was doubtfully reported by Cesati (1844) and by Rota (1853) for the walls of Bergamo, where it was, thereafter, no longer observed. Only a single very luxuriant individual was found.

G. Galasso

***Cynara cardunculus* L. subsp. *cardunculus* (Asteraceae)**

+ (CAS) **TAA**: Torcegno (Trento), a monte di Auseri (WGS84: 46.067450°N, 11.455435°E; CFE: 9934/2), margine stradina, un paio di esemplari sterili avventizi, 750 m, 14 May 2020, leg. *F. Prosser, I. Lopresti*, det. *F. Prosser* (FI). – Casual regional alien species new for the flora of Trentino-Alto Adige.

F. Prosser

***Euphorbia pterococca* Brot. (Euphorbiaceae)**

+ (CAS) **LOM**: Bergamo (Bergamo), Via San Sebastiano (WGS84: 45.712196°N, 9.640030°E), spigolo tra la strada e il muro, 410 m, S, 16 June 2022, *E. Banfi* (FI, MSNM barcode MSNM51881). – Casual regional alien species new for the flora of Lombardia.

Only a single individual was found.

E. Banfi

***Narcissus pseudonarcissus* L. subsp. *pseudonarcissus***

+ (CAS) **CAL**: Molochio (Reggio Calabria), Strada Provinciale, Trepitò (WGS84: 38.287534°N, 16.043408°E), bordo strada, 965 m, 2 May 2022, leg. *A. Morabito*, det. *V.L.A. Laface, A. Morabito, C.M. Musarella, G. Spampinato* (FI, REGGIO).

The few individuals observed probably escaped cultivation or were thrown among the waste materials of nearby gardens where they are commonly cultivated as ornamental plants.

V.L.A. Laface, A. Morabito, G. Spampinato

***Vicia pannonica* Crantz subsp. *pannonica* (Fabaceae)**

+ (CAS) **LAZ**: Anagni (Frosinone), in Via Ciammotte (WGS84: 41.713301°N, 13.198894°E), margine di campi, 250 m, 14 May 2022, leg. *E. De Santis*, det. *E. De Santis*, *F. Bartolucci* (APP Nos 66132, FI, MSNM). – Casual regional alien species new for the flora of Lazio.

E. De Santis, F. Bartolucci

**Nomenclatural and distribution updates from other literature sources, and corrigenda**

Nomenclatural, distribution and status updates, and corrigenda to Bartolucci et al. (2018) and subsequent updates summarised in the Portal to the Flora of Italy (2022) 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

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

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PENSOFT

Società Italiana di Scienza della Vegetazione (SISV)

# New national and regional Annex I Habitat records: from #45 to #59

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## Abstract

New Italian data on the distribution of Annex I Habitats are reported in this contribution. Specifically, 8 new occurrences in Natura 2000 sites are presented and 27 new cells are added in the EEA 10 km × 10 km reference grid. The new data refer to the Italian administrative regions of Apulia, Campania, Calabria, Lazio, Tuscany, Umbria, Sardinia, and Sicily.

## Keywords

Conservation, vegetation, 1210, 2270*, 3120, 3130, 3150, 3170*, 6420, 6510, 91AA*, 91E0*, 91F0, 92/43/EEC Directive, 9540

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## Introduction

In this contribution, we report new distribution data concerning Annex I. We took into account 12 habitats, concerning the Mediterranean biogeographic region. This is the eighth contribution reporting records of new occurrences of Annex I Habitats in Italy. By comparing the 4th Report ex-Art. 17 of Annex I Habitat Monitoring in Europe (Eionet 2019), these cell occurrences are newly recorded for Italy. The phytosociological relevés of each contribution are reported and subsequently archived into the Italian database "VegItaly" (Gigante et al. 2012; Landucci et al. 2012).

## Habitats records

Following the standard format of Gigante et al. (2019b), all species data, site data and descriptions of the new habitat records are hereafter provided. We report a summary in Tab. 1, offering an overview of the novelties. For mapping purposes, we used the open source QGIS Geographic information System (QGIS.org 2021) for mapping purposes.

### #45. Annex I Habitat: 1210 Annual vegetation of drift lines (Perrino EV, Wagensommer RP)

***EUNIS Classification system***: B1.12 - Middle European sand beach annual communities
***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference***: Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Euphorbion peplidis* Tx. ex Oberd. 1952, *Thero-Atriplicetalia* Pignatti 1953, *Cakiletea maritimae* Tx. et Preising in Tx. ex Br.-Bl. et Tx. 1952 (Biondi et al. 2009).

**Table 1**. Synthetic overview of the newly reported data.

| Hab ID | Hab name | Cell ID | Country | BR | N2000 Site | Authors |
|---|---|---|---|---|---|---|
| 1210 | Annual vegetation of drift lines | 10kmE493N201 | Italy | MED | - | Perrino E.V., Wagensommer R.P. |
| 2270* | Wooded dunes with *Pinus pinea* and/or *Pinus pinaster* | 10kmE483N172, 10kmE488N171 | Italy | MED | - | Morabito A., Musarella C.M., Spampinato G. |
| 3120 | Oligotrophic waters containing very few minerals generally on sandy soils of the West Mediterranean, with *Isoëtes* spp. | 10kmE418N193 | Italy | MED | - | Rivieccio G., Bagella S., Farris E., Caria M.C.C. |
| 3130 | Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea* | 10kmE459N207 | Italy | MED | - | Fanfarillo E., Fiaschi T., Angiolini C. |
| 3150 | Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation | 10kmE459N207 | Italy | MED | - | Fanfarillo E., Fiaschi T., Angiolini C. |
| 3170* | Mediterranean temporary ponds | 10kmE418N193 | Italy | MED | - | Rivieccio G., Bagella S., Farris E., Caria M.C.C. |
| 3170* | Mediterranean temporary ponds | 10kmE461N205, 10kmE460N202, 10kmE463N202 | Italy | MED | IT6040023 | Azzella M.M., Fortini P., Minutillo F., Tondi G., Di Pietro R. |
| 6420 | Mediterranean tall humid herb grasslands of the *Molinio-Holoschoenion* | 10kmE441N226 | Italy | MED | - | Fiaschi T., Cannucci S., Bonari G. |
| 6420 | Mediterranean tall humid herb grasslands of the *Molinio-Holoschoenion* | 10kmE486N173 | Italy | MED | IT9340119 | Morabito A., Musarella C.M., Spampinato G. |
| 6510 | Lowland hay meadows (*Alopecurus pratensis, Sanguisorba officinalis*) | 10kmE456N217 | Italy | MED | IT5210068 | Bonini F., Ferri V., Gigante D. |
| 91AA* | Eastern white oak woods | 10kmE492N200, 10kmE493N200, 10kmE493N201 | Italy | MED | - | Mantino F., Forte L., Tomaselli V. |
| 91E0* | Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) | 10kmE479N191, 10kmE476N194, 10kmE477N193, 10kmE476N191, 10kmE476N192, 10kmE476N193, 10kmE478N192 | Italy | MED | IT8050001, IT8050002, IT8050012, IT8050013 | Patera G. |
| 91E0* | Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) | 10kmE442N227 | Italy | MED | - | Mei G., Stinca A., Esposito A. |
| 91F0 | Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*) | 10kmE488N187 | Italy | MED | IT9310044 | Tavilla G., Laface V.L.A., Spampinato G., Musarella C.M., Crisafulli A., Maiorca G. |
| 9540 | Mediterranean pine forests with endemic Mesogean pines | 10kmE465N164, 10kmE457N165 | Italy | MED | - | Gianguzzi L., Bazan G. |

**Table 2.** Habitat 1210.

| | |
|---|---|
| Relevé number | 1 |
| Cell ID | 10km E493N201 |
| Latitude | 40.89486 |
| Longitude | 17.38039 |
| Date | 02/09/21 |
| Area (m²) | 15 |
| Altitude (m a.s.l.) | 1 |
| Cover (%) | 20 |
| Herb layer height (m) | 0.2 |
| Herb layer cover (%) | 20 |
| **Charact. of *Euphorbion peplidis*, *Thero-Atriplicetalia*, *Cakiletea maritimae*** | |
| ^*Cakile maritima* Scop. subsp. *maritima* | 2 |
| ^*Polygonum maritimum* L. | + |
| ^*Soda inermis* Fourr. | + |
| **Other species** | |
| *Lagurus ovatus* L. subsp. *ovatus* | + |
| *Convolvulus soldanella* L. | + |
| *Thinopyrum junceum* (L.) Á.Löve | + |

^Reference plant species of the Habitat 1210, from Biondi et al. (2009).

***Geographic information***: Italy, Apulia, Bari, Monopoli, Capitolo, Lido Baia del Sole, 1 m a.s.l., Coordinates: 40.89486 N, 17.38039 E (Tab. 2, Rel. 1).
***Cells ID in the EEA reference grid***: 10kmE493N201 (Fig. 1).
***Natura 2000 Site Code***: currently not included in any Natura 2000 Site.
***Phytosociological table***: Tab. 2; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).
***Notes***: In the study area, along the litoral sector from Bari to Capitolo, the rocky coast prevails, and the sandy shorelines are very rare and often compromised by man's actions for tourism purposes (Perrino et al. 2013).

## #46. Annex I Habitat: 2270* Wooded dunes with *Pinus pinea* and/or *Pinus pinaster* (Morabito A, Musarella CM, Spampinato G)

***EUNIS Classification system***: N1G (formerly B1.7): Mediterranean coniferous coastal dune forest (Chytrý et al. 2020)
***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference***: Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Pistacio lentisci-Rhamnetalia alaterni* Rivas Martínez 1975, *Quercetea ilicis* Br.-Bl. in Br.-Bl., Roussine et Nègre 1952 (Biondi and Blasi 2015; Biondi et al. 2009).
***Geographic information***: Italy, Calabria, Reggio Calabria, Palmi, 7 m a.s.l. Coordinates: 38.406858 N, 15.869278 E (Tab. 3, Rel. 1); Roccella Ionica, Via Marina Porto delle Grazie, 9 m a.s.l. Coordinates 38.327940 N, 16.429254 E (Tab. 3, Rel. 2).
***Cells ID in the EEA reference grid***: 10kmE483N172 (Tab. 3, Rel. 1), 10kmE488N171 (Tab. 3, Rel. 2) (Fig. 2).
***Natura 2000 Site Code***: currently not included in any Natura 2000 Site.
***Phytosociological table***: Tab. 3; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).



**Figure 1.** Distribution in Italy of Habitat 1210: in black the new cell, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013–2018; Eionet 2019).

**Table 3.** Habitat 2270*.

| Relevé number | 1 | 2 | |
|---|---|---|---|
| Cell ID | 10kmE483N172 | 10kmE488N171 | |
| Latitude | 38.406858 | 38.327940 | |
| Longitude | 15.869278 | 16.429254 | |
| Date | 27/03/22 | 03/05/22 | |
| Area (m²) | 100 | 100 | |
| Altitude (m a.s.l.) | 5 | 5 | |
| Cover (%) | 100 | 100 | |
| Tree layer height (m) | 12 | 10 | |
| Shrub layer height (m) | - | - | |
| Herb layer height (m) | 0.4 | 0.4 | |
| Tree layer cover (%) | 80 | 95 | |
| Shrub layer cover (%) | - | - | |
| Herb layer cover (%) | 10 | 5 | Presences |
| **Charact. taxa of *Pistacio- Rhamnetalia alaterni, Quercetea ilicis*** | | | |
| ^*Pinus pinea* L. | 4 | 5 | 2 |
| ^*Asparagus albus* L. | 1 | . | 1 |
| **Other species** | | | |
| *Lagurus ovatus* L. subsp. *ovatus* | + | + | 2 |
| *Allium triquetrum* L. | 1 | . | 1 |
| *Carduus pycnocephalus* L. | + | . | 1 |
| *Cynodon dactylon* (L.) Pers. | 1 | . | 1 |
| *Daucus carota* L. | + | . | 1 |
| *Fumaria bastardii* Boreau | + | . | 1 |
| *Hordeum murinum* L. | . | + | 1 |
| *Lolium rigidum* Gaudin | . | + | 1 |
| *Chenopodium album* L. | . | + | 1 |
| *Plantago lagopus* L. | . | + | 1 |
| *Sonchus bulbosus* (L.) N.Kilian & Greuter subsp. *bulbosus* | + | . | 1 |
| *Stellaria media* (L.) Vill. | + | . | 1 |
| *Urtica membranacea* Poir. | + | . | 1 |
| *Vicia dasycarpa* Ten. | + | . | 1 |

^Reference plant species of the Habitat 2270*, from Biondi et al. (2009).

***Notes***: The habitat has been identified on the Tyrrhenian coast of Calabria near Palmi and on the Ionian coast near Roccella Ionica (RC). In both locations, the habitat extends a long stretch of the shoreline. These are communities planted on the inland dune system about seventy years ago. They consist exclusively of *Pinus halepensis* and *Pinus pinea*, currently in a precarious state of conservation due to the high density of the planting. This prevents the regeneration of pine trees and the establishment of woody species typical of the Mediterranean maquis.

## #47. Annex I Habitat: 3120 Oligotrophic waters containing very few minerals generally on sandy soils of the West Mediterranean, with *Isoëtes* spp. (Rivieccio G, Bagella S, Farris E, Caria MC)

***EUNIS Classification system***: C3.4 - Species-poor beds of low-growing water-fringing or amphibious vegetation
***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference***: Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Apienion crassipedis* Bagella, Caria, Farris et Filigheddu 2009; *Preslion cervinae* Br.-Bl. ex Moor 1937; *Isoëtetalia* Br.-Bl. 1936; *Isoëto-Nanojuncetea* Br.-Bl. et Tüxen ex Westhoff, Dijk et Passchier 1946 (Bagella et al. 2009; Mucina et al. 2016).
***Geographic information***: Precise coordinates are not available, relevés were done in the surrounding of the specified coordinates. Italy, Sardinia, Sassari, Alghero, La Scaletta 232 m a.s.l. Coordinates: 40.533478 N, 8.369431 E (Tab. 4, Rels 1 to 4); Italy, Sardinia, Sassari, Alghero, Scala



**Figure 2.** Distribution in Italy of Habitat 2270*: in black the new cells, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013–2018; Eionet 2019).

Piccada 309 m a.s.l. Coordinates: 40.528142 N, 8.375761 E (Tab. 4, Rels 5 to 7).

***Cells ID in the EEA reference grid***: 10kmE418N193 (Fig. 3).

***Natura 2000 Site Code***: currently not included in any Natura 2000 Site.

***Phytosociological table***: Tab. 4; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).

**Table 4.** Habitat 3120.

| Relevé number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Cell ID | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | |
| Latitude | 40.533478 | 40.533478 | 40.533478 | 40.533478 | 40.528142 | 40.528142 | 40.528142 | |
| Longitude | 8.369431 | 8.369431 | 8.369431 | 8.369431 | 8.375761 | 8.375761 | 8.375761 | |
| Date | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | |
| Area ($m^2$) | 8 | 6 | 4 | 1 | 6 | 4 | 8 | |
| Altitude (m a.s.l.) | 72 | 72 | 72 | 72 | 309 | 309 | 309 | |
| Cover (%) | 90 | 80 | 100 | 80 | 80 | 90 | 90 | Presences |
| **Charact. and diff. taxa of *Preslion cervinae, Isoëtetalia, Isoëto-Nanojuncetea*** | | | | | | | | |
| ^*Isoëtes tiguliana* Gennari | 4 | 3 | 2 | 3 | 3 | 1 | 3 | 7 |
| *Lythrum hyssopifolia* L. | + | + | 1 | + | 1 | + | + | 7 |
| ^*Middendorfia borysthenica* (Schrank) Trautv. | + | + | 2 | 2 | . | 1 | . | 5 |
| *Juncus bufonius* L. | . | . | + | + | + | . | | 3 |
| *Eudianthe laeta* (Aiton) Fenzl | . | . | + | . | . | . | r | 2 |
| *Lotus hispidus* DC. | . | . | . | . | r | r | . | 2 |
| *Bulliarda vaillantii* (Willd.) DC. | . | . | . | . | 1 | . | . | 1 |
| *Juncus pygmaeus* Richard | . | . | . | . | + | . | . | 1 |
| *Ranunculus cordiger* Viv. | r | . | . | . | . | . | . | 1 |
| **Charact. and diff. taxa of *Ranunculion aquatilis, Potametalia, Potametea*** | | | | | | | | |
| *Callitriche stagnalis* Scop. | 4 | 3 | 1 | 2 | 2 | 2 | 4 | 7 |
| *Ranunculus baudotii* Godr. | 1 | + | . | . | . | . | . | 2 |
| **Other species** | | | | | | | | |
| *Chamaemelum fuscatum* (Brot.) Vasc. | + | + | 1 | + | 2 | r | 1 | 7 |
| *Glyceria spicata* Guss. | 3 | 1 | 3 | 2 | 1 | 4 | 3 | 7 |
| *Eleocharis palustris* (L) Roem. & Schult. | 1 | + | . | + | | | | 3 |
| *Bellis annua* L. | . | . | . | r | + | . | + | 3 |
| *Linum usitatissimum* L. subsp. *angustifolium* (Huds.) Thell. | + | . | + | . | | | + | 3 |
| *Ranunculus sardous* Crantz. | . | + | + | . | . | . | . | 2 |
| *Poa infirma* Kunth | . | . | . | . | + | . | . | 1 |

^ Reference plant species of the Habitat 3120, from Biondi et al. (2009).



**Figure 3.** Distribution in Italy of Habitat 3120: in black the new cell, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013–2018; Eionet 2019), in white (black outline) the cells later reported (Rivieccio et al. 2020).

***Notes***: The alliance *Preslion cervinae* is represented in Sardinia by communities referred to as the Tyrrhenian endemic sub-alliance *Apienion crassipedis* (Bagella et al. 2009). These communities represent a transition between the aquatic and amphibious vegetation and are rich in species of the *Potametea* class.

## #48. Annex I Habitat: 3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea* (Fanfarillo E, Fiaschi T, Angiolini C)

***EUNIS Classification system***: C3.5 - Periodically inundated shores with pioneer and ephemeral vegetation
***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference:*** Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Cyperetum micheliani* Horvatić 1931; *Nanocyperion* Koch 1926; *Nanocyperetalia* Klika 1935; *Isoëto-Nanojuncetea* Br.-Bl. et Tx. in Br.-Bl. et al. 1952 (Mucina et al. 2016).
***Geographic information***: Italy, Lazio, Frosinone, Fumone, 547 m a.s.l., Coordinates: 41.747734 N, 13.258396 E (Tab. 5, Rel. 1); 41.747621 N, 13.258405 E (Tab. 5, Rel. 2); 41.747495 N, 13.258408 E (Tab. 5, Rel. 3).
***Cells ID in the EEA reference grid***: 10kmE459N207 (Fig. 4).
***Natura 2000 Site Code***: currently not included in any Natura 2000 Site.
***Phytosociological table***: Tab. 5; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).
***Notes***: Noteworthy is the co-occurrence of several species being very rare in the Latium region, such as *Cyperus michelianus*, *Potentilla supina* and *Sporobolus alopecuroides* (Fig. 5) (Anzalone et al. 2010). Even the absence of alien species suggests a high conservation value of the habitat. A light grazing activity by sheep was observed. The records are included in the Canterno Lake Natural Reserve.

## #49. Annex I Habitat: 3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation (Fanfarillo E, Fiaschi T, Angiolini C)

***EUNIS Classification system***: C1.3 - Permanent eutrophic lakes, ponds and pools
***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference***: Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Polygonetum natantis* Soó 1927 (Fig. 7a); *Potametum pusilli* Soó 1927 (Fig. 7b); *Nymphaeion albae* Oberd. 1957; *Potamogetonion* Libbert 1931; *Potamogetonetalia* Koch 1926; *Potamogetonetea* Klika in Klika et Novák 1941 (Mucina et al. 2016).
***Geographic information***: Italy, Lazio, Frosinone, Fumone, 547 m a.s.l., Coordinates: 41.746165 N, 13.256657 E (Tab. 6, Rel. 1); 41.746411 N, 13.256578 E (Tab. 6, Rel. 2); 41.746261 N, 13.256659 E (Tab. 6, Rel. 3); 41.746212 N,

**Table 5.** Habitat 3130.

| Relevé number | 1 | 2 | 3 | |
|---|---|---|---|---|
| Cell ID | 10kmE459N207 | 10kmE459N207 | 10kmE459N207 | |
| Latitude | 41.747734 | 41.747621 | 41.747495 | |
| Longitude | 13.258396 | 13.258405 | 13.258408 | |
| Date | 11/08/22 | 11/08/22 | 11/08/22 | |
| Area ($m^2$) | 1.5 | 1.5 | 2 | |
| Altitude (m a.s.l.) | 547 | 547 | 547 | |
| Aspect (°) | - | - | - | |
| Slope (°) | 0 | 0 | 0 | Presences |
| Water depth cm | - | - | - | |
| Cover % | 85 | 90 | 95 | |
| ***Cyperetum micheliani*** | | | | |
| ^*Cyperus michelianus* (L.) Delile | 4 | 5 | 4 | 3 |
| **Charact. and diff. taxa of *Nanocyperion*, *Nanocyperetalia*, *Isoëto-Nanojuncetea*** | | | | |
| *Potentilla supina* L. subsp. *supina* | 2 | 1 | 1 | 3 |
| ^*Gnaphalium uliginosum* L. | 1 | + | 2 | 3 |
| *Sporobolus alopecuroides* (Piller & Mitterp.) P.M.Peterson | . | . | 3 | 1 |
| **Other species** | | | | |
| *Medicago arabica* (L.) Huds. | 2 | 2 | 1 | 3 |
| *Rorippa sylvestris* (L.) Besser subsp. *sylvestris* | 1 | 1 | + | 3 |
| *Amaranthus blitum* L. subsp. *blitum* | 1 | 1 | 1 | 3 |
| *Verbena officinalis* L. | 1 | + | 1 | 3 |
| *Trifolium resupinatum* L. | + | 2 | 2 | 3 |
| *Bidens tripartita* L. | + | . | 1 | 2 |
| *Portulaca oleracea* L. | + | + | . | 2 |
| *Xanthium strumarium* L. | . | . | + | 1 |
| *Convolvulus arvensis* L. | . | . | + | 1 |
| *Persicaria lapathifolia* (L.) Delarbre subsp. *lapathifolia* | . | . | + | 1 |

^ Reference plant species of the Habitat 3130, from Biondi et al. (2009).

13.256613 E (Tab. 6, Rel. 4); 41.749555 N, 13.258047 E (Tab. 6, Rel. 5); 41.749620 N, 13.257996 E (Tab. 6, Rel. 6); 41.749930 N, 13.256355 E (Tab. 6, Rel. 7).
C***ells ID in the EEA reference grid***: 10kmE459N207 (Fig. 6)
***Natura 2000 Site Code***: currently not included in any Natura 2000 Site.
***Phytosociological table***: Tab. 6; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).
***Notes***: The records are included in the Canterno Lake Natural Reserve.

## #50. Annex I Habitat: 3170* Mediterranean Temporary Ponds (Rivieccio G, Bagella S, Farris E, Caria MC)

***EUNIS Classification system***: C3.4 Species-poor beds of low-growing water-fringing or amphibious vegetation.
***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference:*** Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Romuleo requieni-Isoëtetum histricis* Bagella, Caria, Farris et Filigheddu 2009, *Isoëtion* Br.-Bl. 1935, *Isoëtetalia* Br.-Bl. 1935, *Isoëto-Nanojuncetea* Br.-Bl. et Tx. in Br.-Bl. et al. 1952 (Bagella et al. 2009; Mucina et al. 2016).
***Geographic information***: Precise coordinates are not available, relevés were done in the surrounding of the specified coordinates. Italy, Sardinia, Sassari, Alghero, Valverde 72 m a.s.l Coordinates: 40.548869 N, 8.370372 E (Tab. 7, Rels 1 to 7); Italy, Sardinia, Sassari, Alghero, Scala Piccada 309 m a.s.l Coordinates: 40.528142 N, 8.375761 E (Tab. 7, Rels 8 and 9).
***Cells ID in the EEA reference grid***: 10kmE418N193 (Fig. 8).
***Natura 2000 Site Code***: currently not included in any Natura 2000 Site.
***Phytosociological table***: Tab. 7; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).
***Notes***: The dwarf vegetation referred to the association *Romuleo requieni-Isoëtetum histricis* is one of the richest in specialized species among those described for Mediterranean temporary ponds and then considered of priority interest for conservation (Bagella and Caria 2013; Bagella and Podani 2017).

## #51. Annex I Habitat: 3170* Mediterranean Temporary Ponds (Azzella MM, Fortini P, Minutillo F, Tondi G, Di Pietro R)

***EUNIS Classification system***: C3.4 Species-poor beds of low-growing water-fringing or amphibious vegetation.
***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference***: Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Cicendion* (Rivas Goday in Rivas Goday et Borja 1961) Br.-Bl. 1967, *Preslion cervinae* Br.-Bl. ex Moor 1936, *Isoetion durieui* Br-Bl. 1936, *Isoetetalia* Br.-Bl. 1935, *Isoeto-Nanojuncetea* Br.-Bl. et Tx. in Br.-Bl. et al. 1952 (Mucina et al. 2016).



**Figure 4.** Distribution in Italy of Habitat 3130: in black the new cell, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013–2018; Eionet 2019).



**Figure 5.** Aspect of Habitat 3130 in the reported stands (Canterno Lake, Fumone, Frosinone, Italy).

***Geographic information***: Italy, Lazio, Salto di Fondi, Via Covino, 138 m a.s.l., Coordinates: 41.312907 N, 13.334305 E (Tab. 8, Rel. 2); Italy, Lazio, Media Valle Latina, Ceprano, Bosco di Via Sfratti, 2 m a.s.l., Coordinates: 41.553443 N, 13.469985 E (Tab. 8, Rel. 1); Italy, Lazio, Riviera d'Ulisse Regional Park, footslopes of the Gianola-Scauri promontory, 30 m a.s.l., Coordinates: 41.250607 N, 13.679838 E (Tab. 8, Rel. 3).

***Cells ID in the EEA reference grid***: 10kmE460N202 (Tab. 8, Rel. 1), 10kmE461N205 (Tab. 8, Rel. 2), 10kmE463N202 (Tab. 8, Rel. 3) (Fig. 8).

***Natura 2000 Site Code***: currently not included in any Natura 2000 Site (Rels. 1 and 2 in Tab. 8), SAC IT6040023 "Promontorio Gianola e Monte di Scauri" (Tab. 8, Rel. 3).

***Phytosociological table***: Tab. 8; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).

***Notes***: Temporary ponds are ephemeral habitats that are difficult to identify and often developed on patches of few square meters size. The new reports here described regard a large area of the southern Lazio completely devoid of data to date. Two of them refer to areas not included in the Natura 2000 network. The first area (Ceprano) refers to a *Quercus cerris* L. and *Q. frainetto* Ten. coppiced forest where the cutting operations could irreparably damage the integrity and functionality of the temporary pools occurring there (Fig. 9). The second area is located in the surrounding of Lake Fondi, outside the Special Protection Area "SPA IT6040010 – Lago di Fondi", in a pasture partially mixed with Erica arborea L. stands. This area is currently managed by the Fondi municipality for which an urban development is planned, fortunately not yet achieved. The third area is located in rocky temporary pools in a spatial mosaic composed also of *Quercus pubescens* Willd. subsp. *pubescens* and *Q. suber* L. woods, Mediterranean maquis stands dominated by *Erica multiflora* L., *Cytisus laniger* DC. and *Ampelodesmos mauritanicus* (Poir.) T.Durand & Schinz, and steppe-like grasslands with *Hyparrhenia hirta* (L.) Stapf subsp. *hirta* and *Xiphion xiphium* (L.) M.B.Crespo, Mart.Azorín & Mavrodie (Fig. 10). Although this third site is included in a protected area within the Natura 2000 network (IT6040023 – Promonto-



**Figure 6.** Distribution in Italy of Habitat 3150: in black the new cell, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013–2018; Eionet 2019), in white (black outline) the cells later reported (Tavilla et al. 2022).

**Table 6.** Habitat 3150.

| Relevé number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| Cell ID | 10km E459N207 | 10km E459N207 | 10km E459N207 | 10km E459N207 | 10km E459N207 | 10km E459N207 | 10km E459N207 | |
| Latitude | 41.746165 | 41.746411 | 41.746261 | 41.746212 | 41.749555 | 41.749620 | 41.749930 | |
| Longitude | 13.256657 | 13.256578 | 13.256659 | 13.256613 | 13.258047 | 13.257996 | 13.256355 | |
| Date | 11/08/22 | 11/08/22 | 11/08/22 | 11/08/22 | 11/08/22 | 11/08/22 | 11/08/22 | |
| Area (m²) | 3 | 1.5 | 2 | 1.5 | 1 | 3 | 2 | |
| Altitude (m a.s.l.) | 547 | 547 | 547 | 547 | 547 | 547 | 547 | |
| Aspect (°) | - | - | - | - | - | - | - | |
| Slope (°) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Water column height (cm) | 50 | 150 | 100 | 60 | 10 | 30 | 20 | |
| Cover % | 80 | 80 | 100 | 100 | 90 | 100 | 80 | Presences |
| ***Polygonetum natantis*, *Nymphaeion albae*** | | | | | | | | |
| ^*Persicaria amphibia* (L.) Delarbre (aquatic form) | 5 | 4 | . | + | . | + | 1 | 5 |
| ***Potametum pusilli*** | | | | | | | | |
| ^*Potamogeton pusillus* L. | 3 | 1 | 5 | 5 | 5 | 5 | 4 | 7 |
| ***Potamogetonion*, *Potamogetonetalia*, *Potamogetonetea*** | | | | | | | | |
| *Potamogeton crispus* L. | . | . | 1 | 1 | 2 | 1 | . | 4 |

^ Reference plant species of the Habitat 3150, from Biondi et al. (2009).

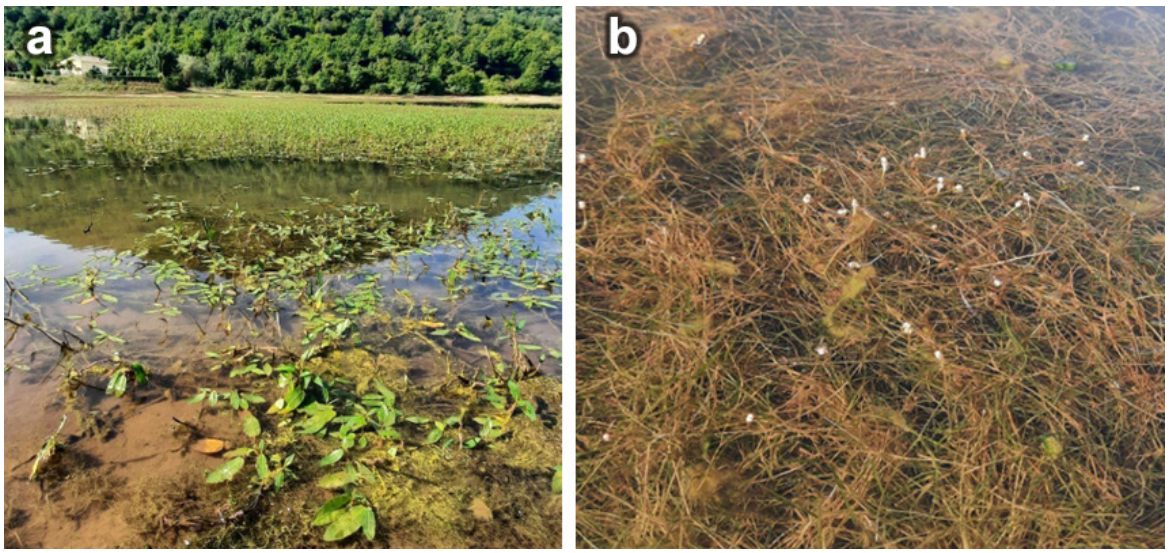



**Figure 7.** Habitat 3150 in the reported stands (Canterno Lake, Fumone, Frosinone, Italy); a - *Polygonetum natantis*; b - *Potametum pusilli*.

**Table 7**. Habitat 3170*.

| Relevé number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cell ID | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | |
| Latitude | 40.548869 | 40.548869 | 40.548869 | 40.548869 | 40.548869 | 40.548869 | 40.548869 | 40.528142 | 40.528142 | |
| Longitude | 8.370372 | 8.370372 | 8.370372 | 8.370372 | 8.370372 | 8.370372 | 8.370372 | 8.375761 | 8.375761 | |
| Date | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | |
| Area (m²) | 2 | 2 | 1 | 6 | 8 | 10 | 0,5 | 3 | 2 | |
| Altitude (m a.s.l.) | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 309 | 309 | |
| Cover (%) | 80 | 65 | 75 | 70 | 70 | 60 | 50 | 50 | 90 | Presences |
| **Charact. and diff. taxa of *Romuleo requieni-Isoëtetum histricis*** | | | | | | | | | | |
| ^*Isoetes histrix* Bory | 4 | 3 | 4 | 3 | 2 | 4 | 2 | 1 | 3 | 9 |
| ^*Romulea requienii* Parl. | 1 | 1 | + | + | + | + | . | + | 1 | 8 |
| **Charact. and diff. taxa of *Isoëtion*, *Isoëtetalia*, *Isoëto-Nanojuncetea*** | | | | | | | | | | |
| ^*Lythrum hyssopifolia* L. | 1 | 1 | + | 1 | + | 1 | 2 | + | + | 9 |
| ^*Juncus bufonius* L. | 1 | + | r | 1 | + | 1 | 1 | 1 | + | 9 |
| *Lotus hispidus* DC. | + | 1 | + | + | + | + | + | + | + | 9 |
| *Ophioglossum lusitanicum* L. | 1 | + | 1 | + | 1 | + | . | r | r | 8 |
| *Bulliarda vaillantii* (Willd.) DC. | . | r | r | . | + | + | . | + | . | 5 |
| ^*Cicendia filiformis* (L.) Delarbre | . | . | r | . | . | . | + | . | r | 3 |

**Table 7.** Continuation.

| Relevé number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cell ID | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | 10km E418N193 | |
| Latitude | 40.548869 | 40.548869 | 40.548869 | 40.548869 | 40.548869 | 40.548869 | 40.548869 | 40.528142 | 40.528142 | |
| Longitude | 8.370372 | 8.370372 | 8.370372 | 8.370372 | 8.370372 | 8.370372 | 8.370372 | 8.375761 | 8.375761 | |
| Date | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | 19/03/10 | |
| Area ($m^2$) | 2 | 2 | 1 | 6 | 8 | 10 | 0,5 | 3 | 2 | |
| Altitude (m a.s.l.) | 72 | 72 | 72 | 72 | 72 | 72 | 72 | 309 | 309 | |
| Cover (%) | 80 | 65 | 75 | 70 | 70 | 60 | 50 | 50 | 90 | Presences |
| ^*Agrostis pourretii* Willd. | 1 | + | + | . | . | . | . | . | . | 3 |
| ^*Juncus pygmaeus* Richard | . | + | . | . | . | + | + | . | . | 2 |
| *Juncus capitatus* Weigel. | . | . | . | . | . | . | . | . | r | 1 |
| **Other species** | | | | | | | | | | |
| *Bellis annua* L. | 3 | 1 | . | r | 2 | + | + | + | + | 8 |
| *Linum usitatissimum* L. subsp. *angustifolium* (Huds.) Thell. | + | + | + | + | . | r | + | r | r | 8 |
| *Chamaemelum fuscatum* (Brot.) Vasc. | 2 | + | . | + | 3 | 2 | + | 2 | . | 7 |
| *Anthoxanthum aristatum* Boiss | + | . | + | . | + | + | + | . | + | 6 |
| *Lysimachia foemina* (Mill.) U.Manns & Anderb. | + | . | 1 | + | . | . | + | + | + | 6 |
| *Trifolium subterraneum* L. | . | . | r | . | + | + | . | + | . | 4 |
| *Tuberaria lignosa* (Sweet) Samp. | r | . | . | . | + | . | . | r | . | 3 |
| *Plantago coronopus* L. | . | . | . | . | 2 | + | . | + | . | 3 |
| *Logfia gallica* (L.) Cosson & Germ. | . | . | + | . | . | . | . | . | r | 2 |
| *Callitriche stagnalis* Scop. | . | . | . | . | r | . | . | . | . | 1 |
| *Carex flacca* Schreb. subsp. *erythrostachys* (Hoppe) Holub | . | . | . | 1 | . | . | . | . | . | 1 |
| *Parentucellia latifolia* (L.) Caruel | . | . | . | . | . | . | + | . | . | 1 |
| *Poa infirma* Kunth | . | . | . | . | + | . | . | + | . | 1 |
| *Sagina apetala* Ard. subsp. *apetala* | . | . | . | . | . | . | . | r | . | 1 |
| *Spergula arvensis* L. | . | . | . | . | . | r | . | . | . | 1 |

^ Reference plant species of the Habitat 3170*, from Biondi et al. (2009).



**Figure 8.** Distribution in Italy of Habitat 3170*: in black the new cells, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013–2018; Eionet 2019), in white (black outline) the cells later reported (Gigante et al. 2019b; Bazan et al. 2021; Tavilla et al. 2022).

rio Gianola e Monte di Scauri) and belongs to a Regional natural Park (Parco Regionale Riviera d'Ulisse), the presence of the 3170 had never been identified for this area and it is not reported in the Standard Form as well. A recent field survey has revealed that many temporary ponds were damaged by the activities of hyper-abundant wild boars (*Sus scrofa*), which use them for mud baths.

## #52. Annex I Habitat: 6420 Mediterranean tall humid herb grasslands of the *Molinio-Holoschoenion* (Fiaschi T, Cannucci S, Bonari G)

***EUNIS Classification system***: included in R31 – Mediterranean tall humid inland grassland (Chytrý et al. 2020).

**Table 8.** Habitat 3170*.

| Relevé number | 1 | 2 | 3 | |
|---|---|---|---|---|
| Cell ID | 10kmE460N202 | 10kmE461N205 | 10kmE463N202 | |
| Latitude | 41.553443 | 41.312907 | 41.250607 | |
| Longitude | 13.469985 | 13.334305 | 13.679838 | |
| Date | 02/05/22 | 19/03/22 | 03/05/09 | |
| Area (m²) | 6 | 20 | 4 | |
| Altitude (m a.s.l.) | 2 | 138 | 30 | |
| Exposition | - | - | - | |
| Slope (°) | 0 | 0 | 0 | |
| Cover (%) | 90 | 70 | 90 | |
| Average vegetation height (cm) | 5 | 10 | 10 | Presences |
| ***Cicendion*** | | | | |
| ^*Lysimachia nardii* Arrigoni | + | . | . | 1 |
| *Eudianthe laeta* Rchb. ex Willk. | + | . | . | 1 |
| ^*Cicendia filiformis* (L.) Delarbre | + | . | . | 1 |
| ***Preslion cervinae*** | | | | |
| *Callitriche brutia* Petagna | . | 2 | . | 1 |
| *Ranunculus ophioglossifolius* Vill. | . | 1 | . | 1 |
| ***Isoetion durieui*** | | | | |
| *Aira elegantissima* Schur subsp. *elegantissima* | 1 | . | . | 1 |
| ^*Isoëtes histrix* Bory | 3 | . | . | 1 |
| ^*Isoëtes durieui* Bory | 1 | 1 | 1 | 3 |
| ***Isoetetalia*** | | | | |
| ^*Isolepis cernua* (Vahl) Roem. & Schult. | + | . | 1 | 2 |
| *Briza minor* L. | 1 | . | . | 1 |
| ^*Isoëtes longissima* Bory | . | 2 | . | 1 |
| ^*Centaurium maritimum* (L.) Fritsch | . | . | 1 | 1 |
| ^*Solenopsis laurentia* (L.) C.Presl | . | . | 1 | 1 |
| ***Isoeto-Nanojuncetea*** | | | | |
| ^*Juncus bufonius* L. | + | . | 1 | 2 |
| ^*Juncus capitatus* Weigel | 1 | . | + | 2 |
| *Juncus hybridus* Brot. | + | . | | 1 |
| ^*Juncus pygmaeus* Rich. ex Thuill. | . | . | 1 | 1 |
| ***Molinio-Arrhenatheretea*** | | | | |
| *Agrostis canina* L. subsp. *canina* | . | 3 | . | 1 |
| *Galium debile* Desv. | . | 1 | . | 1 |
| *Juncus conglomeratus* L. | . | 1 | . | 1 |
| *Juncus inflexus* L. subsp. *inflexus* | . | 1 | . | 1 |
| *Oenanthe fistulosa* L. | . | 1 | . | 1 |
| **Other species** | | | | |
| *Carex flacca* Schreb. subsp. *flacca* | + | . | 1 | 2 |
| ^*Serapias lingua* L. | 2 | . | 1 | 2 |
| *Anacamptis laxiflora* (Lam.) R.M.Bateman, Pridgeon & M.W.Chase | 1 | . | . | 1 |
| *Coleostephus myconis* (L.) Cass. ex Rchb.f. | 1 | . | . | 1 |
| *Linum usitatissimum* L. subsp. *angustifolium* (Huds.) Thell. | 1 | . | + | 2 |
| *Callitriche palustris* L. | . | 1 | . | 1 |
| *Glyceria notata* Chevall. | . | 1 | . | 1 |
| *Gratiola officinalis* L. | . | 2 | . | 1 |
| *Juncus articulatus* L. subsp. *articulates* | . | 2 | . | 1 |
| ^*Riccia fluitans* L. | . | + | . | 1 |
| *Lysimachia arvensis* (L.) U.Manns & Anderb. | . | . | + | 1 |
| *Ranunculus paludosus* Poir. | . | . | + | 1 |
| *Oenanthe pimpinelloides* L. | . | . | 1 | 1 |
| *Xiphion xiphium* (L.) M.B.Crespo, Mart.Azorín & Mav. | . | . | 3 | 1 |
| *Romulea columnae* Sebast. & Mauri | . | . | + | 1 |
| *Scorpiurus muricatus* L. | . | . | + | 1 |

^ Reference plant species of the Habitat 3170*, from Biondi et al. (2009).



**Figure 9.** Habitat 3170* in the *Quercus cerris* and *Q. frainetto* coppiced forest near Ceprano, Media Valle (Latina, Lazio, Italy).



**Figure 10.** Habitat 3170* in the Riviera d'Ulisse Regional Park, at the footslope of the Gianola promontory (Lazio, Italy). The community of *Isoeto-Nanojuncetea* also hosts *Xiphion xiphium*.

***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference***: Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Molinio-Holoschoenion* Br.-Bl. ex Tchou 1948; *Holoschoenetalia* Br.-Bl. ex Tchou 1948; *Molinio-Arrhenatheretea* Tx. 1937 (Mucina et al. 2016).
***Geographic information***: Italy, Tuscany, Siena, San Gimignano, Cusona, 76 m a.s.l., Coordinates: 43.499812 N, 11.108023 E (Tab. 9, Rel. 1); 43.500042 N, 11.107916 E (Tab. 9, Rel. 2); Italy, Tuscany, Siena, Poggibonsi, 76 m a.s.l., Coordinates: 43.495498 N, 11.112934 E (Tab. 9, Rel. 3); 43.495080 N, 11.113151 E (Tab. 9, Rel. 4).
***Cells ID in the EEA reference grid***: 10kmE441N226 (Fig. 11).
***Nature 2000 Site Code***: currently not included in any Natura 2000 site.
***Phytosociological table***: Tab. 9; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).
***Notes***: Mediterranean tall humid inland grasslands of the alliance *Molinio-Holoschoenion* occur in Continental and Mediterranean Italy (Preislerová et al. 2022). They are common in central Italy and Tuscany (Landi et al. 2002; Landi and Angiolini 2006; Lastrucci et al. 2017). Our data confirm this occurrence but contribute to filling a gap about the presence of the habitat in an inner Italian Peninsular area. Our relevés were recorded in tall grass-dominated vegetation of seasonally waterlogged soils along the river Elsa.

## #53. Annex I Habitat: 6420 Mediterranean tall humid herb grasslands of the Molinio-Holoschoenion (Morabito A, Musarella CM, Spampinato G)

***EUNIS Classification system***: R31 (formerly E3.1) Mediterranean tall humid inland grassland (Chytrý et al. 2020)
***Biogeographical Region***: Mediterranea
***National Habitat Checklist of reference***: Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Dactylorhizo-Juncetum effusi* Brullo et Grillo 1978, *Dactylorhizo-Juncion striati* Brullo et Grillo 1978, *Holoschoenetalia vulgaris* Br.-Bl. ex Tchou

**Table 9**. Habitat 6420.

| Relevé number | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| Cell ID | 10kmE441N226 | 10kmE441N226 | 10kmE441N226 | 10kmE441N226 | |
| Latitude | 43.499812 | 43.500042 | 43.495498 | 43.495080 | |
| Longitude | 11.108023 | 11.107916 | 11.112934 | 11.113151 | |
| Date | 18/08/22 | 18/08/22 | 18/08/22 | 18/08/22 | |
| Area ($m^2$) | 25 | 25 | 25 | 25 | |
| Altitude (m a.s.l.) | 76 | 76 | 76 | 76 | |
| Cover (%) | 95 | 100 | 85 | 90 | |
| Aspect (°) | - | - | 270 | 300 | |
| Slope (°) | 0 | 0 | 5 | 10 | Presences |
| ***Molinio-Holoschoenion, Holoschoenetalia, Molinio-Arrhenatheretea*** | | | | | |
| ^*Agrostis stolonifera* L. subsp. *stolonifera* | 1 | 2 | 3 | + | 4 |
| ^*Scirpoides holoschoenus* (L.) Soják | 2 | 3 | . | + | 3 |
| ^*Eupatorium cannabinum* L. subsp. *cannabinum* | 2 | + | . | 3 | 3 |
| ^*Prunella vulgaris* L. subsp. *vulgaris* | + | . | 1 | + | 3 |
| ^*Pulicaria dysenterica* (L.) Bernh. | 1 | . | 1 | 2 | 3 |
| *Ranunculus repens* L. | + | + | . | 1 | 3 |
| *Lythrum salicaria* L. | 2 | . | 1 | . | 2 |
| ^*Cyperus longus* L. | 1 | 2 | . | . | 2 |
| *Jacobaea erratica* (Bertol.) Fourr. | . | . | 1 | 1 | 2 |
| *Paspalum distichum* L. | + | . | 1 | . | 2 |
| *Bidens frondosa* L. | . | + | + | . | 2 |
| ^*Hypericum tetrapterum* Fr. | . | + | . | + | 2 |
| *Galega officinalis* L. | 1 | . | . | . | 1 |
| *Barbarea vulgaris* W.T. Aiton | . | + | . | . | 1 |
| *Carex hirta* L. | . | . | . | + | 1 |
| *Plantago major* L. | . | + | . | . | 1 |
| ^*Trifolium resupinatum* L. | . | . | 1 | . | 1 |
| **Other species** | | | | | |
| *Calamagrostis epigejos* (L.) Roth subsp. *epigejos* | . | 3 | 2 | 2 | 3 |
| *Mentha aquatica* L. subsp. *aquatica* | 1 | . | + | 1 | 3 |
| *Veronica anagallis-aquatica* L. subsp. *anagallis-aquatica* | + | + | + | . | 3 |
| *Artemisia verlotiorum* Lamotte | . | + | . | 1 | 2 |
| *Cyperus fuscus* L. | + | . | . | 1 | 2 |
| *Dittrichia viscosa* (L.) Greuter subsp. *viscosa* | 2 | . | 2 | . | 2 |
| *Echinochloa crus-galli* (L.) P.Beauv. | 1 | . | . | 1 | 2 |
| *Equisetum telmateja* Ehrh. | + | . | 1 | . | 2 |
| *Glyceria notata* Chevall. | + | + | . | . | 2 |
| *Juncus bufonius* L. | + | + | . | . | 2 |
| *Lolium arundinaceum* (Schreb.) Darbysh. | 3 | 1 | . | . | 2 |
| *Persicaria lapathifolia* (L.) Delarbre subsp. *lapathifolia* | . | 1 | . | + | 2 |
| *Persicaria maculosa* Gray | . | 1 | . | + | 2 |
| *Rumex conglomeratus* Murray | + | . | . | + | 2 |
| *Salix purpurea* L. subsp. *purpurea* | . | + | . | 1 | 2 |
| *Schoenoplectus tabernaemontani* (C.C.Gmel.) Palla | . | + | 1 | . | 2 |
| *Aegopodium podagraria* L. | . | . | . | + | 1 |
| *Althaea cannabina* L. | . | . | . | 1 | 1 |
| *Helosciadium nodiflorum* (L.) W.D.J.Koch subsp. *nodiflorum* | . | . | . | + | 1 |
| *Arctium lappa* L. | 1 | . | . | . | 1 |
| *Atriplex patula* L. | + | . | . | . | 1 |
| *Convolvulus sepium* L. | . | 1 | . | . | 1 |
| *Carex pendula* Huds. | 1 | . | . | | 1 |
| *Centaurium pulchellum* (Sw.) Druce subsp. *pulchellum* | . | . | . | + | 1 |
| *Epilobium hirsutum* L. | . | . | . | 1 | 1 |
| *Erigeron canadensis* L. | . | . | . | + | 1 |
| *Euphorbia maculata* L. | . | . | + | . | 1 |
| *Galium aparine* L. | . | . | + | . | 1 |
| *Helianthus tuberosus* L. | . | . | . | + | 1 |
| *Holcus mollis* L. subsp. *mollis* | . | . | + | . | 1 |
| *Lycopus europaeus* L. | . | + | . | . | 1 |
| *Lysimachia arvensis* (L.) U.Manns & Anderb. | . | . | . | 1 | 1 |
| *Nasturtium officinale* W.T.Aiton | + | . | . | . | 1 |
| *Helminthotheca echioides* (L.) Holub | . | | + | . | 1 |
| *Poa sylvicola* Guss. | . | + | . | . | 1 |
| *Polygonum aviculare* L. subsp. *aviculare* | . | . | 1 | + | 1 |
| *Populus nigra* L. subsp. *nigra* | . | . | + | . | 1 |
| *Samolus valerandi* L. | . | . | + | . | 1 |
| *Saponaria officinalis* L. | . | 1 | . | . | 1 |
| *Scrophularia auriculata* L. subsp. *auriculata* | . | + | . | . | 1 |
| *Silene latifolia* Poir. | . | . | . | + | 1 |
| *Sonchus asper* (L.) Hill | . | . | . | + | 1 |
| *Succisa pratensis* Moench | . | 1 | . | . | 1 |
| *Xanthium orientale* L. | . | . | . | + | 1 |

^ Reference plant species of the Habitat 6420, from Biondi et al. (2009).

1948, *Molinio-Arrhenatheretea* Tüxen 1937 (Brullo and Spampinato 1999, Biondi and Blasi 2015).
***Geographic information***: Italy, Calabria, Vibo Valentia, Arena, Arruggiato, 1148 m a.s.l., Coordinates: 38.510383 N, 16.258294 E (Tab. 10, Rel. 1); 1142 m a.s.l., Coordinates: 38.511694 N, 16.258992 E (Tab. 10, Rel. 2); 1146 m a.s.l., Coordinates: 38.510861 N, 16.258442 E (Tab. 10, Rel. 3).
***Cells ID in the EEA reference grid***: 10kmE486N173 (Fig. 11).
***Natura 2000 Site Code***: ZSC IT9340119 "Marchesale"
***Phytosociological table***: Tab. 10; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).
***Notes***: The habitat was identified on the Serre (southern part of Calabrian Apennines) above Arena (VV), located in humid depressions within *Fagus sylvatica* L. forest formations. The association *Dactylorhizo-Juncetum effusi*, to which the habitat aspects detected refer, frames hygrophilous grasslands, characterised by thermophilous hygrophilous species and the dominance of *Juncus effusus*, mainly localised on silty-clayey soils of the mountain belt, periodically subjected to submersion (Brullo et al. 2001). The presence of marsh habitats within beech forests contributes to increase the mountain range's biodiversity levels, which is densely covered by woodland.

## #54. Annex I Habitat: 6510 Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*) (Bonini F, Ferri V, Gigante D)

***EUNIS Classification system***: R22 (formerly: E2.2) Low and medium altitude hay meadows (Chytrý et al. 2020)
***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference:*** Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Salvio pratensis-Dactylidion glomeratae* Ubaldi et al. in Ubaldi 2003 (Syn: *Ranunculo neapolitani-Arrhenatherion elatioris* Allegrezza et Biondi 2011), *Arrhenatheretalia elatioris* Tx. 1931, *Molinio-Arrhenatheretea* Tx. 1937 (Mucina et al. 2016)
***Geographic information***: Italy, Umbria, Perugia, Sant'Anatolia di Narco, dintorni del Laghetto di Gavelli, 1129 m a.s.l., Coordinates: 42.680447 N, 12.911167 E (Tab. 11, Rel. 1); 1124 m a.s.l., Coordinates: 42.681955 N, 12.911021 E (Tab. 11, Rel. 2); 1125 m a.s.l., Coordinates: 42.682135 N, 12.910947 E (Tab. 11, Rel. 3); 1128 m a.s.l., Coordinates: 42.680246 N, 12.909240 E (Tab. 11, Rel. 4).
***Cells ID in the EEA reference grid***: 10kmE456N217 (Fig. 12).
***Natura 2000 Site Code***: SAC IT5210068 "Laghetto e Piano di Gavelli (Monte Coscerno)".
***Phytosociological table***: Tab. 11; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).
***Notes***: The habitat occurrence within the SAC IT5210068 is limited to small but valuable surfaces (Fig. 13). A significative expansion of *Asphodelus macrocarpus* Parl. and *Pteridium aquilinum* (L.) Kuhn has been detected in areas adjacent to the reported stands, testifying the threat to the conservation of this habitat type due to the abandonment of traditional management activities (mowing). The finding occurred during the activities of the Life Integrated project LIFE19 IPE/IT/000015 "LIFE IMAGINE Umbria - Integrated MAnagement and Grant Investments for the N2000 NEtwork in Umbria".



**Figure 11.** Distribution in Italy of Habitat 6420: in black the new cells, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013–2018; Eionet 2019).

**Table 10**. Habitat 6420.

| Relevé number | 1 | 2 | 3 | |
|---|---|---|---|---|
| Cell ID | 10kmE486N173 | 10kmE486N174 | 10kmE486N175 | |
| Latitude | 38.510383 | 38.511694 | 38.510861 | |
| Longitude | 16.258294 | 16.258992 | 16.258442 | |
| Date | 21/07/05 | 04/06/16 | 21/07/05 | |
| Area ($m^2$) | 20 | 50 | 20 | |
| Altitude (m a.s.l.) | 1148 | 1142 | 1146 | |
| Herb layer height (m) | 1 | 1 | 1 | |
| Herb layer cover (%) | 100 | 100 | 100 | Presences |
| **Charact. of *Dactylorhizo-Juncetum effusi*** | | | | |
| *Juncus effusus* L. subsp. *effusus* | 3 | 4 | 5 | 3 |
| **Charact. of *Dactylorhizo-Juncion striati, Holoschoenetalia vulgaris, Molinio-Arrhenatheretea*** | | | | |
| *Dactylorhiza maculata* (L.) Soó subsp. *saccifera* (Brongn.) Diklić | 1 | 1 | 1 | 3 |
| ^*Hypericum tetrapterum* Fr. | 2 | 3 | 2 | 3 |
| *Juncus articulatus* L. subsp. *articulatus* | + | 2 | + | 3 |
| *Cirsium creticum* (Lam.) d'Urv. subsp. *triumfettii* (Lacaita) K. Werner | 1 | - | 2 | 2 |
| ^*Prunella vulgaris* L. subsp. *vulgaris* | 1 | - | 1 | 2 |
| ^*Epipactis palustris* (L.) Crantz | . | 3 | . | 1 |
| *Carex leporina* L. | + | . | . | 1 |
| *Potentilla erecta* (L.) Raeusch. | 1 | . | . | 1 |
| **Other species** | | | | |
| *Mentha aquatica* L. subsp. *aquatica* | 2 | 1 | 2 | 3 |
| *Lysimachia nemorum* L. | + | 1 | + | 3 |
| *Epilobium palustre* L. | 2 | 1 | 1 | 3 |
| *Carex echinata* Murray | 1 | 2 | . | 2 |
| *Equisetum palustre* L. | 2 | . | 1 | 2 |
| *Holcus mollis* L. subsp. *mollis* | 3 | . | 3 | 2 |
| *Geranium versicolor* L. | 1 | . | . | 1 |
| *Carex distans* L. | . | 3 | . | 1 |
| *Chaerophyllum hirsutum* L. | . | . | 1 | 1 |
| *Galium palustre* L. subsp. *elongatum* (C.Presl) Arcang. | . | . | 1 | 1 |
| *Lycopus europaeus* L. | . | . | 1 | 1 |
| *Potamogeton polygonifolius* Pourr. | . | 2 | . | 1 |

^ Reference plant species of the Habitat 6420, from Biondi et al. (2009).



**Figure 12.** Distribution in Italy of Habitat 6510: in black the new cell, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013–2018; Eionet 2019), in white (black outline) the cells later reported (Gigante at al. 2019a).

**Table 11**. Habitat 6510.

| Relevé number | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| Cell ID | 10kmE456N217 | 10kmE456N218 | 10kmE456N219 | 10kmE456N220 | |
| Latitude | 42.680447 | 42.681955 | 42.682135 | 42.680246 | |
| Longitude | 12.911167 | 12.911021 | 12.910947 | 12.909240 | |
| Date | 03/06/21 | 06/06/22 | 06/06/22 | 06/06/22 | |
| Area (m²) | 16 | 16 | 16 | 16 | |
| Altitude (m a.s.l.) | 1129 | 1124 | 1125 | 1128 | |
| Exposition (°) | 335 | - | - | - | |
| Slope (°) | 2 | 0 | 0 | 0 | |
| Cover (%) | 98 | 85 | 90 | 90 | Presences |
| **Charact. and diff. taxa of *Salvio pratensis-Dactylidion glomeratae* (Syn: *Ranunculo neapolitani-Arrhenatherion elatioris*)** | | | | | |
| ^*Arrhenatherum elatius* (L.) P.Beauv. ex J.Presl & C.Presl | 3 | 2b | 3 | 3 | 4 |
| ^*Dactylis glomerata* L. | 1 | 2a | 2a | 2b | 4 |
| *Ranunculus neapolitanus* Ten. | 1 | + | + | 1 | 4 |
| ^*Salvia pratensis* L. | + | . | 1 | 2a | 3 |
| *Ranunculus velutinus* Ten. | . | + | r | 2a | 3 |
| *Campanula rapunculus* L. | r | r | r | . | 3 |
| **Charact. and diff. taxa of *Arrhenatheretalia elatioris*, *Molinio-Arrhenatheretea*** | | | | | |
| ^*Cynosurus cristatus* L. | 2b | 1 | 2b | 1 | 4 |
| ^*Trifolium pratense* L. | 1 | 2a | + | 2a | 4 |
| ^*Lotus corniculatus* L. | + | 2b | + | + | 4 |
| ^*Leucanthemum vulgare* (Vaill.) Lam. subsp. *vulgare* | 1 | 1 | + | + | 4 |
| *Rhinanthus minor* L. | r | r | + | + | 4 |
| ^*Lolium perenne* L. | 1 | . | 2a | 1 | 3 |
| ^*Tragopogon pratensis* L. | 1 | 1 | . | 1 | 3 |
| ^*Poa pratensis* L. subsp. *pratensis* | . | 1 | 1 | 1 | 3 |
| ^*Achillea millefolium* L. | 1 | . | 1 | + | 3 |
| ^*Trisetaria flavescens* (L.) Baumg. subsp. *flavescens* | . | + | 1 | + | 3 |
| ^*Lathyrus pratensis* L. | . | . | + | 2b | 2 |
| ^*Daucus carota* L. | + | 1 | . | . | 2 |
| ^*Rumex acetosa* L. subsp. *acetosa* | + | . | r | . | 2 |
| ^*Plantago lanceolata* L. | r | . | + | . | 2 |
| ^*Leontodon hispidus* L. | . | + | . | + | 2 |
| ^*Poa trivialis* L. | . | . | . | 1 | 1 |
| *Potentilla reptans* L. | . | 1 | . | . | 1 |
| *Colchicum lusitanum* Brot. | . | r | . | . | 1 |
| *Galega officinalis* L. | r | . | . | . | 1 |
| ^*Trifolium repens* L. | . | . | + | . | 1 |
| *Carex distans* L. | . | . | r | . | 1 |
| **Other species** | | | | | |
| *Festuca stricta* Host subsp. *trachyphylla* (Hack.) Patzke ex Pils | 2b | 2b | 2a | 2a | 4 |
| *Medicago lupulina* L. | 1 | + | + | r | 4 |
| *Cerastium ligusticum* Viv. | r | + | + | + | 4 |
| *Veronica arvensis* L. | r | r | r | r | 4 |
| ^*Taraxacum* sect. *Taraxacum* | + | r | + | + | 4 |
| *Trifolium incarnatum* L. subsp. *molinerii* (Balb. ex Hornem.) Ces. | 3 | r | r | . | 3 |
| *Festuca rubra* L. subsp. *microphylla* St.-Yves | . | 2a | 1 | 1 | 3 |
| ^*Bromus hordeaceus* L. | . | 1 | 1 | 1 | 3 |
| ^*Centaurea jacea* L. subsp. *gaudinii* (Boiss. & Reut.) Gremli | . | + | + | 1 | 3 |
| ^*Anthoxanthum odoratum* L. | 2a | . | 1 | . | 2 |
| *Medicago sativa* L. | r | + | . | . | 2 |
| *Myosotis arvensis* (L.) Hill subsp. *arvensis* | r | r | . | . | 2 |
| *Ornithogalum etruscum* Parl. | r | + | . | . | 2 |
| *Vicia sativa* L. | + | r | . | . | 2 |
| *Potentilla pedata* Willd. ex Hornem. | . | 1 | . | r | 2 |
| *Lepidium campestre* (L.) W.T.Aiton | . | r | . | r | 2 |
| *Geranium dissectum* L. | . | + | r | . | 2 |
| *Poterium sanguisorba* L. subsp. *balearicum* (Bourg. ex Nyman) Stace | . | r | + | . | 2 |
| *Arenaria leptoclados* (Rchb.) Guss. subsp. *leptoclados* | . | . | . | r | 1 |
| *Campanula rapunculoides* L. subsp. *rapunculoides* | r | . | . | . | 1 |
| *Cichorium intybus* L. | + | . | . | . | 1 |
| *Convolvulus arvensis* L. | . | . | + | . | 1 |
| *Elymus repens* (L.) Gould subsp. repens | . | . | . | + | 1 |
| *Ervilia hirsuta* (L.) Opiz | . | r | . | . | 1 |
| *Geranium columbinum* L. | r | . | . | . | 1 |
| *Geranium molle* L. | r | . | . | . | 1 |
| ^*Picris hieracioides* L. | + | . | . | . | 1 |
| *Potentilla detommasii* Ten. | . | . | r | . | 1 |
| *Ranunculus millefoliatus* Vahl | . | . | . | r | 1 |
| *Rumex acetosella* L. | r | . | . | . | 1 |
| *Scorzonera laciniata* L. subsp. *laciniata* | . | + | . | . | 1 |
| *Scorzoneroides cichoriacea* (Ten.) Greuter | . | . | . | 1 | 1 |

**Table 11.** Continuation.

| Relevé number | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| Cell ID | 10kmE456N217 | 10kmE456N218 | 10kmE456N219 | 10kmE456N220 | |
| Latitude | 42.680447 | 42.681955 | 42.682135 | 42.680246 | |
| Longitude | 12.911167 | 12.911021 | 12.910947 | 12.909240 | |
| Date | 03/06/21 | 06/06/22 | 06/06/22 | 06/06/22 | |
| Area (m²) | 16 | 16 | 16 | 16 | |
| Altitude (m a.s.l.) | 1129 | 1124 | 1125 | 1128 | |
| Exposition (°) | 335 | - | - | - | |
| Slope (°) | 2 | 0 | 0 | 0 | |
| Cover (%) | 98 | 85 | 90 | 90 | Presences |
| *Sherardia arvensis* L. | . | . | r | . | 1 |
| *Silene latifolia* Poir. | r | . | . | . | 1 |
| *Trifolium campestre* Schreb. | . | + | . | . | 1 |
| *Trifolium striatum* L. | . | . | r | . | 1 |
| *Valerianella* sp. | + | . | . | . | 1 |

^ Reference plant species of the Habitat 6510, from Biondi et al. (2009).



**Figure 13.** Habitat 6510 in the reported stand (around of Gavelli small lake, Sant'Anatolia di Narco, Perugia, Italy).

## #55. Annex I Habitat: 91AA* Eastern white oak woods (Mantino F, Forte L, Tomaselli V)

***EUNIS Classification system***: T19 (formerly: G1.7a) Temperate and submediterranean thermophilous deciduous forest (Chytrý et al. 2020).
***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference:*** Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: F*raxino orni-Quercenion ilicis* Bacchetta, Bagella, Biondi, Farris, Filigheddu et Mossa ex Bacchetta, Bagella, Biondi, Farris, Filigheddu et Mossa in Biondi et al. 2013; *Fraxino orni-Quercion ilicis* Biondi, Casavecchia et Gigante ex Biondi, Casavecchia et Gigante in Biondi, Allegrezza, Casavecchia, Galdenzi, Gigante et Pesaresi 2013; *Quercetalia ilicis* Br.-Bl. ex Molinier 1934; *Quercetea ilicis* Br.-Bl. in Br.-Bl., Roussine et Nègre 1952 (Biondi and Blasi 2015).
***Geographic information***: Italy, Apulia, San Vincenzo, Monopoli (Bari), 200 m a.s.l. Coordinates: 40.925802 N, 17.231979 E (Tab. 12, Rel. 1); Pozzo Cucù, Polignano a Mare (Bari), 280 m a.s.l. Coordinates: 40.904542 N, 17.171749 E and 40.907777 N, 17.168341 E (Tab. 12, Rels. 2 and 3); Caramanna, Monopoli (Bari), 190 m a.s.l. Coordinates: 40.926039 N, 17.245225 E (Tab. 12, Rel. 4).

***Cells ID in the EEA reference grid***: 10kmE492N200 (Tab. 12, Rel. 1), 10kmE493N200 (Tab. 12, Rels 2 and 3) and 10kmE493N201 (Tab. 12, Rel. 3) (Fig. 14).
***Natura 2000 Site Code***: currently not included in any Natura 2000 Site.
***Phytosociological table***: Tab. 12; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).
***Notes***: This priority habitat is distributed in Apulia Region on the Gargano promontory, in the inland areas of Monti Dauni and Murgia, and in a limited portion of the Brindisi province (Eionet 2019). The forest communities investigated are located in the province of Bari, in the inland areas occurring between Monopoli and Polignano a Mare, and represent fragments of woods inserted in a rural context, in private areas between the houses. These woods are dominated by *Quercus pubescens* Willd. and are characterized by rich evergreen species component in the undergrowth. We have opted to classify these forests in the *Quercetea ilicis* Br.-Bl. in Br.-Bl., Roussine et Nègre 1952, similarly to what was proposed by other authors for other pubescent oak forest communities in Sicily, Sardinia, and Calabria (Brullo et al. 2001; Bacchetta et al. 2004; Brullo et al. 2008). However, the debate on the syntaxonomic placing of the xerothermic woods of *Quercus pubescens* is still open. In fact, other authors consider the Mediterranean woods of *Quercus pubescens* rich in evergreen species of central and southern Italy as belonging

**Table 12**. Habitat 91AA*.

| Relevé number | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| Cell ID | 10kmE493N200 | 10kmE492N200 | 10kmE492N200 | 10kmE493N201 | |
| Latitude | 40.925802 | 40.904542 | 40.907777 | 40.926.039 | |
| Longitude | 17.231979 | 17.171749 | 17.168341 | 17.245225 | |
| Date | 27/05/22 | 27/05/22 | 27/05/22 | 27/05/22 | |
| Area ($m^2$) | 100 | 100 | 100 | 100 | |
| Altitude (m a.s.l.) | 200 | 280 | 280 | 190 | |
| Cover (%) | 100 | 100 | 100 | 100 | |
| Tree layer cover (%) | 90 | 90 | 85 | 90 | |
| Shrub layer cover (%) | 70 | 20 | 70 | 60 | |
| Herb layer cover (%) | 30 | 5 | 35 | 20 | |
| Tree layer height (m) | 7 | 5 | 6 | 7 | |
| Shrub layer height (m) | 1.5 | 0.9 | 1.7 | 1.3 | |
| Herb layer height (m) | 0.5 | 0.2 | 0.5 | 0.4 | Presences |
| ^*Quercus pubescens* Willd. | 5 | 5 | 4 | 5 | 4 |
| **Charact. taxa of *Fraxino orni-Quercenion ilicis*** | | | | | |
| *Dioscorea communis* (L.) Caddick & Wilkin | 1 | + | 1 | + | 4 |
| *Cyclamen hederifolium* Aiton | + | + | + | + | 4 |
| **Charact. and diff. taxa of *Fraxino orni-Quercion ilicis, Quercetalia ilicis, Quercetea ilicis*** | | | | | |
| *Phillyrea latifolia* L. | + | 2 | 3 | 2 | 4 |
| ^*Asparagus acutifolius* L. | + | + | + | + | 4 |
| ^*Rubia peregrina* L. | + | + | + | + | 4 |
| *Viburnum tinus* L. subsp. *tinus* | + | . | 1 | + | 3 |
| *Quercus ilex* L. | + | . | 1 | + | 3 |
| *Laurus nobilis* L. | + | . | + | + | 3 |
| ^*Smilax aspera* L. | . | . | 1 | + | 2 |
| *Arbutus unedo* L. | . | . | 1 | . | 1 |
| *Cytisus infestus* (C. Presl) Guss. | . | . | + | . | 1 |
| **Taxa of *Pistacio lentisci-Rhamnetalia alaterni*** | | | | | |
| *Pistacia lentiscus* L. | 4 | + | 1 | 2 | 4 |
| *Rhamnus alaternus* L. subsp. *alaternus* | 1 | . | 2 | 1 | 3 |
| **Other species** | | | | | |
| ^*Hedera helix* L. subsp. *helix* | + | + | + | + | 4 |
| ^*Rosa sempervirens* L. | + | + | + | + | 4 |
| ^*Crataegus monogyna* Jacq. | 1 | + | + | . | 3 |
| *Brachypodium sylvaticum* (Huds.) P. Beauv. | 1 | . | + | + | 3 |
| *Clematis vitalba* L. | 1 | . | . | + | 2 |
| *Osyris alba* L. | . | + | + | . | 2 |
| *Rubus ulmifolius* Schott | 1 | . | . | + | 2 |
| *Prunus spinosa* L. subsp. *spinosa* | + | + | . | . | 2 |
| *Allium subhirsutum* L. subsp. *subhirsutum* | + | . | + | + | 2 |
| *Achnatherum bromoides* (L.) P. Beauv. | + | . | + | . | 2 |
| *Carex depauperata* Curtis ex With. | + | . | + | . | 2 |
| *Carex distachya* Desf. | + | . | + | . | 2 |
| *Melica uniflora* Retz. | + | . | + | . | 2 |
| *Sorbus domestica* L. | + | . | . | . | 1 |
| *Lonicera implexa* Aiton subsp. *implexa* | . | . | + | . | 1 |
| *Prunus mahaleb* L. | + | . | . | . | 1 |
| *Aegonychon purpurocaeruleum* (L.) Holub | . | + | . | . | 1 |

^ Reference plant species of the Habitat 91AA*, from Biondi et al. (2009).

to the classes *Quercetea pubescentis* or *Querco-Fagetea* (Di Pietro and Blasi 1998; Biondi et al. 2004; Blasi et al. 2004; Ubaldi 2003).

The main threats affecting these sites are the effects of human activities (e.g., urbanization, fire, agriculture) and the extreme fragmentation.

## #56. Annex I Habitat: 91E0* Alluvial forests with Alnus glutinosa and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*) (Patera G)

***EUNIS Classification system***: G1.131 - Southern *Alnus glutinosa* galleries

***Biogeographical Region***: Mediterranean

***National Habitat Checklist of reference***: Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).

***Phytosociological reference***: *Angelico sylvestris-Alnetum glutinosae* Brullo et Spampinato 1997, *Alnetum glutinoso-cordatae* Brullo et Spampinato 1997, *Populion albae* Br.-Bl. ex Tchou 1948, *Populetalia albae* Br.-Bl. ex Tchou 1948, *Salici purpureae-Populetea nigrae* (Rivas-Mart. et Cantó ex Rivas-Mart. et al. 1991) Rivas-Mart. et Cantó 2002 (Biondi and Blasi 2015).

***Geographic information***: Italy, Campania, Salerno, Caselle in Pittari, 287 m a.s.l., Coordinates: 40.186791 N, 15.555581 E (Tab. 13, Rel. 1); Castel San Lorenzo, 117 m a.s.l., Coordinates: 40.425153 N, 15.240472 E (Tab. 13, Rel. 2); Laurino, 298 m a.s.l., Coordinates: 40.344312 N, 15.276142 E (Tab. 13, Rel. 3); Castelnuovo Cilento, 16 m a.s.l., Coordinates: 40.190665 N, 15.172522 E (Tab. 13, Rel. 4); Stio, 471 m a.s.l., Coordinates: 40.314957 N, 15.234722 E (Tab. 13, Rel. 5); Sacco, 307 m a.s.l., Coordinates: 40.387160 N, 15.360478 E (Tab. 13, Rel. 6); Felitto, 195 m a.s.l., Coordinates: 40.365201 N, 15.250643 E (Tab. 13, Rel .7); Laurino, 435 m a.s.l., Coordinates: 40.247591 N, 15.411649 E (Tab. 13, Rel. 8).

***Cells ID in the EEA reference grid***: All the relevés are referring to Tab. 13, 10kmE479N191 (Rel. 1), 10kmE476N194 (Rel. 2), 10kmE477N193 (Rels 3 and 6), 10kmE476N191 (Rel. 4), 10kmE476N192 (Rel. 5), 10kmE476N193 (Rel. 7), 10kmE478N192 (Rel. 8) (Fig. 15).

***Natura 2000 Site Code***: All the relevés are referring to Tab. 13, ZSC IT8050001"Alta Valle del Fiume Bussento" (Rel. 1), ZSC IT8050002"Alta Valle del Fiume Calore Lucano Salernitano" (Rels 2, 3, 6, 7), ZSC IT8050012 "Fiume Alento" (Rels 4 and 5), ZSC IT8050013 "Fiume Mingardo" (Rel. 8).

***Phytosociological table***: Tab. 13; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).

***Notes***: The community detected are referred to *Angelico sylvestris-Alnetum glutinosae* (Rels from 1 to 4) and *Alnetum glutinoso-cordatae* (Brullo and Spampinato 1997) (Rels from 5 to 8). The first community is represented by riparian woods with *Alnus glutinosa*, developed in wide valleys occurring from the sea level up to 500-600 m of elevation on periodically flooded soils rich in silt and clay. The second community is a sort of ravine forest characterized by the co-dominance of *Alnus cordata* and it is found along rivers and streams located in steep-narrow valleys at altitudes between 50 and 1450 m (Corbetta et al. 2004). Both communities develop in conditions of

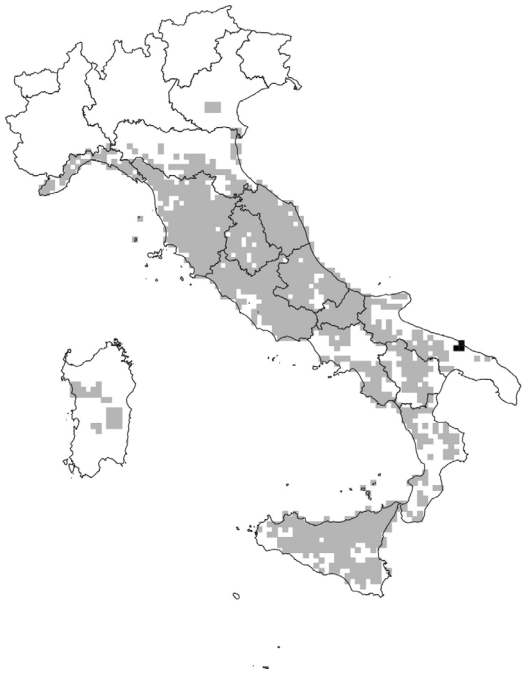


**Figure 14.** Distribution in Italy of Habitat 91AA*: in black the new cells, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013–2018; Eionet 2019).

**Table 13**. Habitat 91E0*.

| Relevé number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
|---|---|---|---|---|---|---|---|---|---|
| Cell ID | 10km E479N191 | 10km E476N194 | 10km E477N193 | 10km E476N191 | 10km E476N192 | 10km E477N193 | 10km E476N193 | 10km E478N192 | |
| Latitude | 40.186791 | 40.425153 | 40.344312 | 40.190665 | 40.314957 | 40.387160 | 40.365201 | 40.247591 | |
| Longitude | 15.555581 | 15.240472 | 15.276142 | 15.172522 | 15.234722 | 15.360478 | 15.250643 | 15.411649 | |
| Date | 16/06/22 | 27/06/22 | 29/06/22 | 30/06/22 | 12/05/22 | 28/06/2022 | 29/06/2022 | 10/05/22 | |
| Area ($m^2$) | 100 | 100 | 100 | 80 | 100 | 100 | 80 | 100 | |
| Altitude (m a.s.l.) | 287 | 117 | 298 | 16 | 471 | 307 | 195 | 435 | |
| Exposition | SE | N | NW | NE | N | NW | SE | NE | |
| Slope (°) | 15 | 10 | 15 | 5 | 30 | 30 | 40 | 5 | |
| Cover (%) | 100 | 100 | 90 | 100 | 70 | 80 | 100 | 90 | Presences |
| **Diagnostic taxa of *Angelico sylvestris-Alnetum glutinosae*** | | | | | | | | | |
| ^*Angelica sylvestris* L. | 1 | 1 | 1 | 2 | . | . | . | . | 4 |
| **Diagnostic taxa of *Alnetum glutionoso-cordatae*** | | | | | | | | | |
| ^*Alnus cordata* (Loisel.) Duby | . | . | . | . | 3 | 4 | 3 | 1 | 4 |
| **Charact. taxa of *Populion* and *Populetalia albae*** | | | | | | | | | |
| ^*Alnus glutinosa* (L.) Gaertn. | 5 | 4 | 4 | 5 | 1 | 2 | 4 | 4 | 8 |
| ^*Petasites hybridus* (L.) G.Gaertn., B.Mey. & Scherb. | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 8 |
| ^*Carex pendula* Huds. | 1 | . | 1 | 1 | 1 | . | 1 | 1 | 6 |
| ^*Equisetum telmateia* Ehrh. | + | 1 | + | . | . | 1 | 1 | . | 5 |
| *Vinca major* L. | + | + | . | . | 1 | . | 1 | 1 | 5 |
| *Hypericum hircinum* L. subsp. *majus* (Aiton) N.Robson | . | 1 | 1 | . | . | . | + | . | 3 |
| ^*Ulmus minor* Mill. | . | 1 | . | . | . | 1 | 1 | . | 3 |
| ^*Rubus caesius* L. | . | . | 1 | . | 1 | . | . | 1 | 3 |
| ^*Sambucus nigra* L. | . | . | + | 1 | . | . | . | . | 2 |
| ^*Populus nigra* L. | . | + | . | + | . | . | . | . | 2 |
| *Ficus carica* L. | . | 1 | . | . | . | . | r | . | 2 |
| *Salix alba* L. | . | . | 1 | . | . | . | . | . | 1 |
| ^*Solanum dulcamara* L. | . | . | . | 1 | . | . | . | . | 1 |
| ^*Humulus lupulus* L. | . | . | . | 1 | . | . | . | . | 1 |
| *Platanus orientalis* L. | . | . | . | 1 | . | . | . | . | 1 |
| *Bryonia dioica* Jacq. | . | . | . | . | 1 | . | . | . | 1 |
| **Charact. taxa of *Salici purpureae-Populetea nigrae*** | | | | | | | | | |
| *Salix purpurea* L. | 1 | 1 | . | . | . | . | . | . | 2 |
| *Salix eleagnos* Scop. | . | + | . | . | . | 2 | . | . | 2 |
| *Vitis vinifera* L. | . | . | . | + | . | . | . | . | 1 |
| **Other species** | | | | | | | | | |
| *Brachypodium sylvaticum* (Huds.) P.Beauv. | 1 | 1 | 2 | . | 1 | 1 | 2 | 1 | 7 |
| *Clematis vitalba* L. | . | 1 | 1 | 1 | 1 | 1 | . | 1 | 6 |
| *Cornus sanguinea* L. | 1 | 1 | 1 | . | . | 1 | 1 | 1 | 6 |
| ^*Hedera helix* L. | . | 1 | . | . | 1 | 1 | 1 | . | 4 |
| *Crataegus monogyna* Jacq. | . | . | r | . | . | . | 1 | 1 | 3 |
| ^*Acer campestre* L. | . | . | 1 | . | . | . | 1 | . | 2 |
| *Convolvulus sylvaticus* Kit. | . | . | | + | 1 | . | . | . | 2 |
| *Corylus avellana* L. | . | . | 1 | . | . | . | . | 1 | 2 |
| *Cyperus longus* L. | 1 | 1 | . | . | . | . | . | . | 2 |
| *Fontinalis antipyretica* Hedw. | . | . | 1 | . | . | . | 1 | . | 2 |
| *Mentha aquatica* L. | + | . | . | + | . | . | . | . | 2 |
| *Ranunculus lanuginosus* L. | . | . | . | . | + | . | . | 1 | 2 |
| *Robinia pseudacacia* L. | . | . | r | . | . | 1 | . | . | 2 |
| *Rosa sempervirens* L. | . | + | r | . | . | . | . | . | 2 |
| *Rubus ulmifolius* Schott | . | . | . | 2 | . | 1 | . | . | 2 |
| *Acer cappadocicum* Gled. subsp. *lobelii* (Ten.) A.E.Murray | + | . | . | . | . | . | . | . | 1 |
| *Acer opalus* Mill. subsp. *obtusatum* (Waldst. & Kit. ex Willd.) Gams | . | . | r | . | . | . | . | . | 1 |
| *Agrostis stolonifera* L. | . | . | . | + | . | . | . | . | 1 |
| *Carpinus betulus* L. | . | . | r | . | . | . | . | . | 1 |
| *Epilobium hirsutum* L. | . | . | . | r | . | . | . | . | 1 |
| *Geranium nodosum* L. | r | . | . | . | . | . | . | . | 1 |
| *Helosciadium nodiflorum* (L.) W.D.J.Koch | . | . | . | 1 | . | . | . | . | 1 |
| *Rubus hirtus* Waldst. & Kit. | . | 1 | . | . | . | . | . | . | 1 |
| *Sparganium erectum* L. | . | . | . | r | . | . | . | . | 1 |
| ^*Stachys sylvatica* L. | . | . | 1 | . | . | . | . | . | 1 |
| ^*Urtica dioica* L. | . | . | . | 1 | . | . | . | . | 1 |
| *Fraxinus ornus* L. | . | . | . | . | . | . | . | 1 | 1 |

**Table 13.** Continuation.

| Relevé number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
|---|---|---|---|---|---|---|---|---|---|
| Cell ID | 10km E479N191 | 10km E476N194 | 10km E477N193 | 10km E476N191 | 10km E476N192 | 10km E477N193 | 10km E476N193 | 10km E478N192 | |
| Latitude | 40.186791 | 40.425153 | 40.344312 | 40.190665 | 40.314957 | 40.387160 | 40.365201 | 40.247591 | |
| Longitude | 15.555581 | 15.240472 | 15.276142 | 15.172522 | 15.234722 | 15.360478 | 15.250643 | 15.411649 | |
| Date | 16/06/22 | 27/06/22 | 29/06/22 | 30/06/22 | 12/05/22 | 28/06/2022 | 29/06/2022 | 10/05/22 | |
| Area ($m^2$) | 100 | 100 | 100 | 80 | 100 | 100 | 80 | 100 | |
| Altitude (m a.s.l.) | 287 | 117 | 298 | 16 | 471 | 307 | 195 | 435 | |
| Exposition | SE | N | NW | NE | N | NW | SE | NE | |
| Slope (°) | 15 | 10 | 15 | 5 | 30 | 30 | 40 | 5 | |
| Cover (%) | 100 | 100 | 90 | 100 | 70 | 80 | 100 | 90 | Presences |
| *Geranium purpureum* Vill. | . | . | . | . | 1 | . | . | . | 1 |
| *Lamium flexuosum* Ten. | . | . | . | . | 1 | . | . | . | 1 |
| *Sanicula europaea* L. | . | . | . | . | . | . | . | 1 | 1 |
| *Scirpoides holoschoenus* (L.) Soják | . | . | . | . | . | 1 | . | . | 1 |
| *Tilia platyphyllos* Scop. | . | . | . | . | . | . | 1 | . | 1 |
| *Allium ursinum* L. | . | . | . | . | . | . | . | 1 | 1 |
| *Dioscorea communis* (L.) Caddick & Wilkin | . | . | . | . | . | . | . | + | 1 |
| *Cardamine impatiens* L. | . | . | . | . | r | . | . | . | 1 |

^ Reference plant species of the Habitat 91E0*, from Biondi et al. (2009).



**Figure 15.** Distribution in Italy of Habitat 91E0*: in black the new cells, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013–2018; Eionet 2019), in white (black outline) the cells later reported (Bazan et al. 2021).

high soil moisture, with thermotypes ranging from thermo-Mediterranean to meso-Mediterranean. These are the first reported sites of occurrence of this priority habitat for Campania Region in the area of the Cilento, Vallo di Diano and Alburni National Park (Fig. 16). The recorded communities, which were both already described for Calabria Region, are located at the northern limit of distribution of the respective associations. Strict compliance with the European Habitat Interpretation Manual EUR28 would not allow the inclusion of some of the forest communities here identified and reported. In fact, Habitat 91E0* was originally described as closely linked to boreal or central European communities. On the other hand, the Mediterranean variants of this Habitat introduced in the Italian manual of interpretation make it possible to also include ravine forests dominated by *Alnus cordata*. It is evident that a critical review is necessary to understand what level of "Mediterranean contamination" is admissible to still be admitted in 91E0*.

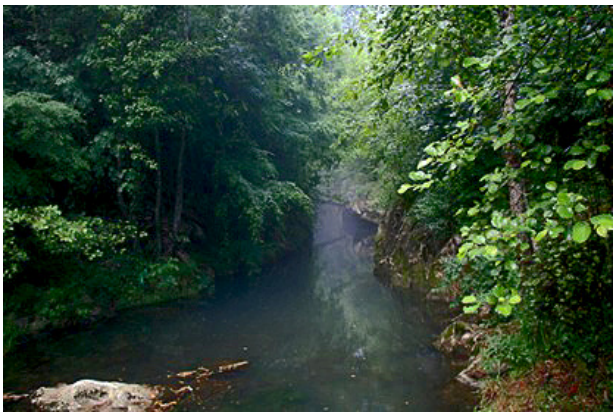


**Figure 16.** Habitat 91E0* in the "Cilento, Vallo di Diano e Alburni" National Park (Campania, Italy).

## #57. Annex I Habitat: 91E0* Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*) (Mei G, Stinca A, Esposito A)

***EUNIS Classification system***: G1.131 - Southern *Alnus glutinosa* galleries
***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference***: Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Populion albae* Br.-Bl. ex Tchou 1948, *Populetalia albae* Br.-Bl. ex Tchou 1948, *Salici purpureae-Populetea nigrae* Rivas-Martínez et Cantó ex Rivas-Martínez, Báscones, T.E. Díaz, Fernández-González et Loidi 2001 (Biondi and Blasi 2015).
***Geographic information***: Italy, Toscana, Firenze, Barberino Tavernelle, Borro Argennino, 305 m a.s.l. Coordinates: 43.531232 N, 11.255291 E (Tab. 14, Rel. 1); 297 m a.s.l. Coordinates: 43.533249 N, 11.258214 E (Tab. 14, Rel. 2); 283 m a.s.l. Coordinates: 43.537742 N, 11.265783 E (Tab. 14, Rel. 3).
***Cells ID in the EEA reference grid***: 10kmE442N227 (Fig. 15).
***Natura 2000 Site Code***: currently not included in any Natura 2000 Site.
***Phytosociological table***: Tab. 14; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).
***Notes***: The relevés describe the riparian forests of *Alnus glutinosa* and *Populus nigra* subsp. *nigra* which occur along the watercourses in the hilly stretches and in the areas with water stagnation linked to the fluvial dynamics of the Chianti hilly complex. The formations described develop on alluvial soils sometimes flooded in the winter, in which however there are particular conditions of edaphic humidity due to the perennial presence of water already a few decimetres from the surface. Given the ecological importance of these environments and considering the scarce information about the dynamics of expansion and regression of these community in the hilly area linked to the abandonment and climate change, it would be particularly interesting a monitoring study of these formations such as the one carried out in similar environments in Croatia (Vukelić et al. 2019).

## #58. Annex I Habitat: 91F0 Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (Tavilla G, Laface VLA, Spampinato G, Musarella CM, Crisafulli A, Maiorca G)

***EUNIS Classification system***: G1.3 Mediterranean riparian woodland
***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference***: Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Aro italici-Ulmetum minoris* Rivas-Martínez ex Lòpez 1976, *Populion albae* Br-Bl. ex Tchou 1948, *Populetalia albae* Br.-Bl. ex Tchou 1948, *Salici purpureae-Populetea nigrae* (Riv-Mart. et Cantó ex Riv-Mart., Báscones, T.E. Díaz, Fernández-Gonzáles et Loidi) Riv.-Mart., Fernández-Gonzáles, Loidi, Lousa et Penas 2001 (Maiorca et al. 2007).
***Geographic information***: Italy, Calabria, Foce del Fiume Crati, C.da La Foggia, 6 m a.s.l., Coordinates: 39.708448 N, 16.522037 E [Tab. 26, Rel. 1 in Maiorca et al. (2007)]; Italy, Calabria, Foce del Fiume Crati, sinistra idrografica, sulla scarpata dell'argine (carraia), 4 m a.s.l., Coordinates: 39.714461 N, 16.520507 E [Tab. 26, Rel. 2 in Maiorca et al. (2007)].
***Cells ID in the EEA reference grid***: 10kmE488N187 (Fig. 17).
***Natura 2000 Site Code***: SAC IT9310044 "Foce del Fiume Crati" [Tab. 26 in Maiorca et al. (2007)].
***Phytosociological table***: Tab. 26 in Maiorca et al. (2007); taxonomic nomenclature according to Conti et al. (2005).
***Notes***: Sub-Mediterranean hygrophilous vegetation occurs in floodplains and along rivers where the flooding regime is very short. Along the estuary of the river Crati in Calabria (Southern Italy), this habitat is characterized by riparian woodlands belonging to the alliance *Populion albae*, which includes the association *Aro italici-Ulmetum minoris* Rivas-Martínez ex López 1976 and other hygrophilous associations such as *Roso sempervirentis-Populetum nigrae* Pedrotti et Gafta 1992, *Angelico sylvestris-Alnetum glutinosae* Brullo et Spampinato 1997, *Angelico sylvestris-Alnetum glutinosae iridetosum pseudacori* Brullo et Spampinato 1997 and the alliance *Alno-Quercion roboris* Horvat 1950 with the association *Clematido scandentis-Populetum albae* (Brullo et Spampinato 1997) Maiorca et al. nom. corr., characterised by the endemic species *Clematis rigoi* W.T Wang (= *Clematis viticella* L. subsp. *scandens* Arcang.) (Tab. 25-26 in Maiorca et al. (2007). Our new record is based on the previous study carried out by Maiorca et al. (2007).

**Table 14**. Habitat 91E0*.

| Revelée number | 1 | 2 | 3 | |
|---|---|---|---|---|
| Cell ID | 10kmE442N227 | 10kmE442N227 | 10kmE442N227 | |
| Latitude | 43.531232 | 43.533249 | 43.537742 | |
| Longitude | 11.255291 | 11.258214 | 11.265783 | |
| Date | 23/08/22 | 24/08/22 | 24/08/22 | |
| Area ($m^2$) | 200 | 180 | 180 | |
| Altitude (m a.s.l.) | 305 | 297 | 283 | |
| Exposition | NNW | NW | NW | |
| Slope (°) | 5 | 4 | 6 | |
| Tree layer height (m) | 18 | 15 | 15 | |
| Shrub layer height (m) | 3 | 3 | 3 | |
| Herb layer height (m) | 0.5 | 0.1 | 0.1 | |
| Cover (%) | 100 | 100 | 100 | |
| Tree layer cover (%) | 80 | 95 | 85 | |
| Shrub layer cover (%) | 35 | 15 | 15 | |
| Herb layer cover (%) | 30 | 10 | 15 | Presences |
| **Charact. and diff. taxa of *Populion albae*** | | | | |
| ^*Alnus glutinosa* (L.) Gaertn. | 3 | 4 | 3 | 3 |
| ^*Populus nigra* L. subsp. *nigra* | 2b | 2a | 2a | 3 |
| ^*Sambucus nigra* L. | 2a | . | 1 | 2 |
| ^*Ulmus minor* Mill. subsp. *minor* | 1 | . | . | 1 |
| ^*Rubus caesius* L. | r | . | . | 1 |
| **Charact. and diff. taxa of *Populetalia albae*** | | | | |
| ^*Solanum dulcamara* L. | r | r | + | 3 |
| **Charact. and diff. taxa of *Salici-purpureae-Populetea nigrae*** | | | | |
| ^*Carex remota* L. | . | r | r | 2 |
| *Rubia peregrina* L. | 1 | . | . | 1 |
| *Crataegus monogyna* Jacq. | 1 | . | . | 1 |
| *Clematis vitalba* L. | 2a | 2a | 2a | 3 |
| ^*Carex pendula* Huds. | 2b | 2a | 1 | 3 |
| **Other species** | | | | |
| *Corylus avellana* L. | 2a | 3 | 2a | 3 |
| *Brachypodium sylvaticum* (Huds.) P.Beauv. subsp. *sylvaticum* | 2a | 1 | 1 | 3 |
| ^*Hedera helix* L. subsp. *helix* | 2a | 1 | 1 | 3 |
| *Fraxinus ornus* L. subsp. *ornus* | + | 2a | 1 | 3 |
| ^*Acer campestre* L. | 1 | 1 | 1 | 3 |
| *Ligustrum vulgare* L. | 1 | 1 | 1 | 3 |
| *Viola reichenbachiana* Jord. ex Boreau | + | 2a | + | 3 |
| *Viola alba* Besser subsp. *dehnhardtii* (Ten.) W. Becker | 1 | 1 | + | 3 |
| *Melica uniflora* Retz. | + | 1 | + | 3 |
| *Primula vulgaris* Huds. | r | 1 | + | 3 |
| *Eupatorium cannabinum* L. subsp. *cannabinum* | 1 | r | r | 3 |
| *Ranunculus lanuginosus* L. | r | + | r | 3 |
| *Rubus ulmifolius* Schott | 2b | r | 1 | 3 |
| *Potentilla reptans* L. | r | r | + | 3 |
| *Mentha aquatica* L. subsp. *aquatica* | 1 | r | r | 3 |
| ^*Equisetum palustre* L. | 1 | r | r | 3 |
| *Aegonychon purpurocaeruleum* (L.) Holub | 2a | . | + | 2 |
| *Ostrya carpinifolia* Scop. | . | 2a | 1 | 2 |
| *Vitis vinifera* L. | . | 1 | 1 | 2 |
| *Orobanche hederae* Vaucher ex Duby | . | r | r | 2 |
| *Daphne laureola* L. | . | 2a | . | 1 |
| *Helleborus viridis* L. | . | + | . | 1 |
| ^*Stachys sylvatica* L. | . | r | . | 1 |
| *Pyracantha coccinea* M. Roem. | 2a | . | . | 1 |
| *Epilobium hirsutum* L. | 1 | . | . | 1 |
| *Asparagus acutifolius* L. | 1 | . | . | 1 |
| *Hypericum tetrapterum* Fr. | 1 | . | . | 1 |
| *Lycopus europaeus* L. | 1 | . | . | 1 |
| *Robinia pseudoacacia* L. | 1 | . | . | 1 |
| *Ajuga reptans* L. | + | . | . | 1 |
| *Helleborus foetidus* L. subsp. *foetidus* | + | . | . | 1 |
| *Juglans regia* L. | + | . | . | 1 |
| *Taraxacum* sect. *Taraxacum* F.H. Wigg. | + | . | . | 1 |
| *Campanula trachelium* L. subsp. *trachelium* | r | . | . | 1 |
| *Pulicaria dysenterica* (L.) Bernh. | r | . | . | 1 |

^ Reference plant species of the Habitat 91E0*, from Biondi et al. (2009).



**Figure 17.** Distribution in Italy of Habitat 91F0: in black the new cell, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013–2018; Eionet 2019).

## #59. Annex I Habitat: 9540 Mediterranean pine forests with endemic Mesogean pines (Gianguzzi L, Bazan G)

***EUNIS Classification system***: T3A (formerly: G3.7) Mediterranean lowland to submontane pine forest (Chytrý et al. 2020).
***Biogeographical Region***: Mediterranean
***National Habitat Checklist of reference:*** Italian Interpretation Manual of the Directive 92/43/EEC Habitats (Biondi et al. 2009).
***Phytosociological reference***: *Cisto cretici-Pinetum pineae* Brullo, Minissale, Siracusa, Scelsi et Spampinato 2002, *Pinion pineae* Feinbrun 1959, *Pinetalia halepensis* Biondi, Blasi, Galdenzi, Pesaresi et Vagge, *Pinetea halepensis* Bonari et Chytrý in Bonari et al. 2021 (Bonari et al. 2021; Brullo et al. 2002).
***Geographic information***: Italy, Sicily, Montemaggiore Belsito, Bosco della Favara (Fig. 19), 755 m a.s.l., Coordinates: 37.817808 N, 13.777869 E (Tab. 15, Rel. 1); Italy, Sicily, Calatafimi, Contrada Bosco Gaggera (Fig. 20), 269 m a.s.l., Coordinates: 37.944113 N, 12.865999 E (Tab. 15, Rel. 2); Italy, Sicily, Calatafimi, Contrada Bosco Gaggera (Fig. 19), 285 m a.s.l., Coordinates: 37.944002 N, 12.866582 E (Tab. 15, Rel. 3).
***Cells ID in the EEA reference grid:*** 10kmE465N164 (Tab. 15, Rel. 1); 10kmE457N165 (Tab. 15, Rels 2 and 3) (Fig. 18).
***Natura 2000 Site Code***: currently not included in any Natura 2000 Site.
***Phytosociological table***: Tab. 15; nomenclature and taxa delimitation according to Portal to the Flora of Italy (2022).
***Notes***: This association was described by Brullo et al. (2002) for the steep and south-facing slopes of quartz-arenitic substrates which are widespread on the Nebrodi and Madonie Mountains, as well as in inland areas of Sicily, up to the Trapani Mountains (Gianguzzi et al. 2015).

The new 9540 habitat sites are distributed on different types of sandy soils that in turns developed on different lithological substrates. Bosco della Favara site (Montemaggiore Belsito, Palermo province) is located on the Numidian flysch, while "Bosco della Gaggera" site (Calatafimi, province of Trapani) is located on the so-called Terravecchia formations, in the thermo-mesomediterranean sub-humid bioclimatic belt. Both the residual stands of pine forests in issue are to be considered the final successional stage of an edapho-xerophilous series linked to the dry acidophilic substrates (*Cisto creticae-Pino pineae* sigmetum). The pine wood community of Calatafimi belongs to a wider land unit dynamically tending to the potential vegetation of the cork oak climatophilous series (*Genisto aristatae-Querco suberis* sigmetum) this latter being characterized by deeper soils than those characterizing the pine forests (Fig. 19). The community of "Bosco della Favara" (Montemaggiore Belsito), on the other hand, develops on small bumps within slopes, emerging from a milder profile a wide area dominated by forests of pubescent oaks (*Erico arboreae-Querco virgilianae* sigmetum; Fig. 20) whose taxonomic identity is currently under critical review (Di Pietro et al. 2020; 2021). The new habitat here presented are a part of a well-preserved land mosaic typical of the Sicilian countryside, that still maintains a high level of floristic and coenological diversity despite a long-term exploitation (Bazan et al. 2020; Castrorao Barba et al. 2021; Bazan and Castrorao Barba 2022).

**Table 15**. Habitat 9540.

| Relevé number | 1 | 2 | 3 | |
|---|---|---|---|---|
| Cell ID | 10kmE465N164 | 10kmE457N165 | 10kmE457N165 | |
| Latitude | 37.817808 | 37.944113 | 37.944002 | |
| Longitude | 13.777869 | 12.865999 | 12.866582 | |
| Date | 13/03/18 | 19/11/16 | 10/11/16 | |
| Area (m²) | 100 | 300 | 350 | |
| Altitude (m a.s.l.) | 755 | 269 | 285 | |
| Exposition | NW | W | W | |
| Slope (°) | 10 | 20 | 26 | |
| Tree layer height (m) | 18 | 18 | 18 | |
| Shrub layer height (m) | 1.5 | 1.3 | 1.5 | |
| Herb layer height (m) | 0.2 | 0.7 | 0.8 | |
| Cover (%) | 100 | 100 | 100 | |
| Tree layer cover (%) | 90 | 90 | 90 | |
| Shrub layer cover (%) | 80 | 100 | 100 | |
| Herb layer cover (%) | 70 | 30 | 35 | Presences |
| **Charact. taxa of *Cisto cretici-Pinetum pineae*** | | | | |
| ^*Cistus creticus* L. | 2 | 1 | 1 | 3 |
| *Eryngium bocconei* Lam. | 1 | 1 | + | 3 |
| **Charact. and diff. taxa of *Pinion pineae*** | | | | |
| ^*Pinus pinea* L. | 5 | 5 | 5 | 3 |
| **Transg. *Quercetea ilicis*** | | | | |
| *Calicotome infesta* Guss. | 5 | 2 | 2 | 3 |
| *Asparagus acutifolius* L. | 1 | + | | |
| *Erica arborea* L. | 1 | 5 | 2 | 3 |
| *Olea europaea* L. var. *sylvestris* Hoffm. & Link | . | 1 | 1 | 2 |
| *Ampelodesmos mauritanicus* (Poir.) Dur. & Sch. | . | 3 | 3 | 2 |
| *Arbutus unedo* L. | . | 2 | 1 | 2 |
| *Phillyrea media* L. | | 1 | 1 | 2 |
| *Quercus pubescens* Willd. | 2 | . | . | 1 |
| *Rubia peregrina* L. | 1 | . | . | 1 |
| *Rosa sempervirens* L. | 1 | . | . | 1 |
| *Ruscus aculeatus* L. | 1 | . | . | 1 |
| *Pyrus spinosa* Forssk. | 1 | . | . | 1 |
| *Arisarum vulgare* O.Targ.Tozz. | . | . | 1 | 1 |
| *Daphne gnidium* L. | . | . | + | 1 |
| **Other species** | | | | |
| *Leontodon tuberosus* L. | 1 | 1 | 1 | 3 |
| *Cistus salvifolius* L. | . | 3 | 2 | 2 |
| *Helminthotheca aculeata* (Vahl) Lack | . | 2 | 1 | 2 |
| *Genista monspessulana* (L.) L.A.S. Johnson | . | 1 | 1 | 2 |
| *Pulicaria odora* (L.) Rchb. | . | 1 | 1 | 2 |
| *Cistus creticus* L. | . | 1 | 1 | 2 |
| *Brachypodium retusum* (Pers.) P. Beauv. | . | 1 | + | 2 |
| *Hyparrhenia hirta* (L.) Stapf. | . | + | 1 | 2 |
| *Lotus tenuis* Waldst. & Kit. ex Willd. | . | + | + | 2 |
| *Spartium junceum* L. | 2 | . | . | 1 |
| *Crataegus monogyna* Jacq. | 1 | . | . | 1 |
| *Carlina sicula* Ten. | 1 | . | . | 1 |
| *Magydaris pastinacea* (Lam.) Paol. | 1 | . | . | 1 |
| *Rumex thyrsoides* Desf. | 1 | . | . | 1 |
| *Petrosedum tenuifolium* (Sm.) Grulich | 1 | . | . | 1 |
| *Hyoseris radiata* L. | + | . | . | 1 |
| *Leontodon siculus* (Guss.) Nyman | + | . | . | 1 |
| *Bellis sylvestris* Cirillo | . | . | 1 | 1 |
| *Dactylis glomerata* L. subsp. *hispanica* (Roth) Nyman | . | . | + | 1 |
| *Fumana thymifolia* (L.) Spach ex Webb | . | . | + | 1 |
| *Carex flacca* Schreb. subsp. *erythrostachys* (Hoppe) Holub | . | . | + | 1 |
| *Ferula communis* L. | . | . | + | 1 |

^ Reference plant species of the Habitat 9540, from Biondi et al. (2009).



**Figure 18.** Distribution in Italy of Habitat 9540: in black the new cells, in grey the cells officially reported in the 4th Habitat report ex-Art. 17 (period 2013–2018; Eionet 2019).

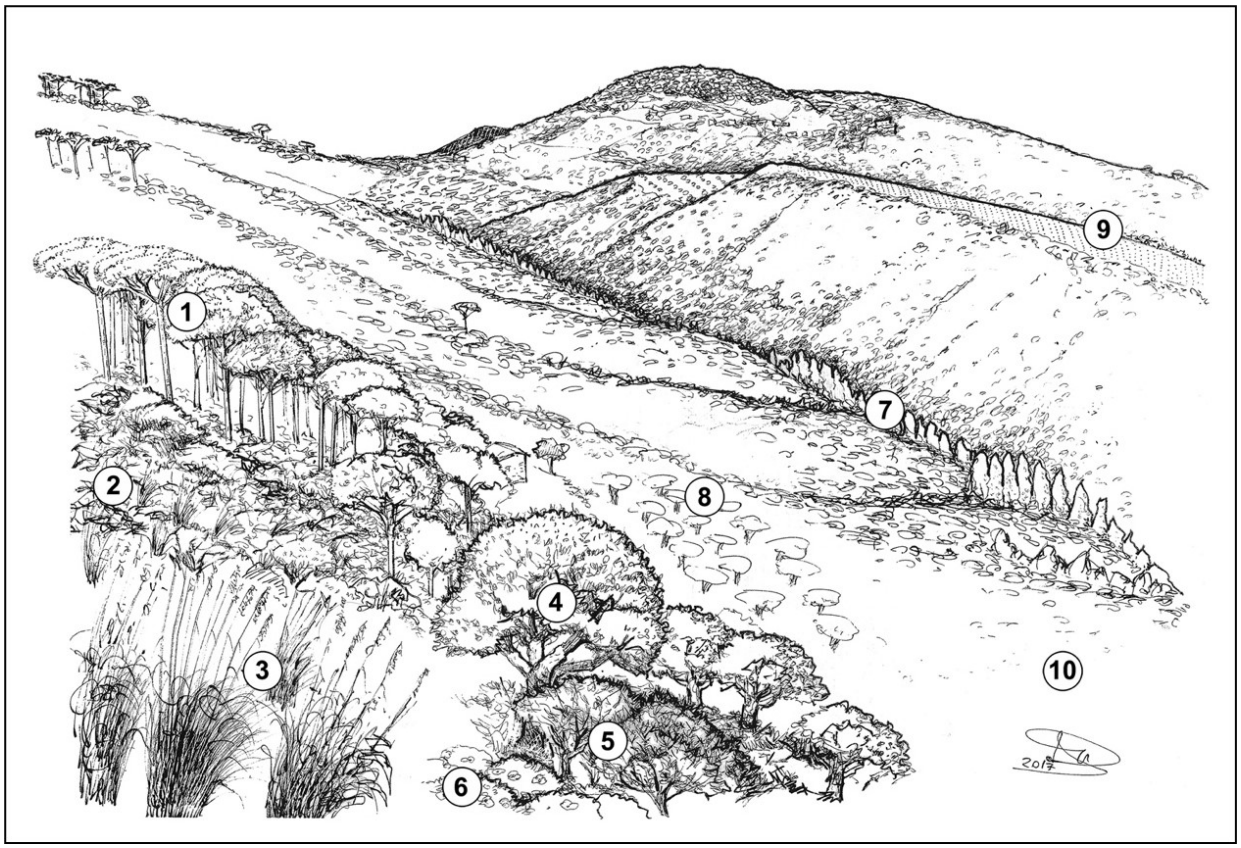



**Figure 19.** NW slope of Bosco di Calatafimi (Sicily): 1) *Pinus pinea* woodland (*Cisto cretici-Pinetum pineae*); 2) *Arbutus unedo* and *Erica arborea maquis* (*Erico-Arbutetum unedonis*); 3) *Ampelodesmos mauritanicus* grassland (*Helictotricho-Ampelodesmetum mauritanici*); 4) *Quercus suber* woodland (*Genisto-Quercetum suberis pistacietosum terebinthi*); 5) *Calicotome infesta* (*Pyro-Calicotometum infestae*); 6) *Cistus salvifolius* garrigue; 7) Riparian vegetation with *Populus nigra* and *Salix alba* (*Salicetum albo-pedicellatae*); 8) Olive grove; 9) Vineyard.



**Figure 20.** Habitat 9540, *Cisto cretici-Pinetum pineae* at "Bosco della Favara e Bosco di Granza" Natural Reserve (Sicily, Italy).

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*Article*

# Contribution to the Ethnobotanical Knowledge of Serre Calabre (Southern Italy)

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**Abstract:** This work presents the results of an ethnobotanical research carried out in the territory of Serre Calabre, province of Vibo Valentia (Calabria, southern Italy). In this territory, the bond between the residents and the rural environment is still strong, because the small urban centers are placed in a predominantly agricultural and forestry environment still managed in a traditional way. The survey took place between January 2019 and July 2021. Data were collected through semi-structured interviews with locals. As many as 17 informants were interviewed and a total of 185 interviews were recorded. Plant specimens were collected under the indication of the informants and then deposited at the herbarium of the Mediterranean University of Reggio Calabria (REGGIO). The data were stored on a digital database and then statistically analyzed some synthetic indexes have also been calculated, such as Relative Frequency of Citation (RFC) and the Cultural Importance Index (CI). The investigation allowed to identify 84 taxa belonging to 39 different families, among which the most represented are Lamiaceae (23 interviews, 9 taxa), Asteraceae (22 interviews, 12 taxa). The identified taxa were prevalently cited for alimentary (46 interviews, 32 taxa) and healing (55, 27) uses. The results obtained show how the traditional knowledge about plants in the Serre Calabre area is still alive, however it is exclusive heritage of elderly people and often only in one or just a few informants. In fact, many practices are no longer in use and will not be transferred to the new generations.

**Keywords:** Biodiversity, Calabria, Cultural Heritage, Ethnobotany, Medicinal Plants, Edible Plants, Plant Conservation

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## 1. Introduction

Ethnobotany is the science that studies the relationships between human beings and the plant world [1]. It deals with collecting and processing all the information about the traditional uses of plants, often related to the culture of a specific geographical area or ethnic group [2-5]. These traditions still survive mainly thanks to oral testimonies [6], handed down from one generation to another, and deserve to be fully recognized as Intangible Cultural Heritage as enshrined in the 2003 UNESCO Paris Convention [7]. Ethnobotany, with its interdisciplinary nature, makes it possible to study the same aspect from different technical and scientific perspectives and to examine complex interactions between human and natural systems [8]. All ethnobotanical knowledge is limited to a small number of people and linked to the perception that the inhabitants of a community have of the environment in which they live: hence, it represents a heritage indispensable for the survival of human societies, but also constantly threatened by the rapid socio-economic changes that accompany the disappearance of rural societies [9]. In Italy, plant and cultural diversity is high, along with the presence of many minor ethnic-linguistic groups such as Frank-Provençals, Occitans, Ladins, Arbërësh and Graecanics [10]

contributing to the great overall richness of the national ethnobotanical knowledge [11,12]. Moreover, the ''Mediterranean diet'', including legumes, cereals, and various vegetables, in addition to fish and other foods, has also been declared by UNESCO as an ''Intangible Cultural Heritage of Humanity'' [13]. The health aspect of the Mediterranean diet applies also to dishes made with wild herbs that are often mixed with typical local products, in diverse recipes and preparations [12,14,15]. Calabria region can be considered an "ecological and social edge" because of the encounter of so many different people in the past (Greeks, Romans, Byzantines, Arabs, Normans, etc.). It is not by chance that the places with the greatest linguistic diversity are also those hosting the greatest biological diversity; consequently, there is also an association between linguistic loss and Traditional Environmental Knowledge (TEK) loss [16]. Moreover, from a socio-economic point of view, Calabria is a region where the rural communities persist, the culture of "subsistence" resists and some archaic customs have been maintained [17]. In recent years, there has been an increase in botanical studies [18,19] and in those ethnobotanical [9,20-23], although the province of Vibo Valentia (central-southern Calabria) is very little investigated [6]. Within this province, the territory of the Serre Calabre was selected as the study area of this research. This is an area where the bond between the residents and the rural environment is still strong and the small urban centers are placed in a predominantly agricultural and forestry environment, still managed in a traditional, extensive way.

The aim of this work is to document the plant lore in the territory of Serre Calabre (Southern Italy), to identify the most frequently used taxa and analyze them quantitatively, in order to contribute to the ethnobotanical knowledge of Southern Italy and guarantee the conservation of this important cultural heritage.

## 2. Materials and Methods

### *2.1. Study area*

The Serre Calabre Massif is located in the southern Apennines, between Sila and Aspromonte. The territory begins at the Limina Pass and ends up at the isthmus of Marcellinara, the narrowest point of the Italian Peninsula, where 35 kilometers separate the Ionian Sea from the Tyrrhenian Sea. The surveys concerned various municipalities, all falling within the administrative province of Vibo Valentia: Vallelonga, Simbario, Brognaturo, Capistrano, Maierato and Nardo di Pace Vecchio. The altitude of the study area ranges between 350 and 900 m a.s.l. (Figure 1).

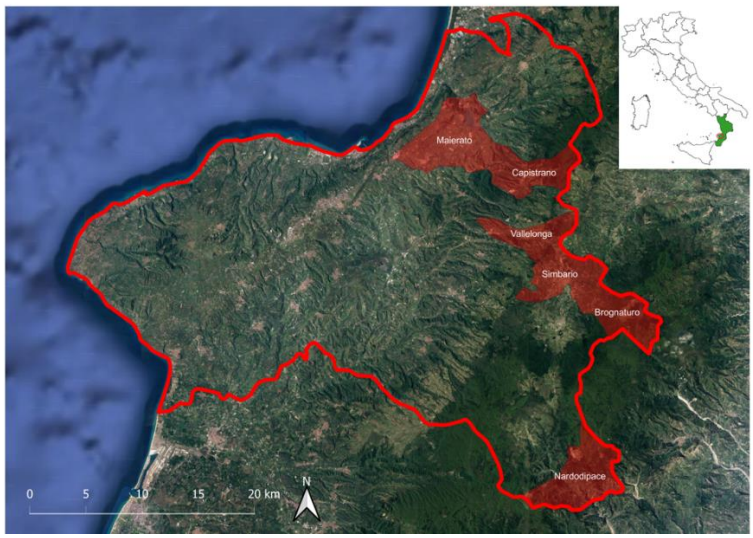



**Figure 1.** Calabria region in the Italian territory and a zoom of the province of Vibo Valentia in which the investigated municipalities (marked in red) fall (Google© 2022).

### *2.2. Ethnobotanical surveys and data collection*

The investigation was carried out respecting the principles of the Code of Ethics of the International Society of Ethnobiology [24]. The survey took place between January 2019 and July 2021, for an amount of 185 interviews. The data were collected through semi-structured interviews with locals, according to Musarella et al. [6]. The information was collected through an emic approach, always considering the point of view of the respondents and therefore the possibility of an unforeseen answer. The interviews have been integrated with samples of plants collected under the indication of the informants, in order to identify the distinctive morphological characteristics of each taxon. As the vernacular name often corresponds to several taxa, similar in the morphological characteristics (at least in the vegetative stage in which they are utilized), it is important to correlate the collected information with the samples object of the interviews. Each interviewed provided information on many taxa and contributed to the compilation of various interviews, and on each taxon often provided information on different uses. Information has been collected on traditional uses of both spontaneous and cultivated plants. Spontaneous plants include those introduced by man for agricultural or forestry purposes. The collected samples were pressed into newspaper sheets and dried up, each with an appropriate label to produce herbarium samples. Subsequently, the samples were identified; for the identification and for the systematic ordering of the taxa, reference was made to the Flora of Italy [25]; the nomenclature of the plant taxa cited in the text is according to The World Flora Online website [26]. Several additional data, such as family, life forms, chorotype, and origin were collected for each taxon during the species list compilation. The life forms and the chorotypes are reported according to Pignatti [27]. To the 9 chorological types proposed by this author, a tenth has been added to bring together the exotic taxa: 10. Alien - Exotic or non-native taxa.

To facilitate further elaborations, based on their origin, the taxa have been grouped into 3 different groups: Native, Alien, and Cryptogenic, according to the Portal of the Flora of Italy [28].

The samples identified, reporting labels with the scientific name, the location, the date, and the habitat of collection, collector and determinator, were deposited at the herbarium of the Mediterranean University of Reggio Calabria (REGGIO, acronym according to [29]). The information collected with the interviews was stored on an electronic database that takes the structure of the interview sheet, using the software "Microsoft Office Access"®. The information was then analyzed and processed statistically with the software "Microsoft Office Excel"®.

The standard interview sheet used for the interviews is divided into 5 sections which are detailed below, according to [6]:

1. The first section regards the informant's personal details (name, surname, age, current and/or past job, location of the interview).
2. The second section regards the names (scientific, Italian common and vernacular) of the plant, the family to which it belongs, the reference number of the herbarium sample and the photos taken, moreover location and period of collection. The vernacular name was provided by the informants during the interviews. The Italian common name was obtained from the Portal of the Flora of Italy [28], while the scientific one from The World Flora Online website [26]: both were found after the interviews.
3. The third section regards the uses and purposes specified in relation to the type of use. Category of use is defined as one of the following general typologies of use: Agro-pastoral, Alimentary, Aromatic, Cosmetic, Domestic, Forage, Handicraft, Ludic, Magical, Medicinal, Ornamental, Religious, Veterinary, Other Uses. It also highlights the used part of the plant (leaves, flowers, etc.), the method of use or administration (e.g.,

infusion, decoction), the techniques and timing of conservation, as well as the origin of the information on the use of the plant, i.e., if it derived from a direct use made by the informants in the present or in the past or learned from other people. This section also deals with the frequency of use of the plant as usual (one or more than one times a week), recurring (one or more than one times a month), casual (few times a year) and rarely (one time a year or more rarely).

4. The fourth section is filled in only if the harvested plant is spontaneous, indicating the habitat in which it grows, its frequency and whether the harvest is for personal use or for business.
5. The fifth section is filled in only if the plant is cultivated, indicating the type of use (personal or for business) and the cultivation technique.

The most anthropological part of the ethnobotanical study also includes eventual place names with botanical references (phytotoponyms or plant place names), the occurrence of plants in myths, legends, rituals, songs, idioms, various cultural practices, etc.

One important aspect of ethnobotanical analysis is the use of quantitative techniques to highlight the importance of traditional uses in the study area. In the present study the following indexes have been calculated:

Relative Frequency of Citation (RFC): it represents how many times each taxon is mentioned by informants. The formula follows the system described by [30]:

$$\frac{FC}{N} \quad (1)$$

where FC is the number of informants who cited a certain taxon and N is the total number of the informants of this study. RFC ranges from zero (when nobody attributes a use for that taxon), to one (when all the informants use that taxon) ($0<RFC\leq1$)

Family Importance Value (FIV): it represents how many times each botanical family is cited by informants, and it is calculated as follows [31]:

$$\frac{FC\ (family)}{N} \times 100 \quad (2)$$

where FC (family) is the number of informants mentioning the family and N is the total number of the informants that took part in this study.

Cultural Importance Index (CI): it is calculated by using the formula suggested in [30]:

$$\frac{UR}{N} \quad (3)$$

where UR is the total number of use citations for each taxon (each interviewed could have done more than one interview for each taxon) and N is the total number of informants.

## 3. Results and Discussion

Seventeen informants were interviewed, 8 men and 9 women, ranging in between 42 and 98 years of age; 7 of them are aged between 40-65 and 10 are aged between 66-99. Most of them are retired and housewives. Elderly women are the main keepers of traditional knowledge in the domain of local food and medicinal plants, while men that mostly worked as farmers and forestry workmen, play an important role in gathering plants for agro-pastoral and handicraft uses. A total of 185 interviews were recorded.

The surveys led to the identification of 84 plant taxa belonging to 39 different families. The complete list with Family, Taxon, Status, Local Vernacular Name, Life forms, Part used, Category of Use, Purpose, FC, RFC, UR, and CI can be found in the Table S1.

Regarding the reported families, were highlighted the most cited (i.e., those with a higher number of interviews) and the most represented, with a higher number of taxa (Table 1).

The most cited and represented families are Lamiaceae (23 interviews, 9 taxa), Asteraceae (22 interviews, 12 taxa), Fabaceae (13 interviews, 7 taxa) and Rosaceae (12 interviews, 6 taxa). The other families recorded less than 10 interviews and less than 4 taxa (Table 1).

**Table 1.** Botanical families reported in alphabetical order with the number of interviews (over a total of 185 interviews) and number of taxa (over a total of 84 taxa) for each.

| Family | Interviews | Taxa |
|---|---|---|
| Adoxaceae | 9 | 2 |
| Anacardiaceae | 2 | 1 |
| Apiaceae | 9 | 2 |
| Apocynaceae | 1 | 1 |
| Araliaceae | 2 | 1 |
| Asparagaceae | 2 | 2 |
| Asteraceae | 22 | 12 |
| Boraginaceae | 5 | 3 |
| Brassicaceae | 1 | 1 |
| Cactaceae | 1 | 1 |
| Caprifoliaceae | 2 | 1 |
| Caryophyllaceae | 1 | 1 |
| Convolvulaceae | 3 | 2 |
| Crassulaceae | 7 | 3 |
| Dennstaedtiaceae | 1 | 1 |
| Dryopteridaceae | 2 | 1 |
| Equisetaceae | 4 | 1 |
| Ericaceae | 8 | 2 |
| Euphorbiaceae | 1 | 1 |
| Fabaceae | 13 | 7 |
| Fagaceae | 3 | 1 |
| Hypericaceae | 2 | 1 |
| Juglandaceae | 2 | 1 |
| Juncaceae | 2 | 1 |
| Lamiaceae | 23 | 9 |
| Lauraceae | 4 | 1 |
| Lythraceae | 2 | 1 |
| Malvaceae | 6 | 1 |
| Myrtaceae | 3 | 1 |
| Oleaceae | 1 | 1 |
| Papaveraceae | 2 | 2 |
| Plantaginaceae | 6 | 3 |
| Poaceae | 9 | 3 |
| Ranunculaceae | 2 | 1 |
| Rosaceae | 12 | 6 |
| Scrophulariaceae | 1 | 1 |
| Thymelaeaceae | 1 | 1 |
| Urticaceae | 6 | 2 |
| Verbenaceae | 2 | 1 |

The most common botanical family, based on the calculated FIV index is Asteraceae with 52.9%, followed by Lamiaceae with 35.3% (Table 2).

**Table 2.** Botanical families reported with the Family Importance Value (FIV) index that represents how many times each botanical family is cited by the informants and FC (Family) is the number of informants mentioning the family.

| Family | FC (Family) | FIV |
|---|---|---|
| Asteraceae | 9 | 52.9 |
| Lamiaceae | 6 | 35.3 |
| Adoxaceae | 5 | 29.4 |
| Fabaceae | 5 | 29.4 |
| Apiaceae | 4 | 23.5 |
| Ericaceae | 4 | 23.5 |
| Malvaceae | 4 | 23.5 |
| Poaceae | 4 | 23.5 |
| Rosaceae | 4 | 23.5 |
| Boraginaceae | 3 | 17.6 |
| Crassulaceae | 3 | 17.6 |
| Urticaceae | 3 | 17.6 |
| Anacardiaceae | 2 | 11.8 |
| Asparagaceae | 2 | 11.8 |
| Convolvulaceae | 2 | 11.8 |
| Hypericaceae | 2 | 11.8 |
| Myrtaceae | 2 | 11.8 |
| Oleaceae | 2 | 11.8 |
| Plantaginaceae | 2 | 11.8 |
| Ranunculaceae | 2 | 11.8 |
| Apocynaceae | 1 | 5.9 |
| Araliaceae | 1 | 5.9 |
| Brassicaceae | 1 | 5.9 |
| Cactaceae | 1 | 5.9 |
| Caprifoliaceae | 1 | 5.9 |
| Caryophyllaceae | 1 | 5.9 |
| Dennstaedtiaceae | 1 | 5.9 |
| Dryopteridaceae | 1 | 5.9 |
| Equisetaceae | 1 | 5.9 |
| Euphorbiaceae | 1 | 5.9 |
| Fagaceae | 1 | 5.9 |
| Juglandaceae | 1 | 5.9 |
| Juncaceae | 1 | 5.9 |
| Lauraceae | 1 | 5.9 |
| Lythraceae | 1 | 5.9 |
| Papaveraceae | 1 | 5.9 |
| Scrophulariaceae | 1 | 5.9 |
| Thymelaeaceae | 1 | 5.9 |
| Verbenaceae | 1 | 5.9 |

Regarding the taxa surveyed, the corresponding life form spectrum (Figure 2) shows the prevalence of Hemicryptophytes (32.5%), followed by Phanerophytes (21.7%).

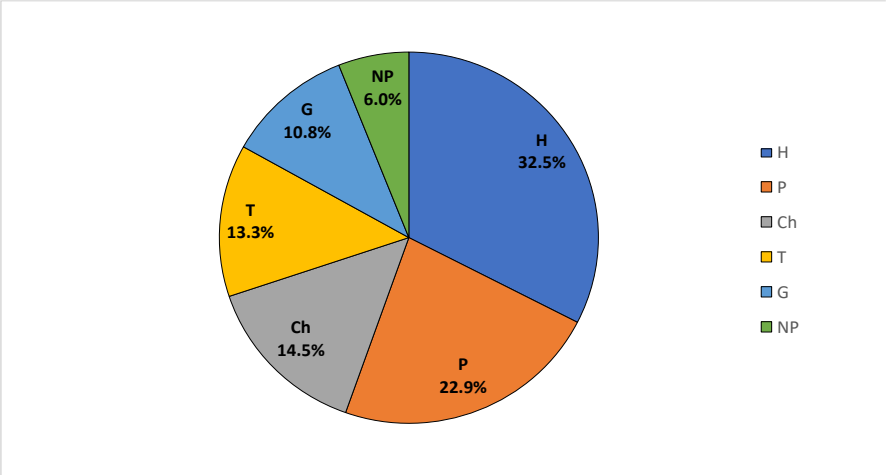



**Figure 2.** Life form spectrum of the taxa recorded from the interviews**.** H- Hemicryptophytes; P- Pharenophytes; Ch- Chamaephytes; T- Therophytes; G- Geophytes; NP- Nanopharenophytes.

The chorological spectrum (Figure 3) shows that the Mediterranean plants are the most represented, on an average, the Mediterranean taxa are about the half of the recorded taxa. In particular, the Stenomediterranean chorotype, represent 28.9% of the total. Also, Eurasian species are highly represented (27.7%) and are more abundant than Euro-Mediterranean ones: this is justified by the fact that the study area has a wetter microclimate in which there are cold, wet winters and hot but not dry summers.

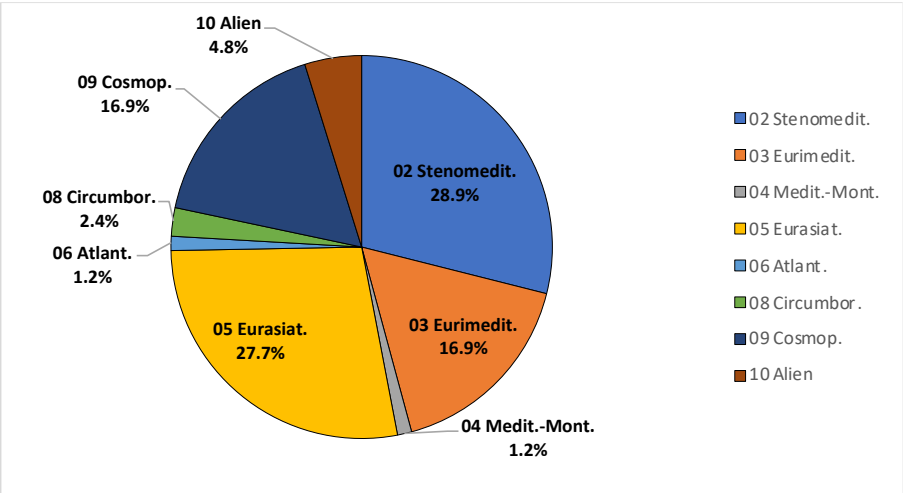



**Figure 3.** Chorological spectrum of the taxa recorded from the interviews. 02 Stenomediterranean - Taxa distributed along the coasts of the Mediterranean; 03 Eurimediterranean - Taxa distributed along the coasts of the Mediterranean but with ample inland irradiations; 04 Mediterranean-Montain - Taxa of the circum-Mediterranean mountains; 05 Eurasiatic - Eurasian taxa; 06 Atlantic - Taxa found on the Atlantic coasts of Europe; 08 Circumboreal - Taxa found in the cold and temperate-cold areas of Eurasia and North America; 09 Cosmopolitan - Taxa widespread in almost all areas of the world and cultivated; 10 Alien - Exotic or non-native taxa.

Concerning the origin, most of the taxa (92.4%) are native, while the alien ones are just 6.5%. In addition to these ones, we identified a very small percentage of cryptogenic (1.1%).

Plants of ethnobotanical interest were collected in 8 different habitats (Figure 4). The following graph shows in which habitat the taxa of ethnobotanical interest are mostly found during the interviews. The taxa of the uncultivated lands, meaning ruderal taxa from marginal areas, courtyards, and roadsides, formed the largest portion (39.1%); in fact, eighty-one out of the 84 taxa grow wild and only three are cultivated, followed by the typical taxa of the Mediterranean scrub (19.0%) and the taxa growing in cultivated and pastures (10.6% each).

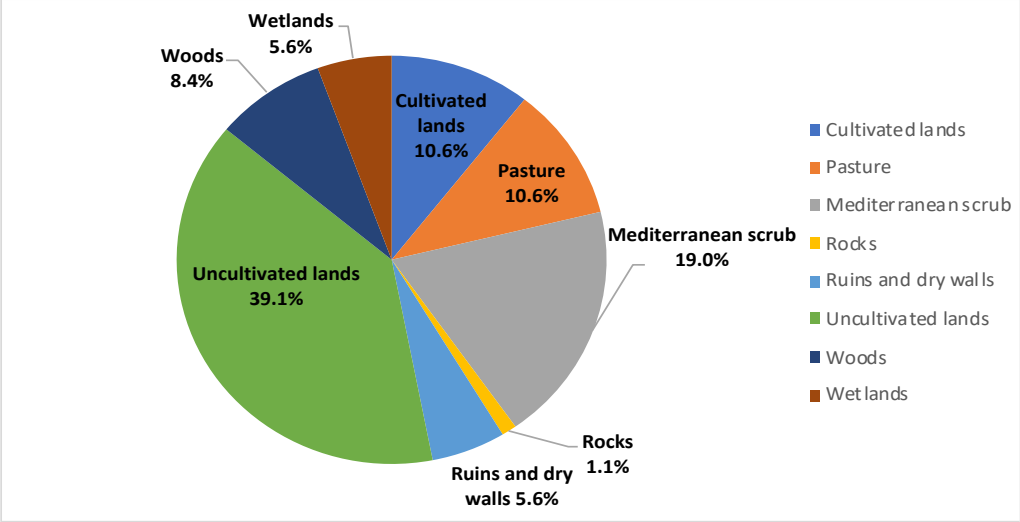



**Figure 4.** Habitats of the taxa recorded from the interviews.

Regarding the used parts of the plants, in general categories of use, the most common parts were leaves (36.4%), followed by flowers (25.0%) (Figure 5).

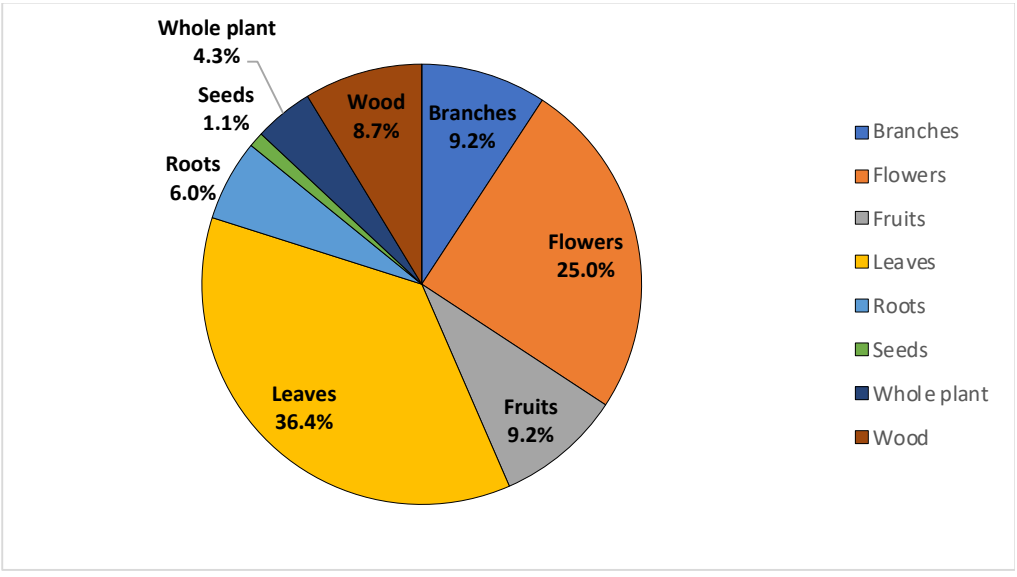



**Figure 5.** Used part(s) of the plants.

The gathering of wild greens is seasonal and therefore the frequency of use of the taxa is reduced to a few times a year (casual e.g., few times a year). Among the identified taxa, the prevalent uses are the alimentary one (46 interviews, 32 taxa), the medicinal one (55, 27); also, the religious (13, 12) and the aromatic ones (15, 8) proved to be remarkably frequent, while the other uses play a minor role (Figure 6). With the term "Other uses" we

intend the ones that do not fall within the general "Category of use" like repellent use and tobacco substitute use.

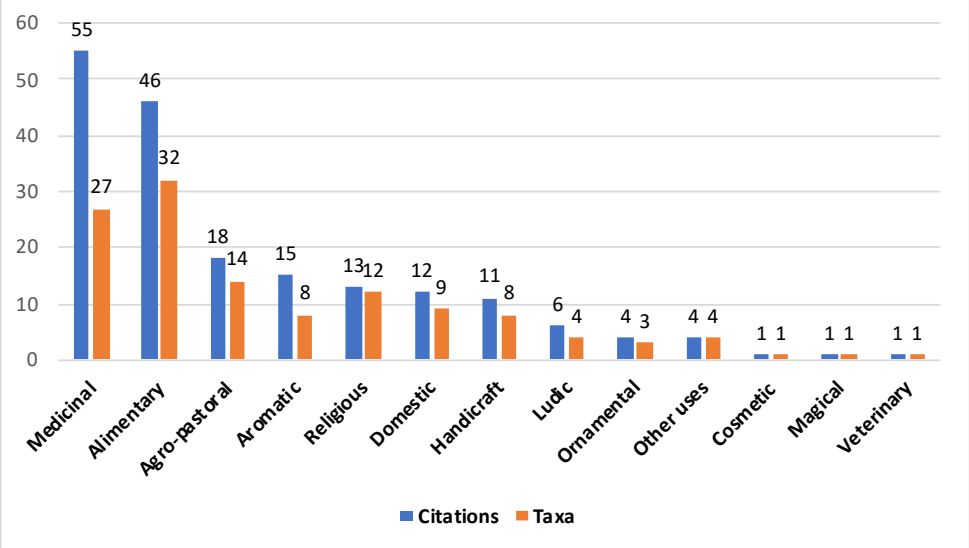



**Figure 6**. Number of citations and taxa for each category of use.

The knowledge on traditional uses of plants was heterogeneous and only 6 taxa were mentioned by three or more informants and only 13 were mentioned by 2 informants (Table 3). This result reflects the unevenness, hence the high risk of disappearance, of specific traditional knowledge in the whole investigated area.

**Table 3.** The knowledge distribution on traditional uses of plants shows the number of taxa known by one or more informants.

| Taxa | Informants mentioning the taxa |
|---|---|
| *Malva sylvestris* L. | 4 |
| *Sambucus nigra* L. | 4 |
| *Ampelodesmos mauritanicus* (Poir.) T. Durand & Schinz | 3 |
| *Erica arborea* L. | 3 |
| *Matricaria chamomilla* L. | 3 |
| *Spartium junceum* L. | 3 |
| *Anethum foeniculum* L. | 2 |
| *Calystegia silvatica* Griseb. | 2 |
| *Clematis vitalba* L. | 2 |
| *Daucus carota* L. | 2 |
| *Genista monspessulana* (L.) L.A.S.Johnson | 2 |
| *Hypericum perforatum* L. | 2 |
| *Myrtus communis* L. | 2 |
| *Picris hieracioides* L. | 2 |
| *Pistacia lentiscus* L. | 2 |
| *Prunus spinosa* L. | 2 |

| | |
|---|---|
| *Sedum cepaea* L. | 2 |
| *Thymus longicaulis* C.Presl | 2 |
| *Urtica dioica* L. | 2 |

The most mentioned taxa were *Malva sylvestris* L. and *Sambucus nigra* L. (4 informants each), as shown in the Table 5 (Basic value FC), that reports the results of quantitative analysis for the 20 most relevant and useful taxa in the area, as cited by the informants. While FC represents the number of informants mentioning the taxon, UR considers the number of interviews or citations. Indeed, rating UR, besides *M. sylvestris* and *S. nigra*, also *Ampelodesmos mauritanicus* (Poir.) T. Durand & Schinz, *Erica arborea* L. and *Matricaria chamomilla* L. had the highest number of interviews. *Malva sylvestris* was cited 6 times for the same medicinal use that will be discussed later. The taxa with a higher number of completely different uses (U) are: *Urtica dioica* L. (4), *A. mauritanicus* (4) [32], *S. nigra* (4), *Lavandula angustifolia* Mill. (3), *Laurus nobilis* L. (3), *Robinia pseudoacacia* L. (3), *Myrtus communis* L. (3) and *Spartium junceum* L. (3) (Table 4).

**Table 4.** Most recurrent taxa sorted by Relative Frequency of Citation (RFC).

| | Basic value | | | | Indices | |
|---|---|---|---|---|---|---|
| **Taxa** | **UR** | **U** | **NC** | **FC** | **CI** | **RFC** |
| *Sambucus nigra* L. | 7 | 4 | 5 | 4 | 0.41 | 0.24 |
| *Malva sylvestris* L. | 6 | 1 | 4 | 4 | 0.35 | 0.24 |
| *Erica arborea* L. | 7 | 2 | 6 | 3 | 0.41 | 0.18 |
| *Ampelodesmos mauritanicus* (Poir.) T. Durand & Schinz | 6 | 4 | 5 | 3 | 0.35 | 0.18 |
| *Matricaria chamomilla* L. | 6 | 2 | 4 | 3 | 0.35 | 0.18 |
| *Spartium junceum* L. | 3 | 3 | 3 | 3 | 0.18 | 0.18 |
| *Urtica dioica* L. | 5 | 4 | 4 | 2 | 0.29 | 0.12 |
| *Anethum foeniculum* L. | 5 | 2 | 5 | 2 | 0.29 | 0.12 |
| *Daucus carota* L. | 4 | 2 | 4 | 2 | 0.24 | 0.12 |
| *Lavandula angustifolia* Mill. | 5 | 3 | 5 | 1 | 0.29 | 0.06 |
| *Equisetum telmateia* Ehrh. | 4 | 2 | 3 | 1 | 0.24 | 0.06 |
| *Umbilicus rupestris* (Salisb.) Dandy | 4 | 1 | 3 | 1 | 0.24 | 0.06 |
| *Laurus nobilis* L. | 4 | 3 | 4 | 1 | 0.24 | 0.06 |
| *Robinia pseudoacacia* L. | 3 | 3 | 3 | 1 | 0.18 | 0.06 |
| *Hypochaeris radicata* L. | 3 | 1 | 3 | 1 | 0.18 | 0.06 |
| *Mentha pulegium* L. | 3 | 1 | 3 | 1 | 0.18 | 0.06 |
| *Plantago major* L. | 3 | 2 | 3 | 1 | 0.18 | 0.06 |
| *Quercus ilex* L. | 3 | 2 | 3 | 1 | 0.18 | 0.06 |
| *Rosa sempervirens* L. | 3 | 2 | 3 | 1 | 0.18 | 0.06 |
| *Salvia officinalis* L. | 3 | 2 | 3 | 1 | 0.18 | 0.06 |

[1] Basic values: UR = Number of interviews ('citations'); U= Number of different categories of use. NC = Number of different purposes; FC = Number of informants mentioning the taxon. Indexes: CI = Cultural Importance Index.

Highest RFC was obtained for *S. nigra* and *M. sylvestris* (RFC=0.24) that result to be the most used taxa; also, *S. nigra,* together with *E. arborea,* are the most culturally significant (CI=0.41). *Erica arborea* is also the taxon with the highest number of completely different uses, considering the purposes of each use (NC=6). When considering the purposes of each use, the medicinal category is the one that have the greatest number of different purposes (24), followed by the handicraft and aromatic ones (10) (Figure 7).

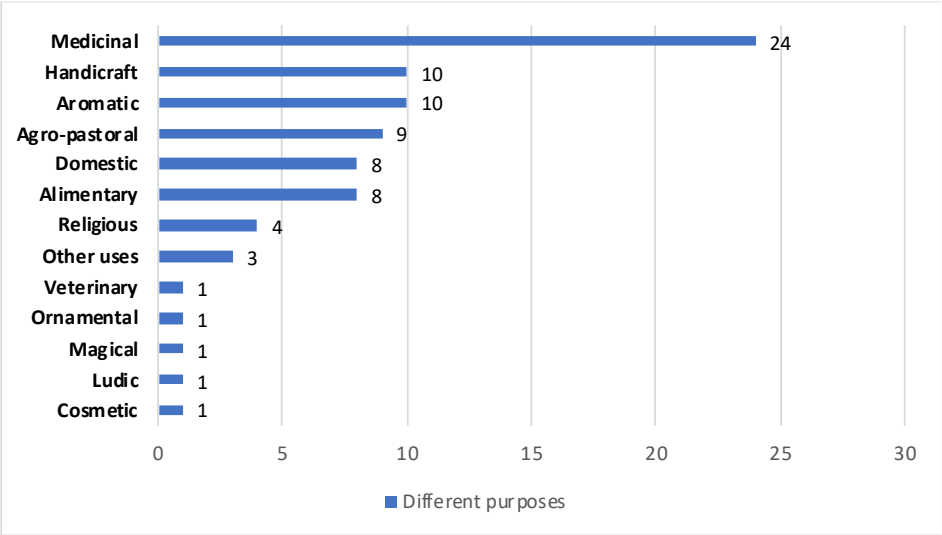



**Figure 7**. Number of purposes for each category of use.

### *3.1. Medicinal plants*

Within the medicinal category, among the 27 taxa identified, the most cited are *M. sylvestris*, *M. chamomilla*, *S. nigra* and *Umbilicus rupestris* (Salisb.) Dandy (Figure 8). Seven taxa were cited to treat pain and 6 were cited as anti-inflammatory, purifying and calming purposes: most of them were boiled in infusion or decoction (Figure 9). The flowers of *M. chamomilla* were the most used to treat general pain, in infusion with the leaves of *L. nobilis* to treat abdominal ailments; this practice survives and is still used today. The roots of *M. sylvestris*, with dry figs added to sweeten, were used in decoction with anti-inflammatory purposes both for gastric problems and inflammation of the teeth and mouth; regarding this use, it was found a popular proverb that recites: *"eppe la bronchita e mi guarivi cu li malohj gugghjuti, mi dozzeru li dienti e mi passaru cu la malohjia; quandu mi vene la cimorra mi pigghju nu tazzoni de maluohj; chi borrissi de chju?"* (English version: "I had bronchitis, and I was cured with cooked mallow, my teeth ached, and I was cured with mallow, when I have a cold, I drink a cup of mallow; what else do you want?").

Dry flowers of *S. nigra* were infused and applied to soothe red eyes or in case of conjunctivitis and in decoction to purify the kidneys; these uses, and plants are commonly shared in the traditional medicine of Calabria and Sicily (see [9,33] for Calabria; [34-35] for Sicily). Fresh leaves of *U. rupestris* were used to heal cyst, pimples, calluses and the locally so-called "giraditu". i.e., an inflammation of the fingers; the same use is also reported for the Reventino Massif area (Central Calabria) [9]. Another taxon whose fresh leaves are used for the same topical purpose, is *Cotyledon orbiculata* L.: the leaves are heated and peeled, i.e., deprived of the superficial epidermis and used to heal cyst. Until today, this use was unknown for Calabria: in fact, no other information was found in regional literature; the same use was found in the work of Camangi & Tomei [36] that investigated the province of Livorno (Tuscany, Northern Italy). Among the 55 interviews, 35 reported boiling as preparation method; on the contrary, according to Hadjichambis et al. [37], the species perceived as healthy were consumed raw more often than cooked. The

same plant taxa might be consumed cooked in one season and raw in another season (e.g., tender shoots vs. old leaves) [12].

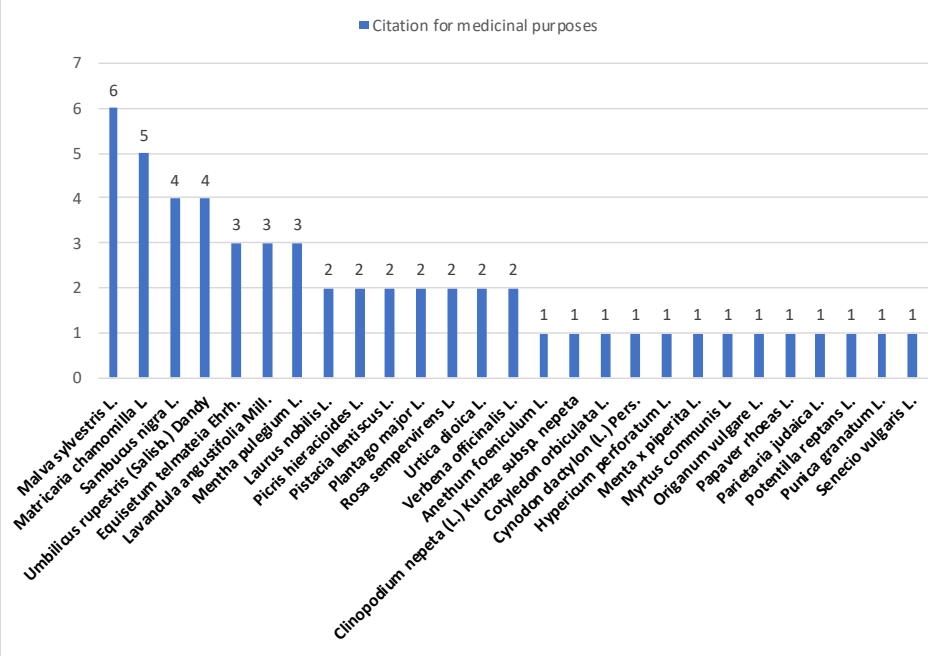



**Figure 8.** Most cited taxa for medicinal purposes.

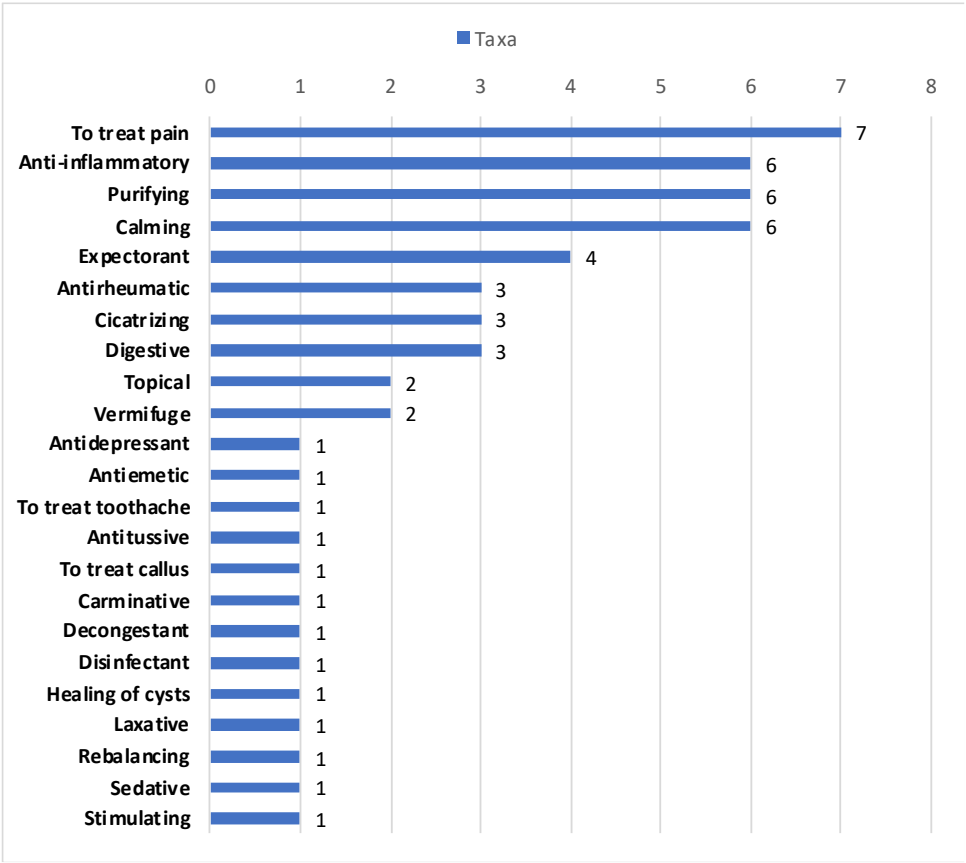



**Figure 9.** Number of medicinal taxa used to treat various ailments.

### *3.2. Alimentary plants*

Among the alimentary use, most of the informants use the taxa for side dishes and rural snacks (Figure 100).

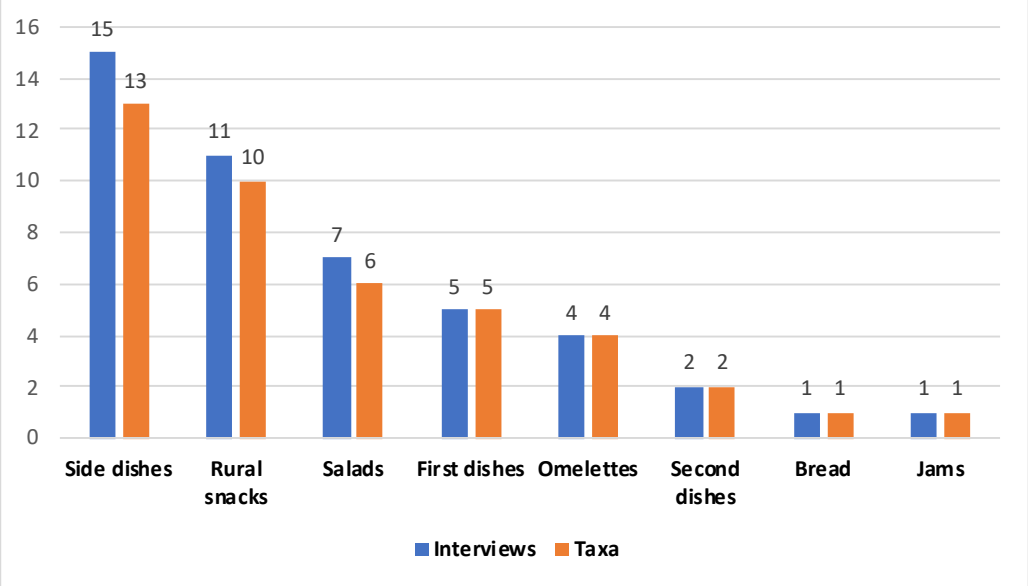



**Figure 10.** Number of interviews and taxa for each purpose of the alimentary category of use.

The most mentioned alimentary taxa were: *Borago officinalis* L., *Daucus carota* L., *Galactites tomentosus* Moench, *Hypochaeris radicata* L. (3 mentions each). The leaves that, usually, are harvested in spring and consumed at the juvenile stage, are mostly boiled, or consumed raw, alone or in association with other vegetables, as side dishes. *Borago officinalis* is according to Ghirardini et al. [38] the most quoted taxa in both the Southern and the Northern Italian sites. Also, Tavilla et al. [39] report numerous food uses of *B. officinalis*. Moreover, in the present study were also reported alimentary uses for *Asparagus acutifolius* L. and *Cichorium intybus* L., that are the most quoted wild food taxa in Southern Italy along with *Anethum foeniculum* L. (= *Foeniculum vulgare* Mill. subsp. *vulgare*), *Reichardia picroides* (L.) Roth and *Sonchus* spp., according to Ghirardini et al. [38]. Regarding our study, *A. foeniculum* appears only in the aromatic category of use, in which it Is the most cited taxon. *Anethum foeniculum* was cited between the most common 16 taxa in Italy concerning the aromatic use, due to its phytochemical profile (the ability to stimulate the excretion of digestive enzymes, carminative properties) [40]. *Sonchus asper* (L.) Hill and *Crepis biennis* L. are both referred with the same vernacular name as "Jùncu", and were cooked the same way (boiled) as well as *C. intybus*, *H. radicata*, and *Hypochaeris laevigata* L. Many taxa of the Asteraceae family are referred to by the vernacular name "Cicuori" as well as "Jùncu"; all of them are more or less bitter herbs, consumed as cooked vegetables, collected at the stage of basal rosette, and often found in different types of agricultural and marginal environments. *Cichorium intybus*, *S. asper* and *Picris hieracioides* L. are widely used all over Calabria as edible but also as medicinal plants according to Marrelli et al. [41], who studied the phytochemical content of these taxa. In the present work, *P. hieracioides*, was mentioned only in the medicinal category of use: the leaves reduced to mush were applied to wounds to cicatrize. Also, *H. radicata* and *H. laevigata* are known to be used traditionally both in the alimentary and in the medicinal category of use in Southern Italy [9,12,42]; their phytochemical content and bioactivity, together with *Hyoseris radiata* L., and *Hyoseris lucida* subsp. *taurina* (Pamp.) Peruzzi & Vangelisti, was studied and compared to fresh plant materials and residual blanching water by Sicari et al. [43]. The results of this study demonstrated the healthy effect of these wild plants, and that the blanching water should be repurposed in food preparation. In fact, because it is a

good source of bioactive compounds, its consumption should be recommended to increase the absorption of micronutrients.

Among the 46 interviews, 24 reported cooking (boiled) as preparation method. In a study carried out in seven countries over the Mediterranean area [37], the predominant preparation method for leafy vegetables greens is cooking (54%) [10]. Ten taxa have been pointed out as "rural snacks", probably because most of the informants worked closely to the natural environment and picked up the fruits directly from the plant, for example *Arbutus unedo* L., *Prunus spinosa* L. and *Rubus ulmifolius* Schott. The same use has also been found in the Peloritani Mounts (NE Sicily) [39]. Many vegetable food products contain a high concentration of polyphenols (e.g., [44,45]), but also flavonoids (e.g., [46,47]) and omega3 fatty acids [12,48]. It is the case of *A. foeniculum, U. dioica, B. officinalis, H. radicata, A. acutifolius*.

According to Jordana [49], to be traditional, a product must be linked to a territory, and it must also be part of a set of traditions, which will necessarily ensure its continuity over time. Many wild edible plants reported in this study can be defined as food–medicine due to the presence of different classes of natural products (e.g., [50-52]) or active compounds (e.g., [53-55]). Since several of these molecules have antioxidant properties and are contained in large quantities in vegetables, the role of these plants in the diet has been reevaluated [12]. Moreover, wild food species contribute to local food systems and to the local gastronomy, playing an important role in the economy of small communities [40].

### *3.3. Religious plants*

The informants have reported 10 taxa as being used for various religious rituals, like to decorate the villages' streets during religious processions like *Anchusella cretica* (Mill.) Bigazzi, E. Nardi & Selvi, or like torches (*Verbascum thapsus* L.) or small candle floating on water (*Pseudodictamnus mediterraneus* Salmaki & Siadati) (Figure 11), especially during the Easter period. *Hypericum perforatum* L. was reported for a specific religious use: on June 24, St. John's Day, it was customary to collect it as a gift to friends in order to establish or reinforce fraternal bonds.



**Figure 11.** *Pseudodictamnus mediterraneus* Salmaki & Siadati. The calyx of flowers was used as small candle floating on water.

### *3.4. Agro-pastoral plants*

Fourteen interviews contained information concerning agro-pastoral use: among them, there are 7 different purposes. A very peculiar use concerns *Euphorbia lathyris* L. (Figure 12): in the past it was a very common plant species, used for several purposes in southern Italy and Sicily [56]. In the territory of the Serre Calabre, *E. lathyris* is still used as a mole ("surici uòrvu" = blind rat) repellent by planting it in their burrows: it was noted that during seeds production, moles leave them.



**Figure 12.** *Euphorbia lathyris* L. with fruits used as mole repellent.

Another interesting purpose among agro-pastoral uses regards *Daphne gnidium* L.: the roots were used in the past for the illegal fishing of eels ("angide"). Similar uses were found in numerous papers regarding Sardinia, Sicily, and other Italian regions [57-60].

A typical agro-pastoral use is to make ropes, ties, and cattle collars with the stems of *A. mauritanicus* (Figures 13 a,b); the same use has been found in several works concerning the southern Italian area [39,61-63].



**Figure 13.** (a) Rope and (b) tie for *Vitis vinifera* L. made with stems of *Ampelodesmos mauritanicus* (Poir.) T. Durand & Schinz.

### *3.5. Most culturally significant taxa*

#### 3.5.1. *Sambucus nigra* L.

As already illustrated, in addition of being the most used taxon, the elder is also the most culturally significant: indeed, the informants provided 4 different categories of use for it: medicinal, aromatic, domestic and handicraft. The medicinal category of use was cited 4 times and as already described in the previous paragraphs, it concerned the flowers, also used to flavor the bread in a typical preparation of the area, called "Pitta de fiuri" or "Pitta china". The bread is filled with hot pepper, anchovies, olives, and onion. The fruits were used to extract ink and to color the homemade soap.

#### 3.5.2. *Erica arborea* L.

This taxon registered the highest number of different purposes (6) within two different categories of use: domestic and handicraft. The roots, collected and cleaned, are still used today to make jewelry and pipes by local artisans. During the study it emerged that this is the only taxon collected for commercial purposes and not only for personal and family uses. The artisanal creation of pipes with the briar root of *E. arborea* is a traditional peculiarity of Serre Calabre area, which over time has become a real commercial activity aimed at a market niche that refers to fans of this way of smoking. To make pipes the briar is boiled and left aside for 20 years and then it is carved. The tree heath produces lignotubers that are highly valued for making smoking pipes also in the Peloritani Mountains of northeastern Sicily as reported by La Mantia et al. [64]. The wood is also used to make traditional musical instruments. With this aim, it is dried for 10 years and then carved to make the melody reeds of the bagpipe known in Calabria as "zampogna". A very similar use was found in [39] where *E. arborea* wood is used to make the different parts of the "ciaramedda" (bagpipe). Regarding this taxon, it was found a popular proverb that recites: *"Quandu hjiure la bruvera, arrivau la vera primavera"* (english version: "When the tree heat blooms, the true spring has arrived"). Moreover, the branches were used to make kitchen tools and like a rudimentary broom to clean the outside yard and as firewood for the oven to prepare homemade bread together with

*Fraxinus ornus* L. (vernacular name: *mijriu*), *Pistacia lentiscus* L. (*scinu*) and *Quercus ilex* L. (*ilici*) A popular proverb about the firewood use was reported by informants: "*Io su lu scinu e fazzu lu luci finu, io su lu mijriu e cchiu finu lu fazzu io, io su l'ilici gravu pe tridici e ajrumu pe quattuardici*" (English version: I am the mastic tree and I make the fire weak, I am the manna tree and I make it weakest, I am the evergreen oak and I weigh for thirteen and I heat for fourteen").

## 4. Conclusions

The results obtained show how the traditional knowledge about plants in the Serre Calabre area is still alive, both in terms of uses and in terms of vernacular names, rhymes, proverbs, and rituals. However, it is exclusive heritage of elderly people who have grown up following the rhythm of nature and in close contact with their land, where they have learned to take advantage of all the resources it can offer. They saw nature not only as the main survival source, but also as a stimulus for creativity, from simple games for children up to handicrafted works. This information is often reported only by one or few informants, as suggested by the large number of plants cited by fewer than 3 informants. Moreover, many practices are no longer in use and survive only as memories or in the form of family lexicon and small daily habits. The change in lifestyle has meant that, even in small countries and rural environments such as those studied, this information is no longer transmitted to the new generations, and the people interviewed are not aware of the huge patrimony of which they are the last holders. Concerning the traditional phytotherapeutic remedies, they were more popular and widespread in the past when medicines were not easily available. On the contrary, in addition to being the most cited category of use, the alimentary use is still popular, with several edible wild plants used both as delicacies and as the ingredients of local specialties.

This work involved a few municipalities in the study area: deepening the work could be the beginning of a larger research in this territory which is still very little investigated from this point of view. In agreement with Gracia et al. [65], the diversification of production using such resources could be a socio-economically sustainable activity in areas with non-optimal farming conditions by contributing to population stabilization in rural areas.

In conclusion, this study has the purpose to preserve this knowledge as a cultural heritage that characterizes the identity of the territory, and make sure it will not be lost; highlighting, where possible, taxa of value and suggesting scientific insights for little-known taxa in relation to their use.

**Supplementary Materials:** The following are available online at www.scipublications.com/xxx/s1, Table S1: List of the taxa of ethnobotanical interest recorded in the Serre Calabre territory. Status: C (cultivated), W (wild). FC: number of informants who cited a certain taxon; RFC: Relative Frequency of Citation; UR: total number of use citations for each taxon; CI: Cultural Importance Index.

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# The Assessment and the Within-Plant Variation of the Morpho-Physiological Traits and VOCs Profile in Endemic and Rare *Salvia ceratophylloides* Ard. (Lamiaceae)

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**Abstract:** *Salvia ceratophylloides* (Ard.) is an endemic and rare plant species recently rediscovered as very few individuals at two different Southern Italy sites. The study of within-plant variation is fundamental to understand the plant adaptation to the local conditions, especially in rare species, and consequently to preserve plant biodiversity. Here, we reported the variation of the morpho-ecophysiological and metabolic traits between the sessile and petiolate leaf of *S. ceratophylloides* plants at two different sites for understanding the adaptation strategies for surviving in these habitats. The *S. ceratophylloides* individuals exhibited different net photosynthetic rate, maximum quantum yield, light intensity for the saturation of the photosynthetic machinery, stomatal conductance, transpiration rate, leaf area, fractal dimension, and some volatile organic compounds (VOCs) between the different leaf types. This within-plant morpho-physiological and metabolic variation was dependent on the site. These results provide empirical evidence of sharply within-plant variation of the morpho-physiological traits and VOCs profiles in *S. ceratophylloides*, explaining the adaptation to the local conditions.

**Keywords:** gas exchanges; leaf mass area; rare species; *Salvia ceratophylloides* Ard.; VOC; within-plant plasticity

## 1. Introduction

*Salvia ceratophylloides* Ard. is a perennial herbaceous species endemic to Southern Calabria, Italy, which was declared extinct in 1997 [1] and recently rediscovered a hundred mature individuals distributed in two sites, 2 Km apart, around the Reggio Calabria hills [2,3]. Nowadays, the *S. ceratophylloides* populations are threatened with extinction because of the habitat modification and destruction by wild urbanization and agriculture [3]. Spread of alien species, such as *Cascabela thevetia*, *Ipomoea setosa* subsp. *pavonii*, and *Tecoma stans*, favored by climate change, establishes an additional threat factor [4,5]. Despite its vulnerability, no quantitative information on the morphological and ecophysiological traits of *S. ceratophylloides* are available, although they are pivotal for understanding the habitat requirements for the conservation of the endemic species.

The viability of endangered and rare species, such as *S. ceratophylloides*, depends on their capability to maintain or even increase their fitness under short- and/or long-term continuous climate change. Because of its rarity, this endemic species usually pointed out specific and narrow habitat requirements suggesting that their responses must occur only

in the actual habitat determining local adaptation through phenotypic plasticity and/or genetic variation [6].

Although the results sometimes appeared conflicting, the plant phenotypic plasticity assumed a significant role in the viability of rare and endangered species. For example, Noel et al. [7] observed a high degree of phenotypic plasticity that conferred an increase of the fitness in *Ranunculus nodiflorus* Ten. suggesting the maintenance of the micro-environment heterogeneity as a habitat-based strategy for its conservation. On the contrary, Westerband et al. [8] observed low phenotypic plasticity in response to drought stress in *Schiedea obovate* (Sherff) W.L. Wagner & Weller, an endangered, endemic Hawaiian shrub, showing a high risk of extinction in the future climate change scenarios. Based on earlier works of the Winn [9,10] and De Kroon's hypothesis [11], which dealt with plant phenotypic variation at sub-individual level (i.e., organ or module), the 'within-plant' rather than "among-plant" phenotypic variation could represent the major source of population-level diversity in several functional traits [12,13]. Recent works pointed out the multiple ecological aspects of the 'within-plant variation' such as the improvement of the exploitation of the heterogeneous-distributed resource [14,15], the adaptation to biotic and biotic gradients [16], the spreading of the ecological breadth of species and individuals [17,18], the increase of the functional diversity of populations [17], and the alteration of plant-antagonist interactions [19–22]. However, no quantitative characterization of the within-plant variation in endangered and rare plant species has been assayed yet.

In this respect, we started a two-year field study (2016–2017) to characterize the *S. ceratophylloides* through a leaf-level morpho-ecophysiological and metabolic approach from its natural habitat. In particular, this species exhibited a leaf morphology characterized by contemporary presence (petiolate leaf) and the absence of petiole (sessile leaf) in the basal and upper part of the shoot, respectively, suggesting a potential within-plant variation. Furthermore, individuals of this species were in two different sites, at a distance of <2 km from each other and preliminary results by SSR, pointed out that the populations of *S. ceratophylloides* exhibited a low level of genetic variability between the two populations [23] and indicating the phenotypic plasticity is the main driver for the local adaptation. In particular, we focused on the photosynthetic performances as a marker of tolerance and growth of species to predict the optimum habitat conditions for the conservation of rare species [24] but also to provide the capacity of plant adaptation to new conditions associated with climate change and the likely changes in plant communities [25]. Further, we considered the leaf mass per area (LMA) as a morphological trait strictly correlated with the functional syndrome and consequently to plant growth and development and, ultimately, plant fitness [26]. Simultaneously, the metabolic profiles of volatile organic compounds (VOCs) could provide information on the plant status and the plant-, microbial- and arthropode-plant communications [27]. The evaluation of all these functional traits could offer useful information for effectively promoting translocation and mitigation operations to restore *Salvia ceratophylloides* rare plant species.

In this framework, the present study was addressed to assess the morpho-ecophysiological and metabolic traits of *S. ceratophylloides* from its natural habitat and investigate the following questions: (1) does the within-plant variation of the photosynthetic performance, morphological traits, and metabolic profiles occur? (2) is the within-plant morpho-physiological and metabolic variation of *S. ceratophylloides* modified between the two localities?

## 2. Results

### *2.1. Physiological Performances and Morphological Traits of S. ceratophylloides*

The net photosynthetic rate ($P_N$) and the photosynthetic photon flux density (I) curves of *S. ceratophylloides* leaves were well-fitted ($R^2 > 0.95$ and $p < 0.05$) and –described by Ye mathematical model [28] (Figure 1). The parameters estimated by non-linear regression have been reported in Table 1. As observed, the leaf type produced a significant and strong effect on most photosynthetic parameters. In particular, the sessile leaves

showed a higher $I_{sat}$ (1578 µmol(photon) $m^{-2}$ $s^{-1}$), $I_{max}$ (766 µmol(photon) $m^{-2}$ $s^{-1}$), $P_{Nmax}$ (11.22 µmol($CO_2$) $m^{-2}$ $s^{-1}$) and $\phi_{(I_0-I_{comp})}$ (0.030 µmol($CO_2$) µmol(photon) $^{-1}$) level than petiolate ones which showed a lower dark respiration rate ($R_D$) (0.69 µmol($CO_2$) $m^{-2}$ $s^{-1}$). This pattern was observed in both sites except for the $P_{Nmax}$, which was statistically different between the two leaf types in relation to the site ($p < 0.05$ LT × Sit interaction, Table 1): the petiolate leaves (6.85 µmol($CO_2$) $m^{-2}$ $s^{-1}$) showed a lower value of $P_{Nmax}$ respect to the sessile ones (19.70 µmol($CO_2$) $m^{-2}$ $s^{-1}$) at Mo site. Further, the significant LT × Sit interaction observed for the $I_{comp}$ and $R_D$ indicated that the parameters difference between the leaf types was affected by the site factor. Indeed, the $I_{comp}$ of the sessile leaf was higher than petiolate ones (8 vs. 22 µmol(photon) $m^{-2}$ $s^{-1}$) at Mo site only, and the same pattern was observed for the $R_D$ (0.53 vs. 1.40 µmol($CO_2$) $m^{-2}$ $s^{-1}$) (Table 1).

The comparisons of the $I_{sat}$ and $I_{comp}$ of *S. ceratophylloides* with those of different functional plant groups are shown in Figure S1. The minimum $I_{sat}$ value of *S. ceratophylloides* fell between that of schlerophylls in habitat at a high light intensity and heliophytes, while the maximum one was within the range between heliophytes and C4 plants. The minimum $I_{comp}$ value of *S. ceratophylloides* was between epiphytes and spring geophytes, while the maximum was between spring geophytes and heliophytes.

The stomatal conductance and transpiration rate of both leaves of *S. ceratophylloides*, measured at 200 and 800 µmol(photon) $m^{-2}$ $s^{-1}$ corresponding to the light intensities around to the $I_{max}$ values of the P and S leaves, respectively, are reported in Tables 2 and 3. Like photosynthetic pattern, the P leaves pointed out a significantly lower stomatal conductance and transpiration rate than S at both light intensities. However, this effect was different between the sites ($p < 0.01$ for LT × Sit interaction, Tables 2 and 3): the S leaves showed higher levels of the stomatal conductance and transpiration rate with respect to the P ones only in the Mo site while any difference between the leaf type has been produced in Pu site. The site's effect was highly significant ($p < 0.001$, Tables 2 and 3) for both ecophysiological parameters, evidencing higher values for the Mo site than Pu.

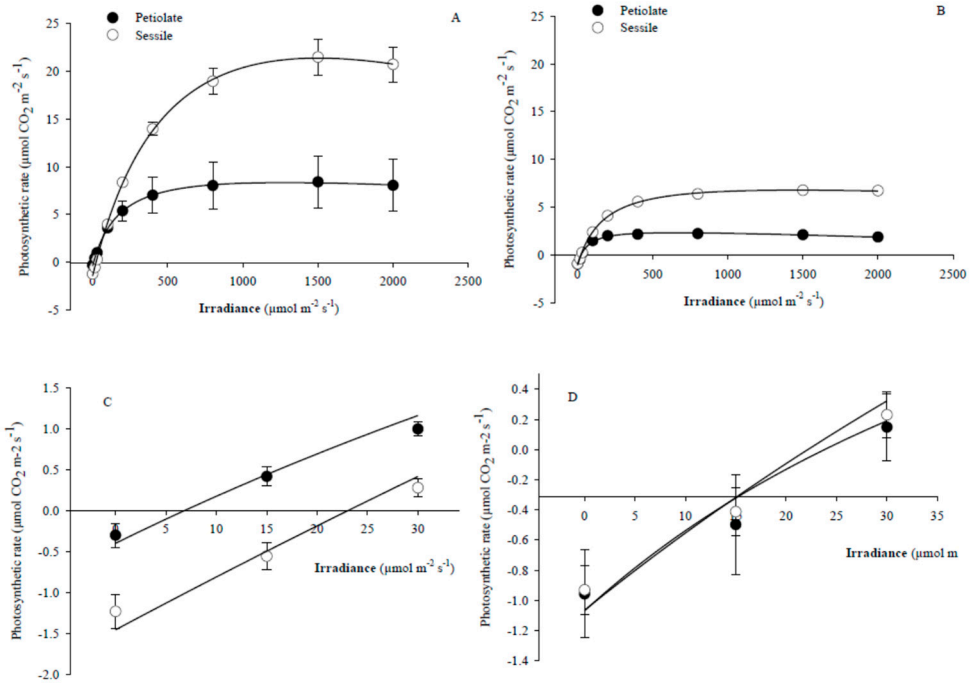



**Figure 1.** Leaf photosynthetic light-response curves measured on petiolate (•) and sessile leaves (○) of the *Salvia ceratophylloides* at (**A**,**C**) Mosorrofa site (Mo) and (**B**,**D**) Puzzi site (Pu). The (**C**,**D**) panels showed the curves at the lowest irradiance values. Data points represent means ($n$ = 4–9). Light curves have been fitted by non-linear regression using the Ye et al. model [28].

**Table 1.** Leaf-level photosynthetic parameters of different leaf types (P: petiolate; S: sessile) of *Salvia ceratophylloides* individuals of two sites (Mosorrofa, Mo; Puzzi, Pu) estimated by non-linear regression using the Ye et al. model [28]. Different lower-case letters represent significant differences at $p < 0.05$ among the average within the column (Tukey's test). Different capital case letters represent statistically significant differences among the means along the rows ($p < 0.05$, Tukey's test).

| | | Site (Sit) | | |
|---|---|---|---|---|
| | **Leaf Type (LT)** | **Mo** | **Pu** | **Leaf Type Average** |
| $I_{comp}$ [μmol(photon) $m^{-2}$ $s^{-1}$] | P | $8^{b}$ | $26^{a}$ | $18^{x}$ |
| | S | $22^{a}$ | $22^{a}$ | $22^{x}$ |
| | Site average | $16^{A}$ | $23^{A}$ | |
| $I_{max}$ [μmol(photon) $m^{-2}$ $s^{-1}$] | P | $312^{b}$ | $310^{b}$ | $311^{y}$ |
| | S | $839^{a}$ | $725^{a}$ | $766^{x}$ |
| | Site average | $655^{A}$ | $577^{A}$ | |
| $I_{sat}$ [μmol(photon) $m^{-2}$ $s^{-1}$] | P | $1027^{b}$ | $818^{b}$ | $911^{y}$ |
| | S | $1559^{a}$ | $1588^{a}$ | $1578^{x}$ |
| | Site average | $1323^{A}$ | $1313^{A}$ | |
| $P_{N(Imax)}$ [μmol($CO_2$) $m^{-2}$ $s^{-1}$] | P | $6.85^{b}$ | $2.17^{b}$ | $4.25^{y}$ |
| | S | $19.70^{a}$ | $6.51^{b}$ | $11.22^{x}$ |
| | Site average | $14.00^{A}$ | $4.96^{B}$ | |
| $R_D$ [μmol($CO_2$) $m^{-2}$ $s^{-1}$] | P | $0.53^{b}$ | $1.07^{ab}$ | $0.69^{y}$ |
| | S | $1.40^{a}$ | $1.09^{ab}$ | $1.19^{x}$ |
| | Site average | $1.01^{A}$ | $1.08^{A}$ | |
| $\phi_{(I_0\text{-comp})}$ [μmol($CO_2$) μmol(photon) $^{-1}$] | P | $0.025^{b}$ | $0.0095^{c}$ | $0.016^{y}$ |
| | S | $0.046^{a}$ | $0.021^{b}$ | $0.030^{x}$ |
| | Site average | $0.037^{A}$ | $0.016^{B}$ | |

**Table 2.** Leaf-level stomatal conductance and transpiration rate of different leaf types (P: petiolate; S: sessile) of *Salvia ceratophylloides* individuals of two sites (Mosorrofa, Mo; Puzzi, Pu) measured at a light intensity of 200 μmol $m^{-2}$ $s^{-1}$. Different lower-case letters represent significant differences at $p < 0.05$ among the average within the column (Tukey's test). Different capital case letters represent statistically significant differences among the means along the rows ($p < 0.05$, Tukey's test).

| | | Sites (Sit) | | |
|---|---|---|---|---|
| | **Leaf Type (LT)** | **Mo** | **Pu** | **Leaf Type Average** |
| Stomatal conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | P | $0.032^{b}$ | $0.016^{b}$ | $0.023^{y}$ |
| | S | $0.113^{a}$ | $0.029^{b}$ | $0.059^{x}$ |
| | Site average | $0.077^{A}$ | $0.025^{B}$ | |
| Transpiration rate (mol $H_2O$ $m^{-2}$ $s^{-1}$) | P | $0.87^{b}$ | $0.55^{b}$ | $0.69^{y}$ |
| | S | $2.59^{a}$ | $0.92^{b}$ | $1.52^{x}$ |
| | Site average | $1.82^{A}$ | $0.79^{B}$ | |

The leaf morphology of *S. ceratophylloides* was reported in Table 4. Leaf type affected the leaf fresh weight, leaf area, leaf water content, and fractal dimension, which were higher in P leaves. This pattern, however, was modified in relation to the site for the LFW and LA only with higher values in the petiolate in Pu site only ($p < 0.05$ LT × Sit interaction, Table 4). Finally, the site factor affected the LFW, LDW, and LWC showing higher values in the Mo site (Table 4).

Value average (±SD) of LMA of *S. ceratophylloides* in comparison with that of the sun- and shade-species herbs, evergreen angiosperm, evergreen species, herbs, and different *Salvia* species are shown in Figure S2. The LMA range of *S. ceratophylloides* fell in that of the herbs, evergreen species, *S. mellifera*, *S. hispanica*, *S. officinalis*, and sun species.

**Table 3.** Leaf-level stomatal conductance and transpiration rate of different leaf types (P: petiolate; S: sessile) of *Salvia ceratophylloides* individuals of two sites (Mosorrofa, Mo; Puzzi, Pu) measured at a light intensity of 800 µmol $m^{-2}$ $s^{-1}$. Different lower-case letters represent significant differences at $p < 0.05$ among the average within the column (Tukey's test). Different capital case letters represent statistically significant differences among the means along the rows ($p < 0.05$, Tukey's test).

| | | Sites (Sit) | | |
|---|---|---|---|---|
| | **Leaf Type (LT)** | **Mo** | **Pu** | **Leaf Type Average** |
| Stomatal conductance (mol $H_2O$ $m^{-2}$ $s^{-1}$) | P | $0.032^{b}$ | $0.016^{b}$ | $0.023^{y}$ |
| | S | $0.107^{a}$ | $0.032^{b}$ | $0.059^{x}$ |
| | Site average | $0.074^{A}$ | $0.026^{B}$ | |
| Transpiration rate (mol $H_2O$ $m^{-2}$ $s^{-1}$) | P | $0.83^{b}$ | $0.55^{b}$ | $0.67^{y}$ |
| | S | $2.44^{a}$ | $1.03^{b}$ | $1.53^{x}$ |
| | Site average | $1.72^{A}$ | $0.86^{B}$ | |

**Table 4.** Biometric and morphological parameters of different leaf types (P: petiolate; S: sessile) of *Salvia ceratophylloides* individuals of two sites (Mosorrofa, Mo; Puzzi, Pu). Different lower-case letters indicated significant differences at $p < 0.05$ among the average within the column (Tukey's test). Different capital case letters indicated statistically significant differences among the means along the rows ($p < 0.05$, Tukey's test).

| | | Sites (Sit) | | |
|---|---|---|---|---|
| | **Leaf Type (LT)** | **Mo** | **Pu** | **Leaf Type Average** |
| Leaf fresh weight [g $leaf^{-1}$] | P | $1.33^{a}$ | $1.38^{a}$ | $1.36^{x}$ |
| | S | $1.40^{a}$ | $0.43^{b}$ | $0.78^{y}$ |
| | Site average | $1.37^{A}$ | $0.77^{B}$ | |
| Leaf dry weight [g $leaf^{-}$] | P | $0.23^{a}$ | $0.22^{b}$ | $0.22^{x}$ |
| | S | $0.27^{a}$ | $0.12^{b}$ | $0.17^{x}$ |
| | Site average | $0.25^{A}$ | $0.16^{B}$ | |
| Leaf area [$cm^2$] | P | $41.4^{ab}$ | $54.4^{a}$ | $48.6^{x}$ |
| | S | $43.6^{ab}$ | $19.9^{b}$ | $28.3^{y}$ |
| | Site average | $32.2^{A}$ | $42.6^{A}$ | |
| Leaf mass x area [g $m^{-2}$] | P | $55.4^{a}$ | $44.1^{a}$ | $49.1^{x}$ |
| | S | $62.3^{a}$ | $61.6^{a}$ | $61.8^{x}$ |
| | Site average | $59.2^{A}$ | $55.3^{A}$ | |
| Leaf dry content [g dry weight $g^{-1}$ fresh weight] | P | $0.17^{a}$ | $0.18^{a}$ | $0.18^{x}$ |
| | S | $0.19^{a}$ | $0.28^{a}$ | $0.25^{x}$ |
| | Site average | $0.18^{A}$ | $0.24^{A}$ | |
| Leaf water content [g $H_2O$ $cm^{-2}$ leaf area] | P | $0.027^{a}$ | $0.020^{a}$ | $0.023^{x}$ |
| | S | $0.025^{b}$ | $0.016^{b}$ | $0.019^{y}$ |
| | Site average | $0.026^{A}$ | $0.017^{B}$ | |
| Fractal dimension | P | $1.67^{a}$ | $1.73^{a}$ | $1.70^{x}$ |
| | S | $1.51^{b}$ | $1.65^{b}$ | $1.56^{y}$ |
| | Site average | $1.69^{A}$ | $1.59^{A}$ | |

### 2.2. VOCs Analysis of *Salvia ceratophylloides* in Its Habitat

The PCA of GC-MS spectra of different leaves and sites of *Salvia ceratophylloides* are shown in Figure 2. The two-dimensional PCA score plot revealed a separation in VOCs profile induced by leaf type, clearer in Mo site than Pu ones. The VOCs profile was also different between the two *Salvia* sites.

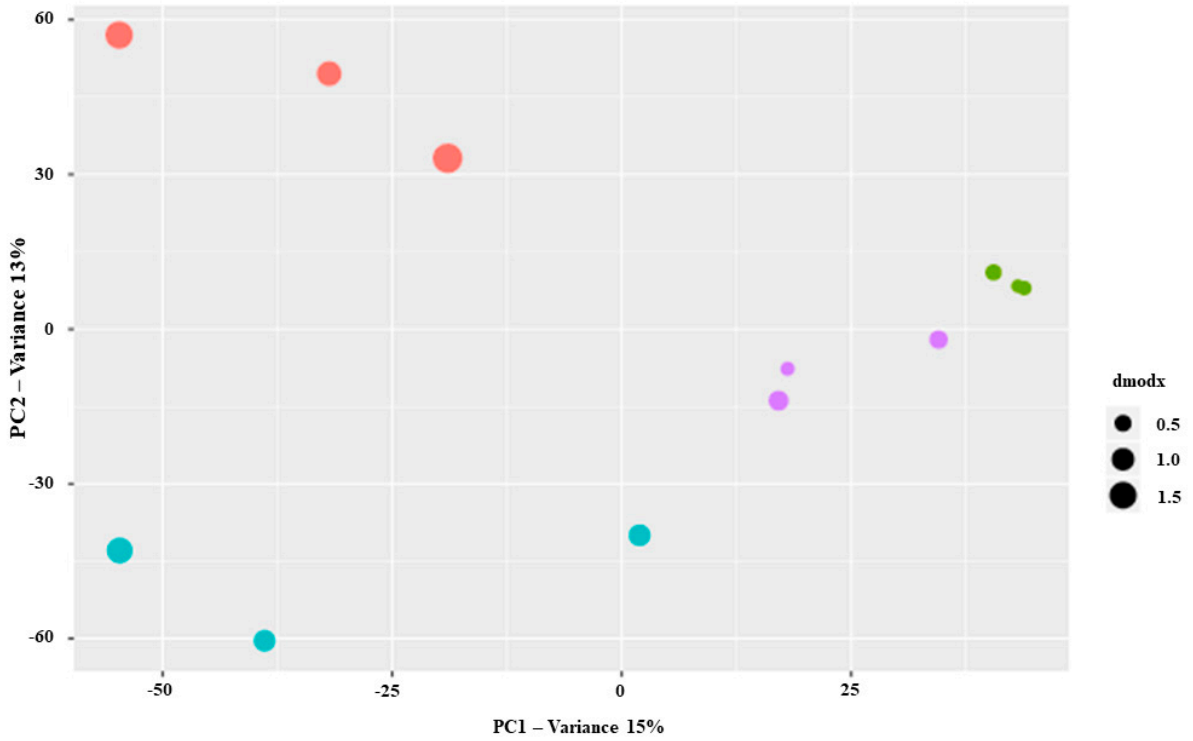



**Figure 2.** Principal component analysis of untargeted metabolomics data from different leaves (sessile and petiolate) and sites [Mosorrofa (Mo) and Puzzi (Pu)] of Salvia ceratophylloides individuals: Mo-sessile (red), Mo-petiolate (green), Pu-sessile (blue) and Pu-petiolate (purple).

VOCs detected by GC-MS are summarized in Table S1. Thirty-nine compounds belonging to different chemical classes were identified. Among them the most representative were monoterpenes (17), sesquiterpenes (7), monoterpene alcohols (4), aldehydes (4), ketons (3), alcohols (2), aliphatic esters (1) and ether (1).

Comparing the amount of the XCMS-extracted peak intensities of each chemical between the S and P leaf types, 13 compounds emitted by both P and S were statistically different (Table 5). In particular, *p*-cymene, sabinene, terpinolene, *β*-pinene, *γ*-terpinene, *α*-terpineol, *α*-cubebene, *α*-muurolene, isovaleraldehyde, 5-methylheptan-3-one, pentan-3-one, *β*-tujone, and dimethyl sulfide were higher in S than P leaves. However, the higher emission of *β*-tujone and *α*-terpineol in S leaves was only observed in Mo site (significant LT × Sit interaction, Table 5). The same pattern was revealed for D-germacrene, which was not modified by both leaf type and the site as single factors. Only six compounds were differently affected by sites: *p*-cymene, *α*-terpineol, *α*-copaene and *α*-cubebene, emitted in Pu more than Mo site which, conversely, produced more *β*-tujone and dimethyl sulfide (Table 5).

**Table 5.** Chemical characterization of volatile organic compounds in fresh sessile and petiolate leaves of two sites [Mosorrofa (Mo) and Puzzi (Pu)] of Salvia ceratophylloides plants.

| | Compound | # Statistics | Sessile | | Petiolate | |
|---|---|---|---|---|---|---|
| | | | Pu | Mo | Pu | Mo |
| 1 | p-Cymene | LT 7.78 *<br>Sit 14.16 **<br>LT × Sit 0.21 NS | 195,813 | 82,392 | 108,569 | 19,607 |
| 2 | Pinocarvone | LT 0.04 NS<br>Sit 6.57 *<br>LT × Sit 0.07 NS | 2406 | 987 | 2444 | 696 |

**Table 5.** *Cont.*

| | Compound | # Statistics | Sessile | | Petiolate | |
|---|---|---|---|---|---|---|
| | | | Pu | Mo | Pu | Mo |
| 3 | Sabinene | LT 11.80 **<br>Sit 0.34 NS<br>LT × Sit 1.70 NS | 554,775 | 873,306 | 195,242 | 73,210 |
| 4 | Terpinolene | LT 12.40 **<br>Sit 0.40 NS<br>LT × Sit 3.09 NS | 128,554 | 218,320 | 62,198 | 19,784 |
| 5 | β-Pinene | LT 7.30 *<br>Sit 0.47 NS<br>LT × Sit 1.73 NS | 92,968 | 150,052 | 53,391 | 35,502 |
| 6 | γ-Terpinene | LT 5.40 *<br>Sit 0.19 NS<br>LT × Sit 0.04 NS | 16,341 | 13,366 | 4610 | 3508 |
| 7 | α-Terpineol | LT 8.13 *<br>Sit 12.91 **<br>LT × Sit 9.04 * | 10,220$^{b}$ | 80,003$^{a}$ | 11,854$^{b}$ | 18,054$^{b}$ |
| 8 | D-Germacrene | LT 0.11 NS<br>Sit 3.47 NS<br>LT × Sit 4.22 * | 2554$^{a}$ | 169$^{b}$ | 1102$^{a}$ | 1218$^{a}$ |
| 9 | α-Copaene | LT 0.62 NS<br>Sit 11.05 *<br>LT × Sit 0.67 NS | 3517 | 601 | 2385 | 625 |
| 10 | α-Cubebene | LT 8.21 *<br>Sit 19.35 **<br>LT × Sit 1.02 | 4,460,201 | 1,371,705 | 2,247,264 | 312,465 |
| 11 | α-Muurolene | LT 9.49 *<br>Sit 0.56 NS<br>LT × Sit 0.99 NS | 14,382 | 15,236 | 7105 | 1038 |
| 12 | Isovaleraldehyde | LT 6.10 *<br>Sit 0.52 NS<br>LT × Sit 0.52 NS | 81,876,770 | 46,391,341 | 3,426,789 | 3,466,464 |
| 13 | 5-Methylheptan-3-one | LT 5.70 *<br>Sit 0.21 NS<br>LT × Sit 0.08 NS | 7776 | 8204 | 1578 | 3291 |
| 14 | Pentan-3-one | LT 7.73 *<br>Sit 2.44 NS<br>LT × Sit 1.20 NS | 321,989 | 649,080 | 114,170 | 171,753 |
| 15 | β-tujone | LT 17.37 **<br>Sit 6.21 *<br>LT × Sit 12.54 ** | 65,370$^{b}$ | 168,599$^{a}$ | 54,660$^{b}$ | 36,692$^{b}$ |
| 16 | (3z)-3-Hexenyl acetate | LT 3.58 NS<br>Sit 5.09 NS<br>LT × Sit 5.46 * | 1253$^{a}$ | 0$^{b}$ | 99$^{ab}$ | 122$^{ab}$ |
| 17 | Dimethyl Sulfide | LT 23.77 **<br>Sit 5.34 *<br>LT × Sit 1.40 NS | 29,866,633 | 54,386,837 | 3,926,181 | 11,857,751 |

#Statistical analysis: two-way ANOVA with 4–9 replications (LT: leaf type; Sit: sites; LT × Sit: Leaf type × Sites interaction); * $0.05 > p < 0.01$; ** $0.01 > p < 0.001$; NS: not significant; Different letters along the row indicated significant differences among the means ($p < 0.05$, Tukey's test).

## 3. Discussion

### *3.1. The Assessment of the Morpho-Physiological Traits of the Rare Salvia ceratophylloides Ard.*

*Salvia ceratophylloides* Ard., an endemic, rare, and critically endangered plant species, has been recently rediscovered on some sites around the Reggio Calabria hills [2,3]. The knowledge of its morphological and ecophysiological traits is very important for understanding the habitat requirements for the conservation [24] and providing its capacity to adapt to climate change conditions and, consequently, to the plant communities distribution [25]. The responses of these traits in *S. ceratophylloides* are reported here for the first time. We mainly focused on two functional traits, the photosynthetic light-response curve and leaf mass per area, which indicate the habitat preferences and responsiveness to environmental conditions [24,29,30]. The photosynthetic response curves to the PAR photon flux and, in particular, the $I_{sat}$ (818–1588 µmol(photon) $m^{-2}$ $s^{-1}$) and $I_{comp}$ values (8–26 µmol(photon) $m^{-2}$ $s^{-1}$) suggested that *S. ceratophylloides* was well adapted to the sunny habitat. Indeed, the minimum and maximum values of the $I_{sat}$ fell within the range defined by sclerophyll of sunny habitat and C4 plants and, the $I_{comp}$ values were included between spring geophytes and heliophytes. The LMA values (44.1–55.4 g $m^{-2}$) of *S. ceratophylloides* were comprised in the LMA range of the herbs [29] and evergreen species [30]. Among the different *Salvia* species, the LMA of *S. ceratophylloides* was similar to *S. mellifera*, *S. hispanica* and *S. officinalis* [31–33], lower than *S. mohavensis* and *S. dorrii var. dorrii* [31], and higher than *S. glutinosa* and *S. pratensis* [34,35]. The different ranges of the LMA of *S. ceratophylloides* with respect to that of some *Salvia* species, were probably correlated with its functional response to the environmental conditions, such as water and light availability [29,30]. For example, *S. mohavensis* and *S. dorrii var. dorrii* showed a higher LMA value because of the adaptation to their native desert area (mountain ranges of the Mojave Desert of southern California, south-western Nevada, and northern Baja California Norte, Mexico) [31]. Although the *S. pratensis* was strictly related to *S. ceratophylloides* (belonging to the same sect. Plethiosphace: [36]) as distributed to the similar area (native from Europe: [37]), it showed lower LMA value [34] probably due to the different growing conditions of *S. pratensis* (pot and growth chamber) in Mommer's experiments. Finally, the LMA values (57 g $m^{-2}$) of *S. ceratophylloides* fell in the range of sun species confirming its preference to the open sunny habitat as reported for the most *Salvia* species [32,38].

### *3.2. Does the Within-Plant Variation of the Photosynthetic Performance, Morphological Traits and Metabolic Profiles Occured?*

Recently, the within-plant variation as an expression of intraspecific phenotypic plasticity is strongly taken into account for its role in plant evolution and ecology at the individual, population, and community levels [12,13]. For example, the within-plant variation in leaf morpho-physiological traits allows the adaptation of each individual to optimize (i) its capturing structures to the heterogeneous local environmental conditions such as light, temperature, and $CO_2$ gradients within plant canopy in trees [14] and perennial herbs [17], and (ii) its cost-expensive defenses against herbivory and pathogens [39,40]. Further, the knowledge of the leaf-level photosynthetic performances within the plant allow to scale at canopy level [41] and understand the competitive strategies for exploring the within-canopy heterogeneous light and $CO_2$ availability. In this respect, the within-plant variation of *S. ceratophylloides* by comparing the morpho-physiological and metabolic traits of petiole and sessile leaves were here tested, for the first time.

The *S. ceratophylloides* individuals exhibited a clear within-plant variation determined by the differences in most functional traits [$I_{sat}$, $I_{max}$, $P_{Nmax}$, $\phi_{(I_0–I_{comp})}$, RD, stomatal conductance, transpiration rate, leaf fresh weight, leaf area, leaf water content, fractal dimension, and VOCs] between sessile and petiolate leaves. Indeed, comparing the leaf types, S pointed out a better photosynthetic performance pointing out a higher net photosynthetic rate, maximum quantum yield, and $I_{sat}$ [1578 vs. 911 µmol(photon) $m^{-2}$ $s^{-1}$]. Conversely,

they exhibited a lower leaf area and capacity to fill the space, as evidenced by FD, respect than the P ones.

Hence, a within-plant efficient subdivision of the functional traits for the resource acquisition and use (light, $CO_2$) was observed in *S. ceratophylloides* with the short-term low-expensive physiological traits in S leaves (uppermost) and the long-term high-expensive morphological traits in P leaves (lowest). Hence, the *S. ceratophylloides* leaves, placed at the top of the shoot and facing high light intensity, temperature, and vapor pressure deficit, could use higher photon and $CO_2$ fluxes for increased their carbon gains by high $I_{sat}$ and stomatal conductance. The spatial distribution of more efficient structures or functions within plants to fit the micro-environmental heterogeneous conditions and maximize photosynthesis and carbon gain was already known in different plant species [42]. Besides the functional traits linked to the resource acquisition, the two leaf types of *S. ceratophylloides* pointed out difference in the stomatal conductance and transpiration with the S leaf showing higher values, limiting the leaf overheating, as reported by Lin et al. [43] in dry areas species. The lower aerodynamic resistance caused by the smaller size and shape of the sessile leaves (lower leaf area and fractal dimension) was further beneficially allied for avoiding leaf overheating [43,44] but also for reducing the water loss by smaller total leaf area. Overall, the leaf position in the *S. ceratophylloides* canopy showed different strategies to cope with the fine-scaled environmental gradients: from higher to lower light intensity and from dry to wet conditions along the uppermost sessile and lowest petiolate leaf gradient.

The within-plant variation of *S. ceratophylloides* was also observed in the VOCs composition and emission. Indeed, the S and P leaves were sharply separated by VOC-based metabolic profiles suggesting different intensity and composition between them. Further, the emission of 14 out of 39 identified VOCs was statistically increased in S leaves respect than P ones, including monoterpenes (p-Cymene, Sabinene, Terpinolene, β-Pinene, γ-Terpinene, and α-Terpineol), sesquiterpenes (D-Germacrene, α-Cubebene, α-Muurolene) and green leaf volatiles ((3z)-3-Hexenyl acetate) mostly involved in defenses against herbivory and pathogens [45] and in responses to abiotic stress [46]. The within-plant variation of VOCs emission in response to herbivory has been already observed in wild and crop species [47,48], but no evidence at the field level has been reported yet. Why do *S. ceratophylloides* plants defend the S more than P leaves by higher VOCs emission? Probably, the upper, younger, sessile leaves are more protected in views of their high-performing photosynthetic machinery and nutritive value (high leaf dry content, although not statistically supported) as suggested by the optimal defense hypothesis [39,40]. Overall, these results pointed out the within-plant functional subdivision at morpho-physiological and metabolic levels of *S. ceratophylloides* mimicking what has been already observed in the wide crown of trees for heat tolerance [49], light acquisition, and differential expression of genetic polymorphisms in the sun and shade leaves of trees [50] and defense responses to herbivory [51].

The within-plant variation of morpho-physiological and metabolic traits was affected by the site suggesting that *Salvia* plants were adapted to local conditions. Indeed, the S and P leaves' morpho-physiological patterns changed between the two sites for most traits (on 12 that showed the leaf type factor as statistically significant, nine traits pointed out LT × Sit interaction). The S leaves pointed out a higher photosynthetic rate, stomatal conductance, and transpiration rate associated with higher dark respiration and $I_{comp}$ than P ones in the Mo site only. These results explained the phenotypic plasticity response to the local conditions [52,53] because preliminary results showed a low genetic variability of *S. ceratophylloides* populations [23]. It has been observed that the within-plant phenotypic variation responded to the microhabitat environmental heterogeneity or fine-grained (small-scale) environmental variations [9,11,14,15] rather than macro-geographical or coarse-grained environmental variations [17,54,55]. In this respect, we hypothesized that the *S. ceratophylloides* individuals in the Mo site, characterized by a significant within-plant variation of the leaf morpho-physiological traits, could face with a higher microhabitat en-

vironmental heterogeneity, especially for light intensity and/or temperature gradients (the most important abiotic stresses affecting the leaf growth), than Pu site. Opedal et al. [56] observed that the microhabitat environmental heterogeneity increased with the topographically complex sites changing the intraspecific traits of 16 plant species. In accordance, the Pu site is characterized by flatter, more open terrains and higher altitude than Mo ones, which conversely is placed at a lower altitude at the base of the valley, closed and with rough terrains likely determining a short duration of light and steeply thermal and light gradients.

Unlike the morpho-physiological traits, the within-plant variation of metabolic profiles was lesser affected by the different sites. Indeed, the PCA pointed out that S and P leaves' metabolic profiles were separated at both sites, and only 4 out 13VOCs exhibited a statistically significant Lt × Sit interaction. Since the VOCs emission is more involved to the biotic stress (plant-plant, plant-herbivory, and plant-pathogen interactions) [27], probably the *Salvia* plants in both sites are faced to similar biotic environment heterogeneity or variability (predation, competition, etc.) differently to the abiotic ones (light, temperature, etc.), determining thus the maintaining of the same within-plant VOCs emission in *S. ceratophylloides* at both sites.

Finally, the metabolite profiling and physiological traits (10 out of 10 parameters, considering the LT × Sit interaction also; Tables 1–3, Figure 2) varied more than morphological features (4 out 7 parameters; Table 4). Why do *S. ceratophylloides* plants choose to invest in the physiological and metabolic capacity more than morphological-related traits in S and P leaves? The physiological plasticity has a low cost and more rapid response with respect to the cost-expensive morphological plasticity, allowing the expression of the most adequate plant phenotype in response to the variable climatic conditions. For example, the plant physiological plasticity is strictly related to an enhanced ability to colonize gaps and open areas and, hence, exploiting the transient environmental resources at low cost by short-term adjustments, such as plant acclimatization [47–60]. Conversely, the plant morphological plasticity is more functional for the plant adaptation in the long-term and probably useful for growing in forest understories [57,61]. The choice to invest in higher plasticity of the physiological traits than morphological ones has also been reported by Herrera et al. [17], which observed that the within-ramet variation in *Helleborus foetidus* L. was more due to the stomatal features than leaf size- and area-related traits causing an increase of seed number produced by each individual [13].

## 4. Materials and Methods

### *4.1. Species and Sites*

*Salvia ceratophylloides* Ard. rediscovered by Crisafulli et al. [2], is a perennial herb, scapose hemicryptophyte, with woody and upright stems with a dense pubescence of glandular and simple patent hairs (Figure S3C). Leaves are opposite pinnate-partite with toothed lobes and morphologically distinct in petiolate (basal, 12 × 4 cm long and less discrete pinnate lobes and presence of the petiole) and sessile (cauline, 3–4 × 1–2 cm long and more incise pinnate lobes, clasp the stem) (Figure S3C). Inflorescences are 20–30 cm in length with 5–6 verticillasters, each with 4–6 flowers.

*S. ceratophylloides* plants were identified in two small hilly and closer sites (<2 Km) around the city of Reggio Calabria, Mosorrofa (Mo), and Puzzi (Pu) (Southern Italy) (Figure S4). Each site consisted of around 60 and 240 individuals for Mosorrofa and Puzzi, respectively. Further, Mosorrofa site is topographically complex in a little valley, while Puzzi pointed out open and flatter terrains (Figure S3A,B). Both sites are characterized by layers of loose sand alternating with benches of soft calcarenites of Pliocene origin. Soils have a sandy texture with a basic pH falling into the group Calcaric Cambisols [62].

Species identification is in agreement with Pignatti [63], and the specimens are deposited in the Herbarium of Mediterranean University of Reggio Calabria (acronym REGGIO).

The *S. ceratophylloides* location pointed out a Mediterranean climate with average annual temperatures of 18 °C and an average annual rainfall of 600 mm mostly in autumn-

winter and a dry summer period. According to Rivas-Martínez [64], the macro-bioclimate is "Mediterranean pluviseasonal oceanic" (upper thermo-Mediterranean thermotype and lower subhumid ombrotype).

### *4.2. Measurements and Samplings*

Measurements and samplings have been carried out in the early summer (May–June) of 2016 and 2017 on two leaf types: (1) the upper sessile (S) (two to three nodes from the apex) and (2) the lower petiolate (P) (from fifth to sixth nodes from the apex) (Figure 1C). For the morphological and physiological analysis, 4–9 and 5–9 samples for petiolate and sessile leaves, respectively, have been collected from each site; while the metabolic analysis has been carried out on 3 leaves of each type and site.

### *4.3. Physiological Analysis*

The net photosynthetic light response curves have been determined using LI-6400XT portable photosynthesis system (Li-Cor, Inc. Lincoln, Nebraska, USA) at 2000, 1500, 800, 400, 200, 100, 30, 15, and 0 μmol $m^{-2}$ $s^{-1}$ irradiance levels. The net photosynthesis has been measured at 500 $cm^3$ $min^{-1}$ flow rate, 26 °C leaf temperature, 400 μmol($CO_2$) mol(air)$^{-1}$ $CO_2$ concentration (controlled by $CO_2$ cylinder). Each measurement was made with a minimum and maximum wait time of 120 and 200 s, respectively, and matching the infrared gas analyzers for 50 μmol($CO_2$) mol(air)$^{-1}$ difference in the $CO_2$ concentration between the sample and reference before any change in irradiance levels. The leaf-to-air vapor pressure difference has been set at 1.5 kPa, continuously monitored around the leaf during the measurements and maintained at a constant level by manipulating incoming air humidity as needed. The measurements were carried out on sunny days between 8:30–11:30 am. Finally, stomatal conductance ($g_s$, mol $H_2O$ $m^{-2}$ $s^{-1}$) and transpiration rate measurements (T, mmol $H_2O$ $m^{-2}$ $s^{-1}$) have been evaluated at each light intensity.

### *4.4. Morphological Analysis*

After the physiological analysis, the same leaves were used for the morphological analysis. In particular, leaf fresh weight (LFW, g) and dry weight (LDW, g), were determined after oven-drying at 70 °C for 2 days, while leaf area (LA, $cm^2$) were scanned at a resolution of 300 dpi (WinRhizo STD 1600) and measured using WinRhizo Pro v. 4.0 software package (Instruments Régent Inc., Chemin Sainte-Foy, Québec, Canada). Further, the leaf fractal dimension (FD) was obtained by the "fractal analysis module" (WinRhizo software), based on the box-counting method with the following settings: maximal pixel size (2.0 mm), box sizes ranging from 2 to 32, filters, and a length/width ratio smaller than 2.00. The FD provides information on the object's space occupation: the fractal dimension approaches the value of 2 as the leaves become dense to the point of "filling in" a shape. For this reason, the FD has been used both for correlating the root architecture to the soil resource acquisition [65], and in the LAI-Light interception models as the correction parameter [66].

Through these parameters, we also calculated the leaf mass per area (LMA, g LDW $cm^{-2}$ LA), strongly related to photosynthetic rate [67], growth rate [68] and decomposition rate [69]; the leaf dry content (LDC, g dry weight/g fresh weight), strongly related with relative growth rate [70], flammability [71], and post-fire regeneration strategy [72]; and the leaf water content or leaf succulence (LWC, g $H_2O$/$cm^2$ leaf area], directly correlated with the plant responses to abiotic stresses [73].

### *4.5. VOC Analysis: HeadSpace/Solid-Phase Micro-Extraction (HS/SPME) GC-MS Analysis*

The volatiles (VOCs) produced by petiolate and sessile leaves of *S. ceratophylloides* have been characterized using the HS/SPME method. One gram of plant material, per sample and replicate (N = 3), was sealed in a 20 mL vial and allowed to equilibrate for 20 min at room temperature. Successively, the SPME gray fiber (StableFlex, divinylbenzene/Carboxen on polydimethylsiloxane coating; 50/30 μm coating; Supleco) was exposed to plant VOCs for 20 min to allow the VOCs adsorption on the fiber.

VOCs were identified using a Thermo Fisher gas chromatography apparatus (Trace 1310) coupled with a single quadrupole mass spectrometer (ISQ LT). The capillary column was a TG-5MS 30 m × 0.25 mm × 0.25 µm. Helium was used as carrier gas with a flow of 1 mL/min. Samples were injected in a split mode with a split ratio of 60. Injector and source were settled at the temperature of 200 °C and 260 °C, respectively. The temperature ramp was settled as follow: 7 min at 45 °C, from 45 °C to 80 °C with a rate of 10 °C × min, from 80 °C to 200 °C with a rate of 20 °C × min then isocratic for 3 min 200 °C. Mass spectra were recorded in electronic impact (EI) mode at 70 eV, scanning the 45–500 *m/z* range.

Native raw chromatograms (RAW), previously converted in mzXML using the tool MSconvert of proteowizard [74], were normalized for TIC intensity, aligned, deconvoluted, and peak intensities extracted using the open-source software XCMS [75]. For peak analysis the GC/Single Quad (matchedFilter) pre-settled method was applied.

After chromatograms processing and peak picking, features and normalized peak areas were imported to Excel for further statistical analysis. Compounds identification was carried out comparing the relative retention time and mass spectra of molecules with those of commercial libraries (NIST Mass Spectral Reference Library) and open-source EI spectral libraries (Mass Bank of North America, Golm Metabolome Database) [76,77].

### *4.6. Statistical Analysis*

Light curves were fitted by nonlinear regression using the Ye et al. [28] model equation:

$$P_N = \boldsymbol{\Phi}_{(I_0 - I_{comp})} \times \frac{1 - \beta \times I}{1 + \gamma \times I} \times (I - I_{comp}) \quad (1)$$

where: $P_N$ is the net photosynthetic rate [µmol($CO_2$) $m^{-2}$ $s^{-1}$]; I is the photosynthetic photon flux density [µmol(photon) $m^{-2}$ $s^{-1}$]; $I_{comp}$ is the light compensation point [µmol(photon) $m^{-2}$ $s^{-1}$]; β is the adjusting factor (dimensionless); γ is the adjusting factor (dimensionless); $\phi_{(I_0 - I_{comp})}$ is the quantum yield obtained at the range between $I_0$ and $I_{comp}$ [µmol($CO_2$) µmol(photon)$^{-1}$]. The following leaf-level photosynthetic parameters were calculated by these equations [28]:

$$P_{gmax} = \boldsymbol{\Phi}_{(I_0 - I_{comp})} \times \frac{1 - \boldsymbol{\beta} \times I}{1 + \boldsymbol{\gamma} \times I} \times (I - I_{comp}) + R_D \quad (2)$$

$$R_D = \boldsymbol{\Phi}_{(I_0 - I_{comp})} \times I_{comp} \quad (3)$$

$$I_{sat} = \frac{\sqrt{\frac{(\boldsymbol{\beta} + \boldsymbol{\gamma}) \times (1 + \boldsymbol{\gamma} \times I_{comp})}{\boldsymbol{\beta} - 1}}}{\boldsymbol{\gamma}} \quad (4)$$

$I_{sat}$ is the light saturation point [µmol(photon) $m^{-2}$ $s^{-1}$]; $P_{gmax}$ is the asymptotic estimate of the maximum gross photosynthetic rate [µmol($CO_2$) $m^{-2}$ $s^{-1}$]; $R_D$ is the dark respiration rate [µmol($CO_2$) $m^{-2}$ $s^{-1}$]. Finally, the $\phi_{(I_{comp}-I200)}$ was calculated as the slope of the linear regression of $P_N$ for values of I between Icomp and 200 µmol (photon) $m^{-2}$ $s^{-1}$ representing the "maximum quantum yield".

Finally, according to Lobo et al. [78], we reported the Imax (µmol(photon) $m^{-2}$ $s^{-1}$) (light saturation point beyond which there is no significant change in $P_N$) and the $P_N$ ($I_{max}$) (µmol($CO_2$) $m^{-2}$ $s^{-1}$) (maximum value of $P_N$ obtained at I = $I_{max}$) instead of $I_{sat}$ and $P_{gmax}$ as more realistically adequate. We used a simple routine to minimize the error sum of squares (SSE) for fitting the models, allowing the determination of equation parameters using the Microsoft Excel spreadsheet and Solver function (Microsoft Excel 2010). Nonlinear regressions were repeated several times in order to minimize the sum of square of deviation between predicted and experimental values to less than 0.01% between two consecutive fits [79].

In order to evaluate the effect of the Years (Y) (2016 and 2017), we used the one-way ANOVA on the gas exchange parameters, which quickly respond to the environmental

conditions. Since the Years factor was not significant ($p > 0.05$) for almost all the gas exchange traits (Table S2), all the morpho-physiological parameters were analyzed by two-way analysis of variance with the Leaf Type (LT) (sessile and petiolate) and Site (Sit) (Mosorrofa and Puzzi) as main factors and their interaction Lt × Sit. Then, Tukey's test was used to compare the means of all the parameters of each LT and Sit. All the data were tested for normality (Kolmogorov–Smirnoff test) and homogeneity of variance (Levene median test) and, where required, the data were transformed.

For the comparison of the LMA and $P_N$ of *S. ceratophylloides* with that of different plant functional groups and *Salvia* spp., we used the Isat and Icomp data obtained from [80,81] for evergreen angiosperm, [29] for evergreen shrub, [30] for evergreen species, [82] for *S. officinalis*, [34] for *S. pratensis*, [35] for *S. glutinosa*, [33] for *S. hispanica*, [31] for *S. mohavensis*, *S. leucophylla*, *S. dorrii* var. *dorrii* and *S. mellifera*.

The TIC intensity normalized dataset obtained from metabolomic data analysis were classified through unsupervised Principal Component Analysis (PCA) where the output consisted of score plots to visualize the contrast among different samples. PCA analysis was carried out on all the features detected by the analysis. Successively, identified and annotated compounds were statistically analyzed through univariate two-way analysis of variance with the LT (sessile and petiolate) and Sit (Mosorrofa and Puzzi) as major factors. Then, the Tukey's test was used to compare the compound means of each leaf type and site ($p < 0.05$).

## 5. Conclusions

The eco-physiological adaptation of *S. ceratphylloides*, a rare and endangered plant species, to its habitat by functional traits was studied. The higher light saturation and compensation point and leaf mass per area indicated a sunny habitat preference of *S. ceratophylloides*. These results suggested that lower competition (low density and diversity), especially with woody species (trees and shrubs), should be favored for its *in situ* conservation. However, the *S. ceratophylloides* habitat has been destroyed and continuously fragmented because of anthropogenic disturbance and environmental deterioration. Consequently, further and deepening study needs to identify the main stressful factors that threaten its growth, development, and fitness. Due to the objective difficulty to preserve the taxon in situ and pending further experimental data on its ecology, as indicated for other nationally threatened CWRs species [83], *ex situ* conservation actions are recommended. For the *ex situ* propagation, we recommend growing the seedlings at least half sunlight (1200 µmol (photons) $m^{-2}$ $s^{-1}$).

Further, for the first time, the "continuous within-plant variation" of the morpho-physiological traits and metabolic profiles of this species was assessed in the field. The results indicated that the physiologic and metabolic traits explained most of its within-plant plasticity, which was also affected by the location. Indeed, the sessile and petiolate leaves of *S. ceratophylloides* showed different photosynthetic performances and metabolic profiles, but the sub-individual variation of the photosynthetic-related parameters, differently to the volatilome, was exhibited in one site only. These within-plant patterns, probably related to the micro-environmental heterogeneity, could optimize the growth and defense machinery for the fitness's improvement to specific habitats. Overall, the magnitude of the within-plant variation should be taken into consideration when designing sampling schemes for the ecological studies of *S. ceratophylloides*.

**Supplementary Materials:** The following are available online at https://www.mdpi.com/2223-7747/10/3/474/s1, Figure S1: Plants of *Salvia ceratophylloides* in the two sites, Mosorrofa [Mo] (A) and Puzzi [Pu] (B). The red circles indicate the places where the *Salvia ceratophylloides* plants have been discovered. (C) Individual plant of *Salvia ceratophylloides* and different leaves: petiolate (P) and sessile leaf (S), Figure S2: Distribution map of *Salvia ceratophylloides*, Figure S3: Light saturation point (µmol(photons) $m^{-2}$ $s^{-1}$) (upper panel) and light compensation point (µmol(photons) $m^{-2}$ $s^{-1}$) (bottom panel) of different plant functional groups. The data [minimum (▮) and maximum value (▮)] are derived from Larcher [80]. The dotted lines are drawn for a better comparison with the

minimum and maximum value of *Salvia ceratophylloides*, Figure S4: Leaf mass per area (g $m^{-2}$) of sun- and shade-species herbs, evergreen angiosperm and species, herbs and different *Salvia* species. The data of LMA of Salvia species, herbs, evergreen angiosperm and species are indicated by minimum (▮) and maximum value (▮) or by the average (black plot point and the standard deviation where reported)] and have been derived from Martins et al. [82] for *S. officinalis*, Mommer et al. [34] for *S. pratensis*, Paź-Dyderska et al. [35] for *S. glutinosa*, Goergen et al. [33] for *S. hispanica*, Knight and Ackerley [31] for *S. mohavensis*, *S. leucophylla*, *S. dorrii* var. dorrii and *S. mellifera*, Poorter et al. [29] for herbs, Duursma et al. [81] for evergreen angiosperm and de la Riva et al. [30] for evergreen species. Box plots point out the distribution of LMA values as observed for a wide range of sun- and shade-species herbs both annual and perennial, with the bottom and top part of the box indicating the 25th and 75th percentile, respectively, the two whiskers the 10th and the 90th percentile, respectively, and the horizontal line within the box the median value. The data for the box plot are derived by scientific literature as indicated in Table S1. The dotted lines have been drawn for better comparisons and pointed out the range of LMA values of *S. ceratophylloides*, Table S1: Two-way ANOVA results and chemical characterization (average and error standard within brackets) of volatile organic compounds in fresh sessile and petiolate leaves of *Salvia ceratophylloides* harvested in two different sites [Mosorrofa (Mo) and Puzzi, (Pu)]. Different lower-case letters indicated significant differences at $p < 0.05$ among the average along the rows (Tukey' test) and they have been only reported when the LT × Sit interaction was significant. The bold identify the statistically significant factors and/or their interaction, Table S2: *F* statistic and *p* values (within brackets) of one-way ANOVA of the leaf-level photosynthetic parameters of *Salvia ceratophylloides* measured in 2016 and 2017.

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