Riunioni scientifiche

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Book of Abstracts

(a cura del Comitato Organizzatore)

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In copertina: logo di Marco Fiorello e Chiara Vallese

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Distribution of *Arbutus* sp. pl. in Western Eurasia since the Last Glacial Maximum

S. De Santis, F. Spada, D. Magri

Keywords: biogeography, Lusitanian geoelement, Mediterranean/Atlantic distribution

In the Old World, four species of *Arbutus* are recorded according to the current outputs of phylogeny and taxonomy. We investigate the present and past distribution of *Arbutus*, in order to achieve a better understanding of the drivers and constraints of its postglacial dynamics. The present-day distribution of the genus, obtained from floristic databases, herbaria, phytosociological surveys, and personal observations, has been produced as a grid map, representing the final step of the history of *Arbutus*. Range maps of past distribution have been obtained for the last 30 ka at 1000-year intervals, based on pollen and macro-remains, including a total of over 1300 fossil sites. Input data only include georeferenced sites with a chronological control (cal BP) from paleobotanical databases, made up of both pollen and macrofossils (wood, leaves, and fruits). The local persistence of *Arbutus* along the Atlantic coast of France across the Last Glacial Maximum is difficult to assess, as even its recent scattered populations are not detected by pollen analysis, in contrast to the Irish population, already recorded since the early Middle Holocene. These marginal populations, as well as the sparse stands living along the coasts of the Black Sea, should be considered very important for conservation actions. In the Iberian Peninsula, a pervasive local persistence during the last glacial period and an increase in population density during the postglacial is recorded. In the Italian peninsula, *Arbutus* is detected starting from Early Holocene, while in the Eastern Mediterranean region, it is recorded only since Middle Holocene.

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Phylogenetic relationships and morphological variation between *Euphorbia adriatica* and *E. japygica* (Euphorbiaceae) in the Apennine Peninsula

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Keywords: Euphorbia, Mediterranean Basin, morphometry, phylogeny, taxonomy

The Balkan, the Apennine and the Iberian Peninsula were important Pleistocene refugia and contraction to these peninsulas during the Pleistocene likely triggered divergence among *Euphorbia hercegovina* (central Balkans), recently described *E. adriatica* (NW Balkan, Italy) and *E. nicaeensis* (western Mediterranean). In addition, the southern Italian populations belonging to this group were tentatively treated as a distinct, putatively polyploid species, *Euphorbia japygica*. *E. japygica* had previously mostly been treated as *E. nicaeensis* subsp. *japygica* and its hairy capsules are considered to be the main morphological character that differentiates it from *E. nicaeensis* s. str. Based on this character, this *taxon* has been reported for Puglia, adjacent Basilicata, and Campania. We used an integrative approach to disentangle relationships between *E. japygica* and *E. adriatica* based on complete geographic sampling of both *taxa*. Specifically, we used ITS sequences to infer phylogenetic position of *E. japygica*, amplified fragment length polymorphisms (AFLP) to disentangle phylogeographic relationships between *E. adriatica* and *E. japygica*, and subsequently relative genome size measurement (RGS) and morphometric analyses to explore differentiation between both *taxa*. Our RGS analyses showed that *E. japygica* is not polyploid, having the same RGS as *E. adriatica*. AFLP analyses indicated that the populations from Puglia and adjacent Basilicata are most divergent and that the genetic divergence does not correspond to the distribution of populations with hairy capsules. Therefore, the treatment of both *taxa* at species level is not justified and they should rather be treated as subspecies of *E. japygica*.

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New insights into the diversification of *Luzula* sect. *Luzula* (Juncaceae) in the Eastern Alps

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Keywords: agmatoploidy, ecological niche, floristics, phylogenomics, phylogeography, plastome-seq, polyploidy, RAD-seq, systematics

Luzula sect. *Luzula* (Juncaceae) is one of the taxonomically most intricate groups of angiosperms, in which diversification is mostly driven by true polyploidy and agmatoploidy (fission of chromosomes), leading to a number of different karyotypes. Eight species with six karyotypes, including di-, tetra- and hexaploids, have been reported for the Eastern Alps, but their distributions and phylogenetic relationships are insufficiently known. Within the recently launched Euregio project 'LUZALP' we explore the evolutionary origin and diversification of the Eastern Alpine species as well as their ecological niche segregation. Extensive field work including (1) sampling of *Luzula* species and (2) registering of accompanying vascular plant species has been performed across the Eastern Alps and provides the foundation for ploidy-level estimation and phylogenomic analyses via RAD- and plastome sequencing as well as for evaluation of niche segregation based on Landolt indicator values. During the talk we will present the project as well as our preliminary results from the field and laboratory work. Interesting preliminary findings include co-occurrences of multiple ploidy levels in the same locality, multiple origins of agmatoploid *taxa* and non-confirmation of some previous reports of occurrences of some rare species (e.g., *L. pallescens*) at different localities.

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Role of genome duplication in changing mountain landscapes: a preliminary report

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Keywords: Alps, altitudinal gradient, biogeography, cryptic biodiversity, polyploidy

Polyploidy is a key feature of plant biodiversity. A recent comprehensive analysis of global chromosome count data has shown that the frequency of polyploids increases with latitude. Much less is known about ploidy variation and distribution in mountain areas. In temperate mountain ranges the frequency of polyploids may rise towards high-elevation habitats (due to, for instance, their higher stress tolerance) and with increasing distance from glacial refugia (due to better colonizing abilities). Employing flow cytometry, we aim to establish ploidy levels of a flora-wide sampling of several ten thousand individuals of angiosperms from 100 elevational transects in the Eastern Alps and spanning from 550 m below timberline to 550 m above it. Generalized linear mixed effects models will be used to analyse whether there is a generic pattern of increasing polyploid frequency with increasing elevation and/or distance from the closest Pleistocene refugium. We will test if climatic niches differ among cytotypes of the same species, fitting species distribution models separately at the species and the cytotype level. Using predictive modelling, we will further investigate if risk from climate change is biased towards low or high ploidy levels and estimate the extent of future cryptic biodiversity loss under climate change scenarios. This project represents an unprecedentedly broad empirical test at the landscape level of the long-standing hypothesis of a positive association between genome duplication and spatio-temporal environmental variation. We will present the project and some preliminary results concerning the distribution of polyploids along the altitudinal gradient.

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Young researchers doing "old" science in a modern way: integrative approaches to test taxonomic hypotheses in the Mediterranean

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Keywords: integrative taxonomy, Mediterranean, systematics

Since Linnaeus, plant taxonomists used morphological differences to circumscribe *taxa*. Nowadays, to build solid taxonomic hypotheses, integrating suitable quantitative methods and proper statistical analyses is crucial, especially in regions harboring high plant diversity, like the Mediterranean Basin. These issues are exemplified here by three species complexes, for which integrated taxonomic approaches are ongoing: the *Santolina chamaecyparissus* complex (Asteraceae), the *Dianthus virgineus* complex (Caryophyllaceae), and *Armeria* sect. *Plagiobasis* (Plumbaginaceae). Integrating morphometry, karyomorphology, molecular phylogeny, and climatic niche analyses solved cases of taxonomic instability within the *S. chamaecyparissus* complex. This approach allowed lumping of two species endemic to Corsica and Sardinia, into a single, polymorphic species, while it revealed new endemic *taxa* from S France and NE Spain. Phylogenetic and karyomorphological approaches, used for *Santolina*, are not suitable to detect differences among *taxa* in the *D. virgineus* complex. Genotyping thousands of genome-wide SNPs and estimating relative genome size in hundreds of populations, revealed that many of the current hypotheses do not seem supported, and that biological variation may be reorganized in fewer *taxa*. Therefore, the selection of investigation methods must be calibrated to the biological and evolutionary features of the group under study. Also the choice of analytical methods can influence the statistical support of the results, specifically in morphometry, where unbalanced and mixed data are common. In closely related species, like *A. saviana* and *A. denticulata*, different classification models based on morphometric data achieved different accuracies, possibly leading to inaccurate species circumscription if only one model is used.

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Water and sludge's fungal community in two Italian urban wastewater treatment plants

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Keywords: diversity, fungal community, fungi, sludge, wastewater

Wastewater treatment has always been an important and debated topic that nowadays is going from being a problem to becoming a possible resource. Processed wastewater could be reused for irrigation purposes and sewage sludges recycled as fertilizers for agriculture. In urban wastewater treatment plants, bacteria represent the core of the biological depuration process, but other microorganisms can grow in wastewater and colonize sludge flocs alongside them, such as fungi (Liu et al. 2017). Fungi are a well-represented component of wastewater community and they can be found in all phases of the depuration process. Some species can also take part to the main depuration process through minor activities such as denitrification, removal of some nutrients and reduction of suspended solids (More et al. 2010); however other species could be potentially harmful if not properly eliminated. Unlike bacteria, whose presence and concentration is continuously monitored at many stages of the process, no regulations are currently in place for monitoring the fungal community. By joining morphological and molecular identification, we investigated the fungal community, paying attention to desired and undesired species, in different stages of two plants for the urban wastewater treatment in Lombardia (Italy). Eurotiales (mainly *Aspergillus* and *Penicillium*), Trichosporonales (*Trichosporon* sensu lato), Saccharomycetales (mainly *Geotrichum*) and Hypocreales (mainly *Fusarium* and *Trichoderma*) were the most represented fungal orders and genera in all the stages and both the plants. In conclusion this study provides an insight on which *taxa* can potentially contribute to each depuration stage and/or keep viable propagules in water and sludges after the collection from the external environment.

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Introgression of an isolated *Primula* lineage suggests the existence of a glacial refugium in the Écrins range (Southwestern French Alps)

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Keywords: alpine flora, ddRAD-seq, Écrins national park, phylogeography, phylogenomics, *Primula pedemontana,* speciation

The species-richness of the flora in the European Alps results from complex interactions between geographical, climatic and environmental factors. In this study, we focused on a complex of closely related Alpine plants: *Primula hirsuta*, *P. pedemontana* and their relatives. Using a large DNA dataset of thousands of single-nucleotide polymorphisms sequenced across 149 individuals spanning all the western Alps, we refined phylogenetic relationships in this clade and explored the evolutionary origins of a mysterious lineage found in one valley of the Écrins range (France): the Valgaudemar. In particular, we demonstrated that this lineage did not originate from a simple allopatric divergence, but from an isolated lineage related to *Primula pedemontana*, which later got introgressed by *P. hirsuta*. This led us to develop a phylogeographic scenario explaining the origins of the Valgaudemar lineage, and shed light on a potential glacial refugium in the south of the Écrins range (Voisin et al. 2022). We believe this study takes part in the deep understanding of the origins of endemism in the European Alps and more generally of the maintaining of species diversity.

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Phylogenetic analysis of *Santolina* genus

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Keywords: mediterranean species, phylogeny, RADseq

The genus *Santolina* L. (Asteraceae, Anthemidae) is distributed in the western part of the Mediterranean basin. The taxonomic history is long and complex: currently the whole genus comprises 29 *taxa*, most of which are divided in two complexes: the *S. rosmarinifolia* one, which includes eleven *taxa* endemic to Iberian Peninsula and North Africa and was subject of extensive systematic and phylogenetic analysis, and the *S. chamaecyparissus* one, which includes fourteen, mainly narrow endemic, *taxa* occurring in Spain, France, and Italy. Four *taxa* are not included in either complexes. Here we presented for the first time a phylogenetic analysis of the whole genus based on genetic data obtained through RADseq. To investigated genome-wide diversity structure we computed a co-ancestry matrix between individuals with RADpainter software and by performed a principal component analyses of genotypes. To assess evidence of historical gene flow, we performed an ABBA-BABA test using Dsuite package. Our phylogeny recognizeed two main well-supported clades in *Santolina* roughly coinciding with the two main morphological complexes. *S. villosa* belonging to the latter complex, shared a common ancestry with species of *S. rosmarinifolia* complex. We provided a first assessment of the taxonomic position of *S. africana*, a species omitted from all previous taxonomic surveys because of its mixed morphological features, now resulting sister to the *S. chamaecyparissus* complex. In conclusion, we build the first phylogenetic hypothesis for the *Santolina chamaecyparissus* complex. Taken together our results set the stage for further investigations of the evolutionary history of this circum-Mediterranean group.

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The Herbarium of the Republic of San Marino: revision and expansion

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Keywords: herbarium, Republic of San Marino, vascular flora

The Republic of San Marino is an enclave microstate in central Italy (61.19 km^2). In early 2022 an update of its vascular flora was published (Alessandrini et al. 2022), almost one century after the first edition (Pampanini 1930), with 169 records accounted for the first time. To increase the floristic knowledge, we launched several initiatives. Alongside field excursions, we revised and expanded the herbarium of the *Centro Naturalistico Sammarinese* – created by Benedetti (2014), who collected around 400 *taxa*. The revision took place in 2021 by rearranging the collection, checking previous identifications and creating a database. During the 2021-2022 period, we actively collected new plant samples. Whenever possible, species new to the flora of San Marino or not already stored in the herbarium were collected in the field, pressed, mounted and registered. We did not collect species with restricted distribution or small populations. We created specific labels to store information about new specimens. Up to now, 605 specimens are stored in the herbarium, accounting for 528 total *taxa* and belonging to 75 families; around 54 % of the San Marino flora is represented in the collection. Regarding future perspectives, we aim to increase the species coverage of the San Marino Herbarium, to register it in the Index Herbariorum list, and to digitise it; we also suggest creating a photographic online repository, accounting for those rare species which were not collected. We hope that the Herbarium can become a valuable reference for researchers and botanists, providing support for their studies.

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Rapid adaptation of the plant species *Galium wirtgenii* to novel conditions in restored meadows

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Keywords: ecosystem restoration, flowering phenology, hay transfer, rapid adaptation

The environmental conditions of degraded sites commonly differ from the natural ones. The success of ecosystem restoration of such habitats might significantly depend on whether restored populations are able to rapidly adapt to these novel conditions. However, rapid evolution during restoration has been only rarely studied. Here, we tested for rapid adaptation of a short-lived perennial plant *Galium wirtgenii* in restored alluvial grasslands. The grasslands have been restored 20 years ago on former arable land by the transfer of hay from nearby natural meadows. The restored sites are more productive than the natural ones, and are mown one to two months earlier. To test for rapid adaptation, we collected seeds from 48 restored and 18 natural sites that served as hay donor, and grew the offspring plants in a common garden. To simulate mowing, we clipped half of the plants when they have been in full bloom. Plants from restored sites grew slower during the first weeks, and flowered earlier. This suggests rapid evolution of an escape strategy, when plants at restored sites hurry to complete their life cycle before they will be mown. We did not detect any differences in regeneration after mowing, probably because regenerating plants rarely produce seeds in the area and thus, rapid regeneration does not enhance fitness. In summary, we found evidence for rapid adaptation to the novel environmental conditions in restored sites, which probably contributed to successful restoration of *Galium wirtgenii* populations in the restored grasslands.

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Biagio Bartalini's herbarium: an insight into the 18th century flora of Siena

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Keywords: biodiversity inventory, biological archive, botanical exploration, Italy, plant taxonomy, pre-Linnaean

Biagio Ignazio Bartalini (1750–1822) was a physician and subsequently a lecturer at the University of Siena and director of the University botanic gardens. In 1776 he published a catalogue of the vascular plants, bryophytes and lichens collected around Siena, based on his herbarium. The herbarium is currently located in the Accademia dei Fisiocritici. It was subsequently studied by other authors, but none of them revised the entire collection. This work aims to make Bartalini's collection informations, available to modern users by revising the samples identifications and creating an accessible database and digital archive of all the specimens. The database will contain the following information on each sample: Bartalini's identification, other authors revision, current species name and conservation status, locality and habitat, as well as a high-resolution photograph. The herbarium contains 567 specimens of vascular plants, 77 bryophytes 29 lichens. Revision of the vascular plants has been completed, while that of the bryophytes and lichens is underway. The revised plant specimens belong to 86 families, 330 genera and 492 species and include 18 alien species and 39 species of conservation concern in European, Italian and/or Tuscan Red Lists. Study of the herbarium revealed important information about the flora of the past, including the presence of species of conservation concern such as endemic, aquatic-wetland and segetal entities. This study provides the basis for future resampling studies and the opportunity to discover how the flora of the study area has varied over more than two centuries under climatic and land use changes.

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Reproductive success through pollinator attraction: a road to neopolyploid establishment?

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Keywords: attractiveness, mating success, minority cytotype, pollinator visitation, polyploidy

Polyploidy, the heritable condition of possessing more than two complete sets of chromosomes, is a common evolutionary phenomenon, especially in vascular plants. Although seminal studies proposed that newly formed polyploids (neopolyploids) are less fit than their diploid progenitors, there is growing evidence that they have evolutionary advantages compared to their diploid progenitors. However, the minority cytotype exclusion (reduced chance of survival and mating of rare tetraploids among the majority diploid population) is the biggest challenge neopolyploids face after their formation, and how they can overcome it remains an enigma. Here, we tested whether having enlarged floral characters (due to the giga effect) increases neopolyploid attractiveness and higher visitation by pollinators, and subsequently higher mating success compared to diploids. For this purpose, we performed a pollinator visitation experiment with diploids and synthetic tetraploids of the *Arabidopsis arenosa* species. During the observations, flower visitors were identified along with foraging routes and visitation times on each plant. We also measured flower size and relative fruit set. Even though the flowers of synthetic tetraploids were significantly larger, pollinator visitation rate did not increase in tetraploids compared to diploids. Tetraploids however showed a higher relative fruit set, suggesting a higher mating frequency than in diploids. In conclusion, our study showed higher reproductive success of tetraploids in comparison to diploids. Nevertheless, this effect did not involve measurable pollinator attraction differences as a mechanistic link, leaving the room open for alternative processes.

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Revealing hidden biodiversity before losing it: the lichens of the Dolomites and the challenge of global change

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Keywords: biodiversity, database, Dolomites, flora, informative system, lichens

The Dolomites, located in the Eastern Alps and included within the UNESCO sites, are increasingly impacted by climate change and anthropization. Under this scenario, many species may face severe extinction risks, resulting in the loss of hidden biodiversity that is still partly undiscovered. This is the case of many neglected organisms that play relevant ecological roles contributing to ecosystem functioning, such as lichens. These symbiotic organisms are highly threatened by global change since their physiology is directly coupled to environmental conditions. The lichen biota of the Alps is generally well known, but a specific synthesis for the Dolomite area is lacking. This project aims to (1) provide an inventory of the lichens of the Dolomites, (2) build a database with the collected data and (3) increase public awareness by developing a dedicated information system to be published online. The first step was the extraction and digitization of data from the available literature and herbaria since the 19th century (still in progress). Each record is being georeferenced, and the nomenclature is updated. At the same time, thanks to open conventions with the Adamello-Brenta and Paneveggio-Pale di San Martino Natural Parks, sampling campaigns are ongoing to collect new data. The collected specimens are identified in the laboratory. The comprehensive collection of data from these important sources represents the first step in building a database of the lichen biota of the Dolomites and in the development of a dedicated information system, fundamental to support future research and improve the efficiency of conservation actions.

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On the occurrence of pollination syndromes of orchids in small Mediterranean islands: species–area relationship (SAR) and factors affecting their biogeography

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Keywords: environmental predictors, functional traits, Orchidaceae, pollination, species-area relationship

The Mediterranean is a hotspot of orchid diversity whose ecological interactions reflect their adaptations to local environmental conditions. Here, we study the insular biogeography of orchids across the Central West Mediterranean Basin using island species–area relationship (ISAR) as a tool to explain patterns of orchid distribution. Our aims are: investigate differences in ISARs for continental and oceanic islands; ii) identify the effect of pollination syndromes on the biological meanings of c and z values; and iii) define which abiotic factors are more influential in shaping orchids. Our final list comprises 113 islands and 80 orchid species. ISARs, fitted by the Arrhenius function, show higher z-values for more specialized pollination strategies and the increase of c-value from autogamic to deceptive strategy supporting the role of these two parameters in understanding ecological patterns. Among factors, area strongly supports occurrence for allogamic, deceptive, food and nest deceptive orchids, habitat diversity strongly predict orchids occurrence, distance from the closest species source has a negative but strong influence for all the groups tested but not for sex deceptive species while elevation slightly predicts the occurrence only of cleistogamic *taxa*. In this study, we highlight how ISARs could be used to identify traits that affect species occurrence going beyond a classic taxonomic approach. We also show that a functional approach could provide relevant biogeographic knowledge in understanding of biological distribution on insular systems.

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Fungal involvement in (bio)plastics degradation in the marine environment

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Keywords: biodegradation, bioplastic, bioremediation, marine fungi, micology

Plastic is a dominant source of pollution nowadays and some companies are working to find suitable alternatives to conventional plastic, like biodegradable plastic. Biodegradation is a complex process that results in an extensive reworking of organic carbon found in plastics until it becomes mineralized, and its rate depends on environmental conditions. Nowadays, it is of great interest to better understand biodegradation mechanisms under natural conditions. Some studies, even if carried out in mesocosms and thus simplifying environment complex dynamics, have focused on the potential role of microorganisms in breaking down and mineralized plastic debris, but very little has been explored about fungi-plastic interactions. Our research focuses on fungal community assemblages on plastic surfaces from a taxonomic and functional point of view and assessing the scope of microbial degradation of polymers in the open environment. Our experimental setup involves film of a biodegradable polymer (Polybutylene sebacate – PBSE), a non-biodegradable polymer (Polyethylene – PE), and cotton (as control). The materials were placed in nets at two different sites in Denmark and exposed to different conditions, such as salinity and depth. Samples were collected every two months for a total period of exposure of 6 months. Preliminary results show that after 6 months biodegradable plastic is almost completely degraded, compared to non-biodegradable plastic which remained intact. Moreover, we were already able to isolate some fungal strains thanks to the enrichment method specifically associated with the different plastics types that seem capable to use the tested polymers as the only source of carbon.

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First data on the reproductive biology of a neglected orchid, *Serapias neglecta* De Not.

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Keywords: mediterranean orchid, microscopy, pollination, self-compatibility

Serapias neglecta De Not. is an endangered orchid, sub-endemic to Northern Italy and France. Since only a few studies of its biology are available, our goal was to gather the first information on its reproductive traits. Furthermore, we tested whether this species achieves pollination like other congeneric *taxa*, following the "shelter offering" strategy, which consists in attracting pollinators by mimicking insect nests with floral elements. Field monitoring, pollination activities and morphological analyses were carried out in three different populations in Liguria (Italy) during spring. We found that all the pollination treatments (including selfing) led to ovary fertilization and seed production. We observed different invertebrate species inside the floral cavities; pollinia were often attached on the stigma of the same flowers when traces of animal visits were present. We have not spotted any invertebrates with pollinia on their body. Naturally self-pollinated flowers successfully developed pods. The surface of the central labellum was covered with long trichomes, showing characteristic protuberances and traces of secondary metabolites. Compared to the leaves, the floral cavity was significantly warmer in the evening, while the temperature was similar during the morning/afternoon. Our data suggest that *S. neglecta* is self-compatible, and that autogamy is readily induced by animal visits. The species is visited by invertebrates that use flowers as a resting place, possibly attracted by the warmer conditions of the cavity and the visual/tactile/odour cues provided by the labellar trichomes. Further investigations are needed to identify the pollinators and conclusively confirm the shelter offering strategy.

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The suitability of *Robinia pseudoacacia* L. leaves for monitoring the deposition of airborne microplastics

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Keywords: atmospheric deposition, biomonitoring, black locust, microplastics

Despite the vast literature showing that microplastic (MP, i.e., plastic particles <5 mm) contamination is ubiquitous in marine and coastal environments, there are limited studies of the atmospheric deposition of MPs. There is evidence that biomonitors such as lichens and mosses, which are well known for their ability to accumulate atmospheric pollutants of potentially toxic elements, can be profitably used for assessing the atmospheric deposition of MPs (Roblin, Aherne 2020, Loppi et al. 2021, Jafarova et al. 2022). However, no studies have used leaves of higher plants as biomonitors of airborne MPs. Here we investigated the suitability of *Robinia pseudoacacia* L. (black locust) leaves for monitoring the deposition of airborne MPs. Leaves (leaflets) of *R. Pseudoacacia* were collected at the end of summer in rural areas and urban parks in the city of Siena, Central Italy. MPs were removed by washing the leaves with deionized water and, after filtration, were examined under a stereomicroscope. MPs were identified based on a hot needle test and other standard visual criteria used in similar studies. The results of the study showed a significant difference in the number of MPs accumulated in remote and urban areas, with higher concentrations in urban areas. This suggests that *R. pseudoacacia* leaves can effectively be used to monitor the deposition of airborne MPs. The deposition rate of MPs was calculated based on the leaf surface area. The abundance and type of MPs at remote sites suggest source pathways are likely dominated by long-range atmospheric transport.

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Effects of population size on fitness traits in four common and four rare congeneric alpine plant species

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Keywords: alpine plant species, fitness, population size, rarity

Due to habitat fragmentation and climate change, plant populations are prone to be smaller and more isolated and thus more vulnerable to local extinction. While it is known for lowland species that small populations have a reduced individual fitness, alpine and rare species are not sufficiently studied in this regard. We assessed how population size and rarity affect seed production, seed mass, seed number, total seed mass per fruit, germination, germination initiation time, seedling survival and seedling height in 90 natural populations of four common and four rare alpine plant species in the Swiss Alps (*Androsace chamaejasme* Wulfen, *A. puberula* Jord. & Fourr., *Primulaceae; Gentiana acaulis* L., *G. alpina* Vill., *Gentianaceae*; *Potentilla crantzii* (Crantz) Fritsch, *P. nivea* L., *Rosaceae; Viola calcarata* L. and *V. lutea* Huds., *Violaceae*). We observed significantly larger seed numbers in larger populations across all species. In the *Gentiana* and *Potentilla* species, seedling survival marginally increased and germination marginally decreased in larger populations. While there was no difference in fitness traits between common and rare species, rare species occurred in significantly smaller populations and positive relationships between fitness and population size were more prevalent in rare than in common species. Our results indicate that population size affects individual plant fitness also in alpine species and that especially rare species might suffer from a reduced fitness in small populations. Reduced fitness in small populations could make these species even more susceptible to environmental changes.

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Diversity and ecological assessment of seminatural dry grasslands habitat types: a case study in the Calabria region

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Keywords: conservation, Habitat 92/43/EEC Directive, Italy, semi-natural grasslands vegetation

The semi-natural dry grasslands, a consequence of traditional agro-pastoral activities, differ in numerous types according to the diversity of climatic conditions and substrates. The purpose of this study is to analyze the diversity and ecological characteristics of the arid and semi-natural grasslands of the Calabria region in order to identify management models compatible with their conservation. The multivariate analysis of the 31 surveys recognized four groups referring to the habitats of the EEC Directive 43/92 according to the Italian Manual of Interpretation of Habitats (Biondi et al. 2012): 6220*a Pseudo-steppe with grasses and annuals of *Thero-Brachypodietea* dominated a *Lygeum spartum*, 6220*b Pseudo-steppe with grasses and annuals of *Thero-Brachypodietea* dominated a *Hyparrhenia hirta*, 6210* Semi-natural dry grasslands and scrub facies on calcareous substrates (*Festuco-Brometalia*) (*important orchid sites), 6230 * *Nardus* grasslands rich in species, on siliceous substrates in montane areas (and sub-montane areas in continental Europe). Box plots made with the Ellenberg indices show the ecological differences between the different habitats. The humidity value is statistically the most significant value for distinguishing between different habitat types. Temperature and continentality are other significant ecological factors. Finally, the diversity analysis, evaluated by calculating the Shannon, Sörensen and Evenness indices, showed that the diversity of the habitats is related to ecological factors and, in particular, that the beta-diversity of meadows increases with the increase of the soil moisture. Ecological study in combination with biodiversity indices helps characterize dry grassland habitats by providing information on the conservation status of these habitats and management strategies.

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Site dependence of local variations in taxonomic and functional diversity of plant communities in semi-natural dry grasslands

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Keywords: biodiversity, community assembly rules, spatial scale, traits, Tuscany habitat

Grasslands represent biodiversity hotspots in temperate Europe and, for this reason, have been extensively studied in the last century. As diversity is the result of a multitude of processes that shape communities, the adoption of a multifaceted approach is fundamental to assess the biodiversity of grassland habitats. Moreover, considering different components of diversity, such as alpha and beta, is crucial to properly distinguish small- (e.g., habitat and biotic filters) and broad-scale (e.g., dispersal limitation) processes acting on communities. Accordingly, we adopted a broad approach, taking into account alpha and beta diversity components of plant diversity to assess whether small-scale changes in grassland biodiversity are site-dependent. Additionally, such framework has been improved addressing a multi-faceted perspective, thus considering both taxonomic and functional diversity. We surveyed 56 sites in grasslands classified as high conservation priority habitat 6210, divided in two biogeographical regions (Mediterranean and Continental) both occurring in Tuscany region, Italy. In each area, on a small scale, the grassland habitat has two distinct community types (i.e. deep soil *vs* rocky soil), and in each of these, we surveyed vegetation and measured four plant traits (LA, SLA, LDMC and plant height) for the species accounting for the 80% of the abundance. Our results showed that plant α-diversity differed taxonomically and functionally only between the two sites, while β-diversity also showed local functional differentiation. Furthermore, we demonstrated that while taxonomic β-diversity is mostly due to species turnover, functional β-diversity is equally due to turnover and nestedness.

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Does specificity of interactions with mycorrhizal fungi influence the distribution of the Mediterranean orchid, *Orchis italica*?

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Keywords: fungi, germination, mutualists, species distributions

Both the distribution and abundance of plant populations may be linked to the availability of mutualists. Orchids depend on particular mycorrhizal (OrM) fungi to germinate from seed and establish new individuals, hence the availability of these fungi may play a key role in explaining their distribution. Previous studies using metabarcoding of OrM fungi associated with the roots of single orchid species over large geographical ranges have shown that OrM communities are composed of various *taxa* and vary according to habitat. In this study we investigated the geographical distribution and diversity of OrM *taxa* associated with the Mediterranean orchid, *Orchis italica* Poir. using both root isolation and high-throughput sequencing (Illumina NovaSeq). Isolation from adult roots resulted in 101 isolates from eight *O. italica* populations in southern Italy. Sequencing of isolated fungi showed that most isolates are from the *Tulasnella calospora* species complex, a mycorrhizal group known to associate with other orchids. Indeed, OrM fungal specificity with tulasnelloid fungi has been previously reported in the other *Orchis* species. However, Novaseq revealed a diverse community of OrM fungi associated with the roots of *O. italica*, beyond tulasnelloid fungi, yet the role of these fungi for the life cycle of *O. italica* needs to be better understood. This highlights the importance of quantifying and identifying the distribution of mycorrhizal associates in understanding the current and future distribution of this species.

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The complex lithology of the Western Alps: how does it shape the vegetation of alpine grasslands?

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Keywords: alpine ecosystems, alpine grasslands, bedrock, soil pH, Western Alps

Alpine ecosystems are of great conservation importance but are nonetheless strongly threatened by climate change. An important objective of modern plant ecology is to identify the environmental drivers responsible for alpine plants' spatial distribution. The aim of this study is to monitor alpine plant communities' composition in relation to bedrock. The relation between plants and soil properties has long been acknowledged in the scientific community (Arnesen et al. 2007), leading to a dichotomic categorization in calcicole plants, which prefer calcareous (thus basic) soils, and calcifuge plants, which prefer siliceous (thus acid) soils (Michalet et al. 2002). This relation is intensified in "young" soils, such as regosol (FAO classification); yet recent studies illustrate how calcicole and calcifuge species can coexist (Wohlgemuth, Gigon 2003). For this reason, intermediate pH ranges are worth exploring (Tyler 2003). The Western Alps are characterized by a marked soil heterogeneity, derived from a variety of bedrocks ranging from calcschists, ophiolites, gneiss, granite and much more, constituting a fitting study area for this matter. In July 2021, in the midst of the vegetative season, we examined grassland ecosystems at about 2500 m above sea level in Aosta Valley, Savoy and the Province of Turin, by selecting a number of plots (1 m^2 each) in which we [1] identified all vascular species, [2] assessed their relative abundance and [3] recorded environmental variables such as soil temperature, soil pH, soil moisture, soil nutrient contents, bedrock type, slope inclination and aspect (Vonlanthen et al. 2006). Multivariate statistical analysis will allow us to assess quantitative relations among bedrock chemistry, soil chemistry and species' distribution.

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Analysis of wild orchids in anthropic and natural ecosystems

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Keywords: biodiversity, Orchidaceae, orchid ecology

Orchids are a highly specialized group of plants, and their survival is linked to a complex network of interactions between abiotic and biotic factors. The loss of native vegetation is one of the main effects connected to global change and human activities that lead to the fragmentation of habitats and reduction of biodiversity. Although many plants do not survive human pressures, several species as terrestrial orchids can grow in man-made habitats that are outside their typical natural environments. Since 2014, some species of orchids have settled spontaneously in the Botanic Garden of the University of Ferrara (Northern Italy). These populations have shown a tendency to rapidly increase size and there are five different species: *Anacamptis pyramidalis* (L.) Rich., *Cephalanthera damasonium* (Mill.) Druce, *Cephalanthera longifolia* (L.) Fritsch, *Ophrys apifera* Huds., *Ophrys sphegodes* Mill. The research project aims to study these orchid populations to improve the knowledge of these species and understand which are the most suitable approaches for proper conservation in natural and semi-natural habitats. We measured the number and the height of individuals, the number of flowers, and the number of fruits. Soil temperature, PAR and VWC have been detected to define which factors influence the growth and development of orchids. Orchids produce a large number of dust-like seeds which are perfectly adapted to long-range wind dispersal. So, the research has been extended to some nearby natural areas such as Po Delta to define the origin of urban populations and monitor population trends both in natural and anthropic habitats.

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Effects of nature conservation on scrub vegetation in two biogeographically contrasting protected areas

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Keywords: alpine and boreal heath, arborescent matorral of *Juniperus* spp., Focal Species, National parks, nature conservation, Special Areas of onservation

Protected Areas are legal tools to counteract biodiversity loss. In National parks (NPs), human activity is limited according to zonation. Special Areas of Conservation (SACs) were created to protect habitats and species whose conservation is highly important. At places, SACs partially overlap with NPs, generating a spatial conservation gradient with areas simultaneously within SAC and NPs (two levels of protection), areas exclusively within SAC, areas without any level of protection (absence of protection). This study investigated the effectiveness of conservation measures on shrub habitats, comparing species richness and Focal Species (FS) along a spatial conservation gradient. We expected habitats undergoing two levels of protection will host more FS. We selected two biogeographically contrasting Italian regions focusing on habitat "Arborescent matorral with *Juniperus* spp." in NW Sardinia and "Alpine and boreal heath" in NE Alps. We sampled 90 plots using a random stratification approach recording species cover of vascular plant during 2022. Absence of protection never hosted the highest amount of FS. In Sardinia, the number of FS was the lowest in correspondence of two levels of protection. The species pool included ruderal, unpalatable, and alien species. In NE Alps, we found no difference on numbers of FS and species richness between two levels of protection and the absence of protection. Our study suggests that the overlap of different designation types does not necessarily implies an improvement of habitat conservation.

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The floristic taxonomic, functional and phylogenetic diversity in seminatural grassland habitats: A case study of grazed and abandoned alpine pastures in the Southern-Western European Alps

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Keywords: biodiversity, conservation, functional traits, phylogeny, seminatural grassland habitat, taxonomy

In semi-natural grassland habitats, pastoral activities allowed the development of a natural-human ecosystem which have driven the co-evolution of different *taxa*, leading to the establishment of new and diverse vegetation assemblages. The rational use of alpine pastures is intended as the optimal load of cattle capable to graze the total phytomass that grasslands are able to produce, without jeopardizing the environmental quality and well-being of the habitat (Bohner et al. 2019). The latter is known to be able to maintain and enriching the biodiversity (Helmus et al. 2007). However, this trend might be reverse in situation of overload and/or underload of livestock (Mouillot et al 2013), and, especially, with the abandonment of pastoral lands (Pruchniewicz 2017). The phenomena trigger the establishment of secondary vegetation succession, leading to reforestation. The EU-CLOE project takes places in three Natural Parks in the South-Western European Alps, where abandonment of pasture lands is ubiquitous. The data was gathered through 104 phytosociological relevés from grazed and abandoned seminatural grassland habitats (Streifeneder et al. 2006). The results confirmed a change in the taxonomical composition of vegetation assemblages among the two cases scenario, as previously found in other studies. The data was then analysed on the basis of two other levels of diversity: functional and phylogenetic. These metrics shed light on assembly processes, reflected by the structure of the niche occupied by communities, and their degree of functional specialization. Whereas phylogenetic methods helped to better evaluate ecosystem quality status. A complex scenario, driven by the history of land-use, degree of grazing pressure and environmental filters, is to be understood for a win-win approach to conservation.

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Functional, spectral and genetic responses of yellow water lily, *Nuphar lutea*, to environmental drivers

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Keywords: environmental gradients, functional traits, genetic diversity, *Nuphar lutea*, spectral traits

The aquatic floating-leaved macrophyte *Nuphar lutea* represents a top competitor species in a context of global change and freshwater degradation, given its ability to access sediment nutrients and shade co-occurring species. It is therefore interesting to understand how this species responds to changes in environmental conditions to forecast future freshwater ecosystem trajectories. In this study, we combine functional, spectral and genetic information to investigate how environmental drivers influence *N. lutea* traits variability at the regional scale. 28 populations were investigated in four lake systems in central and northern Italy. For each population, we measured leaf structural and biochemical traits, as well as leaf reflectance measures and genetic diversity metrics. GAM models were used to investigate the effect of five key environmental variables on traits variation. Conductivity (SPC) was the most common driver of *N. lutea* traits variability followed by sediment quality (phosphorus and organic matter content). The influence of SPC was mediated by a strong site-dependent effect, inducing non-linear responses of traits. Nutrients availability generally increased traits performance, however adaptive responses to potentially stressing conditions were also observed. Genetic diversity negatively correlated with SPC, suggesting a selective environmental pressure on genotypes and traits. The use of spectral traits proved to be informative of plant performance and could be further developed using high-resolution multispectral satellite data to produce site-scale maps of traits variability, allowing a continuous observation of plants responses. To further develop the understanding of plant traits variability, we promote the collection of data associated with more detailed ecological descriptors.

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Changes in the Flora on Bergeggi Islet (NW Italy) across 100 years

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Keywords: Bergeggi island, flora evolution, gull, land-use change, Mediterranean small island, ruderal species

Within the Mediterranean basin thousands of islets show exceptionally high levels of plant diversity, playing a key role in this important global biodiversity hotspot. In this study, long-term changes in the flora of Bergeggi, a small islet in the northern Tyrrhenian Sea, were empirically assessed. Species were assigned to two abundance classes (rare and not rare species) for the years 1907, 1970, and 2020; and to three classes of abundance changes over the period 1907-2020. Regional abundance of declining/extinct species and changes in species abundance were correlated with their morphological and life history traits (life form, perenniality, height, dispersal agent, pollination mode), niche and biogeographic characteristics (habitat specialization, level of endemism, biogeographic origin) and taxonomic group. Floristic change was characterized both in terms of absolute numbers of extinct and existing species and through a measure of relative change in range size. Knowledge of changes in land use and ecological correlates of floristic change made it possible to infer the causes of species change and to identify which traits are associated with species vulnerability. The long-term biological changes documented in the species assemblage of the Bergeggi islet flora are consistent with the predicted consequences of climate and land-use changes that have occurred on the islet during the past century.

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Arable plant communities as surrogates of soil microbiota along a gradient of agricultural intensity

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Keywords: arable weed, bacteria, cross-taxon congruence, environment, fungi, management, surrogate organism

Cross-taxon analyses are important to detect organisms that are surrogates of other components of biodiversity. However, multi-taxonomic surveys can be challenging, expensive and time-consuming. To our knowledge, no studies investigated cross-taxon congruence between vascular plant and soil microbial communities in arable ecosystems. Thus, in this study we evaluated whether arable plant communities can be used as a surrogate of soil bacterial and microfungal communities in the rhizosphere of the crop plant *Allium ampeloprasum* L. (Amarillydaceae), along a gradient of agricultural intensity. No correlations in species richness were detected, but correlations in species composition were significant between all the three biotic communities. However, after controlling this relationship for the effect of environmental factors, only the correlation in species composition between bacterial and fungal communities remained significant. Partialling out the effect of agricultural intensity, all the correlations in species composition were significant. Co-correspondence analysis highlighted that the species composition of plant communities is predictive of that of fungal communities only. These results highlight that consistent shifts in taxonomic composition of arable plant and rhizosphere microbial communities of the crop plant are mostly driven by environmental factors. Regardless of the drivers of congruence, we suggest that the composition of plant communities can be used as a surrogate of those of the rhizosphere microbial communities of the crop plant.

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A global approach to plant functional groups

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Keywords: ecological modelling, ecological niches, functional ecology, TRY

Forecasting how ecological communities will respond to anthropic infrastructures and environmental changes is one of the pivotal tasks of climate change mitigation strategies (Sitch et al. 2008). However, the modelling of plant communities' dynamics in time and space is hampered by the sheer number of species in natural systems. A way to reduce the complexity is grouping species sharing similar ecological niches into functional groups or functional types (Harrison et al. 2010). Often, the creation of functional groups is carried out for each case study ad-hoc in a non-systematic way, limiting its transferability to other geographical areas or study systems (Lavorel et al. 2007). To provide functional groups that are not region-specific but valid for the entire world, we analysed a global functional trait database (TRY) and a plant-soil cooccurrence database to propose a generic plant functional group (PFG) taxonomy (Fig. 1). Based on available functional traits (Boulangea et al. 2012), we grouped all species along 7 principal ecological dimensions: dispersal, soil use, shade tolerance, competition for light, demography, climatic preference, and resistance to disturbance. To this aim, we carried out a multi-step clustering process of species that included a PCOA of trait values across each dimension to retrieve species scores in the functional ordination space, followed by regression trees, using trait values as inputs and specifying PCOA scores as output values. We then combined in hierarchy all dimensions' regression trees to obtain the comprehensive PFGs. Finally, to test whether our PFGs accurately summarize species functional variation, we validated our approach by comparing species and PFG-level diversity indices from plot-based community assessments.

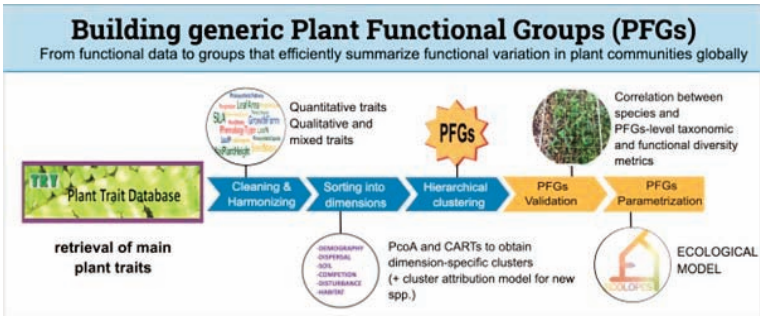

Fig. 1
Plant Functional Groups building workflow.

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Biotechnology applications of fungal strains in paddy soil

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Keywords: bioremediation, fungi, mesocosm, rice plants, tolerance test, trace metals

Fungi constitute an important bioremediants group due to their well-developed enzymatic system and rapid growth rate (Goltapeh et al. 2013, Bharagava et al. 2019). Thanks to an agreement between the University of Genoa and CREA of Vercelli, a mesocosm-scale experiment was set up in the open field. The project has two main objectives: the isolation and identification of fungi from paddy soil; the study of the synergy between fungi and rice plants to evaluate biotechnological applications on matrices contaminated by trace metals. Soil samples were collected for chemical analysis and mycological characterization. Two varieties of rice - Titanio and Crypto - were sown in soil of four different tanks. Three different inocula - containing eight fungal strains - were dispersed in their corresponding tanks at the same time. Four fungal strains of eight were been tested on arsenic solution previously. The tolerance test was conducted using culture medium supplemented with arsenic at two different concentrations (1600/800 µg/L). After 30 days, the tanks were flooded to simulate the traditional cultivation method. Preliminary results have been collected. Fungal strains belonging to 12 different fungal genera have been isolated. Two genera were most abundant: *Penicillium* spp. (19-41%) *Fusarium* spp. (16-47%). Regarding the tolerance test, it was no observed significant differences between test and control diameters. This means that the fungal strains tested are tolerable to substantial arsenic concentrations. Morphometric data of cultivated plants were collected and bioaccumulation and tolerance tests will be conducted on the fungal strains studied in the next future.

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MedGermDB: a seed germination database for Mediterranean plants

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Keywords: automated tools, boolean string, conservation, data extraction, EUNIS, germination database, macroecology, Mediterranean, modelling, pdf search, restoration, seed traits, thermal limits

The study of seed regeneration traits leads to the understanding of plant responses to climate change during early life cycle stages. Measuring seed thermal responses is crucial to identify climate risks for regeneration and can inform the implementation of seed-based solutions to environmental and societal challenges. Unfortunately, seed germination data are still scarce for many regions and *taxa,* and when available remain disaggregated in multiple non-accessible sources. Here, we show a rapid and detailed systematic process for the development of a database that can compile information from different sources to explore macroevolutionary and ecological drivers of seed germination syndromes and requirements. We applied an automatic approach to extract data from the literature. Using a list of Mediterranean species we built a germination database avoiding traditional manual compilation methods that can take a lot of time and effort. In total, thousand of references were screened through an automatic process, and at the moment we are extracting data from hundreds of articles and Mediterranean flowering species with germination information. We have extracted germination primary data such as temperature, dormancy-breaking treatments, photoperiod, and storage for 2669 records from 61 full-texts, 172 species, and 38 families. Finally, applying these data, we will model the species' thermal limits for seed germination, and we will determine the current and future species' thermal mismatches to identify germination syndromes compatible with warming scenarios. Therefore, the gathered data will provide information about regenerative traits that can be used in effective seed-based conservation and restoration actions in the Mediterranean basin.

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To what extent do the effects of organic and conventional agriculture change plant diversity?

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Keywords: organic farming, plant diversity, segetal flora

Loss of biodiversity and related ecosystem services in agricultural landscapes and changes in species composition are mainly promoted by agricultural intensification, while it has then been suggested that organic farming systems may enhance biodiversity. To understand to what extent different farming systems affect plant diversity, this study aimed to assess the segetal flora in three farming systems: conventional, in transition from conventional to organic, and organic. One of the most common indicator of biodiversity is Shannon's entropy, which is related to environmental heterogeneity, and thus to species diversity. Floristic data was collected over a period of 3 years through surveys in Sardinian globe artichoke fields (3 agricultural systems×12 plots×3 surveys per year×3 years). The segetal flora accounted for a total of 110 plant species classified as native or non-native. A significantly lower number of species were detected in the conventional system compared to transition and organic. A number of species occurrences resulted unrelated to the agricultural systems, such as *Oxalis pes-caprae* and *Stellaria media*. Our results showed that organic farming often has positive effects on species richness. However, a higher coverage of plant species was observed in the conventional system compared to the organic and transition. The lower number of plant species found in conventional systems, counterbalanced by a higher total cover, may be the result of the traditional weed control conducted by farmers, which may promote some more aggressive weeds. Conversion of conventional into organic improved plant communities diversity, reconciling sustainability and provision of ecosystem services without decreasing yields.

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Characterization of culturable truffle inhabiting fungi isolated from *Tuber melanosporum*, *T. aestivum* and *T. borchii* ascomata

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Keywords: *Candida*, culture, host-specificity, *Penicillium, Peniophora cinerea,* truffle inhabiting fungi

Truffles in the genus *Tuber* host and feed a wide community of organisms including insects, bacteria, and fungi. Among microorganisms, truffle-inhabiting fungi (TIF) have been poorly investigated and only a limited number of yeast and filamentous species have been identified. In this work, we isolated and barcoded culturable TIF from 16 ascomata of *T. melanosporum*, *T. aestivum*, and *T. borchii* of different provenances. Eighteen strains were identified the species level, four at genus level, and one at order level. *Penicillium* was the most represented genus with five species and the only TIF genus isolated from *T. melanosporum* ascomata. Six TIF had colonies with a yeast morphology, including two species of *Candida*. Five species (*Leohumicola* sp., *Knufia tsunedae*, *Hypocreales* sp., *Sagenomella* cfr. *verticillata*, *Kondoa* sp.) had rare ITS sequences compared to those deposited in GenBank. Except *Peniophora cinerea*, all TIF identified in this work have never been reported in *Tuber* ascomata until now. In-depth investigations on TIF and their host specificity are needed to evaluate the effects of these fungi on the truffle life cycle and the quality of ascomata.

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The cold range limit of prominent alpine graminoid species

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Keywords: alpine, biogeography, freezing resistance, fundamental niche, low temperature, microclimate, range limits, snow cover

Explaining where and why a species occurs why it is absent at other places is a fundamental question in ecology. However, the actual range limits of alpine plant species are largely unexplored. Here, we identify the cold range limits of the prominent alpine graminoids on acidic soils that intermingle in mosaics of high-elevation habitats across the European Alps: *Carex curvula* and *Nardus stricta* (Fig 1). We assessed ground-truth microclimate,

Fig. 1
Cold range limit visualization of the two study organisms (*Nardus stricta, Carex curvula*), close to the alpine research station ALPFOR, Switzerland (8th of June 2020). *Nardus* is widely distributed here, except for the wind-exposed ridge (*Carex* dominance). *Nardus* range limit is indicated with dotted line. Wind-exposed ridge was already snowfree since 25th of December 2019 with soil minimum temperature of -5.0 °C. Shelter area was snowfree since end of April 2020 with soil minimum temperature of -0.6 °C.

snow cover duration, soil chemistry and vegetation characteristics at high spatio-temporal resolution at 115 microsites. Field data were combined with various freezing resistance analyses at 38 microsites by employing mixed regression models. Season length, growing degree hours and soil chemistry did not demarcate the two species' ranges, while their distribution was strongly affected by soil minimum temperature in winter. *Carex* occurred at sites with and without protecting snow cover and resisted low soil temperatures (−13°C). *Nardus* was absent at microsites with snow cover duration < 5 months and soil minimum temperatures below −5°C. During the growing season *Carex* had a higher leaf/shoot freezing resistance (LT50: −16.1°C) than *Nardus* (−13.3°C). Shoot apices tolerated lowest temperatures: *Carex* −30°C, *Nardus* −24°C. However, a vital shoot apex alone did not ensure regrowth after winter, since intact vessels and roots were required. The cold range limits are evidently set by thermal extremes in winter and not by gradual thermal constraints to growth and development (von Büren, Hiltbrunner 2022). Microtopography, thus snow distribution pattern, in concert with the species' freezing resistance explains the cold edge of the fundamental niche of these two species.

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Plant functional traits and ecological strategies analysis as an attempt to define the best bioenergy destiny for Invasive Alien Species biomass

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Keywords: biodiversity, biofuels, CSR plant strategies, eradication, Global change, plant global spectrum, sustainable bioeconomy

Invasive alien plant species (IAS) are one of the biggest environmental problems in Europe, where their eradication is mandatory (UE n. 1143/2014). The biomass of removed plants is considered a waste to be disposed of, but from a circular economy perspective, it could become a feedstock for bioenergy production. We aim to evaluate (i) if some functional types could predict the use of IAS' biomass, and (ii) if plant ecological strategies could predict the characteristics of biomass. We assembled leaf and nutrient traits, and Grime's CSR plant strategies, of 63 IAS occurring in Lombardy. We calculated the C to N ratio (CN) and the gross heating value (GHV) as indicators of the affinity of biomasses to biochemical (CN) or thermal (high GHV) processes.-For a set of IAS having a high ecological impact in Lombardy, we measured the aboveground biomass CN and GHV.-The CN and GHV correlated, respectively, with the leaf economics spectrum and the size spectrum. We identified four groups of IAS. Three groups were composed of IAS with greater organ size, which may be a suitable feedstock for thermal processes (high GHV), but displayed significant differences along the leaf economics spectrum suggesting different rates of biomass production. Two groups, broadly corresponding to herbaceous species, were composed of more acquisitive and fast-growing IAS with low CN, being more suitable for biochemical processes. We found a significant correlation between CSR ecological strategies with biomass traits, especially for herbaceous species.

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Forest structure and management types alters LHS and clonal traits of plant understory in closed stands

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Keywords: clonal traits, coppice, environmental heterogeneity, *Fagus sylvatica*, functional diversity, habitat filtering

We investigated the role of structural features and two management types (coppices with standard, old CWS; high forest, HF) in 56 beech closed forest stands plots located in central Italy in affecting the Leaf-Height-Seed scheme and clonal traits on plant communities of the understory. We expected that (i) stand structure will enhance functional diversity through environmental heterogeneity; (ii) HF stands will host species with traits typical of more old-growth forest conditions like tall (H) species with large seed (SM), high specific leaf area (SLA), large lateral spread (LS), high number of clonal offspring (CO) and higher persistence (PCGO); (iii) HF will enhance functional diversity for all traits because of environmental heterogeneity. We run multiple-linear models on community weighted means (CWMs) and standardized effect size of functional diversity (SES-FD). Increasing deadwood enhances the functional diversity of SLA through micro-environmental heterogeneity, while diameters distribution filters for species with similar sizes. Lying deadwood promoted a variation of CO from phalanx strategy (high CO) to guerrilla strategy (low CO) under more heterogeneous conditions. HF selected high SLA with low PCGO. High forest management enhances functional diversity for SLA and clonal traits, suggesting the role of micro-environmental heterogeneity exerted by mature forest conditions, while diversity of H and SM is reduced. Our study suggests that understory plant community diversity changes in response to forest structure and management. Combining Leaf-Height-Seed with clonal traits offers a promising framework for understanding and predicting plant response to management practices, allowing also to take more informed decisions about forest management.

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New insights on *Tuber magnatum* mycelial soil ecology

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Keywords: ITS primers, italian white truffle, soil DNA amplification, soil mycelia, *Tuber* spp.

The ecology of *Tuber magnatum* Picco and the intriguing role of other soil microorganisms on soil mycelial development and fructification is not totally clarified. In natural *T. magnatum* truffle grounds its mycorrhizas were rarely found, but mycorrhizas and ascomata of other truffles are often present (Leonardi et al. 2013). *T. magnatum* mycelium is more widespread than its mycorrhizas (Zampieri et al. 2009, 2010, Iotti et al. 2014), thus it is the best target to study *T. magnatum* soil development. In this work, the co-occurrence of other *Tuber* species with *T. magnatum* mycelium in several productive areas located in central and northern Italy, was investigated by using species-specific primers. Most (82%) of the examined soil samples had at least one other *Tuber* species in addition to *T. magnatum*. The most common was *T. maculatum* followed by *T. borchii*, *T. rufum*, *T. brumale*, *T. dryophilum*, *T. macrosporum*, and *T. melanosporum*. Instead *Tuber aestivum* was never detected. The pairwise associations between *T. dryophilum-T. brumale*, *T. brumale-T. borchii,* and *T. borchii-T. dryophilum* were statistically significant (Leonardi et al. 2021). Our results, suggest that *Tuber* mycelial network is much more extensive than the distribution of their ectomycorrhizas and ascomata. Furthermore competitive exclusion seems to take place only for root colonization. Moreover, recent studies conducted in *T. magnatum* truffle grounds with species-specific primers, have allowed us to detect its mycelium at depths greater than 40 cm. It would be interesting to verify if also the mycelia of other *Tuber* species occur at such depth.

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Drivers of the growth and establishment of the invasive *Rumex acetosella* in Andean fallow systems

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Keywords: forage production, invasive species, participatory research, traditional fallow management, variation partitioning, weed control

The implementation of intensified crop rotations and agricultural practices in the Andean cropping systems has reduced the effectiveness of traditional fallows in rejuvenating soil fertility and providing forage, and the potential solution of improved fallows must consider the impact on growth of non-native weeds, which is not well understood. This study aimed to i) investigate how biotic and abiotic environmental factors impact the establishment and productivity of weeds in traditional fallows; ii) determine the effectiveness of improved fallows in controlling weedy vegetation in smallholder rotations in the high Andes. Our research focused on the invasive species *Rumex acetosella*, a prevalent concern for farmers in the central Peruvian Andes. In 2017, we conducted a multi-site, participatory research trial in eight farming communities to identify the primary factors influencing the presence and productivity of *R. acetosella* by examining 82 sites with traditional (control) and improved fallow (seeded vetch and oats) treatments, measuring soil properties, categorizing vegetation, and calculating indices for *R. acetosella* pressure, weed pressure, and forage productivity. Our findings suggest that improved fallows effectively suppressed weedy vegetation, including *R. acetosella*, compared to unmanaged controls. Particularly, the abundance of *R. acetosella* was linked to other non-planted species and soil fertility predictors. The *R. acetosella* index was significantly lower in improved fallows than in traditional fallows, and *R. acetosella* biomass was higher in less productive sites, such as those with cooler climates and less fertile soils. Maintaining soil fertility inputs during the fallow phase can thus greatly reduce weedy species biomass.

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Modeling geographic distribution of arbuscular mycorrhizal fungi from molecular evidence in soils of Argentinean Puna using a maximum entropy approach

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Keywords: arbuscular mycorrhizal fungi, metabarcoding, niche modeling, puna

The biogeographic region of Argentinean Puna mainly extends at elevations higher than 3,000 m within the Andean Plateau and hosts diverse ecological communities adapted to aridity, low temperatures and poorly evolved soils. Geomorphology is shaped by drainage networks, often resulting in hypersaline endorheic basins known as *salar*. Local communities rely on soil fertility for agricultural practices and on pastures for livestock rearing. Investigating the scarcely explored microbiological diversity of these soils as indicators of ecosystems functioning might help to predict the fragility of these harsh environments. In this study we collected soil samples within three typical landscapes of Puna: grassland, hypersaline salar and family-run crop fields. Total fungi and arbuscular mycorrhizal fungi (AMF) occurrences were analyzed using eDNA sequencing (Ontivero et al. 2020, Nepote Valentin et al. 2023). A low environmental AMF occurrence was observed in salar, while grasslands and temperature seasonality range were enhancing factors, suggesting a role of seasonal dynamics in shaping AMF communities. The highest AMF abundance was observed in *Vicia faba* cropfields. Species Distribution Modeling (SDM) was performed with a maximum entropy approach within a coherent area of Puna and Altoandino regions to predict the suitability for AMF by including bioclimatic and edaphic predictors. To assess the impact of farming, we also predicted suitabilities excluding the cropfield samples, thus highlighting a lower predicted AMF suitability had these cultivated areas remained unmanaged punean habitats. Thus, SDM approach highlighted the importance of considering anthropogenic factors to accurately predict AMF distribution in the habitats of Puna.

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Plant distribution and modern pollen deposition across an elevation eco-gradient: a case study from the Eastern Italian Alps

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Keywords: elevation gradient, environmental parameters, modern pollen deposition, Southern Alps, vegetation altitudinal belts

This study analyses the distribution of vegetation and its modern pollen representation in moss pollsters along an eco-gradient in the Italian Eastern Alps and explores the effects of terrain and climate variables on both datasets. Mosses were collected in 25 sites in the province of Trento at elevations ranging from ca. 300 to 1400 m a.s.l., from open areas, deciduous, and conifer forests. At each site, vegetation was surveyed according to the Braun-Blanquet method. Climatic data, bioclimatic indices and terrain parameters were obtained for each sampling site. A cluster analysis, supported by a detrended correspondence analysis (DCA) evinced three distinct pollen associations, roughly corresponding to the altitudinal pattern of vegetation in the study area. Multiple factors such as uphill dispersal, the regional pollen load and the presence of high pollen producers may affect the pollen-plant representation along the gradient. Canonical correspondence analysis (CCA) identifies elevation, insolation, spring precipitation, summer temperature, Ellenberg quotient and Summer Water Balance as relevant factors controlling vegetation distribution. Elevation, insolation, summer precipitation and temperature, Ellenberg quotient and the Gams' hygric continentality index explain more variance within the pollen dataset. A qualitative comparison among pollen and the corresponding parent plant occurrence qualifies *Abies alba*, *Fagus sylvatica*, Poaceae and *Cyclamen* sp. pollen as suitable indicators *taxa* of the local vegetation. Several high producers with very effective, long-distance anemophilous dispersal (species of genus *Pinus*, *Ostrya*, *Alnus* and *Juglans*) or mixed pollination mechanisms (anemophilous and insect-pollination: *Fraxinus ornus* and *Castanea sativa*) show no or little association with their parent plants.

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Mulching in lowland hay meadows favors biomass development and reduces plasticity through adaptive convergence of above- and below-ground traits: a possible tool for phytoremediation

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Keywords: fine roots, functional traits, global plant spectrum, heavy metals, leaf economics spectrum, PCB, phytoremediation, root economics spectrum

We evaluated seven years of mulching (i.e., cutting and leaving the crushed biomass to decompose in situ) in a PCBs and HMs soil-polluted Site of National Interest (SIN Brescia-Caffaro). We compared the floristic composition and the above- and below-ground community-level plant traits between areas subject to mowing and mulching or only traditional mowing. Our results highlighted that the abandonment of agricultural activities imposed by soil contamination led to a marked increase in the soil organic carbon and pH, and the over-imposed mulching induced an additional increase in soil nutrients. Mulching favored the establishment of a more productive plant community characterized by a higher biomass development (both above- and below-ground) and a more conservative-resource strategy typical of stable hay meadows. Above- and below-ground plant traits showed a coordinated variation at the community level, highlighting an adaptative convergence between the leaf and root economics spectrum. The plant community of the control area showed higher SLA and SRL, thus indicating higher plasticity. Although mulching selected a two-fold number of metal-tolerant plant species, it didn't significantly affect the composition of plant species able of PCB remedying. However, mulching appears to be a promising tool for enhancing the root web that functions as the backbone for the proliferation of organic contaminants' degrading microbes. Besides these positive effects, favoring species with a higher biomass development, in the long term, may lead to a biodiversity reduction and thus to potential consequences also on the diversity of native species important for phytoremediation.

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Contrasting responses of forest growth and carbon sequestration to heat and drought in the Alps

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Keywords: carbon cycle, climate extremes, drought, GPP, larch forest, stem growth

Climate change is expected to increase the frequency and the intensity of climate extremes, consequently increasing the risk of forest role transition from carbon sequestration to carbon emission. These changes are occurring more rapidly in the Alps, with important consequences for tree species adapted to strong climate seasonality and short growing season. In this study, we aimed at investigating the responses of a high-altitude *Larix decidua* Mill. forest to heat and drought, by coupling ecosystem- and tree-level measurements. From 2012 to 2018, ecosystem carbon and water fluxes were measured by means of the eddy covariance technique, together with the monitoring of canopy development. From 2015 to 2017 we carried out additional observations at the tree level, including stem growth and its duration, direct phenological observations, sap flow, and tree water deficit. Results showed that the warm spells in 2015 and 2017 caused an advance of the phenological development and, thus, of the seasonal trajectories of many processes, at both tree and ecosystem level. However, we did not observe any significant quantitative changes regarding ecosystem gas exchanges during extreme years. In contrast, in 2017 we found a reduction of 17% in larch stem growth and a contraction of 45% of the stem growth period. Indeed, the growing season in 2017 was characterized by the highest water deficit occurred during the study years. Due to its multi-level approach, our study provided evidence of the independence between C-source (i.e., photosynthesis) and C-sink (i.e., tree stem growth) processes in a subalpine larch forest.

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The influence of flower strip structure on the abundance of different arthropod functional groups

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Keywords: apple orchard, flower strips, functional groups, pest control, pollination, vegetation structure

The effect of flower strips on functional groups of arthropods is an important topic in research on pest control and pollination. However, few studies have investigated the influence of the structure and of flower strips on different functional groups of arthropods. In this study, we investigated how fine-scale variation in the structure of flower strips influence the abundance of arthropods belonging to different functional groups (i.e., phytophagous, pollinators, parasitoids, predators and saprophages). In May 2022, we sampled plants and arthropods in 30 plots (1 × 6 m) placed on inter-row annual flower strips in an organic apple orchard in Soave (Italy). In each plot, plant species and the total number of flowers were recorded. Total vegetation cover (%), average vegetation height (cm) and leaf area index (LAI) on the ground were also recorded. Arthropods were collected in the morning and afternoon of the same day using sweep netting in each sampled plot. The relationships between plant community structure and the abundance of different functional groups of arthropods were tested through GLMMs. Pollinator abundance was positively related to vegetation cover and number of flowers, parasitoid abundance was positively related to total vegetation cover, while phytophagous abundance was positively related to plant species richness. Our results suggest that different flower strip attributes influence different arthropod functional groups and that an effective planning and management of flower strips could improve not only the support for pollinators but also for other functional groups involved in pest control.

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Trade-off between growth and survival in plant species used for coastal dune restoration

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Keywords: coastal dunes, ecosystem restoration, growth rate, plant traits, survival rate, trade-off

The growth-survival trade-off has been widely documented for phanerophyte species, while there is little evidence for non-phanerophyte species. To explore the relationship between growth and survival, we monitored 355 individual plants of 13 perennial non-phanerophyte species used in a coastal dune restoration project. Individual plants were monitored every 30 days to calculate relative growth and survival rates. To determine whether plant functional traits explained patterns of growth-survival trade-off, we regressed the relationship between growth and survival on values of leaf and floral traits. We found that the growth-survival trade-off can also be observed in perennial non-phanerophyte plant species. Species of distinct coastal dune communities (i.e., foredune vs. transition dune communities) differed with respect to the growth-survival trade-off, with resource allocation differing depending on the ecological and biotic features of the ecosystem in which they live. Leaf dry matter content and mean number of floral displays explained species position on the growth-survival trade-off axis; species with high growth and low survival rates exhibited an acquisitive strategy, with low values of LDMC, and a low sexual reproductive effort. In contrast, plant species with low growth and high survival rates exhibited a conservative strategy, but also high sexual reproductive effort, suggesting that trade-offs occur in resource allocation among vegetative and reproductive plant structures. The trade-off we found between growth and survival in perennial non-phanerophyte species provides useful guidance for planning cost-effective coastal dunes restoration actions, especially when these are nature-based actions and involve investing resources in plants production and planting.

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Reproductive biology of *Santolina ligustica* Arrigoni

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Keywords: Asteraceae, narrow range, pollen vectors, reproductive strategies, seed germination

Understanding the breeding system, the reproductive success and long-term demographic patterns of endemic species is fundamental to improve strategies for their conservation. *Santolina ligustica* Arrigoni (Asteraceae) is an endemic perennial shrub limited to a few localities in Eastern Liguria (NW Italy), and it grows on ophiolitic substratum. The species is considered "Near Threatened" (NT)according to Red List of the Italian Flora. In this study, we investigated the reproductive biology of *S.ligustica* and assessed its reproductive success. More specifically, we: (a) evaluated the type and the frequency of pollinators; (b) quantified the effort and reproductive success of the plants by tests on capitula (open-pollinated and bagged) and (c) evaluated the seeds' germination performance. A total of 46 different *taxa* of insects were observed. The most abundant visitors were mainly *Coleoptera* (77%) and *Hymenoptera* (19%), suggesting a generalist pollination system. In the open-pollinated capitula, the 7.87 % (SD 11.93) of the florets produced well-formed cypselae, while the bagged capitula did not produce fruits. These results suggest that the plant is auto incompatible and the pollinators activity is crucial. Despite the high visitation rate observed, *S. ligustica* showed a low fruit-set per each capitulum. Seeds of *S.ligustica* can germinate over a wide range of conditions immediately after harvesting, suggesting that seeds are non-dormant. Maximum germination occurs between 15 °C and 22 °C, temperatures that are in line with germination occur in early autumn, after the summer in Mediterranean environment characterized by dry conditions.

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Influence of environmental and structural features on the understory of *Pinus nigra* old-established plantations in northeastern Alps

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Keywords: forest structure, *Pinus nigra*, plantation, understory diversity

Pinus nigra have been largely used for afforestation purposes outside its native range thanks to its high tolerance to environmental stress. We studied how environmental conditions influence the understory of *P. nigra* old-established plantations and how the structure of forests can affect the plant community understories. Our investigation focused on two aspects: (i) determining the relative influence of environmental factors (elevation, aspect, and slope) and structural parameters (tree height, basal area, canopy closure, and stand density) on the understory, and (ii) examining if these parameters have positive or negative effect on the understory. We surveyed 60 *P. nigra* old-established plantations across the Trentino region (northeastern Italy) and collected species cover, stand and environmental data. We estimated the effect of environmental and structural conditions on species richness and community mean of life forms by performing a variation partition and an RDA. We found environmental parameters explain more variation than structural ones. Elevation, slope and stand density affect species richness positively, while aspect affect species richness negatively. Concerning life form, canopy closure increases geophytes and decreases hemicryptophytes, while chamephytes increase with elevation. Our work improves the understanding of the ecological characteristics of herbaceous understory of *P. nigra* old-established plantations.

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The effect of solitary trees on diversity of extremely species-rich grasslands in the White Carpathians

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Keywords: grasslands, scattered trees, species composition, transect, White Carpathians

The ancient grasslands in the southwestern part of the White Carpathians Mts (Czech Republic) are on a fine scale among the world's richest ecosystems. While many studies have discussed the influence of local soil conditions such as moisture, pH and nutrient limitations, and Holocene development on shaping this richness, none of them has yet tested the influence of solitary trees which are, nonetheless, inherent component to this habitat. The species' richest meadows are characterised by abundant scattered trees, especially oaks, that can affect species composition of grasslands by shading, water competition or tree leaf litter. However, it is still unclear how much their current decline may influence the vegetation composition. The sampling design was based on transects placed at selected sites with scattered trees. Along each transect 20 phytosociological relevés with an area 1 m^2 and regular distance from each other were recorded, and measurement of the primary environmental parameters has been done. Among those parameters belong soil pH, soil moisture, tree canopy, microtopography, moisture, and light conditions measured using the carbon and oxygen isotope content of chosen plant species. The results are analysed using both one-dimensional and multidimensional statistical and numerical methods; microtopography is analysed using the ArcGIS Desktop software. We test the hypothesis that the distance to a solitary tree significantly accounts for the vegetation composition, representation of fringe and open-woodland species, and local species richness. Analyses of measured environmental factors will reveal which factors are primarily responsible for the effect of solitary trees on grassland vegetation.

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Pinus pinaster forests at their Italian peninsular southeastern distribution limit

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Keywords: phytosociology, *Pinetea halepensis*, *Pinus pinaster*, syntaxonomy, Tuscany, vegetation

In peninsular Italy, natural *Pinus pinaster*-dominated forests occur in Liguria and Tuscany regions, mostly on siliceous substrates. These forests are classified in the alliance *Genisto pilosae-Pinion pinastri* (class *Pinetea halepensis*, order *Pinetalia halepensis*) and are of conservation interest. The aim of this study is to clarify the syntaxonomical position of *P. pinaster* forests confined to southern Tuscany, at their southeastern limit of native distribution in peninsular Italy. We collected 50 original phytosociological relevés in southern Tuscany and 244 published and unpublished relevés from Tuscany and Liguria. To compare original relevés and previously-described vegetation types, we performed a cluster analysis and a principal coordinate analysis (PCoA). Further, we ran an Indicator Species Analysis (ISA) to identify diagnostic species of each group. The cluster analysis showed the presence of two groups representing forests of southern Tuscany, and northern Tuscany and Liguria, respectively. The latter cluster was further divided into two sub-clusters representing forests occurring on ophiolitic and siliceous substrata, respectively. The cluster analysis, in agreement with the PCoA, suggested that southern Tuscany forests constitute a distinct community from those described further in northern Italy. They are characterized by an array of evergreen heliophilous and thermo-xerophilous species occurring on acidic soils. However, species of the understory showed a more thermophilic feature in southern Tuscany forests in comparison to those found in northern Tuscany and Liguria, impoverished in sclerophyllous shrubs and enriched of mesomediterranean broad-leaved trees. These results give us insights on the phytogeographic and conservation interest of southern Tuscany *P. pinaster* forests.

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Plant traits: a focus on seasonal and annual variations

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Keywords: alpha functional diversity, LDMC, permanent grassland, plant traits, seasonal variability

Nowadays, plant traits are used in several fields, particularly for ecological studies and for developing management plans (Roelofsen et al. 2014). Traits profoundly affect plant resource acquisition and ecosystem processes (Reich 2014). This study aimed to understand how plant traits vary between years and seasons in a Mediterranean grassland. The research was performed in the framework of a European Life project (LIFE Regenerate). The study site was located in the central part of Sardinia (Santu Lussurgiu) at 350 m a.s.l in a permanent grassland system. We applied the point quadrat method to quantify the Specific Contribution (CSP) of each species (Daget, Poissonet 1971). The surveys were replicated twice each year, in spring and winter, between 2019 and 2022. We associated to 61 species, accounting for 80% of the total CSP different traits or attributes: leaf dry matter content (LDMC), biological forms, start-end of flowering, and Ellenberg indices (moisture and temperature). LDMC was calculated by collecting ten leaves from each species and weighing them after and before they had dried using an oven under 70° C for 74 hours. The other data were acquired from open-source websites (e.g., Acta Plantarum 2022) and Pignatti (2005). As a whole 142 surveys were performed and 250 species were recorded. R-studio application was used to conduct the analysis. The indices of Alpha functional diversity vary tremendously between seasons and years. Plant traits should be the subject of more investigation since, as we can see, they provide a rich and significant framework.

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Thermal heterogeneity in epiphytic communities depends on their functional diversity

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Keywords: epiphytic communities, FLIR thermal camera, microclimate

Recently, it has been highlighted how the analysis of phenomena at the organism's own scale is crucial for understanding the actual ecosystem functions of a given community. At the tree-level, non-vascular epiphytes, such as lichens and bryophytes, constitute the ecosystem component capable of regulating microclimatic conditions through chemical-physical processes. In particular, their relationship with the water cycle has been extensively studied, while temperature models at the scale of the individual tree have been overshadowed. In this work, we aimed at investigating the thermal heterogeneity of epiphytic communities at the microscale under varying water availability. Particularly, we hypothesize that thermal heterogeneity at the tree scale, in terms of abundance, distribution, and connectivity of hot and cold spots, depends on epiphytic communities' functional diversity. To achieve this goal, the epiphytic diversity was assessed on 50 sycamore trees (*Acer pseudoplatanus* L.) in a forest site of the Ligurian Apennine (Northern Italy). Then, using a FLIR thermal camera, we captured thermal Infra-Red images under contrasting humidity conditions (dry *vs* wet). The results support our hypothesis: at the tree-scale, the functional traits considered are positively correlated with the surface temperature of epiphytic environment.

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Mapping habitats in Nature 2000 sites in Aosta Valley through photo-interpretation of images from drones and field surveys

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Keywords: Aosta Valley, drones, habitats mapping, Nature 2000, photo-interpretation, UAVs

So far, vegetation monitoring has been conducted mainly in the field, with time-consuming methods and logistical difficulties. But recently, however, remote sensing is becoming a suitable source of data for vegetation classification with satellite and aerial photo-interpretation as most common approaches. These approaches can though produce errors when applied to heterogeneous vegetation on small scales and when pixel size is not small enough to avoid combination of different vegetation. Unmanned aerial vehicles (UAVs), which can reach high resolution with pixel size of a few centimeters, represent a solution to monitor vegetation dynamics, partially replacing field work, reducing costs and acquiring images with high temporal resolution. However, few studies have used UAV images to classify vegetation. Through UAV images photo-interpretation and comparison with field surveys we updated habitat cartography of 5 Nature 2000 sites of Aosta Valley. The aim was to define and test a protocol for UAV images detection taking into account the vegetation phenology to guarantee the acquisition of the best images. The design and classification of polygons were done verifying phytocoenosis, the main species that make up the layers and phenological trends through field surveys. Old and updated maps were compared to quantify the increased information details obtained from high-resolution images and the validity of the method. Results show a resolution increase in the habitat cartography, the correct definition of best conditions and times of the year for image acquisition, and the need of field verifying of real vegetation conditions for its correct classification.

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Fungal revalorisation of industrial and agroby-products

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Keywords: fungal biotechnology, mycology, mycoproteins, novel foods

Global population is constantly growing, as well as the food demand: producing it in a sustainable way is the challenge of the coming years. Among the necessary actions, reducing food losses and making better use of the already existing resources, agroindustrial by-products included, are the first to be taken. Fungi can grow on a wide range of organic substrates, and fungal fermentations have been used for a long time to produce, transform and preserve food. Extremely valuable for their nutritional properties (high in protein and fiber content, while low in fats and sugars), fungi represent an important environmentally friendly solution to produce novel foods and feeds. In this project, we aim to test different agroindustrial by-products as growth substrate for fungal strains, then to scale up the production of a protein-rich biomass and, finally, to produce a prototype feed and food. The choice of fungi, agroindustrial by-products and target consumers will be based on scientific literature. Then, small-volume fermentations (solid state and submerged liquid ones) will shed a light on the chemical-physical variables that influence the fungal growth the most, and will provide fermented biomasses, of which their chemical composition will be analysed. Next, the most influencing parameters will be optimised, conducting targeted tests according to computational statistical approaches. Then, tests on the fermented products will assess their nutraceutical value and antioxidant properties. The final scale-up will provide enough biomass to start structuring the final feed and food for the nutritional and palatability tests.

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The Aspromonte's peat bogs, unique environments in the centre of the Mediterranean (Calabria, southern Italy)

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Keywords: 7140, biodiversity, endangered species, rare habitats, sphagnum, vegetation

Peat bogs in the Mediterranean territories are rare and localized. In Calabria, sphagnum peat bogs are mainly present in the Sila Massif, with a few sites on the Catena Costiera and Serre. In Aspromonte, they are distributed between 700 and 1900 m a.s.l. They are all referable to the EEC Directive 43/92 habitat "7140: Transition mires and quaking bogs" characterized by a vegetation forming peat deposits and floating mats, with oligotrophic to mesotrophic waters, in which the ombrotrophic and minerotrophic (groundwater) components are mixed as the colonized surfaces are mainly flat or undulating, with small depressions. The vegetation study was carried out using the phytosociological method with 10 field surveys. A total of 90 *taxa* of vascular plants were recorded. Aspromonte's peat bogs belong to the association *Sphagno inundati-Caricetum echinateae*, alliance *Caricion fuscae*, order *Caricetalia fuscae*, class *Scheuchzerio-Caricetea fuscae*. These are rather mobile floating bed with sphagnum pads on the surface, crossed by small rivulets with slowly flowing water; in the latter we can found plants belonging to the association *Ranunculo fontani-Potametum polygonifolii*, alliance *Hyperico elodis-Sparganion*, order *Littorelletalia uniflorae*, class *Littorelletea uniflorae*. Twelve sites were surveyed, of which 3 new and 2 considered extinct. Eleven sites fall in the Aspromonte National Park and 3 also fall within the Natura 2000 network. This study made it possible to update the conservation status of each peat bog and detect critical points, mainly due to anthropic activity, such as variations in the overall hydrological system and grazing or transit of livestock, including wild fauna.

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Characterization of three Molise autochthonous lentil (*Lens culinaris* Medik.) landraces

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Keywords: agro-biodiversity, conservation, characterization, plant biology

Agro-biodiversity is a small component of biodiversity, providing genetic resources relevant to food, agriculture, and human health. However, agro-biodiversity, and particularly autochthonous landraces, characterized by high genetic variability, strong adaptation to stress conditions, and the presence of secondary metabolites, are threatened with extinction, primarily due to their replacement by commercial varieties. This study aimed to characterize three autochthonous lentil landraces from different villages in the Molise Apennines—Capracotta, Rionero Sannitico, and Agnone—in comparison to other autochthonous populations—one from Umbria (Castelluccio di Norcia, IGP), one from Lazio (Rascino), and one commercial variety (Turca Rossa)—with a multi-integrating approach (morpho-physiological, genetic, and metabolomic analysis) to support their conservation. In the first phase, the germination seed test and nine IBPGR morphological descriptors were used to evaluate autochthonous germplasm's quality and diversity. Instead, eight ISSR molecular markers were used to assess genetic variability and phylogenetic relationships among populations. Except for the Castelluccio di Norcia lentil (%G = 66.67%), all populations showed good germination capacity (%G > 90%), while the morphological descriptors, clustering analysis and Principal Component Analysis (PCA) revealed high similarity among populations, aside from the Rascino lentil. The PCA and clustering analysis of the genetic profiles divided all populations into two main groups: one including the three autochthonous populations of the Molise region, and another formed by the other three. Further genetic investigation associated with metabolomic analysis and *in vivo* testing of bioactive compounds will identify relationships and peculiar characteristics of landraces to valorize them from a nutraceutical and health point of view.

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Helical graphs to visualize the NDVI temporal variation of forest vegetation in an open source space

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Keywords: biodiversity, biomes, data visualization, global change, remote sensing

Global change caused by human activity has several effects on the biomes of Earth, such as land fragmentation, deforestation, pollution, anthropization of natural landscapes and alterations in the functioning of ecological systems. In this context, remote sensing represents an important tool to assess ecosystem changes, as it allows to collect a huge amount of data at different time and spatial resolutions concerning different components of Earth system (land, ocean, atmosphere, and cryosphere), from which different measurements such as precipitation patterns, global temperatures, snow cover and aerosol can be determined. The aim of this work is to exploit this wide availability of data to display the ecosystem changes using a new visualization method: the helical graphs. The helical graphs represent the change of a variable over time, reporting on the y-axis its moving averages and on the x-axis its rates of change. These new charts were tested on vegetation indices retrieved from Google Earth Engine (https://earthengine.google.com/) to visualize trends on selected biomes of Earth. The results show that the helical graphs are a useful tool to highlight trends that might not be easy detected in a time series. In conclusion, the helical graphs can have a lot of applications in ecology, especially exploiting the wide amount of data available thanks to remote sensing.

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Land-use transformations in traditionally managed ecosystems: the case of Transylvania, central Romania

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Keywords: biodiversity conservation, biodiversity loss, land-use change, Romania, traditional landscape, Transylvania, wood pasture

Biodiversity loss has become a severe obstacle to the ecosystems functioning. Several drivers contribute to this worrying pattern including land-use changes. Maintaining and sustaining Earth's ecosystems healthy largely depends on biodiversity conservation. Scientific evidence reports traditional land-use systems supporting high biodiversity, therefore representing a focal landscape to study. Knowing vegetation dynamics and land-use change trajectories of traditional landscapes could provide a useful guide for preserving plant diversity and improving ecosystem benefits. Accordingly, it becomes necessary to document spatiotemporal changes in Land Use Land Cover (LULC) in traditional landscapes and how minor changes affect land use over time. Transylvania's central Romanian wood pastures are an excellent example of traditional cultural landscapes. Our study focuses on such traditional landscapes disappearing in Eastern Europe due to abandonment and anthropogenic impacts in rural areas. Remote sensing and Google Earth Engine a promising tools for continuous LULC monitoring. Overlapping protected Natura 2000 sites and nonprotected sites will allow us to study how legal protection, management practices and socioeconomic changes from 1986 to 2022 have affected LULC categories. We will compare spatiotemporal changes in Transylvanian wood pastures within protected areas and surrounding landscapes through the Landsat time series. Assumedly, i) The landscape in Transylvania is highly fragmented; ii) Land-use transformations occurred at a lower rate in protected areas; iii) Agricultural lands were abandoned regardless of legal protection. By studying the changes in Transylvanian wood pastures over time, we will understand how socioeconomic impacts have shaped these landscapes, their plant diversity, and how protected areas contributed.

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Traditional agroforestry systems in Europe revisited: Biodiversity, ecosystem services, and future perspectives

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Keywords: biodiversity, ecosystem services, landscape services, traditional agroforestry systems

Traditional agroforestry systems are land-use practices still widespread in tropical and subtropical countries, while in Europe have significantly decreased due to land-use intensification, land abandonment, and urbanization. Nevertheless, scientific evidence reveals that traditional agroforestry systems significantly support biodiversity and ecosystem services and may positively contribute to socioeconomic rural regional development. We worked out a review that follows the PRISMA approach and compiled comprehensive information on traditional agroforestry systems in Europe. Based on the differentiation of different land-use systems, also considering the agricultural as well as forestry components, we compiled information regarding current distribution, management (agrodiversity), biodiversity and agrobiodiversity, ecosystem and landscape services, threats, and restoration initiatives. From a total of 3,304 studies that dealt with agroforestry systems in Europe, both "modern" (e.g., buffer strip) and "traditional" (e.g., meadow orchards), we filtered out 158 studies from 35 European countries which represent the basis for in-depth investigation. We found, for example, that the traditional pastoral agroforestry system in the Mediterranean region, the so-called Dehesa, can harbor up to 300 plant species as well as 238 bird species, of which 134 are breeding birds. With regard to carbon storage, the traditional orchard agroforestry system in Germany stocks ranged between 6.5 and 9.8 Mg C ha−1, showing significantly higher values compared to an intensively used grassland with around 3.4 to 6.7 Mg C ha−1. With the remarkably high benefit for biodiversity and ecosystem services provided, the important role and multifunctionality of traditional agroforestry systems in Europe should be acknowledged and promoted.

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Conservation of steppe element on old cemeteries in the Lower Dnipro region

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Keywords: flora, natural heritage sites, steppe element

Changes in natural landscapes lead to the loss of a large proportion of the steppes. Cemeteries are "islands" of natural vegetation in close proximity of urban areas, often harboring rare and endangered plant species. The key importance of cemeteries in nature conservation is therefore nowadays unquestionable (Moysiyenko et al. 2021). Old cemeteries of Lower Dnipro region preserve steppe vegetation. Only cemeteries built on the virgin part of the steppe, near old villages or old cemeteries in city, may preserve steppe vegetation. Old cemeteries of Lower Dnipro region have classes of steppe vegetation *Festuco-Brometea* Br.-Bl. et Tx.ex Soó (steppes) (steppe psammophytic communities). The high number of sozopheytes (23 species) typical of the steppe (26,7%), such as *Festuca valesiaca*, *Koeleria cristata*, *Stipa capillata*, and a large proportion of natural non-synanthropic species (32,3%), against a low number of invasive species indicates a relatively good state of preservation of steppe vegetation in old cemeteries. Old cemeteries should be subject to special protection not only as monuments but also because they are places for conservation of steppe vegetation and rare species.

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The street trees of Rome: changes in the pattern of distribution and derived criteria of selection

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Keywords: ecosystem services, urban biodiversity, urban ecology, urban plannin, urban trees

Street trees play a significant role in cities' urban ecosystems where edification sprawl is rapidly growing, and green spaces are limited. Among the italian cities, the street of Rome host the highest richness of tree species. The city at territorial level is divided into 15 municipia. Our aim was to analyze the variation of the species distribution within the city's municipia. We create a dataset where we calculated the frequency for all the species divided into municipia; we also calculated the recurrences per street of the species collected in the various municipia. In addition, the dataset was enriched with some biological (size class, flower's sex, flower type, foliage shape, fruit type) and ecological (chorotype) parameters. The final aim is to understand whether there have been criteria or not in the design of the planting of tree species based on the city's toponymy and the species' respective characteristics. On the frequencies of biological features, we developed a cluster analysis and PCA. The highest value in species richness was (municipia I and II, which are also the smallest in size), where the most significant numbers of street tree individuals (15897 and 19687) and biodiversity (71 and 72 species) were observed. *Pinus pinea* L. has the highest number of occurrences in five municipia, followed by *Platanus × hispanica* Mill. ex Münchh. (in four municipia). *Quercus ilex* L., representing the Mediterranean sclerophyllous forest, generally has high values but less than expected. Some relevant differences also occurred among municipia and street typology. An ecological approach is needed for a better selection.

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Climatic changes and bioindication values of vegetation in Pasargadae WHS (Iran): needs for protecting monuments and natural values

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Keywords: archaeological sites management, biodiversity conservation, climate change, plant ecology, ruderal vegetation

The vegetation growing in archaeological areas plays an essential role in the conservation of biodiversity and its knowledge can be of great utility to understand the bioindication values of environmental and edaphic factors. Ongoing global climate change may be a major contributor to the modifications that may occur to vegetation. To analyse the bioindication value of vegetation on climatic or other natural or anthropogenic changes, we selected the WHS of Pasargadae (Iran). Vegetation surveys were carried out on different vegetation types in the area, and the ecological traits of the species were also analysed. A vegetation mapping were also carried out using different aerial photos. A bio-climatic analysis was also carried out. The results showed that several vegetation types are settled in the area. They are the results of an ecological gradient driven by environmental and edaphic factors and anthropogenic stress. Some species have been found to have a key-ecological value. Among them, we underline *Stipa barbata* Desf., which dominated in natural semi-rupestrian habitats; *Bellevalia saviczii* Woronow, which also frequently occurs in clayey soils; *Glycyrrhiza glabra* L., which is linked to silty-sandy alluvial deposits; and *Hordeum murinum* L., which mainly occurs in trampled areas. We also found interesting remnants of vegetation with a dominance of *Alhagi maurorum* Medik, that is very resistant to extreme conditions. The high plant diversity still present, threatened by the increasing xeric condition of the site, should be considered when planning management activities for archaeological sites, and protected for its relevant historical and naturalistic value.

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Spatial patterns of grassland diversity in a Mediterranean island

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Keywords: biodiversity, grasslands, vegetation

Semi-natural grasslands represent one of the most relevant habitats deriving from land use in Mediterranean areas, for their role in nature conservation and associated ecosystem services. Their structure and composition are related to environmental and management pressures at local and regional scales. Understanding their variability in relation to these factors is essential for their management and conservation. This research aims to describe spatial patterns of Mediterranean grasslands composition and structure in relation to environmental variables, such as elevation, aspect, slope, land use, geological substrate and management type. Nonetheless, no unified database for Sardinian grasslands is currently available, hindering investigations in this area. In light of this, we initially merged different datasets collected in ten projects between 2011 to 2021 in Sardinia into a single dataset. All the information from the different datasets has been standardized, from environmental data to the taxonomic nomenclature homogenization. For all these ten datasets, vegetation surveys were carried out by recording all plant species and their relative cover within a 2x2 m georeferenced plot. In the framework of these projects, 744 plots were collected in about 1,300 vegetation surveys. Environmental variables were obtained either in the field or using open-source data such as Copernicus images. Information about management was acquired through interviews with local farmers. In the upcoming step, the collected data will be processed to define spatial patterns of grassland diversity in Sardinia. In addition, our data will be made available, via vegetation databases, for analyses on a wider scale.

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Effects on pastoral value and floristic diversity by the invasive alien species *Arctotheca calendula*: a case study in central-east Sardinia (Italy)

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Keywords: *Arctotheca calendula,* biodiversity, capeweed, IAS, pastoral value

Severe degradation of habitats and loss of ecosystem services have been documented due to invasive alien species (IAS) invasions (Pyšek et al. 2020). Prevention, early detection and rapid intervention are considered the most effective means of managing IAS (Brundu et al. 2015). *Arctotheca calendula*, capeweed, native to South Africa, is nowadays extensively naturalized in Australia, and has been introduced in many other regions, such as in the Mediterranean basin, European countries, and parts of the American continent (Brundu et al. 2015). Capeweed has been reported as a cause of severe yield losses in Australia, a competitor with native plants in California, and these impacts can apply to the Mediterranean agricultural areas, pastures, and rangelands (Brundu et al. 2015). We aimed to assess if capeweed presence and abundance could negatively affect pastoral value and floristic diversity (Bagella et al. 2020). The study area was located close to Oristano (Sardinia, Italy), where 2 ovine farms, partially invaded by capeweed were monitored. Three random relevès were performed in spring 2020 and 2021, at each sample site using a 2 × 2 m plot, for a total of 57 relevès. Based on capeweed abundance classes, three clusters of relevès were formed. Although this alien species seems not particularly impactful at low levels of cover, in the most invaded plots, a loss of species richness and pastoral value were observed. Indeed, we suggest to consider *A. calendula* as a priority species for containment or eradication, early detection of new invasion foci and prompt management in rangelands.

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A multi-level analysis to identify and characterize some Italian autochthonous common bean (*Phaseolus vulgaris* L.) landraces under a changing environment

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Keywords: agro-biodiversity, conservation, global change, ISSR marker, landraces, morphological characters, phaseolin, stress response

Agrobiodiversity is currently jeopardized by several environmental and socio-economic changes which caused an unprecedented loss of landraces, therefore effective characterization and conservation activities should be undertaken in order to avoid their disappearance. In this study, the diversity of seven Italian common bean (*Phaseolus vulgaris* L.) landraces, collected from Molise (CV, MO, PI and SA), Basilicata (SMR and TR) and Tuscany (MA), was explored by using a multi-level approach. Morphological (seed morphological characters), genetic (ISSR molecular markers) and phaseolin banding pattern (Andean or Mesoamerican) analysis were performed along with salt and osmotic stress reponse investigation, by evaluating biomass, proline, malondialdehyde (MDA), chlorophyll and carotenoid contents. All the populations showed Andean phaseolin, while seed morphological characterization separated CV and SMR from the other populations and ISSR analysis showed genetic similarity among Molise bean populations and the ones coming from Basilicata and Tuscany. Salt stress caused decrease in biomass accumulation in SMR, SA (root, stem and leaf), PI (root and stem) and in MA (leaf), with increased levels of proline, while osmotic stress negatively affected dry biomass only in SA (root, stem and leaf), SMR and MA (leaf), with no relevant changes in proline contents. MDA levels were found unchanged or decreased both in stress sensitive (SMR, SA, PI, MA) and in stress tolerant populations (CV, MO, TR), but, in these latter, the higher levels of chlorophylls and carotenoids found might play an antioxidative role against stress. The multi-level characterization approach performed proved to be an efficient method to explore landrace diversity and identify climate change resilient populations.

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Landraces can be agri-food resources for the sustainable development of mountain areas: the case of "Copafam" bean (*Phaseolus coccineus* L.)

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Keywords: agrobiodiversity, bean, landraces, mountain resources, novel food

Nowaday, about 80% of global agrobiodiversity has been lost since the last century. Landraces are populations of cultivated plants that have a distinct historical origin and locally adapted; Italy is rich in agrobiodiversity but many of these varieties are little or not at all scientifically characterized. The main objective was the characterization, conservation and enhancement of "Copafam" bean (*Phaseolus coccineus* L.) in order to evaluate its possible input as a raw material in the agro-food industries for the creation of innovative and functional products. For this purpose, the nutritional and phytochemical characteristics of the "Copafam" bean was explored. Moreover, the sensory properties and consumers' hedonic ratings in a model food formulation (biscuits) made by this landrace was assessed using citizen science approach. The results show that the "Copafam" bean had a high dietary fiber content (34.83 ± 2.48 g/100 g dw) and it resulted in a great source of secondary metabolites as polyphenols (121.36 ± 5.31 mg GAE/g dw), flavonoids (6.51 ± 0.17 mg/kg dw), and anthocyanins (28.11 ± 0.16 mg Cy3 G/kg dw), having remarkable antioxidant activity too (76.42 ± 1.27 %) (Pedrali et al. 2022). Biscuits made from "Copafam" flour were characterized by a darker color and crunchy texture, and it was considered acceptable by consumers. All these characteristics make it a resource of great interest for innovative forms of consumption like fortified foods. This research showed that landraces can represent a great resource for an innovative food industry aiming to preserve agrobiodiversity and promote the sustainable development of mountain areas.

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Culture-based approach to improve monitoring and treatment of toxic cyanobacteria in drinking waters

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Keywords: case study, culture-based approach, cyanobacteria, cyanotoxins, drinking water treatments, monitoring strategies, strain isolation

In waters for drinking purpose, phototrophic cyanobacteria may pose a serious threat for human health, since several species may produce toxic metabolites, namely cyanotoxins, exhibiting different chemical structure, mechanism of action and toxicity. Poisonings due to cyanotoxins have been reported worldwide, affecting both animals and human who can be exposed through ingestion of contaminated water, aerosol inhalation or by dermal contact. Additionally, cyanobacteria may massively proliferate in freshwaters forming harmful blooms, which ecologically impact the surrounding environment and diminish water quality. Unfortunately, the occurrence of cyanobacterial blooms has recently increased, likely as a consequence of climate changes; moreover, blooms are often associated with the presence of cyanotoxins, making cyanobacteria management in water intended for drinking purpose challenging. The monitoring of cyanobacteria and their toxins in water bodies destined to potabilization is therefore crucial, as well as the treatments that are used for their removal. Although field experiments are useful to establish the sources of interferences during monitoring activities and to address the ecosystem-level impact of tested treatments, general difficulties may arise. In this context, the use of approaches based on isolation and cultivation of cyanobacteria, including toxic species, could be a valid alternative to conduct monitoring and treatment studies. Culture-based approaches could increase our understanding of cyanobacteria toxicity, by in-depth characterization of strains aimed at investigating new emerging toxins. In this work, a series of case studies based on isolation and cultivation of cyanobacteria are presented, covering aspects related to monitoring strategies, drinking water treatments and discovery of emerging toxins.

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Characterization of fungal biodiversity in fields of *Lavandula angustifolia*

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Keywords: fungal biodiversity, fungal characterization, mycology

Since the beginning of soil studies, the subterranean complexity behind high soil quality fascinated the scientists interested in crop improvement. Roots and rocks, soil pH and humidity all play a role in guaranteeing the best harvest (Liliane et al. 2020). However, plants and minerals are not alone in this collective enterprise, as bacteria and fungi are present as well (Tian et a. 2020). Mycorrhizal fungi are present at root level, forming a strict symbiosis and helping nutrients' capture by the plants (Zhang et al. 2019). Other cases are known where non-pathogenic fungi occupy the same ecological niches that pathogenic ones would live in, which indirectly protects plant tissues from aggression (Qiao et al. 2019). Moreover, fungi can parasitize plant predators, acting as bio-control agents protecting sensitive crops and investments (Ramakuwela et al. 2020). The project here presented will deal with the results obtained in characterizing the fungal organisms below *Lavandula angustifolia* (Miller) fields. Screening of culturable specimens has led to the identification of 16 fungal genera. Our results suggest that changes in soil conditions and in agricultural practices, such as mulching, can cause direct changes in both the qualitative and quantitative aspects of soil fungi. Comparison with previous scientific literature will point out which of the specimens are the most promising study subjects to investigate the plant-growth promoting factors (PGPF) originally present in the community. Future prospects will see PGPF fungi applied to fertilizing products in *Lavender* fields, as well as quantification of crop improvement after the product's application.

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How does riparian forest clear-cutting affect plant diversity and composition along a Mediterranean river?

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Keywords: anthropogenic disturbance, biodiversity, community assemblage, harvesting, management, lant diversity, recovery

In Mediterranean riparian forests, clear-cutting causes long-lasting changes in riparian biota. In this work, we examined the patterns of modifications of riparian forests and their possible recovery from a clear-cutting event. We conducted a systematic vegetation survey of riparian forests along the Arbia river in central Italy. Plot placement was random stratified within 2 contiguous 20 m wide strips in 500 m long sectors. Clear-cutting events within plots were classified by producing an historical analysis of aerial photographs and categorized in three age classes: recent (< 10 years ago); intermediate (between 10 and 20 years ago); old > 20 years ago). We used ANOVA and PERMANOVA models to analyze the response of vegetation attributes to clear-cutting and strip position. There were a significant increase of alien species richness and abundance and a decrease of woody species richness in recent clear-cut areas compared to those with an old clear-cutting event. Significant compositional changes occurred in woods with a recent clear-cutting: nemoral species decreased and generalist, ruderal and alien species increased. Riparian forests of internal strips, rich in pioneer and hygrophilous species, are impacted by logging but seem to quickly recover thanks to their natural resilience to disturbances by flood. Conversely, clear-cutting events in the external strips did not affect any of the investigated vegetation attributes due to the effect of past anthropogenic disturbances and the dominance of *Robinia pseudoacacia*. Our results confirm that clear-cutting events have long-lasting effects on forest riparian communities, emphasizing the fragility of Mediterranean river ecosystems.

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Using stored seeds for plant translocation: the seed bank perspective

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Keywords: *ex situ* conservation, GSPC Target 8, literature review, questionnaire, seed bank

Billions of seeds from wild species are currently stored in hundreds of conservation seed banks around the world. Plant translocation from these stored seeds is a key conservation priority and one of the targets of the UN's Global Strategy for Plant Conservation. How these seeds are used for plant translocation and what obstacles seed banks encounter has not been investigated. To explore this issue, we circulated a questionnaire across international networks, complemented with a literature review on plant translocation from stored seeds. We received responses from 104 seed banks in 34 countries. Just over 70% had previously used their collections for plant translocation, with a median of 12 translocations per bank. The main limitations for translocation were identified as "funding" and "resources", with a lack of seeds and expertise also mentioned as obstacles. Only 10% of banks had no constraints on their ability to carry out plant translocation. With 96% of respondents indicating they would like to carry out future plant translocations, there is a willingness by seed banks to use their collections more extensively, but a lack of funding and resource availability is limiting the potential for embarking on translocation activities. The literature review identified 12 articles which specified that seed bank stored seeds were used for plant translocation, suggesting that plant translocations from *ex situ* seeds are rarely published in the scientific literature. Our results indicate that if nations are to achieve their international conservation targets, funding and resources for the use of banked seeds should be prioritised.

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Leaf anatomical and eco-physiological responses to water stress in grapevine as mediated by basalt dust foliar distribution

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Keywords: basalt dusts, climate change, drought stress, grapevine

Climate change is challenging viticulture sustainability in Southern Italy due to increasing temperatures and frequency of severe drought events which are reducing yield and quality of grapes. In this context, there is compelling need to design cultivation strategies to improve the efficiency in the use of resources, especially water. The purpose of this work is to understand if the foliar distribution of reflecting dusts can mitigate the effects of water stress in *Vitis vinifera* L. subsp. *vinifera* 'Falanghina' grapevine in Southern Italy. The experiment was conducted in 2021 and 2022 in a commercial vineyard of the "Cantina Sociale La Guardiense", in the Sannio wine district, in Guardia Sanframondi (BN), where four treatments were set up by combining two main factors, i.e. reflective dust distribution and water supply, as follows: 1) rainfed, with basalt dusts; 2) rainfed, without basalt dusts; 3) irrigated, with basalt dusts; 4) irrigated, without basalt dusts. The irrigation plan was defined weekly to reintegrate the water lost by transpiration and basalt dusts were distributed on the leaf surface during the vine vegetative-productive cycle. Vegetative growth and ecophysiological status (gas-exchanges, leaf water potential and chlorophyll "a" fluorescence) were monitored in the main phenological phases. Leaf functional anatomical traits (e. g. lamina thickness, localization of phenolics, stomatal size and frequency) were quantified. The results showed different responses to water stress conditions, helping to understand the acclimation mechanisms of the vine in relation to the inter-annual variability and the dusts efficacy.

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Neophyting – Investigations into effective management of invasive plants along elevation gradients

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Keywords: biological invasions, clinal variation, elevation gradients, management, seed bank

Because of the numerous detrimental impacts that invasive plants can have in their new range, managers have adopted strategies to counteract the spread and reduce the damage caused. Current management guidelines focus on traits and reproductive strategies of exotic species, yet the variation along environmental gradients is generally neglected. We hypothesized that accounting for environmental variation may allow for improved efficiency of control measures. To test this hypothesis, we conducted a targeted removal experiment of two perennials (*Solidago canadensis* and *Lupinus polyphyllus*) and one annual (*Erigeron annuus*) alien plant species along elevation gradients in the Eastern Swiss Alps. In addition, we analyzed the seed bank size of the study species by means of a germination experiment. We found the efficiency of control measures to depend on the life history of the plants, with a drastic reduction in cover observed in perennial species. Surprisingly, we did not find a significant change in cover depending on the elevation of managed sites, indicating that the effectiveness of removal did not change significantly with altitude. In addition, we observed higher germination of the annual study species and a diminishing number of seedlings emerging along the altitudinal gradient, suggesting that variation in seed bank size can influence management outcomes. Based on these insights, we suggest focusing on long-term management programs of perennials, which should entail the sowing of native seed mixtures. In conclusion, our findings indicate that research about the efficiency of control measures along elevation gradients can be useful to refine management programs.

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Elevation shapes understory temperate forest community: interspecific *vs* intraspecific variability

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Keywords: community weighted mean, environmental heterogeneity, functional diversity, intraspecific trait variability, National Park Foreste Casentinesi, Rao's quadratic entropy, temperate forests

Besides the lack of studies to test environmental heterogeneity, trait-based investigation has been considering traits as fixed attributes neglecting intraspecific variation ("ITV"). ITV may play an important role in species coexistence, affecting ecosystem functioning and services. In this study we focus on common functional traits describing aboveground understory functional diversity along an elevational gradient. Our questions were: i) does intra-specific trait variability decrease in importance along the elevation gradient? ii) does the increase in elevation confirm the shift from a diverging situation to one of convergence due to less stringent conditions? iii) do the selected traits respond in the same way along the elevation gradient? Our study area was located in the Parco Nazionale Foreste Casentinesi, Italy. Plots were selected after dividing the elevational gradient into 7 belts (150 m). For each belt 4 plots were selected (10x10 m). Functional traits collected and measured were: vegetative plant height; Specific Leaf Area (SLA); Leaf Dry Matter Content (LDMC); Leaf Area (LA). We quantified two main indices, i.e. Community Weighted Mean (CWM) and Rao's Quadratic Entropy (Q); to disentangle trait variability we used the Trait flex anova approach. Our observations were in line with the theory of habitat filtering: species smaller (decrease in plant height) and with a quicker growing rate (decrease in LDMC) were found as elevation increased, with a greater contribution of species turnover respect to ITV. Even if contribution of ITV was small, taking this aspect into consideration can help our understanding of species response towards abiotic variations.

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Implementing a coastal risk index using vegetation data to support management actions in Mediterranean coastal dunes

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Keywords: coastal risk, dunes habitat, nature conservation

The increasing anthropogenic impact on coasts and the associated threats with sea level rise and coastal erosion make it urgent to develop different methodological approaches to assess coastal risk. Risk assessments provide information about the pressure to which the coasts are exposed, their adaptive capacity, and is an important tool to facilitate coasts management. The aim of this study was to assess the risk state to which two valuable stretches of the Tuscan sandy coastline (central Italy) are exposed: the Migliarino - San Rossore - Massaciuccoli and the Maremma Regional Parks. The total coastline of the two study areas is about 35 km long and was divided into contiguous units of 1000 × 500 m. Following the method proposed by Rangel-Buitrago & Anfuso in 2020, the risk index was calculated for each unit considering geomorphological, socioeconomic, cultural and ecological variables. In addition, 35 transects (8-242 m long) perpendicular to the shoreline were randomly placed within each unit, starting from the annual vegetation of marine drift lines to the fixed dunes dominated by *Juniperus* sp. pl. Along each transect, we registered the presence of dune habitats identified in accordance with the European Nature Information System (EUNIS) classification in contiguous plots of 2 × 2 m. Our results suggest that the implementation of this index with vegetation data returns a more complete picture of the conservation status of the Tuscan coastline and that it can be a useful tool which can help to focus more targeted and effective management actions.

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Diversified and complex survival history within which refugium? Phylogeography of the endemic plants of the Dolomites

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Keywords: Dolomites, endemic plants, glaciations, phylogeography

Massive glaciers covered a major part of high European mountain ranges during the Quaternary glacial periods. Mountain species found refugium in peripheral areas or unglaciated spots within the ice core. The Dolomites underwent strong glaciation, but presented plausible chances for cold stage survival, as shown by the high diversity, endemism rates and genetic diversity values of alpine species. Here, we investigated how three alpine endemic species of the Dolomites (i.e., *Campanula morettiana* Rchb, *Primula tyrolensis* Schott ex Rchb. and *Saxifraga facchinii* Koch) responded to the glacial and postglacial events, unraveling the areas of putative refugia. For this purpose, we implemented phylogeographical analyses based on restriction-site associated DNA sequencing (RADseq) data from a range-wide populational sampling. Furthermore, we run species distribution models (SDM) to model the climate habitat suitability at present and at the Last Glacial Maximum. *C. morettiana* and *P. tyrolensis* showed a strong intraspecific structure with a clear genetic differentiation among eastern and western populations on either side of the Piave valley, indicating the southern and southeastern Dolomites as peripheral refugia for both species. The colder adapted *S. facchinii* showed a strong intraspecific genetic structure with highly differentiated populations also over short distances, congruent with local northern nunatak survival. Our research challenges the hypothesis of postglacial expansion from a single major southern refugium, since the Dolomites provided glacial refugia for high alpine to nival species also in the central and northern ranges, while the southern and southeastern Dolomites provided more extensive peripheral refugial areas for subalpine to alpine species.

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Permament plots for the study of plant colonisation in proglacial foreland: two case studies in the Gran Paradiso National Park reveal a faster colonisation than expected

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Keywords: glacier foreland, monitoring, National Park, primary succession, vegetation dynamics

Since the end of the Little Ice Age, glaciers in the alpine mountains have been progressively retreating in response to the climate crisis, releasing vast surfaces to the colonisation of biota. Plant establishment has been studied for decades, mainly through the chronosequence approach (Daget, Poissonet 1971). Revisiting permanent plots can provide much more reliable information (Pickett 1989) although it is less adopted because it is more demanding. Our study aims to provide evidence of how quickly vegetation colonisation is occurring in proglacial forelands (Erschbamer, Caccianiga 2016) by revisiting at a span of five years the vegetation composition in permanent plots distributed over two proglacial chronosequences in the Gran Paradiso National Park. For both, at time 0 were identified 6 stages of the chronosequence on the terrain deglaciated by about 5 to 165 years, and in each stage, 3 permanent plots were delimited for a total of 18 permanent plots for each glacier foreland. In each plot, the vegetation was surveyed using the vertical point-quadrat method and the vegetation cover and the number of species was calculated. After 5 years vegetation surveys were repeated in all respective plots using the same methodology. Revisiting the plots 5 years later showed how quickly the vegetation is colonising the proglacial debris, (Fickert, Grüninger 2018) the vegetation cover increased 17-19 times faster than predicted by the chronosequence approach while the number of species incresead up to 21 times faster. Such rapid dynamics are likely related to the strong climatic changes (Pörtner et al. 2019), e.g. the higher temperatures in summer and the longer growing season that previously severely limited the establishment of several species.

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Italian Database of Plant Translocation IDPlanT: best practices, errors and perspectives of half a century of plant translocation in Italy

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Keywords: best translocation practices, conservation translocation, costs of translocation, IDPlanT, Italian Plant Translocation Database, threatened plants, translocation aftercare, translocation outcome

IDPlanT is the Italian Database of Plant Translocation. The translocation activities in Italy have taken place since the first recorded case in 1958, but a national repository was still lacking. In fact, most translocation cases are not published in the scientific literature or data are limited or not reported at all. IDPlanT allowed the establishment of the first complete account of plant translocation performed in Italy. Based on the 185 cases currently included, Linear Models (LMs) were used to identify key techniques that can improve translocation outcomes measured as quantitative outcome (i.e., the survival rate at the last monitoring) and qualitative outcome, with a focus on propagation method, demography of the population of origin, habitat suitability assessment, release method, aftercare and monitoring. These variables are related to the final survival of translocated plants, with vegetative propagation of propagules, habitat suitability assessment based on vegetation characteristics, aftercare and periodical post-translocation monitoring, showing a positive relationship with survival and the use of propagules from decreasing source populations and direct seed sowing, demonstrating a negative relationship with the final survival. The amount of money spent on translocation was not related to the survival rate, but in this case, the analysis was based on a low number of cases. Comparing these relationships with the translocation techniques used, allowed to identify the best practices, errors made and future directions in plant translocation in the specific Italian and Mediterranean contexts, increasing the conservation relevance of these actions, and in turn improving the chances of success in restoring threatened species.

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Plant diversity changes and species turnover after 13 years in southern alps: a case of study in the Orobic Alps

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Keywords: climate change, local extinction, monitoring, plant migration, soil temperature

Rising temperatures are leading to an increment in species richness and plant diversity in alpine regions', alongside with summits' greening caused by graminoids and shrub abundances increments. At the same time, cryophilic and endemic species are severely menaced by both climate change and competition. Here, we compare the vegetation in two resurveys (2009 and 2022) performed in the Orobic Alps GLORIA (GLobal Observation research Initiative in Alpine environment) study site, alongside microclimatic data. The study site comprehends four low elevation alpine summits at the southern outskirt of the Italian alps, that act as a first sentinel for monitoring change. We assessed the species that increased and decreased the most, also checking for local extinctions and colonizations. Subsequently, we analysed changes in species richness, diversity (Diversity profiles defined by Hill numbers) and Turnover, along with soil Temperature and snow cover period length across the years. After 13 years, average summer soil temperature increased significantly, while snow cover period length decreased over time. Several new species colonized the site, while only few species disappeared. As a consequence, plant diversity increased. Nevertheless, as few common species became more abundant, especially within the lower summits, diversity profiles became steeper, underling a change in the plant community structure. Moreover, the summits were characterized by a high level of species turnover, highlighting a fast change in plant communities' composition as a response to climate change.

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Assessment of priority species inside and outside the protected areas within the European Union

L. Ricci, M. Di Musciano, P. Zannini, A.R. Frattaroli, A. Chiarucci, R. Cazzolla Gatti, F.M. Sabatini, C. Beierkuhnlein, A. Walentowitz, A. Lawrence, S. Hoffmann

Keywords: EU biodiversity tratégy for 2030, Natura 2000, plant diversity, protected area

The Natura 2000 (N2K) protected area (PA) network is a crucial tool to slow biodiversity loss in Europe. Despite covering a large area, its representativity across *taxa* and bioregions remains uncertain, and only few studies assessing its effectiveness at conserving species diversity have considered confounding factors such as land cover. Here, we used Propensity Score Matching (PSM) to test if more plant species are contained inside N2K PAs than outside, while accounting for the confounding effects of biogeographical regions, terrain ruggedness, and land cover, the latter quantified as the proportion of artificial, forest, semi-natural, and agricultural areas. Using reported plant species data from Habitats Directives with a resolution of 100 km^2 we calculated alpha diversity after matching within each cell of the grid. To have a complete assessment of the role of PAs in conserving biodiversity we did the same for the different groups of *taxa* reported in the Habitat and Birds directives: mammals, birds, amphibians, reptiles, arthropods, fishes, molluscs. Differences in alpha diversity between PAs and non-PAs cells were assessed by fitting a generalized linear mixed model. The results highlighted a common pattern, with a higher number of plant species inside than outside N2k PAs. Among bioregions, plant species richness and species richness of amphibians, arthropods, birds, and mammals were significantly higher inside PAs than outside except for the Boreal region. Our results indicate a general effectiveness of N2k PAs in preserving plant biodiversity. However, this effectiveness still has room for improvement especially for certain taxonomic groups and bioregions.

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Impact of the aquatic invasive alien *Ludwigia hexapetala* on the native *Utricularia australis*: evidence from an indoor experiment

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Keywords: allelopathy, aquatic bladderwort, freshwater ecosystem, interspecific competition, invasive macrophyte, non-native versus native plants, water primrose

Ludwigia hexapetala is an aquatic plant considered highly invasive in Europe since it alters freshwater habitats by forming dense mats both in water and along banks, outcompeting native plants. This study investigates the impact of the alien *L. hexapetala* on the growth of the native *Utricularia australis*, an aquatic carnivorous plant. An indoor experiment was performed by setting up tanks with both species ("arena test") and tanks where *U. australis* grew by itself (control test). Water chemical - physical parameters, and *U. australis* growth rate and morphological traits were measured weekly. Water samples were analysed via UV-visible spectra to test the presence of allelochemicals (mainly quercitrin) produced by *Ludwigia*. Results showed that *L. hexapetala* alters water chemical - physical parameters: in arena test there was a lower pH, higher conductivity, and lower dissolved oxygen in water than in the control test. In addition, *L. hexapetala* negatively affected *U. australis*, which grew significantly less in arena test than in the control both in length and internodes number. Fresh weight, trap number and internode length decreased during the experiment, but where *L. hexapetala* was present, this decrease was significantly larger. Quercitrin was found only in arena tests, as an allelochemical product released by *Ludwigia*. Overall, this study showed that *Ludwigia* significantly alters water parameters and negatively affects *Utricularia* growth, showing an aggressive, competitive behaviour against the native species. Therefore, the spread of *L. hexapetala* can represent a serious threat to the conservation of native plant diversity occurring in freshwater habitats it invades.

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Gaining insight into the drought tolerance mechanisms in chickpea

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Keywords: biochemical parameters, phenotypic parameters

Latest genomics-based research has laid the foundation for further understanding of the activation of different genes associated with drought tolerance and sensitivity. Chickpea (*Cicer arietinum* L.) is an important grain-legume crop that is mainly grown in rainfed areas, where terminal drought and heat stress at flowering and seed filling are major constraints to its productivity. Recent advancements in coping with these challenges comprise the application of RNA-Seq approaches to the understanding of the differential gene regulation in desi and kabuli chickpea varieties. This work aims to decipher molecular mechanisms underlying drought stress mechanisms in chickpea through an integrative multi-omics approach (RNA-seq and whole genome bisulfite sequencing) combined with phenotypic analysis (chlorophyll content, photosynthetic measurements), biochemical analysis and agronomic traits (qualitative parameters). Two varieties of chickpeas: desi (brown-coloured small seed) and kabuli (white or beige-coloured large seed), represented by 4 selected genotypes each, and one cultivar (Blanco lechoso) were used for the experimental setup. A total of 10 biological replicates were grown for each genotype, under two different hydric conditions combined with heat stress during the last growth phase and the flowering time. Results indicate a tendency of better photosynthetic performance for the kabuli type than the desi chickpea type with differences among used genotypes. Moreover, 4 out of 9 genotypes show a decrease of chlorophyll content under drought stress, 5 genotypes display no statistical difference in chlorophyll content and two genotypes have a significant increase of chlorophyll production.

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Exploring the potential of automated image analysis for plant stress detection

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Keywords: abiotic stress, image analysis, machine learning

Plants often experience adverse or stressful environments that could influence their phenotype. Visible stress symptoms have long been studied, but their manual scrutiny can be challenging, time-consuming, and error-prone. However, there are currently very few instances of machine learning (ML) models that can automatically and efficiently detect plant stresses, especially abiotic ones, from image-derived traits. This study aims to fill this gap using digital phenotyping tools based on automated image analysis and to compare them with standard analytical procedures. To reach this goal, *Arabidopsis thaliana* (L.) seedlings were exposed to different salinity stress levels (50 mM and 150 mM NaCl). After 10 days of treatment Electrolyte Leakage (EL), Relative Water Content (RWC), and Dry Weight (DW) were measured, along with morphological traits obtained from RGB images. The performance of 2-class (presence or absence of stress) and 3-class classification models (absence, medium, and high-stress levels) was then evaluated. We found that the growing environment and substrate type had a strong impact on plants; EL appeared to be one of the key discriminant features, followed by chroma ratio and chroma difference indexes. The accuracy of the 3-class model was 76,6%, as opposed to the binary classification model's 93,3%, but these values ulteriorly improved after the feature selection process. With these findings, we demonstrate the great potential of image analysis, highlight the positive impacts of automation, and emphasize the importance of explainable ML. Our future goal is to enhance the model's robustness and reliability and generalize it to different species and stresses.

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Macro-micromorphological characterization of the medicinal species *Matthiola incana* (L.) W.T.Aiton and *Erysimum* × *cheiri* (L.) Crantz

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Keywords: Brassicaceae, *Erysimum* x *cheiri*, *Matthiola incana,* papillae, pollen, stomata, trichomes, violaciocca

Matthiola incana (M) and *Erysimum* × *cheiri* (E), belonging to the Brassicaceae family, are species acknowledged in the traditional medicine of different countries (Liang Jin et al. 2016, Mosleh et al. 2019) (Fig. 1). Their several uses in international medicine depend on the type and quantity of the active compounds contained, such as terpenes, steroids, alkaloids, glucosides, flavonoids and phenols (Erum et al. 2017, Miceli et al. 2019). In Italy both species are known by the common name "violaciocca" and used for magical, religious and medicinal purposes. *M. incana* is mentioned as emetic, laxative, for the treatment of cough and skin infections; *E.* x *cheiri* is indicated as a diuretic and to treat sprains, but used at low doses, as it contains potentially toxic cardiotonic heterosides (Guarrera 2006). The distinctive features of these two species were identified through macro and micro-morphological analysis (LM and SEM). The observations showed the following characteristics: colour of the flowers: purple/pink in M; yellow/ochre/purple in E; type of floral and leaf trichomes: unicellular, branched, starred, with smooth surfaces in M; T-shaped with two bifurcated arms, calcified and warty in E; type of stomata: anisocytic and anomocytic in both species; type of petal papillae: pointed in M, rounded in E; type of pollen: spheroidal, inaperturate with conspicuously cross-linked ornamentation in M; tricolpate with reticulated ornamentation in E. Botanical morphological characteristics are recognizable even in the plant material in the form of fragments, as in the case of herbal preparations used on the market (Abdel Khalik et al 2005).

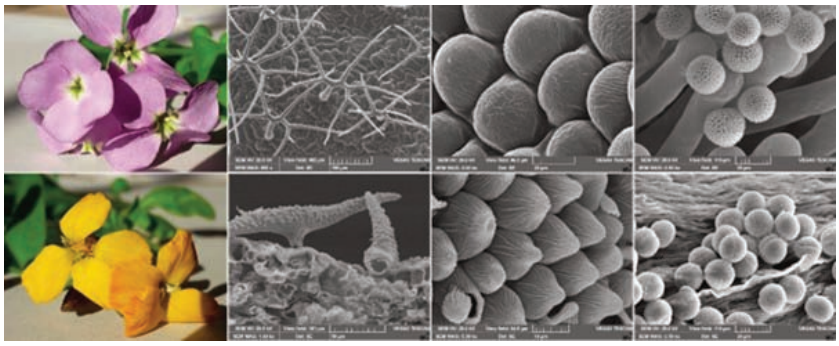

Fig 1
Above: *Matthiola incana*; below: *Erysimum x cheiri.* From left to right: flowers, trichomes, papillae, pollen.

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Testing biochar-soil mixtures to boost the performance of lettuce (*Lactuca sativa* L.) plants

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Keywords: biochar, growth, lettuce, phytotoxicity, proteins

The circular economy aims to recycle existing products as long as possible by extending their life cycle, helping to minimize waste, and generating additional value. Biochar is a carbonaceous material derived from the pyrolysis of biomass and its use as soil amendment is an ecological choice due to its positive role in mitigating climate change by storing CO_2. This study was addressed to test the effect of different biochar dosages on the leaf fresh biomass and the content of total soluble proteins and chlorophyll to identify the optimum biochar level able to guarantee the best performance of *Lactuca sativa*, chosen as model plant. Biochar was added to the soil at six different dosages: 0%, 5%, 10%, 25%, 50% and 100%. Lettuce seeds (cv. "Romana") were germinated and, after two weeks, seedlings were transplanted into pots containing the abovementioned biochar dosages for 30 days. The results showed a similar trend between the chlorophyll and the biomass of lettuce, with a linear increase of both parameters along with increasing biochar dosage up to 10%; beyond this threshold, the biomass and chlorophyll content were reduced. In contrast, the protein content increased with increasing biochar concentration. Interestingly, at higher biochar concentrations, plants most likely found unfavourable growth conditions and spent a large part of their energy to increase protein synthesis, attempting to survive. It was concluded that amending soils with up to 10% biochar boosts the performance of lettuce plants, but that overcoming that threshold of biochar may cause phytotoxic effects.

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Early response of woody roots to bending

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Keywords: calcium signalling, ion channels, mechanical stress, RNAseq

Mechanical stress impacts plant growth and development. Research on poplar showed asymmetric changes on the bent root axis, with new lateral roots on one side and reaction wood on the other. Hormone and metabolite levels were different on each side. Network-based analysis of proteomic signatures identified functions and pivotal genes involved in the signalling pathways. ROS and Ca^{2+} were confirmed as central players in the intracellular messenger system. Mechanosensitive channels (CNGCs and MCAs) are activated by membrane tension through unidentified molecular mechanisms, hindering exploration of genetic and molecular mechanisms regulating reaction wood and lateral root formation. In the present study, our aim is to identify new molecular actors involved in short-term mechano-response and the related pathways, using two model species: the herbaceous plant *Arabidopsis thaliana* and the woody tree model specie *Populus nigra*. The objectives are to highlight the role of the Ca^{2+} and ROS signalling pathways, as major stress signalling elements. Preliminary gene expression results of membrane-bound calcium sensors and mechanosensitive ion channels (CNGCs, MCAs) unravelled the involvement of MCA2 into the early mechanical-stress responsive early period, in *Arabidopsis thaliana*. In the future, *in vivo* calcium imaging using *Arabidopsis* lines expressing the genetically encoded calcium indicator (GCaMP3) will be performed to better understanding the bending stress-specific calcium influx. Furthermore, RNA sequencing of bent roots will uncover the differentially expressed genes in the different root bending sectors/sides, which will be combined to a comparative network analysis of both model species to decipher potential conserved stress perception and response strategies.

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Cambial cell analysis as a tool for understanding the tree response to irrigation and fertilization management in semi-arid regions

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Keywords: afforestation, elm, microcores, poplar, vascular cambium

The last decade has seen large-scale afforestation efforts in difficult environments as a means of rehabilitating ecosystems and mitigating climate change. Two key factors that define a higher survival rate and successful establishment are species selection and appropriate management. The Green Belt Project in Mongolia is one such effort, where decade-old experimental plantations of *Populus sibirica* and *Ulmus pumila* have been exposed to combinations of irrigation (control-none, 2L h^{-1}, 4L h^{-1}, 8L h^{-1}) and fertilization treatments (control-none, sheep manure compost, NPK-fertilizer). Previous research concentrated on above and belowground morphological and functional traits, demonstrated that the species respond differently to the used treatments. While *P.sibirica* has bigger biomass production potential, it is also more sensitive to water scarcity. *U.pumila* is more drought-resistant, but fertilizers cause a greater negative impact. However, we currently do not understand how these factors affect cambial cells, the main active structure in woody plants responsible for a wide range of developmental plant activities. The current study examines the shoot and root response to the combined effect of the different treatments across three active seasons using cambial cell analysis. Preliminary studies enabled microcore samples protocol development for further microscopic examination of the cambial cells characteristics. Once analyzed, new understanding of the response induced in the cambial cells of both species would be obtained. When combined with the findings from the previous studies, it may provide a better comprehention of the cambial cells role behind the observed response regarding the morphological and biomass variations.

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Tracking evolutionary, cellular and developmental cues in arbuscular mycorrhizas

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Keywords: arbuscular mycorrhizas, cellular and developmental biology, evo-devo

Growing evidence indicates that the symbiotic nitrogen fixation in legumes recruited part of the signaling pathway established by the first land plants to support arbuscular mycorrhizal (AM) symbiosis. Hornworts, the earliest diverging lineage in bryophytes, are excellent experimental systems to infer character evolution and reveal the nature of the most recent common ancestor of land plants. We will exploit a recently published transformation protocol for *Anthoceros agrestis* (Frangedakis et al. 2021) to insert fluorescent constructs and investigate whether symbiotic pre-penetration responses are conserved between legumes and hornworts. Additionally, a method for *A. agrestis* in vitro mycorrhization is under development. Meanwhile, we are dissecting the role of clathrin-mediated endocytosis (CME) in the development of the symbiosis, taking advantage of fluorescent constructs available in the model legume *Medicago truncatula*. Previous studies using tyrphostin A23, a CME inhibitor, demonstrated the requirement of CME for the regulation of early nodulation genes in response to Nod-factors (Wang et al. 2015). To investigate whether CME is part of the common symbiotic signaling pathway, we treated *M. truncatula* roots with AM fungal signals (Myc-factors) in the absence or presence of two CME inhibitors (tyrA23, Dynasore). We demonstrated the suppression of AM symbiosis early marker genes upregulation upon CME inhibition. Nevertheless, no significant reduction was observed in nuclear Ca^{2+} spiking response, suggesting CME is required for gene regulation but its inhibition is not sufficient to stop upstream symbiotic signaling. We discuss the new questions opened by such unexpected results and propose additional investigations to clarify this new scenario.

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Effects of wood distillate (pyroligneous acid) on yield parameters and elemental composition of three leguminous crops

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Keywords: crop nutritional quality, crop yield, legumes, wood distillate

Breeding crops for 8 billion humans represents a major challenge in current agriculture. Despite boosting crop yields, the excessive use of chemical fertilizers and pesticides has entailed a rapid degradation of agroecosystems as well as an unsustainable use of soil and water (FAO 2020). In this context, the exploitation of waste vegetable biomass is becoming a promising approach to formulate more sustainable products for agricultural application (Grewal et al. 2018). Recently, wood distillate (WD, also known as pyroligneous acid), a by-product obtained from the distillation of gases produced during the pyrolysis of woody biomass, has been included in the list of products that can be used in organic farming in Italy (Italian Ministerial Decree 6793 2018, Mathew et al.2015). Although the plant growth-promoting effects of WD have been shown in different cereal and horticultural plants, less information exists concerning its effects on legumes. The present work investigated the effects of WD on both yield parameters and elemental composition of bean (*Phaseolus vulgaris* L.), chickpea (*Cicer arietinum* L.), and lentil (*Lens culinaris* L.) plants. Application of WD showed yield-promoting effects in *L. culinaris*, which significantly increased plant- and shoot- biomass, as well as the number, weight and total protein content of both its pods and seeds. Furthermore, WD-treated plants differentially increased the concentration of key elements in the seeds, including Fe, Na, Mg and K. These outcomes suggest that WD can be an optimal candidate to grow high-yielding legume seeds as well as to improve their nutritional quality.

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New approaches for Ni-free tomato production

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Keywords: agricultural practices, allergies, law limits, nickel free, product specification, tomato

Tomato, *Solanum lycopersicum* L., is one of the main components of the Mediterranean diet. However, despite its nutritional importance, contact or ingestion of tomatoes may cause health impacts in allergic population (Ricciardi et al. 2014), due to the nickel content in the fruits. Nickel (Ni) is a metal deriving from natural or anthropogenic processes and its concentration in agricultural soil may vary depending on the chemical and physical characteristics of the substrate, on the inputs of water, soil conditioners and fertilizers, on the stage of fruit ripening and on the growing methods (Poulik 1999, Bressy et al 2013, Kumar et al. 2015, Roccottiello et al. 2022). Although European Food Safety Authority has set up a tolerable daily intake of Ni (EFSA 2020), there is no specific regulation for Ni content in food and no product specification to obtain Ni-free tomatoes. Therefore, we aim to evaluate practices to limit Ni uptake and subsequent accumulation in fruits with different agricultural practices, with the support of the PSR-TOMATO project. The concentration of Ni in fruits before the trials' beginning ranged between 0.02-0.06 mg/kg per fresh weight. Subsequently, two field treatments to chelate Ni resulted in a metal reduction by an order of magnitude, specifically in the soilless culture. Finally, a Ni limit of 0.01 mg/kg of fresh fruit biomass was obtained to define a Ni-free product and allow shaping an adequate product specification considering current regulations, listing all the procedures required to obtain a Ni-free product, and allowing future safe consumption for allergic people.

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Water-fresh plants floating on plastic-waters: the effects of PET micro/nanoplastics on *Spirodela polyrhiza* (L.) Schleid.

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Keywords: freshwater, microplasics, nanoplastics, physiology, pollution, *Spirodela polyrhiza*

A vast amount of literature about the impact of micro/nanoplastics (MNPs) on animals is available, whereas information about their potential threat on other organisms is limited. The aim of this work was therefore to test if MNPs of polyethylene terephthalate (PET) can impact the growth of *Spirodela polyrhiza* (L.) Schleid., a freshwater plant species. MNPs of around 220 nm were produced in water solution from PET bottles through reiterated cycles of homogenization in a blender. They were then used to prepare N-medium with two environmentally-realistic concentrations of MNPs (around 0.05 and 0.1 g L^{-1}) and were thus administered to *S. polyrhiza* colonies for ten days under controlled conditions. The presence of MNPs did not significantly affect the growth of *S. polyrhiza,* even if an impairment of photosynthesis was revealed by a significant decrease in chlorophyll fluorescence parameters; this result was correlated with less starch accumulation in treated plants. Ionome analysis showed an alteration in the concentration of some elements (i.e. Mg, Mn, Cu) in the tissues of treated plants, emphasizing that plastic particles are able to interfere with nutrient uptake. Interesting results were obtained from the study of oxidative stress: MNP-treated plants, especially those grown with 0.1 g L^{-1} MNPs, showed a higher concentration of hydrogen peroxide and, simultaneously, of glutathione, whereas no significant differences were reported for malondialdehyde levels. Our study demonstrated that PET MNPs, even if without altering the growth of *S. polyrhiza*, induced ionome alteration, photosynthesis impairment and oxidative stress, pointing out the hazardousness of this ubiquitous material.

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Diversity of Volatile Organic Compounds (VOCs) in the orchid *Himantoglossum robertianum* (Loisel.) P.Delforge sampled in ecologically diverse populations in Sardinia Island (Italy)

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Keywords: essential oil, GC/FID, GC/MS, Orchidaceae, VOCs

Volatile Organic Compounds (VOCs) are produced by plants to address several physiological and ecological tasks and as a consequence the environment strongly influences VOCs profiles (Possel, Loreto 2013). VOCs are frequently studied in orchids for their role in reproductive biology but are rarely studied in relation to plants' growing conditions. Within a project aiming to analyse the volatile profile of Sardinian orchids, we studied the VOCs content in the inflorescences of the naturally occurring Mediterranean orchid *Himantoglossum robertianum* (Loisel.) P. Delforge in six ecologically diverse populations in Sardinia Island (Italy). *H. robertianum* essential oils obtained by steam distillation were characterized by GC-FID and GC-MS analysis. A total of 79 compounds were detected, mainly belonging to the chemical classes of saturated hydrocarbons, esters, alcohols and ketones. The studied populations shared the majority of compounds and considering chemical classes individually no differences between populations emerged. Nevertheless, multivariate statistics separated *H. robertianum* populations based on their chemical profiles. Differences were positively linked to the geographical distance separating populations and reflected the climatological features of the sampling sites (daily minimum and maximum temperature, precipitation, precipitation-to-temperature-ratio and solar radiation). More precisely, *H. robertianum* collected in milder environments resulted in less complex volatile profiles, indicating a marginal investment in the synthesis of defensive secondary metabolites while *H. robertianum* growing in the cooler and wetter study sites, where very low temperatures may represent a severe abiotic stressor for the study species, showed typical and well characterised chemical profiles.

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Plant cultivation in Space: the influence of ionizing radiation in plant anatomical and eco-physiological traits

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Keywords: ionizing radiation, leaf functional anatomical traits, microscopy, plant radio-resistance, Space farming

As on Earth, higher plants play a key role for human life support in Space where they regenerate vital resources (oxygen and water) and produce fresh food, in sustainable closed artificial ecosystems, defined as Bioregenerative Life Support Systems (BLSSs). Nevertheless, the presence of ionizing radiation (IR) in Space represents a significant source of abiotic stress, potentially compromising plants' performance as regenerators in BLSSs by inducing alterations at morpho-anatomical, eco-physiological, and biochemical levels depending on intrinsic radiation and plant properties. For this purpose, we tested the responses of two crop models, namely microgreens and a leafy crop, to IR by evaluating plant development and growth after irradiation. Specifically, we exposed dry seeds of *Brassica rapa* L. subsp. *sylvestris* var. *esculenta* and *Lactuca sativa* L. var. *capitata* to increasing doses (0-control, 0.3, 1, 10, 20, and 25 Gy) of iron ions (56Fe). After the irradiation, microgreens and plants were cultivated under controlled environmental conditions, monitoring germination, survival, and growth performances. At harvest, morpho-anatomical parameters were analyzed, along with biochemical traits. Results showed that the responses of both model crops depended on species, dose, and parameter analyzed. Moreover, both stimulatory and inhibitory effects were observed. The overall findings were relevant to help clarifying the mechanisms of plant radio-resistance and were valuable for applications to define shielding requirements for Space cultivation facilities. Results based on the experiment Bio_08_DeMicco, performed at SIS18 GSI Helmholtz Centre for Heavy Ion Research, Darmstadt (Germany) within FAIR Phase-0.

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Ficus carica L. phytochemicals modulate lipid metabolism and adipogenesis

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Keywords: adipogenesis, *Ficus carica* L., furanocoumarins, 1H-NMR profile, lipid metabolism, seasonality

Ficus carica L. is one of the most promising traditional plants for the treatment of metabolic disorders. Its biological activity is related to the content of molecules with anti-diabetic, anti-hyperglycemic and anti-obesity properties. Due to the phytochemical profile variation in response to several environmental factors, such as seasonality, the aim of this study was to investigate if the *F. carica* leaves metabolome and biological activity were influenced by different harvesting seasons. The *F. carica* leaves were collected in spring (FCs) and autumn (FCa). The leaves extract phytochemical profile was determined by means of 1H-NMR. Finally, the 3T3-L1 adipocytes cell line was used to test the phytoextracts effects on the lipid accumulation and modulation of key adipogenic genes. According to the 1H-NMR analysis, the FCs extracts showed a higher content of caffeic acid derivatives, glucose and sucrose, while the FCa extracts had a higher content of malic acid and furanocoumarins (psoralen and bergapten). As shown by in vitro assays, only the treatment with the FCa extracts significantly reduced lipid accumulation and negatively modulated genes involved in adipogenesis. This study highlights that the *F. carica* leaves extracts could be a promising source of anti-obesity and anti-adipogenic compounds; however, because the plant's biological activity is strongly related to the phytochemical profile, the influence of seasonality on the plant metabolome needs to be considered.

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Drought-induced physio-molecular responses individually affect the water storage strategy of three Italian cultivars of olive trees (*Olea europaea* L.)

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Keywords: drought stress, gas exchange, *Olea europaea*, osmoprotectants, plant water status

Climate change will cause a decrease in water availability, which will limit the quantity and quality of water available for agriculture, especially in a semi-arid area such as the Mediterranean. In this context, understanding how plants respond to drought and identify drought-adapted genotype play an important role in stabilizing crop performance. One of the most cultivated plant in the Mediteranean is olive tree (*Olea europaea* L.), which is known to be quite resistant to drought. However, different genotypes do not respond to water stress to the same extent. In this work, 18-month-old plants from three different olive cultivars (Giarraffa, Leccino and Maurino) were monitored during a month of drought stress (without irrigation) in a growth chamber. The aim of the work is to investigate the management of water resources in drought conditions and its influence on plant health and photosynthesis. Work focused on the distribution of water content in the soil, stem, and leaves and the water loss regulated by stomatal density and conductance. Water retention mechanisms were studied in leaves by analysing both proteins (dehydrins and osmotin) and the osmoprotectant proline. The three cultivars mainly differ in their strategy for water conservation by closing stomata (Giarraffa) or by increasing the content of hydrophilic molecules (Leccino and Maurino). Maurino shows the highest levels of electrolyte leakage, but effects on the photosynthetic apparatus appear earlier in the cultivar Leccino. These results reveal a genotype-specific water management strategy under drought conditions, which could play a central role in stress tolerance.

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Distinct tomato cultivars are characterized by a differential pattern of biochemical responses to drought stress

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Keywords: biodiversity, drought, sustainability, tomato

Future climate scenarios suggest that crop plants will experience environmental changes that can affect their productivity. Among the most harmful environmental stresses is drought, defined as a total or partial lack of water availability. It is essential to study and understand both the damage caused by drought on crop plants and the mechanisms implemented to tolerate the stress. Tomato is common and economically relevant in the whole Mediterranean basin and, in previous studies, the behaviour of 13 distinct tomato cultivars in response to a chronic drought condition at both vegetative and reproductive stages was analysed (Conti et al. 2021, 2022). In this study, we focused on four cultivars of tomatoes, which were the most relevant. We investigated the biochemical mechanisms of plant defense against drought by focusing on proteins specifically involved in this stress, such as osmotin, dehydrin, and aquaporin, and on proteins involved in the general stress response, such as HSP70 and cyclophilins (Fig. 1).
Since sugars are also known to act as osmoprotectants in plant cells, proteins involved in sugar metabolism (such as RuBisCO and sucrose synthase) were also analyzed. The results show crucial differences in biochemical behaviour among the selected cultivars and highlight that the most tolerant tomato cultivars adopt quite specific biochemical strategies such as different accumulations of aquaporins and osmotins. The data set also suggests that RuBisCO isoforms and aquaporins can be used as markers of tolerance/susceptibility to drought stress and to select tomato cultivars within breeding programs.

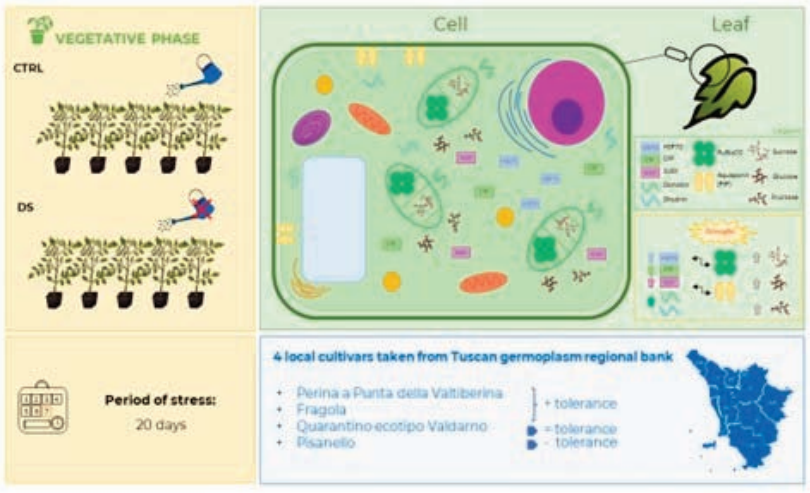

Fig. 1
Schematic representation of experimental design.

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Lavandula austroapennina from southern Italy: polar bioactive compounds analysis for its re-use and valorization in cosmeceutical field

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Keywords: Cilento Național Park, HaCaT, *Lavandula austroapennina*, polar extract, tradițional use, UHPLC-HR-MS/MS

Several species of *Lavandula* genus are cultivated worldwide for their phytotherapeutic use and the high EOs production. *L. angustifolia* is the most economically important species and, based on morphology treats, is disjointed in two subspecies (Upson, Andrews 2004): *L. angustifolia* Mill. subsp. *angustifolia* and *L. angustifolia* subsp. *Pyrenaica* (DC.) Guinea. Recently, according to morphological, genetic and phytochemical EOs analysis (Passalacqua et al. 2017, Despinasse et al. 2020), populations of *L. angustifolia* subsp. *angustifolia* from southern Italy are described as a new endemic species: *L. austroapennina* N.G. Passal., Tundis & Upson. In Cilento National Park this species was traditional used for disinfectant and lenitive purpose (Salerno, Guarrera 2008, Di Novella et al. 2013) and, in the past, was a key player of a flourishing production EOs chain. The aim of this work was to enhance and recover this resource to promote the re-use of *L. austroapennina* for its economic value. The plant was harvested in Mt. Cervati, dissected into its different organs, which were ultrasound assisted macerated in *n*-hexane and methanol, and chemically profiled by UHPLC-HR-MS/MS. Thus, to promote the cosmeceutical use of this plant, a cytotoxic screening was carried out on HaCaT cells by MTT test, along with antioxidant activity assessment, while scratch assay to investigate the wound-healing properties. Data acquired evidenced the efficacy of the polar extract at low doses and exposure times, which leaves and stems were more prominent. These results suggest the use of the plant is chemically interesting, beyond its essential oils.

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Oak (*Quercus robur* L.) leaf extracts as innovative and sustainable supplements for animal nutrition

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Keywords: condensed tannins (CTs), flavonoids, in vitro fermentation, oak leaves, *Quercus robur* L., UHPLC-ESI-Q*q*TOF HR-MS analysis, volatile fatty acids

The improvement of livestock nutrition with natural products is becoming a prerogative for producers and veterinarians to guarantee both well-being and product quality. Plant material, or extracts therefrom, might be an interesting source for novel food additives in livestock nutrition to ensure the animal welfare and the quality of the products, since the banning of feed antibiotics by the EU in 2006 (Formato et al. 2022a). In this regard, bioactive compounds of oak leaves could be valuable candidates as innovative alternatives to preserve livestock and its productivity with effects on ruminal fermentation (Formato et al. 2022b), feed digestion, health, and performance. Here, *Quercus robur* L. leaves were of interest, whose alcoholic extract underwent fractionation obtaining two organic fractions differently enriched in bioactives. To confirm this, all fractions were preliminarily screened for their total phenol (TFC), flavonoid (TFC) and condensed tannin (TCT) content as well as for their antioxidant capability by means of DPPH$^{\bullet}$ and ABTS$^{\bullet+}$ tests, and ferricyanide FRAP assay. Then, a deeper chemical investigation of the fractions was carried out through UV-Vis spectroscopy and UHPLC-HRMS/MS, proving a unique distribution of flavonoids and tannins *vs* fatty acids and terpene compounds. Furthermore, all the differently chemically constituted fractions were tested to evaluate their effects on in vitro ruminal fermentation. An increase in total volatile fatty acids was found, while the relative content of each fatty acid was adjusted differently by oak leaf extract and organic fractions with different impact on in vitro gas production and fermentation rate.

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Herbicide stress-induced miRNAs transcription changes in resistant *Echinochloa crus-galli* (L.) P.Beauv. biotypes

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Keywords: *Echinochloa crus-galli* (L.) P. Beauv., epigenetics, herbicide stress, miRNAs transcription

In compliance with the European regulations concerning the placing of plant protection products on the market (Reg EC/1107/2009), repeated use of a narrow range of herbicides with similar modes of action has led to weed herbicide resistance evolution. Target site resistance (TSR), in which a DNA missense mutation is involved, and non-target site resistance (NTSR), which occurs due to herbicide detoxification, are known to be the main resistance phenomena. Furthermore, it has been hypothesized how, under conditions of herbicide stress, epigenetics may contribute to the onset of herbicide resistance (Markus et al. 2018). *Echinochloa crus-galli* (L.) P.Beauv. is a typical, but not exclusive, rice fields weed. It is highly adaptable and has developed herbicide resistance against many chemicals. These features make it very dangerous for agricultural yield (Cusaro et al. 2022a). To assess miRNAs transcription induction and their regulatory role towards genes involved in herbicide detoxification (CYP450, GST and eIF4B), hence resistance, miRNAs and genes expression profiling was analyzed by qRT-PCR before and after herbicide administration. Results showed that herbicide stimulates the transcription of some miRNAs. When miRNAs are over-transcripted, they inhibit the expression of proteins involved in herbicide detoxification, leading to susceptibility. Instead, miRNAs under-expression lead to enhanced protein expression and herbicide detoxification, hence resistance occurrence (Cusaro et al. 2022b). A thorough understanding of epigenetics regulation of genes acting in herbicide resistance, considering epigenetic–environment interactions, will contribute to improve precision weed management (PWM) technologies, favoring less impactful and more sustainable strategies to control herbicide resistance.

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Hemp seed phytochemicals: different players for innovative cosmeceuticals in skincare

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Keywords: cosmeceutical, hemp seed oil, UAM extraction, UHPLC- HR MS/MS

Hemp seed (HS) oil is a precious source of essential omega-3 fatty acids (e.g. α-linolenic and γ-linolenic acid), besides flavonoids, tocopherols and carotenoids, whose topical application could provide potential skin anti-inflammatory anti-aging effects. Indeed, previously literature data suggested α-linoleic acid, involved in the synthesis of anti-inflammatory prostaglandins and leukotrienes, has a positive role in the maintenance of barrier function, maturation and differentiation of stratum corneum cells, and cytokine suppression. On the other side, γ-linolenic acid is responsible for a reduction of pro-inflammatory leukotriene B4 levels, mediated by an increased amount of dihomo-γ-linolenic acid in the skin, and it also improves skin barrier reducing transepidermal water loss in atopic dermatitis. In the light of above, a "traditional" O/W cream emulsion, together with unusual and innovative formulations, prepared using only natural ingredients, were used as solid or semi-solid vehicles to exploit HS oil for cosmeceutical purposes in skin care products. Antioxidant compounds, such as N-caffeoyl tyramine and cannabisin B, isolated from HS meal, were used as additives, together with cannabidiolic acid. This latter, properly recovered from the plant aerial part, was exploited for its antimicrobial efficacy. In particular, the spherification technique was applied to create innovative alginate/HS oil-based cosmeceuticals. Macroscopic changes in color and odor, phase separation, pH, were monitored at 7, 14 and 28 days. Cytotoxicity of HS oil, pure additive compounds, and cosmeceutical formulation was further investigated through MTT assay towards HaCat keratinocyte cells, while the antioxidant and healing properties were by testing ROS intracellular formation and performing scratch-wound assay. All the formulations appeared stable at the applied mechanical stresses, regardless the storage time and composition. Furthermore, organoleptic analysis did not evidence any changes in texture, color and odor. The HS based formulations favored epidermal keratinocyte migration, thus restoring the wound-mimic gap in confluent monolayer of keratinocytes.

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UHPLC-ESI-QqTOF-MS/MS characterization of 5 different *Olea europaea* L. cultivars of Campania region

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Keywords: flavonoids, *Olea europaea* L, phenolic secoiridoids, total ion chromatogram (TIC), UHPLC-ESI-QqTOF-MS/MS

Olives (*Olea europaea* L.) and olive oil have been widely studied for their flavor and health benefits, but olive leaf chemical composition has only recently attracted interest (Orak el al. 2019). Indeed, they contain several specialized compounds (Ryan et al. 2002, Taamalli et al. 2012) with anti-bacterial, anti-inflammatory and antioxidant applications in nutraceutical and food sectors. Moreover, olive leaves by the pruning and harvesting of olive trees represent one of the by-products of olive oil industry with negative environmental impact. In this context, it was of interest to explore the potential resource of olive leaves, mainly in relation to their cultivar biodiversity. Herein, the leaves from five cultivars were collected after pruning in an orchard near Caserta, and extracted by a green ultrasound-assisted extraction (Lama-Muñoz et al. 2019), using *n*-hexane and then ethanol. All extracts were profiled by UHPLC-ESI-QqTOF-MS/MS techniques. The total ion chromatograms (TICs) of the *n*-hexane extracts showed a similar chromatographic behavior, and MS/MS data largely agreed with the high content in α- and γ-linolenic acid. Ethanol extracts were differently composed by sugars, also polyols, beyond flavonoids and phenolic secoiridoids. The cultivars Frantoio, Leccino, Carolea, and Caiazzana accounted of phenolic secoiridoids, mainly oleuropein, whereas they also represent a good source of pentacyclic triterpenes (e.g. pomolic and oleanolic acid). The cultivar Itrana did not exhibit oleuropein signal, while it appeared rich in flavonoid aglycones (e.g. luteolin, apigenin, diosmin). Data acquired highlight that chemical composition could be mostly affected by genotypes, along with fruit ripening season and environmental conditions.

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A joint approach of morphological and UHPLC-HRMS analyses to throw light on the autochthonous Chestnut for nutraceutical innovation of their waste

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Keywords: circular economy, European chestnut, green extraction, LC-HR MS/MS, polyphenols, waste management

Nowadays, chestnut by-products represent underutilized agricultural and forestry waste that can be exploited as a significant resource to produce high-value natural active compounds. In response to the current perspective of containment of agro-industrial waste, through the increase in the sustainability of production and the activation of an economic circularity of the company, the phytochemical study of the different components of the shell of autochthonous cultivars represents the first step for an effective enhancement of resources. In this study, two chestnut cultivars, 'Verdole' and 'Santimango', have been characterized by using the UPOV guidelines and their fruit were properly dissected to collect the outer and inner shells, and episperm. Each chestnut part, previously crushed, shredded, and passed through diverse sieves, underwent ultrasound-assisted extraction using ethanol. The total content of condensed tannins, and the total content of flavonoids and phenols, as well as the antiradical capacity by DPPH and ABTS assays, and the Fe (III) reducing power, have been evaluated in each shell component. Although all the samples showed dose-dependent antioxidant efficacy, plant matrix size strongly impacted on extraction efficiency. The relative metabolic profiles have been recorded by means of a non-targeted Ultra-HighPerformance Liquid Chromatography–High Resolution Mass Spectrometry (UHPLC-HRMS) highlighting the occurrence of different polyphenol subclasses, whose quantitative ratio varied among the chestnut parts investigated in the two cultivars.

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Eucalyptus EOs: Chemical composition and applications in Pests control – A review in progress

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Keywords: *Eucalyptus* EOs, insects, mites, pests control, phytochemicals

The genus *Eucalyptus*, belonging to the Myrtaceae family, is native from Australia and includes about 900 species (Naithani 2015). *Eucalyptus* plantations are extended worldwide, and particularly in the tropical and temperate world (CABI 2019). Plants giving large biomasses rich in essential oils (EOs) can represent a great source of bioactive natural compounds. EOs can act as insecticides and acaricides, and represent valuable alternatives to the synthetic pest controllers, being biodegradable and human-environmental safe products (Manda et al. 2020). Botanical repellents/insecticides/acaricides can be applied as a strategy in pests management programs, and laboratory investigations represent an important preliminary step that provide an understanding of insect/mite-plant interactions (Hikal et al. 2017), allowing their applications in the areas of food storage, plant protection and human health. A total of 122 articles were analysed regarding 76 *Eucalyptus* species and 4 hybrids, among which *E. globulus* and *E. camaldulensis* result the most studied species. The major constituents of most *Eucalyptus* EOs result monoterpenes and sesquiterpenes: 1.8-Cineole, α-Pinene, p-Cymene, α-Terpineol, Limonene, ɣ-Terpinene, α-Phellandrene, β-Pinene, Globulol, Aromadendrene, β-Phellandrene. The EOs reviewed were tested on 47 insects and 15 mites species. *Aedes aegypti*, *Musca domestica*, *Tribolium castaneum*, *Callosobruchus maculatus*, *Sitophilus oryzae*, *Pediculus humanus* result to be the target species most studied. Several developmental stages of the tested animal have been investigated: eggs, larvae, pupae/nymphae, and adults. Contact, topical and fumigant toxicity, fecundity, ovicidal, repellent and antifeedant activity, acetylcholinesterase inhibition, and antennal response have been evaluated. Results are expressed as lethal concentrations/doses, lethal times, percentages etc. (Paramavisan et al. 2017).

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First evidence of CAM photosynthesis in carnivorous plants

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Keywords: CAM photosynthesis, carnivorous plant, *Pinguicula*, titratable acidity

Fueled by increasing public awareness of climate change, the crassulacean acid metabolism (CAM) as a water saving strategy of plants adapted to drought stress moved stronger into focus of scientific discussion in the last decade, especially the possible applicability in bioengineering for heat and drought stress resilience in crops. Whilst our understanding of their biochemical pathways continuously expands, the evolution of the complex CAM trait in plants largely remains unknown and new CAM plants are still discovered. All known carnivorous plants are considered to exclusively perform C_3 photosynthesis. However, recent studies highlighted the effectiveness of using simple acid tests to detect CAM activity (including weak CAM types), by comparing intracellular acid levels in leaves at sunset *versus* at sunrise, the latter being increased in CAM plants due to aggregation of malic acid in the cells' vacuoles. Applying this method, we here present evidence for heat - and drought - induced CAM activity in several Mexican species of the carnivorous plant genus *Pinguicula* which serves as first evidence of CAM photosynthesis in carnivorous plants. This might be linked to the cool and dry Mexican winters and the hence seasonally reduced availability of water or flying insects for carnivorous nutrition, enforcing the plants to rely more on the water-efficient CAM photosynthesis pathway in the non-carnivorous winter leaves. Moreover, we provide new insights into the *Pinguicula* leaf anatomy. However, further research is necessary to estimate the proportion of CAM activity in their photosynthesis *in situ* and to understand the evolutionary origin of this specific CAM pathway.

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Can combined application of compost and biochar always have a positive synergistic effect on polluted soil and plant growth?

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Keywords: biochar, compost, metal(loid)s, polluted technosol

A combination of compost and biochar has been found to be a potential strategy to significantly improve the physicochemical properties and stabilize metal(loid)s in contaminated soil. However, to the best of our knowledge, no study has been done to determine the impact of biochar and compost mixture applied at various rates on mining technosol. Thus, we investigated the effect of different doses of compost (20%, 40%, 60% w/w) in combination with biochar (0%, 2%, 6% w/w) on soil physiochemical characteristics, the As and Pb mobility in soil pore water (SPW), and also on the ability of *Arabidopsis thaliana* (ecotype Columbia-0) to grow and accumulate metal(loid)s within different organs. We showed that all combination modalities increased the mining technosol's pH and electrical conductivity, stabilized Pb and mobilized As. However, only the *Arabidopsis* plants grown in the technosol amended with a mixture of 20% compost and 6% biochar showed enhanced growth performance. An opposite trend was observed in the case of As, reaching the highest As content in root of plant grown on 20% compost alone or with 2/6% biochar. Overall, results indicated the mixture of 20% compost with 6% biochar as the optimum combination in terms of improving plant growth and As uptake. Besides this, the other treatments displayed their inability to improve plant growth which points towards a possible toxic effect of the combination of high amount of compost with biochar, probably due the oversupply of micronutrients.

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A comparative *in silico* analysis of *Arabidopsis thaliana* and *A. helleri* strategies of the roots for cadmium phytoremediation

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Keywords: *Arabidopsis helleri, Arabidopsis thaliana,* heavy metal stress, phytoremediation

The strategy of using plants to remediate heavy-metal polluted soils is named phytoremediation and is promising, cheap and easy-to-apply (Shah, Daverey 2020). Recently, *Arabidopsis halleri* has been shown to be capable of hyperaccumulating Cd into the roots and, despite its genetic resemblance to the close evolutionary species and model *Arabidopsis thaliana*, the functional peculiarities and key genes involved in this remediation process have not been highlighted (Honjo, Kudoh 2019, Sarret et al. 2002, Hassan et al. 2022). This *in silico* study aims to fill this gap analyzing RNA-seq data and already available knowledge to infer module organization and key genes associated to Cd stress in both *A. halleri* and *A. thaliana* roots. Pathways common and peculiar to the species were highlighted as pivotal to the response of the plant to Cd stress (Fig. 1). This comparison sheds light on the different pathways and allow the identification of target as promising to improve phytoremediation strategies.

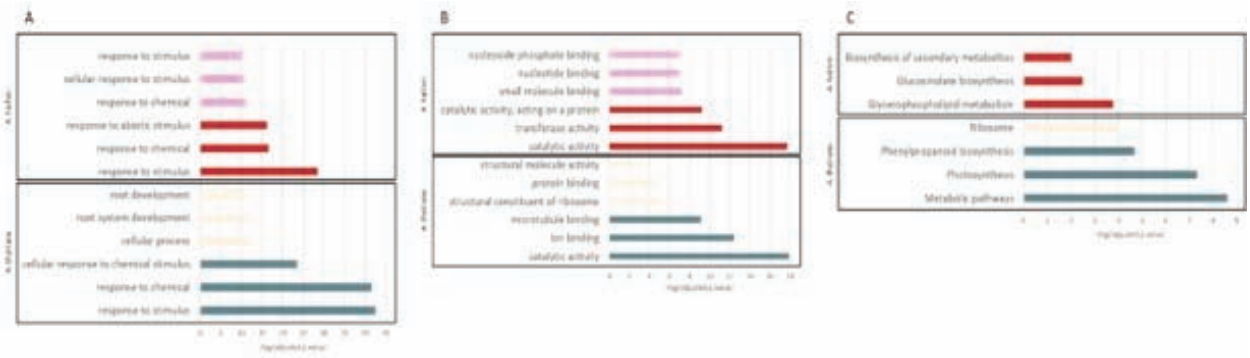

Fig.1
Gene Ontologies and KEGG pathway enrichment: bars represent the top three overrepresented biological processes (A), molecular functions (B) or KEGG pathways (C) identified for the genes belonging to selected Cd-associated modules of co-expressed genes in both *A. thaliana* and *A. halleri*. Bars colors trace modules and x-axis represent -$\log_{10}$(adjusted p value).

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Update on local knowledge of medicinal plants in the Graecanic area (Calabria, Southern Italy)

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Keywords: biodiversity, ethnobotany, cultural Heritage

In many rural areas of the Mediterranean Basin, wild plants still play an essential role (Gentile et al. 2022). This study aimed to collect ethnobotanical information on the medicinal uses of wild plants in the Graecanic area (Reggio Calabria, S-Italy) to preserve and enhance traditional knowledge. Semi-structured interviews were conducted using an interview sheet according to Musarella et al. (2019), and plant samples were collected. Fourteen informants were interviewed, 100 interviews were recorded and 33 *taxa* were identified. The results show that the most cited families are Asteraceae (22 interviews), Lamiaceae (20), and Lauraceae (12); about the *taxa,* the most cited are *Clinopodium nepeta* (L.) Kuntze subsp. *nepeta* (17), *Laurus nobilis* L. (12), and *Matricaria chamomilla* L. (8). Within the category of medicinal uses, the most significant purposes were painkilling (22 interviews and 11 *taxa*), digestive (13, 6), anti-inflammatory (8, 7), and healing (7, 3). The most important *taxon* within the painkilling purpose was *L. nobilis* with six interviews, which was mainly used in the preparation of decoctions, together with *M. chamomilla* for quiet abdominal pain. The most cited *taxon* for digestive and anti-inflammatory purposes was *C. nepeta* subsp. *nepeta*, whose leaves are usually chewed and spit out or used in the preparation of decoctions. A typical use of this *taxon* also concerns its healing purpose: the leaves were pounded to create a paste and rubbed on wounds. In conclusion, these preliminary results prove that traditional ethnobotanical uses in the Graecanic area are still present and medicinal plants represent excellent medicinal substitutes.

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Life Drylands: a project for the conservation of lowland continental dry habitats

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Keywords: life drylands

Open dry habitats are increasingly rare and threatened in all of Europe. In Po plain, host a rich biodiversity, provide ecosystem services, have a great phytogeographic value and host a peculiar floristic composition. However, human impact and lack of proper management are causing their degradation, fragmentation and, in many cases, disappearance. Active management is fundamental and the LIFE NAT/IT/000803 "LIFE DRYLANDS" project started in 2019 with the aim of preserving the Natura 2000 Habitats 2330, 4030 and 6210 in 8 sites of the western Po Plain. The project's general objectives are the restoration of the target habitats and the creation of core areas and ecological corridors to reduce their fragmentation and increase their connectivity. These objectives will be achieved by means of 6 actions. 1: restoration of the vertical and horizontal structures of the target habitats according to a dynamic approach that preserves pioneer, typical and mature aspects. 2: control/reduction of the invasive woody species most responsible for biodiversity loss. 3: improvement of the floristic composition 4: *ex-novo* creation of new patches of the target habitats. 5: production, transfer, and replication of guidelines for the management and monitoring of the target habitats. 6: raising public awareness about the importance of Natura 2000 Habitats. The project also aims at providing an increase in awareness about to the huge value of habitats and organisms that are poorly or not considered, such as terricolous lichens. It also stresses the greater effectiveness of protecting entire habitats, instead of single species, to preserve biodiversity.

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Mediterranean wild edible plants: diversity, conservation, and potential use

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Keywords: biodiversity conservation, biogeography, crop wild relatives, edible plant, Mediterranean

The gathering and consumption of Wild Edible Plants (WEPs) has always characterised the history of the Mediterranean Basin. WEPs have represented an asset for food security for centuries: they are highly adapted to local environments and resistant to pathogens, greatly nutritious, and often rooted in the local cultural identity (Ulian et al. 2020). Nevertheless, major changes in food systems and markets over the past decades have brought the rapid abandonment of such practice, together with degradation of the natural habitats WEPs are usually found in. Today, not only we rely on less than 10 plants for almost our entire caloric intake (FAO 2020), but climate change is increasingly putting the cultivation of such species at risk. The revitalisation of Mediterranean WEPs within our food systems could foster diet diversification and improve the resilience of several crops. But what will be the future of such overlooked resources under forthcoming global warming? By means of a highly interdisciplinary methodology, the present work will catalogue the taxonomic diversity of WEPs, indicate their conservation status, and map their distribution across the Mediterranean region. Moreover, it will explore the seed regeneration characteristics of selected priority species under various climatic scenarios, highlighting their potential for propagation, domestication, and crop improvement. Findings will emphasize which species will be valuable resources for future food systems, as well as which will require urgent conservation actions. Thereby, they will form the basis for future nature-based solutions to be put in place, enhancing the link between conservation strategies and sustainable use of plant genetic resources.

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A “Phyconomic” approach to the exploitation of algal biomass

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Keywords: biorefinery, green economy, macroalgae, phyconomy, seaweed

Macroalgae is a promising source of bioactive substances such as pigments, fatty acids, polysaccharides, sterols or halogen-organic compounds. With a view to traceability, not only of products but also of raw materials, DNA barcoding allows organisms to be permanently “labelled”, regardless of any subsequent taxonomic or nomenclatural variations. The productivity of massive crops is frequently conditioned by pathogens. New pathogens are continuously isolated from aquaculture facilities even if the etiology of these pathologies is not fully understood. The optimization of massive production through maintenance cultures in the laboratory represents a salient point of experimentation in this field. Therefore, based on the requests of the manufacturing companies, the techniques for controlling contamination in crops and the influence of environmental parameters on product quality and biomass yield currently represent the topics of greatest interest. The aim of the research work is the improvement of cultivation and molecule extraction techniques, as well as the evaluation of the possibilities of European native species of macroalgae. Interest was directed to the search for species relevant for extraction protocols in biorefineries, with two or more products deriving from a single starting biomass, with the aim of selecting and genetically labeling the best species from both the quantitative and qualitative of the extracts. A final analysis was also carried out on the feasibility and scalability of the various pilot projects, both in terms of yields and costs, in the framework circular economy, aiming at the sustainable exploitation of an environmentally friendly resource with a positive environmental impact.

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Research and conservation bias in plants and habitat diversity

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Keywords: conservation bias, plant blindness, research bias

Global biodiversity is declining, forcing scientists to define conservation targets and priorities. Mounting evidence suggests that some organisms attract more research and conservation than others. This awareness disparity can bias our understanding of biodiversity, influencing policy decisions, societal interests, and allocation of fundings. Compared to animals, plants receive significantly less research and conservation attention, a phenomenon termed "plant-blindness". This is problematic: plants are the base of most terrestrial food webs and their role in habitat shaping is established even in some marine environments. We studied research bias in plant conservation to assess if plant awareness disparity affects research choice and allocation of conservation fundings. We found that animals received three times more funding than plants. Within plants, species at northern latitudes, with broader ranges, and with blue/purple flowers received more funds regardless of their extinction risk. At the habitat-level, we found no relationship between expenditure and conservation status of the habitat. We also documented an aesthetic bias in research and conservation: the beauty of a certain species favours it as a candidate for scientific analysis. This phenomenon has deep cultural roots, and affects especially those scientists who work outside of laboratories. By combining bibliometric data with trait-based approaches, we demonstrate that morphological traits and specific colourations, as well as range size, have significantly more impact on species choice for flowering plants than traits related to ecology and rarity. Altogether, our results can inform ways forward to achieve research and conservation goals that are more objective, comprehensive, sustainable, and cost-effective.

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Biodiversity, climate change and land-use management at the Neolithic site of Palù di Livenza (4400 and 3600 cal BC) told by pollen

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Keywords: biodiversity, environment, Neolithic, Northern Italy, pollen

Palynology is a very useful tool when approaching the analysis of biodiversity, environment and climate of our past. Applying palynology to archaeological sites, allows also to discover how ancient populations took advantage of their territory, how they managed the resources of the surrounding environment and how they influenced first local vegetation assemblage and then environment and climate (Mercuri 2014). The aim of the palynological analyses carried out at the Neolithic site of Palù di Livenza (4400 and 3600 calBC) is to deepen the knowledge about the palaeoenvironment studying both on-site and off-site records (cored at ca. 300 meters from the archaeological site). The results from the off-site sequence show an extended forest cover mainly composed of mixed oakwoods with high percentage of wet areas with hygrophilous trees (*Alnus*, *Populus* and *Salix*). During the Neolithic phases, it is visible a slight decrease of arboreal plants and cereals, Anthropogenic Pollen Indicators (Mercuri et al. 2013) and Local Pastoral Pollen Indicators (Mazier et al. 2006) are documented in little but significant amount, suggesting the presence of fields. Also in the on-site record, during the Neolithic, cereals are documented all along the sequence in high percentage. Woods are mainly present at the final stage of the settlement, when the environment became wetter with the establishment of swamps and was probably no longer suitable for the settlement. This study is included in a PON project aimed at reconstructing biodiversity, environment and human/environment dynamics in northern Italy from the Neolithic period to the end of the Bronze Age.

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Study on the perception of the urban's plant diversity and estimation of the well-being of the population through a sentiment analysis approach

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Keywords: biodiversity, environmental policies, machine learning, quality of life, sentiment analysis, wellbeing

In the last decades, there has been a growing interest in assessing the effects of urban green and blue spaces (wetlands) on the users' physical health and psychological well-being. In a global context of increasing urbanization, adopting a criterion of environmental sustainability requires an assessment of how both green space and urban blue space can substantially improve the quality of human life to make a positive contribution to social, economic, and environmental policies. However, few empirical studies have attempted to relate these benefits to plant biodiversity. Our central hypothesis is that urban (and/or peri-urban) green and blue areas characterized by a different level of plant diversity can determine a different effect on the well-being and health of the user communities. To test it, we rely on an interdisciplinary approach that combines philosophical investigation of the concepts of well-being and quality of life, automated analysis of web texts, and botanical and environmental research. The main objectives of the study were to (i) assess the affection of users to the urban green and blue areas. The analysis has been carried out through automatic analysis of the texts produced within social media (sentiment analysis); (ii) to relate the degree of affection with the level of taxonomic and functional diversity of the plant community characterizing the studied areas; (iii) to define how the degree of preference of sites (green or blue) affects the well-being of the users regarding the subjectivistic model of the quality of life.

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Surviving the ravages of Time: 18th vs 20th and 21st century plant-based medicinal remedies in Valle Imagna (Bergamo, Italy)

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Keywords: agrimony, ancient remedie, modern ethnobotany, Valle Imagna

This investigation stemmed from the previous analysis of an 18th century manuscript found in Valle Imagna (Bergamo, Italy) and containing 200 plant-based medicinal remedies. We designed an ethnobotanical investigation to make a comparison between past and current phytotherapy knowledge in this territory. The field survey was conducted through semi-structured interviews (November 2021-November 2022). All data was then entered in a database and processed. Finally, a comparison between the field results and the ancient remedies of the manuscript was performed. 110 interviews were conducted and the use of 106 medicinal species, belonging to 46 families, was noted. The most used species were *Malva sylvestris* L., *Tilia cordata* Mill., and *Agrimonia eupatoria* L. The comparison with the remedies in the manuscript highlighted a similar use for 14 species. For example, agrimony was used in Valle Imagna until the 1960s-1970s for the treatment of deep wounds. Its fresh leaves were applied directly on the open wound and set in place with a gauze. Furthermore, wound healing compresses with the infusion or the decoction of the whole plant were applied. These kinds of medication call back to an ancient poly-herbaceous remedy in the manuscript against deep leg ulcers based on compresses of wine decoction of this species and on the direct application of the cooked poultice thus obtained. These preliminary results allow us to speculate on how slivers of ancient plant-based remedies used in Valle Imagna during the 18th century might have survived the passage of time, coming down the centuries to us today.

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Two Botanic Gardens to preserve the traditional bio-cultural heritage in Valmalenco (SO, Italy): an Open Science strategy

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Keywords: botanic garden, ethnobotany, local bio-cultural heritage, open science

Ethnobotany of mountain regions is receiving increased interest due to the impact of global warming on the local biodiversity. The preservation of plant's traditional know-how represents an alternative strategy for their sustainable development, in accordance with the "cultural tourism" plans. Within the European Interreg Italy-Switzerland B-ICE project (2019-2022), an ethnobotanical survey was conducted in Valmalenco (Sondrio, Lombardy, Italy) through semi-structured interviews. 401 informants were interviewed, providing information on 227 species, belonging to 77 families, and referring to 12 fields of use. To preserve this "bio-cultural landscape" the project provided the realization of two Botanic Gardens in Caspoggio. The "Didactic Botanic Garden" was designed for children to offer educational paths: 30 species were selected paying attention to their tradition, *habitus* and display of flashy flowers and fruits, useful in the interactive labs. *Ad hoc* botanic labels and illustrative panels were realized. The "High-rise Botanic Garden" was conceptualized to share a scientific approach to the selected 40 *taxa*, arranged into 8 flowerbeds, each linked to a different field of use. The primary data, extension area, maximum height, floral display, flowering period, habitat, and any incompatibility among the species were considered and a high-level interpretative apparatuses were achieved. Still, under an Open Science perspective, a two-days event was organized. The return of the scientific results to the study area represented a challenge to make people participate in the research progress, with the main goal to create awareness about the values of the traditions, with positive effects on the tourist attractiveness of the territory.

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Spontaneous plant communities within a Mediterranean green roof

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Keywords: green roofs, Mediterranean area, plant communities, urbanization

To counteract the environmental issues posed by the urbanization process, municipalities start planning green spaces, and promoting green roofs (Oberndorfer et al. 2007). These latter represent harsh environments for plants, specifically in the Mediterranean area (Catalano et al. 2013). Therefore, little is known about the plant communities able to grow on a Mediterranean green roof (MGR). Addressing this knowledge gap, the study focused on the spontaneous vegetation of a MGR in Genoa (NW Italy) to characterize the dynamics of plant communities in relation to extensive and intensive substrates. Plant communities were assessed through phytosociological relevées in June (t0) and September 2022 (t1). The vegetation was removed from 14 plots of 1 m2 for each substrate at t0 and t1. and weighted at t1. Differences were checked in species composition both qualitatively (t0) and through a Non-Metric Multidimensional Scaling (NDMS) (t1). Diversity indices were calculated, and Kruskal-Wallis test was performed at t1. Species turnover indices were computed between t0 and t1. Taxonomic diversity was higher in the extensive substrate than in the intensive one at t0, while no significant difference was shown at t1. Nevertheless, species composition changed according to substrates and time. Turnover values were higher in intensive substrate compared with extensive one, while fresh biomass was higher in the extensive substrate compared with the intensive one. Our findings further confirm the relevance of the substrate in selecting plant species on GR, specifically in the Mediterranean area.

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Exploitation of fungi in biomining on Martian regolith simulant

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Keywords: bioleaching, biomining, fungi, space resource exploitation

Biomining is a new technique that is being studied for its industrial and economic relevance and for its low environmental impact. Indeed, this technique uses microorganisms that have a low energy demand. Fungi play a significant role in metal recovery. The leaching process by fungi is possible by acids and the main reaction is called acidolysis. In this way, the metal is solubilized in the solution and water is formed. Fungi, which are heterotrophic organisms, require a source of organic carbon for their growth; with a perspective of applying this technique in an industrial context or even in future extraterrestrial contexts, this could be considered an advantage as it would allow the *in-situ* recycling of organic waste. The technique chosen for biomining was spent-medium bioleaching, which involves separating the acid production phase from the metal element extraction. The acids are released by the fungal strain within a culture medium in which the mycelium optimally grows; subsequently, the fungus is removed from the medium and only the latter is put in contact with the rock powder. The acids that are present in the culture medium lead to the extraction of metallic elements through acidolysis and complexolysis reactions. Thanks to the results obtained it was possible to develop a liquid culture medium capable of inducing acid production in the selected strain. In addition, the process of acidolysis, detectable through the change in pH, appeared to take place on the regolith. Analyses with HPLC, LA-ICP-MS and particle size analysis are now underway.

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The unknown botany: The case of the Collection of Edibles and Organic Remains of National Archaeological Museum of Naples

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Keywords: archaeobotany, ancient organic remains, botanic collection, food plants, plant remains, Vesuvian area

The eruption of Vesuvius of 79 AD was one of the greatest disasters of Antiquity; the sites destroyed by this eruption provide a complete picture of the culture of the Roman population in the 1st century AD. Among the archaeological areas, the Vesuvian region constitutes an exceptional case also as regards the wealth of plant remains. These finds have been collected and stored since the beginning of the archaeological excavations, going to form the so called "Collection of Edibles and Organic Remains", today stored in the National Archaeological Museum of Naples (MANN); this is the most complete collection of the world of plant remains dated to the Roman period. Our work provides a first comprehensive overview of the specific features of each find of plant remains stored in the MANN. The finds censused 261 records (for each find, whether consisting of a single specimen or thousands, a record number was assigned) comprising 51 *taxa*. In particular 20 woody species and 31 herbaceous species have been identified. The most frequent are the cereals *Triticum dicoccum* and *Hordeum vulgare*, the pulses *Vicia faba* var. *minor* and *Lens culinaris*, *Ficus carica* (Fig. 1) and *Pinus pinea*. Our work has shown several identification errors in previous works, especially as regards cereals and pulses. In addition we concluded that both a significant part of this collection and several archaeological data have been lost. On the basis of these results we assume that this collection was neglected for a long time; in large part this is because archaeobotany has long been ignored by archaeologists.

Fig. 1
Ficus carica recovered from the Vesuvian region.

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Evaluation of antioxidant, antimicrobial and tyrosinase inhibitory activities of extracts from *Tricholosporum goniospermum*, an edible wild mushroom

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Keywords: antimicrobial activity, anti-tyrosinase activity, scavenger-reducing activity, *Tricholosporum goniospermum*

Tricholosporum goniospermum (Bres.) Guzmàn ex T.J. Baroni (Tricholomataceae) is an excellent edible mushroom with unknown compounds and biological properties. In this study, *n*-hexane, ethyl acetate, and methanol extracts from fruiting bodies and liquid-cultured mycelia were compared for the analysis of phenolic compounds, the evaluation of the antioxidant activities and enzymatic inhibition of α-amylase, acetylcholinesterase, butyrylcholinesterase, and tyrosinase. Additionally, *T. goniospermum* extracts were evaluated for antimicrobial activity against Gram+ and Gram- bacteria, clinical yeast isolates, and fungal dermatophytes. The isolation of the mycelium of *T. goniospermum* in pure culture was obtained starting from a small fragment of the fruiting body (Angelini et al. 2020). The preparation of fungal extracts is reported in Angelini et al. (2020). The total phenolic content was determined using the colorimetric method. Different assays were used to evaluate the antioxidant activity *in vitro*: DPPH, CUPRAC, and FRAP. *T. goniospermum* extracts from fruiting bodies and mycelia were analyzed for the quantitative determination of phenols by an HPLC fluorometer. The antimicrobial activity was evaluated by the following the CSLI methods. The methanolic mycelium extract was the richest in gallic acid, while the ethyl acetate extract from the fruiting bodies was the only one containing catechin. Ethyl acetate extract also showed the most significant antimicrobial and anti-tyrosinase agent activity. All *T. goniospermum* extracts tested showed potent antimicrobial activities. In particular, the ethyl acetate extract showed the highest efficacy as an antimicrobial agent and antityrosinase. This may be related, albeit in part, to its catechin content, thus suggesting innovative pharmacological applications of *T. goniospermum* extracts.

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Untargeted metabolomics used to describe the chemical composition, antioxidant and antimicrobial effects of extracts from *Pleurotus* spp. mycelium grown in different culture media

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Keywords: antimicrobial effect, metabolomics, phenolic compounds, *Pleurotus* species

Much of *Pleurotus* species research has focused on the potential of various lignocellulosic by-products for satisfactory mushroom yields, extraction of secondary metabolites and pharmaceutical and food applications. No data exist on the effect of cultural media on the mycelium content in bioactive compounds and on their functional properties. This work aimed at investigating the impact of two different cultural media on both mycelium growth and concentration of bioactive compounds, antimicrobial and antioxidant activity. The mycelium of four *Pleurotus* species, *P. columbinus, P. ostreatus, P. nebrodensis,* and *P. eryngii* species complex was cultivated *in vitro* using two substrates: PDA (as control - S1), and PDA enriched with 0.5 % of wheat straw (S2). For the mycelium extracts we evaluated: the metabolic profile through LC-MS/MS analysis, the antimicrobial activity following broth-microdilution method of CLSI and the antioxidant effect through ABTS and DPPH assays. The differential metabolites covered a total of 58 pathways, comparisons were made between the metabolic profiles of *Pleurotus* spp. mycelia grown on S1 and S2. We found that the metabolic pathways are strongly influenced by the chemical composition of the growth substrate, for instance the folate biosynthesis is greater for M11 grown on S2. The antibacterial effects were particularly evident for extract M14 against *Escherichia coli*, whereas the antifungal effects were evident against *Arthroderma currey*, *Trichophyton rubrum* and *Candida parapsilosis*. The best antioxidant activity was shown by the S1 extracts. More investigations, aimed at evaluating the influence of growth substrate on *Pleurotus* spp. antimicrobial and antioxidant properties are necessary.

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Changes in the urban street trees in the last decades: the case study of the city of Sassari (Italy)

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Keywords: ecosystem services, green management, urban green

Street trees are crucial since they provide several ecosystem services and enhance the quality of life (Kurn 1994). Different types of trees have different functions and benefits: if tree types change in streets, then benefits also vary accordingly (Shah et al. 2022). To contribute to the evaluation of the changes in street tree composition in the Mediterranean environment in recent decades, we present a case of study, which concerns the city of Sassari. This city has a typical Mediterranean climate and about 150,000 inhabitants. Detailed data on street trees date back to about 30 years (Achenza 1995). Considering this, the aim of this study was to compare the current situation with that of 30 years ago. The current data has been collected by walking along the city streets and taking notes of all the tree and shrub species present. Comparisons has been made between the total number of species present in each street, the average number of species per street and the number of streets where each single species is present. On the basis of the results obtained, it has been possible to make comparisons in terms of biodiversity and qualitative characteristics of the road trees (Viñas, Solanich 1995), also taking into account the positive and negative aspects for each single specie (Salmond 2016). These results will be useful for green management not only in the city of Sassari, but also for any other one with similar features (Jiajia, Ferry 2022).

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Aerobiological monitoring in urban and rural environments: diversity and perspectives

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Keywords: aerobiological monitoring, pollen, *taxa*

Numerous studies in the field of aerobiology have shown that airborne pollens depend on vegetation and environmental conditions, with considerable spatial variations. In fact, the presence of pollen is mainly linked to flora and vegetation, although long-distance pollen transport may also contribute. The present study was conducted to assess differences in pollen concentration, considering phenological and production indicators from four different aerobiological monitoring stations located in the territory of the metropolitan city of Rome, belonging to the Rome Monitoring Centre of the University of Tor Vergata, in environmental contexts with different vegetation and urbanization. Obviously, this floristic diversity is reflected in an equally varied pollen spectrum. Sampling was conducted using Hirst volumetric traps, and pollen data were collected according to standardised methodologies referring to the European standard CEN/TS 16868:2019. Thirteen *taxa* were considered. Pollen season limits were calculated using the method of Jäger et al. (1996), and the data were subjected to Pearson's correlation test and cluster analysis. The results showed differences both in the floristic composition found in the vegetation surrounding the sampling sites, and in the descriptors of the phenological and production indicators at the sampling sites and in the years considered. Although a certain agreement on the start of the pollen season is observed for the different *taxa*, a heterogeneity of the pollen rainfall was evident at the different sites and in the different years. Concluding, collected data support the importance of installing multiple aerobiological stations within large cities for aerobiological monitoring.

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Quantifying ecosystem services within urban nature-based solutions in the city of Genoa

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Keywords: biodiversity, CO_2 capture, evapotranspiration, key performance indicators, Nature-based Solutions, urban resilience

Nature-based Solutions (NbS) are actions to protect, sustainably manage or restore natural ecosystems (Cohen-Shacham et al. 2016). Although ecosystem services are well-known (Maes et al. 2020), a clear assessment of NbS effectiveness with quantitative key performance indicators (KPIs) has not been yet standardized. During 2020-2022, at the former Gavoglio barracks (Genoa, NW Italy), the project H2020 UnaLab allowed setting up restoration practices to realize an urban park of 13 ha with 12 different NbS for stormwater management whose benefits should be assessed. The aim of this study was to evaluate the NbS through KPIs. The biodiversity (plants, birds and pollinators) was assessed through the Shannon's index, birds' species richness, ratio between passerine and non-passerine species; the evapotranspiration rate was calculated through Thornthwaite's equation and the carbon storage via evaluation of the woody biomass and CO_2 equivalent stored. All the evaluated KPIs highlighted a low-biodiversity condition with 52 plant *taxa*, 26 bird species, and 25 pollinator insect species. This is probably related to the time required to restore the urban area that needs more time to allow a good colonization by stable population of animals and to overcome the planting stress. A subsequent monitoring with the same KPIs will provide additional data to evaluate changes in species richness and abundance, increase of CO_2 storage and evapotranspiration rate. The study results and the comparison with the other front-runner cities involved in the Unalab project will enable the development of a European NBS Reference Framework on benefits, and replicability of NbS, which will guide cities across Europe and beyond.

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Environmental education at school: methodologies and multidisciplinary spaces

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Italy is the first European country that included, by the law n.92/2019, the environmental education as a curricular subject in schools of all levels. The law provides for 33 hours of teaching which include constitution, digital competences, and environmental education as part of the "Civic education". A further innovation is the indication that this discipline cannot be supported by a single teacher since it refers to the transverse nature of the new teaching. In this context, professional figures such as environmental educators play a pivotal role in supporting teachers. The aim that I set myself was to develop a new environmental education approach designing and conducting workshops based on different topics for schools of all levels. This methodology has found great success above all the teachers I worked with, because it has allowed them to carry out a laboratory to explore topics that otherwise they would not have addressed by putting into practice theoretical. A very important theme that I developed concerned the school garden, which can help in teaching topics such as environmental education and active citizenship. Unfortunately, this open space available to teachers and pupils is often not adequately exploited, but it can become an excellent open-air environmental education laboratory. In conclusion, this new approach demonstrates that, through the participatory planning of the workshops carried out, pupils and teachers have been able to look at their own spaces with different eyes and evaluate together how to best respond to training and growth needs of everyone.

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