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Sustainable restoration of Mediterranean forests

edited by D. Chiatante, G. Domina, A. Montagnoli & F. M. Raimondo

Abstract

Chiatante, D., Domina, G., Montagnoli, A. & Raimondo, F. M. (eds): Sustainable restoration of Mediterranean forests — Fl. Medit. 27: 5-76. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

This contribution includes the 62 oral and 24 poster presentations of the international congress "Sustainable restoration of Mediterranean forests, analysis and perspective within the context of bio-based economy development under global changes", Palermo 19th - 21th April 2017, organized by the International Union of Forest Research Organizations (IUFRO), the University of Insubria, the Tuscia University, the University of Palermo, the Italian Society of forest restoration (SIRF), the Botanical Society of Italy (SBI) and the Italian Academy of Forest Sciences. The congress program is organized in four main technical Symposia: Forest restoration in Mediterranean climates (Europe/other continents); Scientific and technological advancements for a sustainable forest management; Political, social, and economical implications related to forest restoration activities; Forest restoration, landscape management, and ecosystem services. The four key themes of the symposia will be developed by answering the following questions: How climate change and its extreme events is affecting the Mediterranean vegetation in general and forests in particular; how new technological advancements will impact upon and will support the strategies to be implemented for leading to a sustainable forest management in Mediterranean Region; how to interconnect stakeholders, economists, policy makers with forest and landscape scientists in order to form a network able to guarantee a full integration of national forest infrastructures within the context of worldwide strategies for a circular economy; how the introduction of an Adaptive Measure (AM) approach could combine Adaptive Forest Management (AGM) with Forest Landscape Restoration (FLR).

Addresses of the editors:

Donato Chiatante & Antonio Montagnoli, University of Insubria, Department of Biotechnology and Life Sciences, Via Dunant 3, 21100 Varese, Italy. E-mail: donato.chiatante@uninsubria.it, antonio.montagnoli@uninsubria.it

Gianniantonio Domina, Department SAF, University of Palermo, via Archirafi 38, I-90123 Palermo, Italy. E-mail: gianniantonio.domina@unipa.it

Francesco M. Raimondo, Department STEBICEF/Section of Botany and Plant Ecology, University of Palermo, via Archirafi 38, I-90123 Palermo, Italy. E-mail: francesco.raimondo@unipa.it

Oral presentations

Forest adaptation and restoration under Global Change - concept and status of an IUFRO Task Force

Andreas Bolte[1]*, Palle Madsen[2], Mercy Afua Adutwumwaa Derkyi[3] & John A. Stanturf[4]

[1]Thünen Institute of Forest Ecosystems, Alfred-Möller-Straße 1, 16225 Eberswalde, Germany.
[2]University of Copenhagen, Forest and Lancscape College, Nødebovej 77A, 3480 Fredensborg, Denmark.
[3]University of Energy and Natural Resources, Dept. of Forest Science, School of Natural Resources, P.O. Box 214, Sunyani, Ghana.
[4]U.S. Forest Service, Southern Research Station, 320 Green Street, Athens, GA 30602-2044, United States of America.
* Corresponding author: andreas.bolte@thuenen.de; Phone: +49 3334 3820 344

Keywords: Adaptive Forest Management (AFM), Forest Landscape Restoration (FLR), best practice approach, capacity building, online survey.

Rising world population and increasing demands on forest ecosystems goods and services as well as on meat and dairy products are cascading into forest degradation or even deforestation. At the same time, forest ecosystems are facing fundamental disruptions by e.g. extreme weather events and accompanying biotic threats. Due to these changing conditions, we need more information on the adaptive capacities of trees and forests as well as on the options and limitations of Adaptive Forest Management (AFM) from the stand-scale embedded within Forest Landscape Restoration (FLR) activities to the landscape-scale. The IUFRO Task Force *Forest Adaptation and Restoration under Global Change* is dedicated to compiling globally-available scientific and technical knowledge and experiences on an adaptation of forests and forest landscapes. The TF conceptual pathway has three aims: identifying knowledge gaps, comparing existing activities and techniques, and elaborating best practice approaches. This shall be done by (1) considering all actions that increase adaptive capacity of forests and forest land, (2) combining Adaptive Forest Management (AFM) concepts on a stand-scale with Forest Landscape Restoration (FLR) concepts at the landscape-scale, (3) linking national and trans-national policies, as well as trans-disciplinary expertise in various fields, and (4) integrating experts and working activities among various IUFRO units. Critical challenges are the limits on worldwide transfer of information about forest adaptation and restoration, as well as the need for capacity building in developing countries. Thus, TF activities are recently focusing on regional training workshops with local practitioners and the establishment of a database including worldwide knowledge and experience about successes and failures of forest adaptation and restoration activities. Data are gathered using a multilingual online survey and will be used for disseminating local and regional best practice approaches for forest adaptation and restoration.

Successful experiences of restoration of Mediterranean forests in Chile, South America

Veronica Loewe*, Gerardo Vadevenito, Manuel Acevedo, Marta Gonzalez, Susanna Benedetti, Eduardo Cartes & Ivan Quiroz

NFOR, Sucre 2397, Santiago, Chile.
* Corresponding author: vloewe@infor.cl; Phone: +56996896499

Keywords: dune, plant production, rainwater harvest.

Restoration of highly degraded Mediterranean ecosystems involves the assessment of both nursery propagation mechanisms of the main tree and shrub species that compose those ecosystems and the silviculture that ensure restoration success in the field. The following experiments are presented: -Rainwater harvesting techniques in areas with rainfall below 250mm. Oasification techniques (infiltration trenches, limans, terraces, diversion channels) had a positive effect. -Techniques for restoring the sclerophyll forest on the Andes (1500 ma.s.l.) using materials available in the area or waste materials (old car tires) were designed, promoting survival increase and growth promotion. -*Peumus boldus* forest, endemic species exhibiting wide plasticity and geographical distribution; leaves are used for medicinal purposes, traditionally harvested from natural forests degraded due to non-sustainable extraction practices. The response to management under different harvest intensities was evaluated, identifying those that favor resprout emergence and a better recovery. -*Nothofagus alessandrii* forest, endemic species endangered. Nursery plant production was studied, evaluating containers size and fertilization, and field establishment with and without individual protection. -Mixed forest of *Nothofagus obliqua*, *Aextoxicon unctatum* and *Laurelia sempervirens* affected by a fire. The effect of establishment with contrasting levels of artificial protection on survival and growth was evaluated for 2 years. Results show the importance of protective elements during establishment to favor initial development and increase survival. -Stabilization of coastal sand dunes with *Pinus pinea*, characterized by its capacity to adapt to nutrient and water deficit conditions and to dunes. Experiments conducted in Chile and Argentina are presented. Even though the techniques used were different, the results were excellent, with localities having being safeguarded from the advance of sand dunes.

Forest degradation, conservation and restoration in the Mediterranean Basin

Roberto Mercurio

SIRF, Via S. Camillo de Lellis, Viterbo, Italy. E-mail: rmercurio@inwind.it

Keywords: degradation, forest restoration, human and spiritual growth.

The degradation of Mediterranean forests for overgrazing and overutilization has characterized the past centuries. In the 20th century started an important reforestation plan of bare lands mainly with conifers ending in the same century and representing a primeval form of forest restoration.

Following the Conference on the Human Environment of Stockholm at the beginning of the '70s and the development of the green movement in the western Countries, the resulting strategies were based on the creation of many protected areas and developing conservative idea of passive forest management, underestimating the role of restoration of many degraded forests unable to furnish eco-services.

The restoration of degraded forest systems represents the challenge of the 21th century. The peculiarity of forest restoration in Mediterranean Basin begins counteracting the current causes of degradation such as forest fires, land abandonment, heedless urbanization, wars and criminal acts, adapting criteria and techniques to a high densely populated and altered territory by millenary human activity.

Forest restoration should be focused on improving ecological functionality and human well-being e.g. preventing floods and desertification, and enhancing carbon dioxide absorption.

Restoration is not a simple technique, it needs a public consensus and a human moral and spiritual growth.

Increasing diversity and resilience of Aleppo pine stands: thinning and introducing hardwood species

Bernard Prévosto[1]*, Jordane Gavinet[2] & Catherine Fernandez[2]

[1]Irstea, route de Cézanne CS 40061 13 182 Aix-en-Provence cedex 5, France.
[2]Aix-Marseille University (IMBE), Campus St Charles Case 4 3 place Victor Hugo 13331 Marseille cedex 3, France.
* Corresponding author: bernard.prevosto@irstea.fr; Phone: +33 (0)4 42 66 99 25

Keywords: plant-plant interactions, thinning, soil moisture, light.

In Mediterranean forests, silvicultural methods to increase the resilience of the existing stands are needed to face climate change challenges. Promoting mixed stands, in particular mixed pine-hardwood stands, is of interest as it combines the rapid growth of pine and the resprouting capacity of the hardwood species.

To implement this strategy in southern France, we have introduced 2800 seedlings of six hardwood species in monospecific Aleppo pine stands and in the open. The species used were two shrubs, two deciduous trees, two common late-successional oak trees and an exotic tree. Species were planted or sown (oaks) in stands previously thinned to produce three cover treatments: low (heavy thinning), medium (medium thinning) and dense (no thinning). Seedlings were monitored during 6 years and some physiological traits were measured. Besides, light availability and microclimatic factors were also recorded.

Results showed that seedling responses to the treatments were species-specific but seedling development was always the lowest in the dense cover treatment. Survival of the deciduous trees was only slightly modified under medium to low pine cover compare to the open whereas height growth was largely stimulated. This result can be explained by a higher photochemical stress of these species in full light conditions whereas soil moisture remained higher in the open than in forest stands. In contrast, survival and development of the two shrub species and of the evergreen oak were improved in the open. Last, establishment of the exotic tree was largely compromised by frost damages.

Introduction of hardwood species in pine stands is a promising technic to improve forest resilience. Low to medium pine cover is favourable to deciduous trees but not to shrubs which are better adapted to open conditions. In fact, deciduous trees exhibit a shade-tolerance whereas they are subjected to photoinhibition under full light. Dense stands are particularly unfavourable to seedling establishment due to light limitation and need to be thinned.

Sustainable forest restoration of degraded relict forests in Sicily

Gianniantonio Domina[1]*, Francesco Maria Raimondo[2] & Sebastiano Ciccarello[2]

[1]Department SAF, University of Palermo, via Archirafi 38, Palermo, Italy.
[2]Department STEBICEF, University of Palermo, via Archirafi 38, Palermo, Italy.
* Corresponding author: gianniantonio.domina@unipa.it; Phone: +39 3477027156

Keywords: colchic-atlantic vegetation, Madonie Mts., Nebrodi Mts.

In the Mediterranean region the Miocenic and Pliocenic vegetation was almost entirely destroyed or heavily disturbed by the geo-climatic events of the Quaternary. The glacial phenomenon of the Pleistocene determined the nearly complete disappearance of the subtropical aspects of lauriphyllous forests. Impoverished evergreen forests residual from the colchic-atlantic vegetation still survive today on the oldest mountain ranges of the Mediterranean and testimony this humid subtropical climate vegetation. Examples are widespread above all in the Caucasus (Colchide) and in the Macaronesian areas, remains of a unique zone crossing the Mediterranean from East to West. Scattered remains occurs inside deciduous broadleaf formations in Mediterranean mountains. In some cases these are extra-zonal vegetation belts with remarkable phyto-geographic and landscaping interest as in Sicily on the Nebrodi and on the Madonie mountains. These formations, included in the class *Querco-Fagetea*, are characterized respectively by *Quercus cerris* in the Nebrodi (*Ilici-Quercetum cerridis*) and *Q. petraea* subsp. *austrothirrenica* in the Madonie (*Ilici-Quercetum austrothyrrenicae*) and share species as *Ilex aquifolium, Daphne laureola, Ruscus aculeatus, Hedera helix* and *Evonimus europaeus*. Often highly degraded aspects occur due to the overexploitation and grazing persisted from the XIX Century to years following the second World War. More than thirty-five years, after the institution of the Regional Natural parks of the Madonie and Nebrodi, some areas of natural expansion of these woods occur. Anyway, the human intervention to restore the natural floristic richness and to make possible this process in heavily degraded areas is necessary. The most suggested actions are those on small areas with plantlets coming from seeds collected on site.

Bryophytes as ecological indicators in beech woods of Sicily

Marta Puglisi[1]*, Patrizia Campisi[2], Maria Privitera[1], Maria Giovanna Dia[2] & Giovanni Spampinato[3]

[1]Department of Biological, Geological and Environmental Sciences, University of Catania, Via A. Longo 19, Catania, Italy.
[2]Department STEBICEF, University of Palermo, Via Archirafi, 38, Palermo, Italy.
[3]Department of Agricultural Science, Mediterranean University of Reggio Calabria, Località Feo di Vito, Reggio Calabria, Italy.
* Corresponding author: mpuglisi@unict.it

Keywords: bryophytes, beech woods, bioindicators, Sicily.

Beech woods, which have in Sicily one of the southernmost places of their distribution area, are localized in the mountain belt of North and North-Eastern Sicily, at an altitude of 1300-1900 m, reaching 900 m on the Peloritani. They are referred to the priority habitat 9210*, according to the Natura 2000 network of the European Union. Beech woods settle on different soils, such as incoherent sandy volcanic (Etna), calcareous or silico-arenaceous (Madonie) and clayey-schistose soils (Nebrodi and Peloritani). Bryophytes are considered important components of forestry ecosystems. Many of these organisms are specific to particular types of microhabitats and sensitive to changes such that species richness, abundance and specific composition, are directly correlated to microhabitat quality. Thus, bryophytes are able to provide information on the state of health of forestry ecosystems, pointing out where it is appropriate to perform restoration interventions. The analysis of the Sicilian beech woods, carried out using biological and ecological parameters (life form, life strategy, ecological indices, human impact), has emphasized a high rate of bryophyte diversity with more than 170 species, some of which are threatened and candidate to the inclusion in the new European red list. A multivariate analysis was used to examine the bryophyte composition of beech woods, showing a high diversification of the floras of different mountain ranges. Overall, it is a very peculiar bryoflora, when compared with that of other Italian beech forests. Data obtained from ecological and biological parameters are consistent with the climatic, microclimatic and edaphic characteristics of examined woods. The human impact, although not high, is present, mostly on the Etna. Sicilian beech woods, for their peculiarity highlighted also from the bryophyte flora, must be protected and supervised for their persistence over time. Thus, it is necessary to monitor these forests to plan any restoration with a more effective vigilance on Etna beech woods.

Current processes affecting forests and challenges for forestry in Mediterranean area

Marco Marchetti

University of Molise, Department of Bioscience and Territory, Contrada Fonte Lappone, 86090 Pesche (IS), Italy. E-mail: marchettimarco@unimol.it

Keywords: resilience, Mediterranean, adaptive management, monitoring, ecosystem services.

Forest ecosystems provide several goods and services playing a crucial role in guaranteeing human wellbeing. Particularly, the Mediterranean basin is worldwide recognized as a biodiversity hotspot not only for its environmental characteristics but also for the long-time co-evolution between humans and natural ecosystems, primarily forests. In Mediterranean forests, feedback loops of biotic and abiotic interactions across hierarchical scales create persistent and peculiar scale-specific patterns (e.g. cultural and historical landscapes). In particular, forest management, which traditionally provided a great diversity of products, has slowly focused towards the almost exclusive wood production, thus resulting in a repeated over-simplification of forest stands (e.g. extensive coppice forests or even-aged pure stands). Mediterranean landscapes and related forest stands have thus become simplified, due to either intensification of production systems (both agricultural crops and woods) or as a consequence of land abandonment, wood encroachment, landscape homogenization and desertification. Other than the pure environmental aspects, socio-economic and cultural ones should be even taken into account, being responsible for the loss of cultural other than biological diversity (i.e. referring to Cultural and Natural Capital, respectively).

Land abandonment, ownership fragmentation and increased demand for energy wood are the main societal challenges which affect forests and forestry in Mediterranean context. Moreover, climate change and biodiversity conservation play a crucial role for managing forest ecosystem while improving the potentiality of forests to supply and provide goods and services over space and time. As a consequence, there is the need to develop new adaptive indicators and techniques for the rapid and continuous monitoring in order to enhance forests health and their sensitivity to global changes. The main aim is to improve resilience, resistance and stability of forest ecosystems under uncertain future conditions and in response to the changing socio-economics' need and expectations on natural resources (i.e. ecosystems services).

Resilience in Mediterranean pine forest after recurrent wildfires: new tools to identify the role of restoration

Leonor Calvo*, Elena Marcos, Victor Fernández-García, José Manuel Fernández-Guisuraga & Susana Suárez-Seoane

University of Leon, Area of Ecology. Faculty of Biological and Environmental Sciences, León, Spain.
* Corresponding author: leonor.calvo@unileon.es; Phone: 0034987291567

Keywords: Pinus pinaster, *wildfire severity, wildfire recurrence, vegetation regeneration, Landsat and WorldView-2 images.*

Current predictions of global change effects in the Mediterranean Basin include an increase in the severity and recurrence of wildfires, which may reduce ecosystem resilience, altering the provision of public goods and services. Fire-prone ecosystems, such as *Pinus* forests, are very susceptible to effects of highly recurrent and severe fires, and in some of them it is necessary to select the most effective post-fire management strategies to increase

their resilience. In this work we try to analyse the use of satellite images with different spatial resolution (Landsat and WordView-2) to identify the post-fire regeneration of a fire-prone forest ecosystem subjected to different regimes of fire recurrence and severity. Furthermore, we analyze the importance of climax context in the resilience of these ecosystems. To achieve these aims, we selected fire-prone forests dominated by *Pinus pinaster* and *Pinus halepensis* that were greatly affected by large wildfires in Spain during 2012, in León and Valencia. We studied 19 structural variables of the vegetation, at the level of *Pinus pinasater* population and at the level of understorey community through field sampling three years after wildfires. We used reflectance values, spectral indices and first and second order textures from Landsat and Wordview imagery as predictors to monitor vegetation recovery in two scenarios of fire recurrence (High-Low) and severity (High-Low). Main results showed that vegetation recovery models calibrated from WorldView-2 imagery provided high predictive accuracy, both at the level of the *Pinus pinaster* population and the understory community. All considered post-fire regeneration variables had greater predictability using first or second order textures or ensemble models that integrate spectral indices as predictors along with textures. Landsat-8 predictors explained better the community recovery. In this type of fire-prone ecosystems, high spatial resolution satellite images can be used in a wide range of research and management applications.

Forest restoration in Tuscany: from the mountain to the sea

Giovanni Quilghini & Alessandro Bottacci

Corpo forestale dello Stato, Roma, Italia.
*Corresponding author: g.quilghini@forestale.carabinieri.it

Keywords: conservation, Natural State Reserves, alien species.

Since its establishment in 1910, the Special Agency for National Forest Estate (Azienda Speciale per il Demanio Forestale) has aimed at expanding and managing the forest area owned by the State, thus setting the basis of a widespread public property that successively gave birth to Natural State Reserves and many National Parks.

The criteria initially inspiring forest management and restoration were necessarily focused on economics, as a possible tool to solve the social and political problems that historically interested marginal territories, often affected by a lack of infrastructures and the irrational exploitation of natural resources.

The great forest restoration efforts were inevitably impacted by the two World Wars, when forests paid huge tributes to sustain the costs of both conflicts. With the end of WWII, a long period of patient restoration began, during which each property was managed according to a Forest Management Plan.

In recent times, with the institution of Natural State Reserves, productive issues have lost ground to nature conservation policies. Protection and conservation have progressively acquired more and more strength in the cultural background of foresters, alongside with the sustainable use of natural resources. Important initiatives, as the creation of the first strict reserve in Italy (Sasso Fratino) and the acquisition of the Montecristo Island (today a natural reserve) to the National Forest Estate, foreran the beginning of national conservation policies.

Nonetheless, the restoration efforts are not yet complete.

This contribution wants to bring to the attention of the scientific and technical community the conservation activities done within the historical fir forests in the Biogenetic Natural Reserve of Camaldoli, recently interested by several extreme atmospheric events that uprooted and broke many trees. Also, we'll illustrate the results of the long-term restoration of priority habitats in the Montecristo Island where, through two LIFE Projects (one concluded in 2014, another ongoing), we focused on limiting the invasion of alien animal and plant species, and on conserving the habitat of animal species with high environmental impact, but of high conservation interest, such as the Montecristo goat.

Restoring oak populations: a case study of applied assisted migration applied on *Quercus robur* [Po Valley, Italy]

Fulvio Ducci[1]*, Roberta Proietti[1], Giovanbattista De Dato[1], Maria Cristina Monteverdi[1], Piero Belletti[2] & Enrico Calvo[3]

[1]CREA SEL, Forestry research centre, viale S. Margherita, 80, Arezzo, Italy.
[2]University of Turin, DISAFA, ULF Agriculture genetics, Largo P. Braccini 2, 10095 Grugliasco, Turin, Italy.
[3]Dip. U.O. Servizio per il territorio la montagna e le filiere, Regione Lombardia ERSAF, Via Pola, 12, 20124 Milan, Italy.
* Corresponding author: fulvio.ducci@crea.gov.it; Phone: 00390575353021 - 00393333266077

Keywords: restoration, Quercus robur*, pedunculate oak, assisted migration, Po valley.*

Pedunculate oak (*Quercus robur*) and sessile oak (*Q. petraea*) are widely distributed in fertile valleys and floodplains in Europe. In the Po valley these oaks have been progressively harvested since the Roman age and were sensibly reduced during the 19th century to recover soils for agricultural crops, factories and infrastructures in one of the most productive regions in Italy. Similar situations occurred also in other regions of the Peninsula where these oaks were formerly spread until the hard human influence in the last three, five centuries reduced the huge populations and phragmented the range in small and rare spots. These oaks deriving from a common ancestral *taxon* are interfertile and partially sympatric, sharing similar habitats, but in different eco-pedological areas. They are interfertile typically unidirectional with pollination from sessile towards pedunculate oak. That explains the sympatrism of both the species and the peculiar adaptive behavior of this complex to water availability. As a consequence, gene flows in the huge oak primary forests were severely reduced or interrupted with losses of fitness and genetic variation. Together with pollution, lowering of the water table and climate change effects, these features make eligible as an example of marginality due to human impact. In the framework of a huge programme to partially re-establish several plain ecosystems in the region, a new secondary oak forest was planted [40.0 ha] in early 2000's in a completely cleaned area, with the aim to obtain a seed source where the remaining Po valley gene pool is collated, to reestablish at least partially gene flow connections and to start an experimental field test on assisted migration for future monitoring. After genetic analyses demonstrated the recent interruption of past gene flows, seed material sampled from fifteen different natural English oak populations was used to establish the experiment in Carpaneta (Lat. 45°11'0.96" Long. 10°53'42", province of Mantua). The objective of this paper is to show the applied of assisted migration study case of Carpaneta forest, how it was projected and structured and its meaning as an experiment on assisted migration in an area considered an ancient diversity hub for this species.

Differences in ecophysiological responses to seasonal drought of three co-existing oaks in Northern Greece

Filippos Bantis[1]*, Kalliopi Radoglou[2] & Wolfgang Brüggemann[1]

[1]Institute for Ecology, Evolution and Diversity, Goethe University, Max-von-Laue-Str. 13, Frankfurt am Main, Germany.
[2]Democritus University of Thrace, Pantazidou 193, Nea Orestiada, Greece.
* Corresponding author: fbanths@gmail.com; Phone: 0030 6986617061

Keywords: Quercus ilex, Q. frainetto, Q. pubescens, *drought stress, chlorophyll fluorescence.*

Oaks constitute one of the most common tree genera in Europe with wide expansion under varying environmental conditions. Considering the expected increased drought and heat conditions in future climate scenarios for the Mediterranean region, it is important to identify oak species that are robust under extreme temperatures and drought conditions. The objective of the study was the comparison of the physiological status of three economically and ecologically valuable oak species (*Quercus ilex, Q. frainetto* and *Q. pubescens*) growing under the same environmental conditions in natural coppice stands in NE Greece, in response to seasonal drought stress. The three species co-exist in the same habitat and the studied trees were of similar age and size. Measurements were conducted every 15-20 days until leaf falling between June and September 2016. We studied predawn leaf water potential and fast chlorophyll fluorescence induction curves (OJIP test), chlorophyll content index and relative water content. Meteorological data from the region, such as temperature, precipitation and relative humidity were also collected. Photosynthetic parameters such as PI(abs) and PI(tot) reacted to summer drought conditions, with *Q. frainetto* showing the lowest values as compared to the other two species. The discrepancy between the species increased with duration of the drought period. At the same time, *Q. frainetto* revealed the lowest predawn water potentials. Our results indicate that *Q. frainetto* is less suitable for future forestry applications in the studied climate/elevation zone than *Q. pubescens* and *Q. ilex*.

Phytotoponyms a tool to forest landscape analysis and its transformations. The case study of Calabria (Southern Italy)

Giovanni Spampinato[1]*, Rita Crisarà[2], Piergiorgio Cameriere[1] & Carmelo Maria Musarella[1]

[1]Department of Agriculture - Mediterranean University of Reggio Calabria, Loc. Feo di Vito, Reggio Calabria, Italy.
[2]Via Trabocchetto 1, Reggio Calabria, Italy.
* Corresponding author: gspampinato@unirc.it; Phone: +39 3288974768

Keywords: phyotoponyms, Calabria, land use change, forests.

Place names provide important information about history, language and human relationships with the land. Phytotoponyms (plant place names) could be used in analyzing current and past distribution of plants and vegetation and to highlight the changes in the land use due to the human impact and/or climate change aimed to support forest restoration. To assess this possibility we have considered all the phytotoponyms related to species and forest ecosystems in Calabria (Southern Italy). As data source we used the official Calabrian topographic maps in scale 1:25,000 and 1:10,000, and the literature data on the Italian toponymy. To interpret place names related to plants and avoid mistakes, we carried out a linguistic and naturalistic joint analysis. We identified 1460 phytotoponyms belonging to 48 forest species and 321 place names related to forests. The most common plants are *Castanea sativa* (9.7%), *Quercus pubescens* s. l. (7%), *Salix* sp. pl. (6.5%), *Q. frainetto* (5.1%), *Q. suber* (5%). All the phytotoponyms were geo-referenced and incorporated into a GIS. Phytotoponyms distribution maps were generated and compared with the current Calabrian forest vegetation, using digital orthophotos, land use maps and literature data. A good correspondence between phytotoponyms and forest vegetation for mountain belt was highlighted, only for *Q. frainetto* we found a reduction in some area. Instead, in the coastal and hilly belt, we observed a significant decrease in the area covered by forest, such as cork woods, thermophilic oak woods and Mediterranean bush, and the disappearance of wet forests with *Fraxinus oxycarpa*. The spread of phytotoponyms concerning species linked to the forest degradation, as *Spartium junceum* and *Ampelodesmos mauritanicus*, highlights an ancient anthropic impact on forests. Overall, the use of phytotoponyms is an important tool to analyze the changes in the vegetation cover. It can provide useful information about restoration of forest ecosystems.

Experiences on good standard density restoration in oak coppices

Leonardo Nocentini* & Massimiliano Tancredi Hajny

SIRF, Via. G. Cimabue 16, Arezzo, Italy. E-mail: l.nocentini@gmail.com; Phone: +393286876300

Keywords: restoration, oak coppices, standard density, sprouting capacity.

The main purpose of the research is to describe effects of silvicultural cuttings in an oak (*Quercus cerris* L. and *Q. robur* L.) coppice woodland, with a very high intensity of standards. The number of standards goes up to almost 90% of the stems, divided in 4 different age classes, with only the remaining 10% still recognizable as shoots. The number of standards varies from 250 to 300 trees/hectare. The experimental trial,

applying two different intensities of silvicultural cuttings, tend to regulate the standards density to enhance the sprouting capacity and wood production. This particular reduction of standard density is allowed by forestry regulations only in few Italian regions, due to the assumption that the stump of high diameter will not generate new sprouts. Dendrometric and structural measures brought to an experimental design with two different areas, in which 155 and 120 standards where left standing. All new sprouts on cut stumps were counted and measured in diameter and height for the first three years and finally after 6 years. In both areas, the response in terms of new sprouts on nearly all stumps was positive. The growth rate both in diameter and height, as well as the number of new sprouts, was comparable to data of a normal coppice woodland, also on the largest stumps of old standards. After six years, the mean value of sprouts are 4 cm in diameter and 5,9 m in height, on a number of sprouts/stump of 3,8. Furthermore we observed a mean increment in the diameter of standards of almost 5 cm. Results of measured data are reported.

Prioritization of restoration actions at a regional scale

Jordi Cortina*, Alejandro Acebal, Antonio Aledo, Andreu Bonet, German Lopez & Guadalupe Ortiz

University of Alicante-SER Europe, Dept. Ecology and IMEM, Alicante, Spain.
* Corresponding author: jordi@ua.es; Phone: +34 693258878

Keywords: participative restoration, multicriteria analysis, cost-benefit analysis, ecosystem services.

Ecological restoration is an efficient tool to combat land degradation and enhance human wellbeing. Commitments to achieve ambitious large-scale restoration targets have been presented over the last years. The implementation of ecological restoration actions at landscape and regional scales demands the development of planning tools allowing the prioritization of restoration actions. At these scales, most prioritization instruments focus on single habitats and ecological criteria, failing to address land heterogeneity, and incorporate socio-economic and cultural values. We have developed a participative approach to map areas of high priority for restoration in a dry-subhumid to semiarid 224,000 ha-region in SE Spain. The area comprises nine homogeneous landscape units, from wetlands to forests, and various protected areas, and hosts 829,980 inhabitants. We built a platform composed by 88 stakeholders, and surveyed them on the criteria to prioritize restoration actions and the value of ecosystem services they obtain from the different landscape units. Priority criteria, the provision of ecosystem services and economic costs of restoration will be used to map priority areas for restoration. This map will be used as a decision aid tool to discuss the most efficient options for ecological restoration, and engage social actors in ecological restoration programs.

Forest restoration in the Mediterranean region of Turkey

Derya Esen* & Oktay Yildiz

Duzce University Faculty of Forestry, Duzce Universitesi Orman fakultesi Konuralp Yerleskesi, Düzce, Turkey.
* Corresponding author: deryaesen@duzce.edu.tr; Phone: +905303229515

Keywords: afforestation, degradation, environmental, socio-economic.

Turkey stands out with high biological diversity. Undulated topography varying in short distances along with great climatic variation has greatly contributed to this rich biological diversity. In this heterogeneous topography and climate, there exist many fragile forest ecosystems. The Mediterranean part of the country stands out with environmental conditions that are often not very conducive to plant establishment and growth. Typically, this region has long hot and dry summer seasons. Frequent forest fires, drought, soil erosion and sodification are among the ecological stresses in today's forest ecosystems. The Mediterranean Region of Turkey has hosted many civilizations throughout the history. Anthropogenic disturbance has therefore been another major player in the system, shaping up the region's forestlands. There is still considerable human population living in small villages in the forestland in the region. These communities largely depend on forests, agriculture and animal husbandry for living and put pressure on forest resources. Overexploitation, tourism, urban development, grazing, and mining are major issues that Turkish foresters have to tackle and protect already fragile forest resources. The governmental forestry agencies had attempted to address the restoration issues with many expensive afforestation projects in the area, which were however concluded with major disappointment. The agencies has recently changed its approach and begun to implement ecological restoration projects supplemented with socio-economic measures. Natural regeneration supplemented with seedling and planting, converting coppices to high forests, and afforestations through terraces on steep slopes, prioritizing the local forest communities for forestry jobs, afforestation with income-generating native tree species, establishing stands with beekeeping, restoration of pastures within forestlands for grazing, providing loans with no or low interest rates for housing are among the integrated rehabilitation efforts implemented in this region to mitigate the impact of anthropogenic and environmental stresses.

Conservation of forest biodiversity in Sicily: contribution of the University of Palermo Germplasm Bank (Italy)

Franco Palla, Francesco Maria Raimondo & Anna Scialabba*

University of Palermo, Department STEBICEF, Via Archirafi 38, 90123 Palermo, Italy.
* Corresponding author: anna.scialabba@unipa.it; Phone: +399123891230

Keywords: germplasm banks, Abies nebrodensis*, seed preservation.*

Germplasm Banks dedicated to the wild plants seeds conservation play a unique role in integrating the *in situ* conservation of endemic, rare or endangered plant species. One of the missions of the Seed Bank of the University of Palermo (HBP-Bank) is to support the conservation of biodiversity with particular attention to the spectrum of genetic diversity of plants belonging to Mediterranean habitat. *Abies nebrodensis* (Lojac.) Mattei is a relict species consisted of 30 natural individuals, gathered in a small area of the Madonie Natural Park in Sicily (1500 -1600 m above s.l.), recorded on the checklist "TOP 50 Mediterranean Island Plants". It is also one of eight conifers species critically endangered because of reproductive biology issues. *A. nebrodensis* species has been monitored *in situ* in order to evaluate the state of conservation of natural population and to implement the number of individuals. Its preservation has been integrated since 1994 with *ex situ* conservation of 83 accessions in the HBP-Bank in the long-term conservation conditions. The scientific strength of HBP germplasm collection is supported by results of several studies on taxonomy, seed biology and genetic diversity.

The embryonic loss observed into seeds produced in natural environment can reduce the genetic variability of germplasm collection. This study, carried out on the *A. nebrodensis* population, demonstrates that a five-year planning is needed to collect enough seed to represent the genetic variability intra-population. This seed collection scheme can represent a useful tool to apply on other forest endangered species spread in Sicily and in the Mediterranean area.

Atlas cedar regeneration and structure at forest edges (Djurdjura, Northwestern Algeria): role of microsite and anthropogenic disturbance

Yassina Amirat [1]*, Fazia Krouchi[1], Nadia Abdelkrim[1], Francois Lefevre[2] & Arezki Derridj[1]

[1]Département d'Agronomie, Faculté des Sciences Agronomiques et Biologiques, Université M. Mammeri, BP 17, Tizi-Ouzou, RP 15000, Algeria.
[2]Unité de Recherches Forestières Méditerranéennes, INRA, Avenue A. Vivaldi, 84000, Avignon, France.
* Corresponding author: amiratyassina@gmail.com

Keywords: Cedrus atlantica, *structure, dynamics, anthropogenic disturbance, North Africa.*

Cedrus atlantica forest stands are reported (mainly from a floristic perspective) to be subject to anthropogenic disturbance and microclimate constraints regarding the initial regeneration stages, but data on stand structure to illustrate constrains are lacking. The present study is an attempt to provide some data on the regeneration and structure stand at Atlas cedar forest edges.

The study was undertaken on plots of 25×25 m or 25×50 m. The sampling procedure included the type of cover (pure and mixed Atlas cedar -holm oak stands), elevation (low, intermediate and high) and slope. Structural features (tree height, diameter and density of individuals) were examined on *Cedrus atlantica* and associated ligneous species within.

The results revealed a structure dominated by Atlas cedar in the overstory, while the understory comprised few trees and shrubs of *Quercus rotundifolia, Juniperus oxycedrus* and *Crateagus laciniata.* The study evidenced a potential for Atlas cedar extension at the forest edges in situations of low or reduced anthropogenic disturbance. Indeed, we recorded a maximum of 1352 steam/ha in one situation, value that is only exceeded, in the same forest, by recruitments established on a cleared soil following a road realization in 1979. The recruitments observed in our study obviously established in the absence of any direct nurse effect (by common juniper) as may be observed in other situations across the same forest. In less favorable or/and more disturbed situations, we observed a low of 80 steam/ha coupled with very low number of samplings despite of a sufficient reproductive output as indicated by the number of cones recorded on adult trees.

The study highlights the importance of a regeneration strategy aiming at protecting the juveniles until they reach a sufficient size to escape the grazing effects. Eventhough such strategy is unlikely to succeed in the absence of cooperation between forest managers and livestock owners.

The importance of bioecological characteristics of white-bark pine (*Pinus heldreichii*) for the target seedling production

Vera Lavadinovic*, Vasilije Isajev, Ljubinko Rakonjac & Zoran Poduška

Institute of Forestry, Kneza Viseslava 3, Belgrade 11030, Serbia.
* Corresponding author: veralava@eunet.rs; Phone: +381-11-3553454

Keywords: white-bark pine, variability, afforestation.

White-bark pine (*Pinus heldreichii* Christ.), is a Tertiary relict and an endemic species indigenous to the Balkan Peninsula and Southern Italy (Calabria and Basilicata). Investigations carried out in Serbia and Montenegro in natural populations, of this species as well as in plantations 20 - 30 years old and cultivated trees on the green areas in towns, shown that this species exhibits individual and group variation in morphological and genetic characteristics. The same range of variability is present in natural progenies in forests. Significant differences were determinated in nurseries between half-sib progenies in height, average number of branches and increment of seedlings growth at age from two to ten years. In addition, some irregularities of generative reproductions were noticed, such as morphological and functional characteristics of strobiles and occurrence of viviparity. This paper presents the importance of previous investigations for the target seedling production, of white bark pine, intended for the afforestation of unfavorable environmental conditions in highland regions of Eastern Mediterranean.

The use of species in plantations renaturalisation and reforestation in Sicily

Federico Guglielmo Maetzke*, Donato Salvatore La Mela Veca, Tommaso La Mantia, Emilio Badalamenti & Sebastiano Sferlazza

Università di Palermo, viale delle Scienze, 11, 90128, Palermo, Italy.
* Corresponding author: federico.maetzke@gmail.com; Phone: 0039 3289866185

Keywords: plantations renaturalisation, reforestation, use of species.

Afforestation and reforestation activities in Sicily have been widespread in the last century, in order to increase the forest area that was seriously reduced in the former centuries. Notwithstanding this, Sicily is still characterized by only the 12% of the regional surface covered by woods and forest. The reforestation in the last century was carried out using conifers and eucalypts, just in order to ensure a quick protection of slopes and pastureland, coping diffuse erosion events, and those intervention had a remarkable success. Nowadays, the target of enlarging the forest areas in the island is still compulsive, but the use of species, considering the actual knowledge and nature consciousness has been completely reassessed basing on the indigenous species. In this view, in order to develop an useful tools for forest plantation planning, in the last regional forest plan the entire regional area was analyzed and ecologically homogeneous areas have been identified to join and target arboriculture and/or forestation plantation activities, to choose tree and shrub species for different environments. The resulted tool was a map of ecologically homogeneous areas and a selection of species suitable for reforestation. After a ten years of implementation and operative use it is useful to enhance those tools by completing the analysis with a specific study aimed to detail the correct use of indigenous species of trees and shrubs. In this work we examined the above described Regional Plan tools and considered the most recent studies on indigenous flora in order to develop a more detailed and locally suitable guide lines to use species both in reforestation and in restoration activities. This last topic is actually compulsory, because of the need of renaturalisation of conifers and eucalypts plantations, that is one of the main target of forestry in Sicily.

The role of phanerogams and cryptogams in the recolonization of cork oak forests crossed by wildfire in Sicily

Patrizia Campisi*, Maria Giovanna Dia, Francesco Maria Raimondo, Giuseppe Venturella & Maria Letizia Gargano

University of Palermo, via Archirafi, 38, 90123, Palermo, Italy.
* Corresponding author: patrizia.campisi@unipa.it

Keywords: Cork oak forests, Sicily, post fire recolonization, cryptogams, phanerogams.

The actual distribution and structure of cork oak woods is the result of a process of anthropogenic alteration (utilization of cork, deforestation, coppicing, overgrazing, changes in land use, fire). Additional causes of threats in *Q suber* woods are pests and fungal disease. Although cork oak is an active pyrophyte the decortication of trunks makes trees more vulnerable to external agents and to fire in particular. Post-fire species are mainly carbonicolous fungi, some *Ascomycetes* make their appearance after around six weeks while other fungi begin to appear from the second year. The proliferation of fungal hyphae in the ash, as well as of some pioneer mosse protonemata, promotes soil aggregation and storage of nutrients. Bryophyte phytocoenoses including species with rapid gametophyte development, spore germination favored by fire or high production of propagules. The association *Funarietum hygrometricae* is one of the first autotrophic plant communities that are already developing in the first year after the fire in numerous microsites within the forest areas. The dominant species is *Funaria hygrometrica,* one of the few mosses able to associate with mycorrhizal endophytes, that contribute to strengthen the tolerance (or sensitivity) of plants to passage of wildfire, but also influence the dynamics of regeneration of forest coenoses. Trees of genera *Quercus*, *Pyrus*, *Fraxinus*, *Celtis* and *Arbutus* express this dynamic together with some hemiparasites (*Viscum*, *Loranthus*) and epiphytes (*Polypodium*), shrubs (*Calicotome, Chamaerops, Citysus, Cistus, Erica*, *Genista*). Additional elements are species of the genera *Asparagus*, *Daphne*, *Lavandula*, *Teucrium*, *Aira*, *Arisarum*, *Carex*, *Eryngium*, *Inula*, *Melica*. Also parasitic plants (*Limodorum*, *Cytinus*), ferns (*Asplenium*), other bryophytes (*Riccia* , *Bryum*, *Didymodon*, H*omalothecium*), fungi (*Amanita*, *Russula*, *Leccinum*, *Boletus*) and lichens (*Cladonia*) characterize the post-fire forest coenoses in Sicily.

Analysis of Yew (*Taxus baccata*) participation to structural features of Atlas cedar forest stands at Chrea (Algeria)

Idir Guechoud[1]*, Fazia Krouchi[1], Federico Vessella[2] & Arezki Derridj[1]

[1]Department of Agronomy, Faculty of Biological and Agronomic Sciences, University M. Mammeri, PB 17, Tizi Ouzou, RP 15000, Algeria.
[2]Dipartimento di Scienze Agrarie e Forestali (DAFNE), Universita` della Tuscia, Via San Camillo de Lellis, snc, 01100 Viterbo, Italy.
* Corresponding author: guidir56@gmail.com

Keyword: *Yew,* Taxus baccata*, stand structure, Atlas cedar forest, Chrea National Park, Algeria.*

Yew (*Taxus baccata* L.) is a rare and endangered species in Europe and North Africa (Morocco and Algeria). There are few studies devoted to this species in Algeria. Therefore there is a need to fill the gap in this regard. This study is a part of a larger project that aims at describing structure of stands where yew is actually present for a better understanding of driving factors likely to determine its regeneration and persistence. In this purpose 21 plots (25×25 m) were retained for a structural study in a cedar forest (Chrea National Park).

Structural features of Yew were investigated with consideration of some stand parameters i.e. canopy closer, orientation, and slope. Density and size (total height, DBH) were measured on all individuals in the case of Atlas cedar and yew and only on individuals with height ≥ 1.30m in the case of other ligneous.

Results indicate that Yew can reach up to ½ of the cover height, but participates mostly to midstorey. The other ligneous participate mostly to the under and midstorey, while the overstory is exclusively composed by cedar.

Regarding density, yew revealed to be more frequent under closed canopies, which are in the same time the most favourable to its establishment.

Adaptation measures for sustainable forest operations

Woodam Chung[1]* & Enrico Marchi[2]

[1]Oregon State University, 267 Peavy Hall, Corvallis, United States of America,
[2]Università di Firenze, Dipartimento di Gestione dei Sistemi Agrari, Alimentari e Forestali Firenze, Italy.
* Corresponding author: woodam.chung@oregonstate.edu; Phone: +1-541-737-8248

Keywords: operational planning, harvesting techniques, worker safety, environment.

Global and regional changes in climate can alter forest ecosystems, disturbance processes, and local work environments, affecting forest operations from tree planting to restoration to timber harvesting. Migration of tree species to higher altitude caused by climate change might expand production forest land areas, but require advanced harvesting techniques for environmentally sound steep ground operations. Widespread damage from extreme weather events, insects and wildfires can increase the occurrence and amount of salvage harvest, but value recovery from damage trees and worker safety could become potential issues. Increased seasonal restrictions on forest operations due to change in local climate require higher operational efficiency in order to maintain the previous production level in a shorter amount of time without compromising worker safety and environment. In areas with increased erosion and landslides, forest operations must be undertaken with more care particularly in regions where more intense rainfall events are anticipated. While the aforementioned shifts can present challenges for many forest practitioners around the world, well-planned adaptation efforts are opportunities in sustainable forest management. In this presentation, we introduce an emerging concept of sustainable forest operations, and suggest adaptation measures for conducting forest operations under the changing climatic environments, hoping that such measures improve the adaptive capacity of forestry sectors while minimizing potential negative consequences.

Selecting surrogate species to improve experience of forest ecosystems in youngest nature-disconnected generations: a framework to select Experiential Key Species.

Corrado Battisti[1] & Alessandro Zocchi[2]

[1]'Torre Flavia' LTER (Long Term Ecological Research) Station, Protected areas Service, Città Metropolitana di Roma Capitale and Department of Biology, University of Rome III, Rome, Italy.
[2]Independent scientific consultant, Rome, Italy.
*Corresponding author: c.battisti@cittametropolitanaroma.gov.it

Keywords: ecosystems value, education planning, children well-being.

Worldwide, young generations show a larger and larger digital-based behaviour and indoor lifestyle and, mainly in anthropized contexts, their progressive disconnection from

nature is evident. This fact has important implication in (i) children well-being (observing, exploring, and manipulating natural components they learn about the world around them, developing spatial intelligence, creative- and system-thinking, attitude to problem solving, and reducing physio-psychological Nature Deficit disorders), and in (ii) people awareness of biodiversity and ecosystem values (preventing a digital-distraction from neighbouring ecosystems that, consequently, become neglected ,forgotten, and vulnerable to human-induced threats). Therefore, it is necessary to know which species are more indicated to improve children's experience and, consequently, pro-environmental behaviours. Here, we propose a simple, quick and explorative framework procedure for the selection of Experiential Key Species (EKS) applicable for sites where check-lists of animal or plant species are available. These species should: (i) be relatively widely distributed and abundant on site, (ii) stimulate a direct experience, and (iii) convey emotions and promote play for their intrinsic eco-behavioural traits. We assumed that experience provided from a species may be considered an event with a proper magnitude, considered as a product of intensity and frequency of occurrence. Therefore, for each species it is possible obtain expert-based scores of Experiential Magnitude on a three-level scale. Knowing the ecology and behaviour of EKS it is also possible to select EKS areas for conservation and education planning. We foster forest scientists and conservationists to improve this procedure of EKS selection in critical contexts, also adding further regime attributes.

Predicting the current and future potential distributions of *Cerdus atlantica* in North Africa using Maxent

Abdelkade Bouahmed[1]*, Federica Vessella[2], Fazia Krouchi[1], Bartolomeo Schirone[2] & Arezki Derridj[1]

[1]Faculty of Biological and Agronomic Sciences, University Mouloud Mammeri of Tizi-Ouzou, Algeria.
[2]DAFNE, Tuscia University, Italy.
* Corresponding author: a.bouahmed@yahoo.fr

Keywords: Cedrus atlantica*, North Africa, potential distribution, Maxent, future refugia.*

Species distribution models (SDMs) have been widely used in recent years for many purposes. In the present study, we used such tools to predict the current potential distribution of *Cedrus atlantica* in North Africa where the species occurs naturally and constitutes the most emblematic tree. Future projections of the modeled niche conditions have been applied to inquire about future refugia of the species under anthropogenic climate change following two scenarios of Representative Concentration Pathways (RCPs 4.5 and 8.5) relating to 2070.

A machine learning method (Maxent) was employed to predict the potential distribution of the species integrating 24 environmental variables. The accuracy of the model was tested using the area under the curve (AUC) of receiver operating characteristic (ROC) method. A jackknife test in Maxent was used to explore the most important environmental variables affecting the species distribution.

Preliminary results showed a current potential distribution of the species larger than its current geographical distribution, validating the hypothesis that the areas occupied by the species do not fully reflect the environmental potentialities. Future projections of the model revealed a significant contraction of the species potential distribution and even its disappearance in many localities of the Algerian Tell. Future species refugia would be found at high altitudes and in other areas which are not part of its current distribution, e.g. the Moroccan Western High Atlas and Aures region eastward.

Our results are valuable tools for reforestation and emphasize the need to intervene at several levels for the conservation of this endemic species. These mainly include actions to restore degraded cedar forest and an *ex-situ* conservation strategy according to its future defined refugia, focusing on localities that have demonstrated a high probability of occurrence.

Wood responses to drought in Mediterranean forests: evidences from xylogenesis and functional wood traits in tree-ring series

Veronica De Micco[1]*, Angela Balzano[1], Enrica Zalloni[1], Giovanna Aronne[1], Katarina Čufar[2], Paolo Cherubini[3] & Giovanna Battipaglia[4]

[1]University of Naples Federico II, Dept. Agricultural Sciences, via Università 100, Portici (Naples), Italy.
[2]University of Ljubljana, Biotechnical Faculty, Department of Wood Science and Technology, Jamnikarjeva ul. 101, 1000, Ljubljana, Slovenia.
[3]Swiss Federal Research Institute, WSL, Birmensdorf, CH-8903, Switzerland.
[4]Università degli Studi della Campania (ex Seconda Università di Napoli), Dip. Scienze e Tecnologie Ambientali, Biologiche e Farmaceutiche, via Vivaldi, 43, Caserta, Italy.
* Corresponding author: demicco@unina.it; Phone: +39 081 2532126

Keywords: Drought, Mediterranean woods, tree rings, xylogenesis, wood anatomy.

The increasing risk for drought stress and heat waves due to expected climate warming have a significant impact on wood formation in Mediterranean species. Decreased wood production can be responsible for the decrease of productivity of Mediterranean forests with negative consequences on related ecosystem services such as carbon fixation in long-lasting wood pools. Responses of Mediterranean woods to environmental factors are species-specific: peculiar patterns of cambial activity lead to the formation of intra-annual-density-fluctuations (IADFs) in tree rings which are ”positive anatomical anomalies” to cope with intra-annual variations in temperature and water availability.

Here, we analyse xylogenesis and quantify functional wood traits in long tree-ring series in Mediterranean species (*Pinus* sp. pl., *Arbutus unedo* and *Q. ilex*) with intra-annual resolution, linking anatomical parameters with climate. This approach allowed detecting the periods of IADF formation and identifying environmental factors triggering them. Results highlighted the different aptitude of analysed species to form IADFs, which were characterised by different timing of formation, anatomical appearance and ecological meaning. Intra-annual variations of functional wood traits related to efficiency/safety of water transport were consistent with intra-annual variations of carbon stable isotopes which are linked with intrinsic water use efficiency. The analysis of xylogenesis and of intra-annual wood anatomical traits, together with information on stable isotopes, proved to be valuable to distinguish between limitations in cell enlargement and cell differentiation due to water deficit or carbon availability. The combination of different kinds of data offered new perspectives in the interpretation of physiological and ecological processes during wood formation. The different sensitivity to environmental fluctuations found in the wood anatomy of the various species should be taken into account in forest management because of its influence on forest dynamics.

Effect of soil compaction on early growth of *Quercus robur* seedlings since germination

Barbara Mariotti*, Martina Cambi, Fabio Fabiano, Alberto Maltoni, Andrea Tani & Enrico Marchi

Università di Firenze, Via San Bonaventura 13, Firenze, Italy.
* Corresponding author: barbara.mariotti@unifi.it; Phone: +393491834158

Keywords: forest operations, seedlings growth, seedling root-system, pedunculate oak.

Negative consequences of compaction can be particularly relevant for seedlings development. Plantlets may delay both germination and penetration of the soil surface by the radicle and the alterations in compacted soil may also affect plants rooting through variations in structural arrangement in attempt to avoid the mechanical obstacle. This study aimed at assessing the soil compaction on growth of *Quercus robur* seedlings during the first month since germination. The experiment was carried out in a nursery, where compaction was obtained by direct compression of the soil surface on the top of containers using a compression machine in laboratory. In particular, we investigated the effect of soil compaction on morphological attributes of seedlings grown in plastic containers on above and below ground traits during the first month after germination. Three compaction levels were considered (low:<0.5 MPa, medium: 1 MPa, and high: 2 MPa). Results showed significant differences in seedlings traits among treatments and a constraint effect of increasing levels of compaction on early seedlings growth. The effect was particularly detrimental on root system development in depth, thus, it represents an additional critical factor for regeneration establishment, particularly in Mediterranean environments where the early growth stages are crucial to overcome the dry season.

Concerns and evidences on genetic diversity in planted forests

Vladan Ivetic* & Jovana Devetakovic

University of Belgrade, Faculty of Forestry, Kneza Viseslava 1, Belgrade, Serbia.
* Corresponding author: vladan.ivetic@sfb.bg.ac.rs

Keywords: planted forests, genetic diversity, reforestation, afforestation, forest reproductive material.

Planted forests are important source of various services (economic, environmental, and social) with increasing portion in the total world's forest area. Genetic diversity is a fundamental for success and sustainability of planted forests. Facing the concern of reducing of genetic diversity in planted forests, this study offers a review of evidences on comparisons between the levels of genetic diversity in forests established by different regeneration methods. A total of 28 papers comparing genetic diversity in natural forests versus various regeneration methods of 22 tree species examined by the range of markers are reviewed. In the most number of cases there are no significant differences in genetic diversity between natural and planted forests, followed by almost equal number of cases with decreased and increased level of genetic diversity. The loss of rare alleles, but also the new alleles are reported in planted forests. Although the origin of planting material in the most of the cases in unknown, the size of parental population is determinant for the level of genetic diversity in the new forest, with the provenance and seed collection strategy as the most important management practices in planting projects.

The contribution of historical ecology to functional restoration: case studies from Apennines forests

Gianluca Piovesan[1]*, Alfredo Di Filippo[1], Goffredo Filibeck[1], Irene Tunno[2] & Scott Mensing[2]

[1]Dafne - Università della Tuscia, Via SC de Lellis, Viterbo, Italy.
[2]Deparment of Geography - University of Reno, Office: Mackay Science Mail Stop: 0154, Reno, United States of America.
* Corresponding author: piovesan@unitus.it; Phone: +393804999787

Keywords: old-growth forests, naturalness degree, chrono-functional indicators, pollen records: historical ecology.

In functional restoration programs, studying of old-growth (OG) stands and historical landscapes is key to describing the reference conditions associated with natural forest ecosystems. A nested historical approach based on high resolution paleoecological reconstructions and dendroecology is needed for the description of complex processes underlying the unique ecological features of Mediterranean landscapes. Tree-ring metrics are able to describe the intensity and time distribution of biological and ecological processes. Tree-ring derived canopy age features (e.g. longevity), disturbance/suppression history and growth trajectories have recently been proposed in a chrono-functional monitoring framework to quantify the naturalness of OG stands. Trees in well-conserved primary OG forests experienced several long suppressions, showing the highest complexity in recruitment history, canopy accession and growth trajectories. In OG beech forests, the best tree-ring metrics were more related to stand structural complexity, than biomass-related metrics. However, tree-ring metrics are site specific (e.g. biogeoclimate dependent) The proposed framework of tree-ring indicators describes functional traits tightly related to forest naturalness and may thus become a tool to provide a benchmark to measure the impact of silvicultural practices or evaluate the effectiveness of ecological restoration.

Ecological classification of beech forests through tree ring chronologies was found to be congruent with floristic composition patterns. Thus, similarities in tree-ring chronologies of the past between sites might be used to infer analogies in past floristic assemblages, allowing detailed coenological reconstruction at community scale for the last five centuries. Moving to multi-millennial time-scales and to wider spatial scales (landscapes), vegetation reconstruction from fast sedimentation basins allow for detection of forest contraction and expansion phases, and the associated changes in composition, related to socio-economic and techno-cultural changes and/or climatic oscillations. Merging decadal tree-ring information with pollen time series can provide evidences of common climatic/anthropogenic signals, allowing us to disentangle the effects of anthropogenic impacts on forest area from climatic variations.

Moving towards a definitive high-resolution map of cork oak in the Mediterranean Basin to restoration purposes

Federico Vessella[1]*, Javier López-Tirado[2] & Bartolomeo Schirone[1]

[1]Department of Agriculture and Forestry (D.A.F.N.E.), Università degli Studi della Tuscia, Via San Camillo de Lellis, snc, 01100, Viterbo, Italy.
[2]Department of Integrated Sciences, Faculty of Experimental Sciences, International Campus of Excellence of the Sea (CEIMAR) and Environment, Biodiversity and Global Change (CEICAM-BIO), University of Huelva, Avda. Tres de Marzo s/n, Huelva-21071, Spain.
* Corresponding author: vessella@unitus.it

Keywords: Quercus suber*, high-resolution punctual map, niche modelling, genetic diversity, forest restoration.*

Species distribution, ecology and their roles within vegetation dynamics are basic requirements in conservation planning, which includes restoration and management actions devoted to ensure long-term biodiversity persistence within landscape units or networks at broad scale. However, few tree species were punctually mapped at single-site level. In Europe the only example is *Fagus sylvatica*, a climacic species not appropriate for reforestation purposes, unless peculiar techniques such as the Miyawaki method are adopted, while pioneer/early successional species are more functional. In the Mediterranean Basin efforts focused on local endemisms or rare species with narrow occurrence, thus easy to map, while the most representative forest species are still a challenge.

Here we attempted an study about *Quercus suber* L. (cork oak) across the Mediterranean, coordinating the efforts of different workgroups, pre-existing geodatabases and recent field surveys or updates.

Results pointed out a heterogeneous knowledge of the species occurrence, more refined in Italy and Spain, less in France, Portugal and North Africa. However, setting a common denominator of 30 arc-seconds resolution (ca 1 km^2), it was already possible to get a first global distribution of cork oak, made of 155,209 polygons standardized into 75,028 cells at the abovementioned resolution.

These data are encouraging for getting the definitive cork oak punctual distribution in the Mediterranean.

Feedbacks could be addressed to policy makers, stakeholders and experts interested in conservation and restoration purposes. Further applications, coming from such an output, concern the assessment of the different scenarios of global change and real-world implications of human activities as complementary forces able to alter in space and time the current cork oak occurrence and its genetic diversity, towards modelling approaches. Finally, fragmentation, functional connectivity, potential suitable areas detection and assisted migration could complete the picture leading to a comprehensive knowledge about the species management.

Responses of water use efficiency to drought in Mediterranean forests: evidences from stable isotopes

Giovanna Battipaglia[1]*, Paolo Cherubini[2] & Veronica De Micco[3]

[1]Università degli Studi della Campania (ex Seconda Università di Napoli), Dip. Scienze e Tecnologie Ambientali, Biologiche e Farmaceutiche, via Vivaldi 43, Caserta, Italy.
[2]Swiss Federal Research Institute, Zuercherstrasse 111, Birmensdorf, Switzerland.
[3]Dipartimento di Agraria, Università di Napoli "Federico II", via Università, 100, Portici, Italy.
* Corresponding author: giovanna.battipaglia@unina2.it; Phone: 0039 3472373118

Keywords: water use efficiency, isotopes, tree rings, drought.

Water stress is a major determinant of plant species distribution. Extreme climatic events, such as drought, are among the main drivers of forest dynamics and are usually related to forest decline of drought-sensitive tree species, especially in regions, such as the Mediterranean Basin, where water resources are expected to be further limited by climate change. Understanding contrasting drought sensitivity among tree species and how these differences will affect their water and carbon balances is therefore an important topic to forecast responses of Mediterranean forests to global warming and increasing drought stress. Here, we evaluate interspecific differences in intrinsic water use efficiency (WUEi) and the ratio of photosynthesis to stomatal conductance in Mediterranean species (e.g., oak, pines) with different growth strategies and different forest management, using stable isotopes of carbon (d13C) and oxygen (d18O) in annual tree rings. Tree rings are very powerful record of environmental changes occurring during tree growth at annual and intra annual scales. The combination of d13C and d18O in tree rings can provide specific information on the underlying ecophysiological processes. Our results indicate consistent differences in WUEi in the analyzed species, largely determined by leaf traits and differences in stomatal conductance control. The stable isotopes approach resulted to be extremely useful to characterize with intra-annual resolution the plant ecophysiological strategies under drought stress, offering new perspectives in the interpretation of physiological and ecological processes. Intra-annual variations of stable isotopes ratio were also consistent with intra-annual variations of functional wood traits related to efficiency and safety of water transport. Our findings can be used to inform selection of tree species and of management practices, allowing maximization of carbon sequestration for a given water budget and minimizing climate change-induced death of trees.

Mycoforestry in Sicily: a proposal to enhance the multifunctionality of forests

Maria Letizia Gargano* & Giuseppe Venturella

University of Palermo, Department of Agricultural and Forest Sciences, Viale delle Scienze, Bld.5, I-90128 Palermo, Italy.
* Corresponding author: marlega@libero.it; Phone: +393490906252

Keywords: mycoforestry, fungi, Sicily.

Mycoforestry is forestry that aims to build on traditional rules to encourage forest ecosystem resilience while creating optimal conditions for fungal communities. Main goals of mycoforestry are: preservation of native forests, recovery and recycling of woodland debris, enhancement of replanted trees, strengthening sustainability of ecosystems, economic diversity. There is a large variety of fungi living in forests, each of which has a specific and complementary relationship to the diversity of native species, the ages of trees, the presence of dead trees or rich forest litter, etc. Fungi are the main responsible of wood decomposition and thus carbon and nutrient cycling, and they also form mycorrhizas in associations with trees and shrubs. The "mycosilviculture" is considered a global and profitable type of silviculture.

Developing adapted forest management practices appears to be means to improve production of prized edible ECM mushrooms such as *Boletus* and *Tuber* species and saprotrophic fungi. The first principle for the creation of a mycoforestry system is to utilize native fungal species (i.e. *Pleurotus*, *Ganoderma*, *Hericium* species). Mycoforest technology is a new application to inoculate wild edible and medicinal mushrooms directly in forests. In particular, this technology is able to introduce edible/medicinal mushrooms with high market value directly in forests with the aim to obtain a secondary crop to forests, besides timber. It can be used by private and public enterprises and local administrators interested in developing a wild mushroom harvest industry, to obtain an economic profit from forests or in relation with rural development in forest areas.

Adaptation and restoration of Mediterranean forests: the role of the hidden half

Antonio Montagnoli[1]*, Mattia Terzaghi[1], Gabriella Stefania Scippa[2] & Donato Chiatante[1]

[1]University of Insubria, Department of Biotechnology and Life Sciences, via Dunant 3, 21100 Varese, Italy.
[2]University of Molise, Department of Bioscience and Territory, contrada Fonte Lappone, 86090 Pesche (IS), Italy
* Corresponding author: antonio.montagnoli@uninsubria.it; Phone: +39 0332 21 7654

Keywords: fine root dynamics, root morphology and architecture, root plasticity, abiotic stress.

Although the root system represents approximately half of the plant biomass, due mainly to difficulties in methodology, it is still poorly investigated and understood. However, the root system provides essential functions to the plant such as anchorage and water and nutrient uptake. Moreover, in order to cope with environmental constrains, plant roots show high plasticity, which can give important information on specific plant adaptation mechanisms. For example, coarse roots displacement shows a clear asymmetry when plant grows on slope conditions. Thus, root plasticity knowledge may implement plant *reforestation* and/or *afforestation* activities, such as seedlings establishment, on steep slopes or in those areas where a prevailing wind occurs. Fine roots, which respond to a strict cost-benefit analysis, are fast produced and discarded in a complex seasonal dynamics and modify their development depending on the soil water availability. In this case, in areas characterised by a seasonal drought period, studying fine root compartment may indicate the best species or genotype for an *assisted migration* approach. Finally, as all models predict a worsening of climate change effects on Mediterranean vegetation, independently from the type of forest restoration strategy that will be adopted, studies regarding how roots will cope and respond to these stressors become of primary importance.

New approach of aerial seeding to restore Mediterranean mountains: a case of study in Parco Nazionale della Majella (Abruzzi, Italy)

Maria Raffaella Ortolani[1]*, Massimiliano Marani[1], Avra Schirone[1], Gabriele Camillotti[2], Giampiero Ciaschetti[3] & Teodoro Andrisano[3]

[1]Dipartimento di Scienze Agrarie e Forestali (DAFNE), Università della Tuscia, Via San Camillo de Lellis, snc, 01100, Viterbo, Italy.
[2]Italian National Forest Service.
[3]Ente Parco Nazionale della Majella.
* Corresponding author: raffaellaortolani@libero.it

Keywords: aerial seeding, reforestation, Parco Nazionale della Majella, forest restoration, Mediterranean mountains.

The planting of the seedlings is presently the main reforestation technique. However, there could be cases in which the seeding is still the more suitable approach due to economic or technical reasons. On the other hand, the seeding is not a solution if difficulties linked to the site access occur. Especially in the Mediterranean mountains, dramatically steep conditions of some terrain make impossible the normal reforestation operations using seeds. For this reason, aerial seeding reforestation is a valid alternative.

We tested a new approach of aerial seeding using a clay shells appropriately modelled to be thrown by helicopters. These shells contain a mix of biodegradable materials that assist the germination.

To check the effectiveness of this clay shells, we selected two areas with *Fagus sylvatica* L. populations located in Parco Nazionale della Majella (Abruzzi, Italy). These beech forests have suffered severe damage in the summer 2007 because of a fire that affected an area of over 2300 hectares. Since 2010, the Park directorate realized six plots about 1000 square meters in the burned area, almost characterized by steep slopes. In those plots, a plantation of native forest species was carried out and the number and the height of the plants were detected every year. Number and the height of coppice shoot of the stumps, resprouting after burnt, were investigated.

To promote the natural vegetation cover, we used the alternative approach using clay shells with *Fagus sylvatica* L., *Acer pseudoplatanus* L., *Spartium junceum* L. and *Fraxinus ornus* L. seeds. After the thrown by the helicopter, a monitoring phase was carried out to verify the localization of the clay shells, the number of not broken shells and the actual success of seeding.

Although the experimental phase is still in progress, the new technique of aerial reforestation, gave encouraging results. However, further aspects to be analysed about the study of the treatment and preparation of the seeds to be used and the analysis of the mixture within the clay shells are needed.

Nursery production of wide variety forestry seedlings in order to enhance the biodiversity and the regeneration success in forest restoration

Kalliopi Radoglou

Department of Forestry and Management of Environment and Natural Resources, Democritus University of Thrace, Pnatazidou 193, N. Orestiada, Greece. E-mail: radoglou@fri.gr; Phone: +306932820875

Keywords: reforestation, regeneration success, semi-arid ecosystems, survival.

That task to maintaining high biodiversity is hard when trying to regenerate disturbed ecosystems, especially under harsh dry summer conditions, which is usually the case for Mediterranean ecosystems. The goal of the restoration efforts is to accomplish the enhancement of biodiversity and the regeneration success through the engagement of innovative new technologies, in nursery production and planting techniques in the field.

Nursery production involves actions such as seed collection of a wide variety of forest species (shrubs and trees) and germination protocols for breaking the dormancy in all these species. Furthermore, growth protocols are needed for many species in order to achieve high seedling quality and guarantee high survival rates after transplanting. Seedlings can grow through the innovative use of the "prototype unit", which is an automated, controlled growth conditions machine that enables the vast production of seedlings through the use of mini-plugs and LED Lamps.

Results are presented for more than 26 forest species produced in the nursery, grown under the standard nursery methods along with seedlings that were grown through the innovative use of the prototype unit. These results on seedling survival were produced from three regenerated sites of Northern Greece, two years after the planting. Results indicate that factors such as characteristics of the regenerated sites as well as species which are aimed to be planted are crucial and determine highly the success of the regeneration effort.

Florogenetic origin explains forest resprouting capacity across topographical gradients in peninsular Italy

Camilla Wellstein[1]* & Francesco Spada[2]

[1]Faculty of Science and Technology, Free University of Bozen-Bolzano, Piazza Università 5, 39100 Bozen, Italy.
[2]Department of Environmental Biology, University of Rome "La Sapienza", Botanical Garden of Rome, Largo Cristina di Svezia 24, 00165 Rome, Italy.
* Corresponding author: camilla.wellstein@unibz.it

Keywords: resprouting capacity, statistical analysis, environmental features.

Resprouting in tree species plays a crucial role for their survival under conditions of natural disturbance and human impact. Here, we assess for species rich late successional forests across altitudinal gradients on the western side of the Apenninic chain in central Italy the degree of their resprouting capacity. We combined species composition from twenty 400-m^2 forest plots with information on resprouting capacity for 43 tree species. We analyzed the relationships between resprouting capacity and topographic and climatic variables. The results are based on NMDS ordination, linear models and ANOVA. Based on diverse and relatively chaotic disturbance regimes across the landscapes we expected irregular patterns of resprouting capacity. However, surprisingly, we found clear gradients in this functional trait across the forests. Resprouting capacity of forest stands decreased with increasing altitude from the Tyrrhenian coast to higher elevations. It emerged that resprouting capacity significantly differed between groups of distinct florogenetic origin. Evergreen laurophyllous and sclerophyllous species (paleotropical geoflora) had significantly higher resprouting capacities than deciduous mesophytic species (arctotertiary geoflora). The distribution of these florogenetic stocks along the altitudinal gradient shows a concentration of the evergreen species at lower altitudes while deciduous species are restricted to higher altitudes. The pattern of resprouting capacity of forest stands along altitudinal transects of the central Italian Apennine chain are most likely the legacy of biogeographical historical processes and residuality. Our findings on the landscape-level patterns of forest resprouting capacity have important implications for evaluating the vulnerability towards future climatic and land-use changes.

Forest road planning and maintenance under climate change

Mika Yoshida[1]*, Rin Sakurai[2] & Hideo Sakai[3]

[1]University of Tsukuba, 1-1-1, Tenno-dai, Tsukuba, Ibaraki, Japan.
[2]University of Miyazaki, 1-1, Gakuen-Kibanadai-Nishi, Miyazaki City, Japan.
[3]The University of Tokyo, 1-1-1, Yayoi, Bunkyo-ku, Tokyo, Japan.
* Corresponding author: yoshida.mika.kf@u.tsukuba.ac.jp; Phone: +81-29-853-4610

Keywords: climate change, LiDAR, road network, soil erosion, watercourse.

Forest roads are exposed to recent violent climate change, and have suffered, or will suffer unprecedented disasters such as concentrated heavy rain. Since the water drain system has not expected the climate change, it should be upgraded and maintained appropriately not only in the forest roads in little precipitation areas like sub-boreal and/or Mediterranean areas but also in the high-precipitation areas like Japanese climate. For the development of planning and maintenance of forest road, the prediction and evaluation of watercourses is getting important. By using laser imaging detection and ranging (LiDAR) technology, it was easy not only to survey the quantity of earth work by comparing before and after construction of forest road, but also to find the changes of watercourses by road making on the slope surface. The designed water drainage based on the estimated watercourses is effective to predict the collapse area, and useful for efficient maintenance plan. The quantity of collapse on cutting slope was surveyed in a steep mountainous area in Japan comparing with the predicted collapse areas and the effectiveness of maintenance based on the prediction was evaluated.

The use of multipurpose species in forest landscape restoration. The case of Salento (Apulia, Italy)

Tatiana Marras[1]*, Camilla Wellstein[2], Domenico Ragno[3], Agnese Allegrini[1] & Bartolomeo Schirone[1]

[1]Dipartimento di Scienze Agrarie e Forestali (DAFNE), Università della Tuscia, Via San Camillo de Lellis, snc, 01100, Viterbo, Italy.
[2]Faculty of Science and Technology, Free University of Bozen-Bolzano, piazza Università 5, 39100 Bozen, Italy.
[3]Agenzia Regionale per le attività Irrigue e Forestali, Regione Puglia, Bari, Italy.
* Corresponding author: tatianamarras@unitus.it

Keywords: reforestation, Mediterranean landscape, multipurpose species, Qurercus suber, Olea europaea.

Many fruit trees show adaptive features and morphological traits that make them suitable for reforestation purposes, e.g. *Castanea sativa, Juglans regia, Olea europaea, Prunus dulcis, Prunus avium, Ficus carica, Corylus avellana, Ceratonia siliqua, Pyrus communis* and *Malus domestica*. Considering the role of their wild relatives in vegetation succession, these species might be valuable for forest restoration of Mediterranean landscapes that largely underwent strong and long-term anthropogenic changes. The restoration of the vegetation cover on Corfu Island in the 16th century is such an example. Here, we present the potential use of *Olea europaea* combined with *Quercus suber* and *Myrtus communis* for restoring the tree cover, which recently disappeared largely in Southern Apulia (Salento). Preconditions for this project are: cork oak in Apulia is dying out; following pathogen infestations by *Xylella fastidiosa* thousands of hectares of olive tree groves have been uprooted; land cover has to be restored to avoid further environmental degradation; olive growers would like to replant olive trees but it is currently forbidden, except the Leccino variety, which is the only one resistant to *X. fastidiosa*; the restored landscape has to show agricultural features to not distort the past landscape but to enable an easy development towards natural forest in case of abandonment. Olive tree is a multipurpose species which, when let run wild, is able to perfectly integrate itself in the ecological succession from the Mediterranean maquis to the holm oak forest. Cork oak follows the same dynamism. Therefore, a mixed plantation of olive tree and cork oak might evolve to an evergreen Mediterranean forest with prevalence of holm oak and participation of cork oak and an understory composed of maquis species, such as the myrtle. Southern Apulia is rich in such examples. At a technical level, different plantation models dedicated to finding the optimal plantation density are proposed and discussed, given the heliophily of all the species.

Use of terrestrial laser scanner to monitor structural and biometrical variables in degraded peri-urban forests

Ugo Chiavetta[1]*, Gianluigi Mazza[1], Nicolò Camarretta[2], Paolo Cantiani[1], Isabella De Meo[3], Alessandro Paletto[1] & Alessandra Lagomarsino[3]

[1]Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Research Centre for Forestry and Wood, viale Santa Margherita 80, Arezzo, Italy.
[2]ARC Training Centre for Forest Value & School of Biological Sciences, University of Tasmania, Private Bag 55, Hobart, Australia.
[3]Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Research Centre for Agrobiology and Pedology, via Lanciola - Cascine del Riccio 12/A, Firenze, Italy.
* Corresponding author: ugo.chiavetta@crea.gov.it; Phone: 3289733580

Keywords: terrestrial laser scanner, forest structure, monitoring, forest management, Italy.

Monitoring forest structural features is of key importance, particularly for understanding current dynamics in managing degraded forests. Moreover, in peri-urban forests, it plays the role of direct protection against damages to humans and things caused by increasing extreme meteorological events. In the framework of climate change, the continuous, objective and accurate monitoring of degraded forest structure is a fundamental strategy to assess changes in carbon pools.

New technologies can help reducing time and costs of forest structure monitoring. The Terrestrial Laser Scanning (TLS) is one of the most accurate instruments to measure and assess three-dimensional configuration of physical object.

In this study, we aimed at assessing the efficacy and efficiency of TLS in monitoring degraded forest ecosystem structure and evaluating the impact of forest management practices. We applied the TLS technology in an unstable black pine forest showing different levels of structural problems, located near Florence (central Italy). We tested the feasibility of TLS in extracting the more common structural metrics from 18 permanent sample plots of about 530 m^2. Results show that this technology can be used for the proposed aim under certain circumstances. We concluded that the use of TLS in monitoring forest structure and management impact requires each time a specific analysis in order to be operationally feasible, economically convenient and scientifically correct.

Mediterranean forests: Guidelines for adaptive measures

Orazio Ciancio[1] & Francesco Maria Raimondo[2]

[1]Italian Academy of Forest Sciences, piazza T. A. Edison, 11, 50133 Firenze, Italy. E-mail: ciancio@aisf.it
[2]Department STEBICEF/Section of Botany and Plant Ecology, University of Palermo, via Archirafi 38, I-90123 Palermo, Italy. E-mail: francesco.raimondo@unipa.it

Keywords: protection, management, use, restoration, project, forest expertise, Mediterranean area.

The Mediterranean forests are the result of an ancient and progressive anthropic modification of the original forests; they are the outcome of the millennial and varied forms of use made by man and of his subtraction of the same spaces, mainly for agriculture and urbanization. In recent decades, the primary critical factor of destruction has been the intensification of fires and the increase of their frequency, phenomena facilitated – in some countries in particular – by the depopulation of mountains followed by the abandonment of woods and the upcoming of uncontrolled forms of utilization. The genesis and biological and structural characterization of Mediterranean forests are strongly influenced by climate, and the derived woods are affected by the stress of repeated uses and grazing. At the same time, hot, dry summers and recurrent fires hinder their recovery or reconstruction. Soil loss due to erosion is added to natural and anthropogenic factors. In order to ensure protection to these forests, many countries have adopted active prevention, control and intervention measures; nevertheless, their implementations depends much on the policies of individual governments. Their management, however, cannot be done regardless of a systemic vision and, therefore, by sustainable approaches. More control is needed on the multiple uses of the forest, excluding the traditional uses of wood, aimed at obtaining energy assortments - since many years outmoded by widespread use of fossil fuels and alternative sources – above all on recreational purposes and, therefore, it is necessary to strengthen an active presence on the territory, as well as a more targeted organization and regulation. Finally, the project of restoration of degraded forests - as well as of the re-naturalization of forest stands based on exotic species or reconstitution of a forest - today cannot disregard to follow specific protocols aimed at active conservation of the Mediterranean forests biodiversity – thus, having regard also to its biogeographic structure – as well as to apply systemic silviculture techniques based on floristic and vegetation patterns inferred from phytosociological studies performed in almost all forest communities of the Mediterranean. Forest managing and planning are functions that can never be entrusted to unskilled practitioners, but only to technicians with biological, pedological, ecological and silvicultural expertise: namely, technicians that possess or are able to acquire scientific knowledge and suitable techniques for the delicate task of bringing back nature in the Mediterranean forests or of recreating them, no longer with productive aims but mainly for their environmental value and for the conservation of their biogeographical specificity. Five, then, the main points of discussion of the round table in program: protection, management, use, restoration, project and forest expertise.

Formal commitments on Zero forest degradation and on deforestation-free supply chain: an effective mean of forest protection?

Davide Pettenella[1], Lorenzo Ciccarese[2], Aynur Mammadova[1] & Caroline Sartorato[1]

[1]TESAF Department, University of Padova, Italy.
[2]ISPRA, Rome.

Keywords: zero deforestation commitment, leather industry, supply chain, smallholders, livestock.

Formal commitments by the private sector and governments on degradation-free and zero net deforestation have increased since the 2014 New York Declaration on Forests. Majority of companies with commitments are manufacturers and retailers located in developed countries, while those operating upstream of supply chains and in developing countries still lag behind. Recent scientific studies single out livestock as the largest driver for tropical degradation and deforestation followed by palm oil and timber production. Despite the significant impact and several multiparty initiatives, the sector still lags behind in terms of commitments and policies toward degradation and deforestation free supply chains. The situation is especially dare in Brazil, the biggest cattle producer country in the world, with constant conflict and diverse interests over forest resources.

This study explores the direct linkage between leather industry and forest degradation and deforestation in Brazil by concentrating on the value chain of leather, and analyses opportunities for small scale farmers to adopt deforestation free practices. Vast literature review and application of supply chain governance theories help to identify possibilities and hurdles of adoption deforestation commitments by smallholders.

Opportunities for forest landscape restoration especially in dry lands

Eduardo Rojas-Briales

Polytechnic University of Valencia, Spain.

Keywords: food security, biodiversity protection, climate change mitigation, bioeconomy.

The traditional approach to reforestation has evolved towards forest landscape restoration (FLR) learning from the previous experiences. The figures published by the GPFLR of available area for FLR without affecting food security are impressive and could reverse considerably the legacy of centuries of deforestation. Overall support for FLR is explained by its multiple wins in terms of soil, water and biodiversity protection, climate change mitigation and adaptation, rural livelihoods and long term renewable raw material supply key for the transition to bioeconomy. In touristic suitable or periurban areas, improving landscape values should be as well considered.

Most of this area is located in dry lands were with exception of the Sahel, deforestation has ceased. In many of the affected countries, fighting against political instability could be added to the list of multiple wins of FLR. The recent FAO assessment on dry land forests provides as well very valuable information on the existing forest area.

While the consensus is very solid on FLR many breaks condition to unlock its full potential, especially related to available funds due to the huge area identified. Comprehensive answers are required from physical nature (assisted natural regeneration, cheaper low cover pre-forests, planed lateral expansion, efficient forest fire systems, seed collection facilities, nurseries, agro-forestry, etc.), social (vocational training schools), institutional (public forest services), legal (forest tenure), financial (identifying additional sources) and market (out grower schemes). It should be recalled that a chain breaks in its weakest point and there for a full coverage approach is preferable. While focusing on forest area enlargement, preserving and managing the existing forests is the best tool for forest area enlargement both from a physical and social perspective.

Grazing as a conservation tool for priority habitat types in Prespa National Park and the case study of *9562 - Grecian *Juniper* woods: philosophy, implications and opportunities

Irene Koutseri*, Anna Logotheti & Vassiliki Roumeliotou

Society for the Protection of Prespa, Agios Germanos, Prespa, Greece.
* Corresponding author: i.koutseri@spp.gr

Keywords: priority habitat types, Grecian juniper woods, conservation measures, agro-environmental schemes.

Habitat type 9562 *Grecian *Juniper* Woods (GJWs) found within the Prespa National Park (PNP) in Greece has been classified as priority, according to the EU Habitats Directive (92/43/EEC) and is one of the 7 priority habitat types of the PNP that depend on grazing for their conservation.

The abandonment of traditional agroforestry practices leading to the encroachment of broadleaved species on GJWs, has been identified as the main threat to the habitat. The EU LIFE12 NAT/GR/539-JunEx project on GJWs has been designed so as to use the approach of rangeland science, where specific guidelines have been developed in order to use sustainable grazing as a tool towards the restoration and improvement of functions of the GJWs. Based on these guidelines, pilot actions are currently being implemented.

The ultimate goal of this approach is to provide the opportunity to relevant stakeholders (e.g. stock-breeders) and competent local authorities to appreciate the returns from habitat conservation and sustainable implementation of grazing and forestry practices. Regarding implementation of grazing, the project beneficiary, the Society for the Protection of Prespa (SPP), a locally-based NGO, promotes this approach through collaboration with primary sector cooperatives and local authorities/stakeholders for the all priority habitats in need of grazing within the PNP.

Primary sector activities and conservation management are promoted as complementary activities for sustainable habitat management. At the same time streamlining of national policies and EU policies and funding opportunities for the agricultural and the conservation sectors is locally recognized as a tool and several joint local initiatives prepare the ground for the development of relevant agro-environmental schemes.

Although hands-on conservation and local initiatives are producing results, integration of EU policies within relevant national legislation and practice is facing obstacles rendering the sustainability of project actions uncertain.

Anticipating climate change and transforming degraded forests: The billion hectare challenge

John A. Stanturf*

US Forest Service, 115 kingston way, Athens, United States of America. E-mail: drdirt48@gmail.com; Phone: 001 706 202 8066

Keywords: Bonn Challenge, adaptation management, assisted migration, learning organization.

Restoring forest ecosystems is an increasingly important task for forest science globally, where an estimated 2 billion hectares are deforested or degraded. Urbanization, rising income and consumption levels, and other social disruptions present contradictory pressures on use of forest land. Additionally, climate change, particularly extreme weather events, increases the need for active restoration. Forest Landscape Restoration is promoted as a long-term process to meet the billion hectare challenge by regaining ecological integrity and enhancing human wellbeing. A strict reading of ecological integrity, however, means to restore to pre-degradation species composition and forest structure. Rapidly changing environmental conditions, exacerbated by extreme weather events, may render past conditions maladaptive. A focus on restoring function and enhancing resilience is at the core of adaptation strategies for coping with climate change. Strategies may be incremental, anticipatory, or transformational. These strategies vary in their orientation toward future conditions but share similar objectives of favoring genotypes adapted to future climate; resisting pathogens; managing herbivory and invasive plants to ensure adequate regeneration; encouraging species and structural diversity at the stand or landscape levels or both; and providing connectivity and reducing fragmentation. Unfortunately, knowing when to act is more of a challenge than what to do. Nevertheless, management actions that differ from traditional practices could face significant social and organizational resistance. Thus, adaptive and nimble organizations are needed to that can anticipate climate change and meet the billion hectare challenge. Such organizations will have developed future scenarios, planned responses in advance of extreme events, and put in place monitoring adequate to provide early warning of changing mean conditions.

On the forest restoration times

Orazio La Marca[1]*, Monica Notarangelo[2] & Nicola Moretti[3]

[1]Università degli Studi Firenze, via S. Bonaventura 13, Firenze, Italy.
[2]CRA, piazza Nicolini, Trneto, Italy.
[3]Università Studi Basilicata, via dell'università, Potenza, Italy.
*Corresponding author: lamarca@unifi.it; Phone: +393407739076

Keywords: natural, evolution, thinning, Turkey-oak, coppice.

The Authors, based on observations carried out for about 20 years in a Turkey-oak abandoned coppice, within a protected area of Gargano, examine some dendrometric parameters in comparative sample plots, respectively subjected to forest management (with two increasing thinning intensity) or left to natural evolution. Analysis of data shows that after seventeen years plots thinned with very strong intensity have lower standing volume with respect to plots thinned with strong intensity, even if the gap is reducing over time. Anyway, all managed plots have had noticeable growth and yield, with low mortality rate for either oaks and other tree species. Conversely, plots left to natural evolution have had the worst performance in terms of growth and yield to such an extent that plots thinned with strong intensity currently have the same standing volume. Furthermore, the high mortality occurred has strongly reduced the number of other tree species as well as that of oaks.

Monitoring of soil carbon and nitrogen cycling in degraded forest after thinning intervention for ecosystem restoration and climate change mitigation

Alessandra Lagomarsino[1]*, Kalliopi Radoglou[2], Foteini Doukalianou[3], Alessandro Elio Agnelli[1], Gianluigi Mazza[4], Ugo Chiavetta[4], Isabella De Meo[1] & Michail Orfanoudakis[2]

[1]Consiglio per la Ricerca in Agricoltura e l'analisi dell'economia agraria (CREA) Research Centre for Agrobiology and Pedology (CREA-ABP), via di Lanciola 12, Firenze, Italy.
[2]Democritus University of Thrace, 69100, Komotiní, Greece.
[3]DAMT - Xanthi Forest Directorate, Prof. Rossidi 1, Xanthi, Greece.
[4]Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Forestry and Wood Research Centre, viale Santa Margherita 80, Arezzo, Italy.
* Corresponding author: alessandra.lagomarsino@crea.gov.it; Phone: 0552492240

Keywords: carbon, climate change mitigation, soil.

Forests ecosystems generally act as a net sink for carbon, contributing to climate change mitigation by removing atmospheric CO_2 and storing it in different carbon pools (i.e. biomass, soil, deadwood, litter). Forest degradation, implying a decrease in canopy cover and regeneration, as well as forest fragmentation, contribute to atmospheric green-house gas (GHG) emissions through decomposition of remaining plant material and soil carbon. These larger emissions are no more balanced by the C storage capacity in woody biomass and soil, due to unstable structural conditions of the degraded stands. In this context, the restoration of degraded pine forests derived by plantation with the aim to reestablish and improve the natural functioning processes, offer a cost-effective means to mitigate climate change, both

reducing emissions from deforestation and forest degradation and increasing carbon removals. FoResMit project aims at quantifying the mitigation potential of innovative forest management, including sources and sinks for GHG. Two Mediterranean coniferous forests have been selected in Italy (monte Morello, Tuscany) and Greece (Xanthi forest, Thrace) and subjected to traditional and innovative thinning, compared to un-managed forests.

Comprehensive data on C storage potential of degraded pine forest and GHG emissions are lacking. To cover the existing gap, not only CO_2, but also CH_4 and N_2O emissions have been monitored for the first months after thinning. The contribution of deadwood to GHG emissions has been measured in laboratory and in the field. Carbon and nitrogen pools of mineral soil and forest floor have been monitored before and after the thinning intervention. Litter fractions have been separated in un-decomposed, fragmented and humified and their carbon and nitrogen content measured, to follow litter degradation process.

The influence of environmental variables (site conditions, temperature, moisture) on pools and fluxes has been evaluated, and first results showed a high relevance compared to forest management.

Eucalyptus **plantations in Italy and forest rehabilitation: the way towards a sustainable management**

Giuseppe Pignatti[1]*, Gianni Facciotto[2], Giulio Sperandio[3] & Stefano Verani[1]

[1]Council for Agricultural Research and Economics (CREA-PLF Roma), via Valle della Quistione, 27, Roma, Italy.

[2]Council for Agricultural Research and Economics (CREA-PLF), Strada Frassineto, Casale Monferrato, Italy.

[3]Council for Agricultural Research and Economics (CREA-ING), via Pascolare, Monterotondo, Italy.

* Corresponding author: giuseppe.pignatti@crea.gov.it; Phone: +39 6 61571034

Keywords: Eucalyptus *plantations, forest rehabilitation, sustainable forest management, Italy.*

Since the beginning of the twentieth century *Eucalyptus* species have been planted in the Mediterranean regions of Italy, in order to achieve several purposes: reforestation of degraded agricultural land, reduction of soil erosion, wood production, social (lower unemployment) and other environmental benefits. Soon a debate emerged on the advisability to plant exotic species as *Eucalyptus* and the difficulty to manage the plantations in order to reestablish native forest vegetation. Nowadays forest rehabilitation of *Eucalyptus* plantations could be an opportunity to improve forest products and services, but strongly depends on the ecological and productive conditions of the forest stands.

In the framework of a Ministry of Agriculture Food and Forestry Policies financed project (FAESI), we analysed National Forest Inventory (INFC2005) data belonging to stands where *Eucalyptus* sp. pl. were present. In the 87 plots, distributed in 7 Regions of Italy and classified into 10 different forest types, the stand volume varies widely, with a mean of 71 m^3/ha. In all the plots *Eucalyptus* is predominant in volume to other forest species, in 60% of the plots it is the only tree species present. *Pinus halepensis*, originally planted together but capable also of regeneration after fire, is the most frequent native tree species. Less than 36% of the plots have regeneration and only in 46% of the plots shrubs are present.

Considering the overview given by NFI data, we made three different hypotheses for forest rehabilitation in order to improve the capacity of *Eucalyptus* plantations to deliver forest products and services. Plantations could be managed as usual for timber and biomass purposes, or completely replaced by planting different native forest species, or managed following principles of continuous cover forestry to expand social and environmental functions. Each option has different starting requirements and outputs in terms of products and services, as well as conditions of technical and economic feasibility which are discussed.

A new collaborative project on the Caspian forests of Iran: a gene pool for the adaptation of European forests?

Palle Madsen[1]*, Khosro Sagheb-Talebi[2] & Ole Kim Hansen[1]

[1]Dept. of Geosciences and Natural Resource Management, University of Copenhagen, Nødebovej 77A, 3480 Fredensborg, Nødebo, Denmark.
[2]Research Institute of Forests & Rangelands (RIFR), P.O.Box 13185-116, Tehran, Iran.
* Corresponding author: pam@ign.ku.dk; Phone: +4540453019

Keywords: Refugial population, genetic diversity, adaptation potential.

Refugial populations of several European tree species are expected to have more genetic diversity and greater adaptation capacity than European populations of these species in general. This phenomenon has been described for European silver fir (*Abies alba*). Compared with 17 other European provenances across its natural range, a Calabrian provenance showed superior growth and health in Danish provenance trials established in the 1930s and inventoried at age 44. It was the southernmost provenance tested in these field trials located more than 500 km north of it northern distribution limit. Similarly, the Caspian forest in Northern Iran can be considered an important refugial area in relation to European species of rich deciduous forests covering 1.8 million ha. The Caspian forest holds a rich species diversity that includes both many European species as well as several closely related species. We present at recently initiated collaborative research project that aims for exploring and documenting the genetic diversity and adaptation potential of Caspian provenances compared with commonly used Danish or European provenances in Denmark. One of the main research challenges and goals are to uncover whether the case of Calabrian silver fir is unique or if a similar superior adaptation potential exists within the refugial populations of other tree species which are native or closely related to native European species.

From afforestation and reforestation to forestoration, from goods to services. How science and society can shape the transition

Lorenzo Ciccarese[1] & Davide Pettenella[2]

[1]ISPRA - Institute for Environment Protection and Research, Division for Species and Habitat Conservation and Land Sustainable Management, Rome, Italy.
[2]TESAF Department, University of Padova, Italy.

Keywords: ecosystem services, science, society.

Despite the increasing recognition and attention from industry, government, the media, and private citizens to ecosystem services provided by forest ecosystems, global deforestation and forest degradation rates remain alarmingly high: global forestland base is shrinking at a rate of 13 Mhay-1 and only 1/5 of the world's old growth original forest cover remains intact. Both the extent and quality of forest habitats continue to decrease and the associated loss of biodiversity jeopardizes forest ecosystem functioning and the ability of forests to provide ecosystem services. Against this backdrop, it is of major importance not only to conserve but also—as stated inter alia by the UN Convention on Biological Diversity, the Agenda 2030 for Sustainable Development, the Paris Agreement and the EU Seventh Environment Programme—to restore forest ecosystems. This is why there is increasing interest worldwide in the science and practice of forest restoration, we define forestoration.

In step with the theories and principles of restoration ecology, forestoration has its major focus on restoring the relation between biodiversity and forest ecosystem functioning. Under this perspective forestoration includes establishment of short-rotation, single- or multiple-species, plantations on abandoned or degraded soils (while offering little improvement of biodiversity), reclamation planting on former mining soils, where abiotic factors limit establishment and growth of native vegetation, restoration plantings in secondary forests or assisted regeneration in selectively logged forest. Forestoration can be achieved either through controlling pressures on forests, such as fires, invasive species or unsustainable harvesting, or through techniques to accelerate forest recovery such as planting programs or attracting seed dispersers. These activities all have in common that they consist of active and intended management interventions, whilst forest natural succession is regarded as unintended, nor prescribed or directed by humans.

The objective of this paper is to analyze the current and future role of science and society in shaping the transition to wide ambit of forest restoration approaches, with a view to enhancing the full range of benefits they can provide and delivering transformative change for landscapes and people. The paper, while recognizing the key role of the forest sector in restoration efforts, emphasizes the need to integrated different disciplines and sectors, particularly agriculture, soil science, energy, economics and sociology, to formulate sustainable forestoration policies and planning processes. Public participation, involving landowners as well as the general public, will be a key factor in the forest restoration planning process. The scope of forest restoration should always be defined with the support of local people as this is a prerequisite for any successful investment.

Restoration and sustainable management of beech (*Fagus sylvatica*) stored coppices in North Western Italy

Renzo Motta[1]*, Roberta Berretti[1], Pierpaolo Brenta[2], Fabio Meloni[1], Antonio Nosenzo[1], Pier Giorgio Terzuolo[2] & Giorgio Vacchiano[1]

[1]Dip. DISAFA, University of Turin, Largo Paolo Braccini 2, Grugliasco, Italy.
[2]IPLA, C.so Casale 476, Torino, Italy.
* Corresponding author: renzo.motta@unito.it; Phone: ++39 0116705538

Keywords: silviculture, sprouting, conversion, restoration, neglect.

In northwestern Italy most beech forests have been traditionally coppiced until the recent past due to the high request of firewood and wood charcoal. Over the last decades, however, local and global socio-economic changes have caused a decline in firewood exploitation. As a consequence in beech coppices there has been lenghtening of rotations or neglect. The beech is highly sensitive to the lengthening of the rotation due to its poor sprouting capacity. In the last 40 years, the main way to contrast this trend has been a systematic conversion from coppice to high forest throughout repeated thinnings. Because most of such silvicultural treatments required are costly, and the entire conversion process lasts many decades, this policy is not sustainable yet. In the Piedmont region, only half of the existing 135.000 ha of beech forests are actively managed of which about 7000 are still coppiced and more than 60.000 ha are currently stored coppices or coppices under conversion to high forest.

In this study we have: a) analyzed the sprouting capacity of the beech in different forest types and age classes; b) analyzed the availability of different timber assortments in mature and stored coppices; and c) tested new economically sustainable silvicultural approaches to ensure and enhance continued provision of ecosystem services requested from the forest.

Results about sprouting capacity and timber assortments and preliminary results about silvicultural treatments are presented.

Conservation of the biodiversity and sustainable restoration of cork oak Maamora forest (Morocco)

Mohamed Fennane[1], Francesco Maria Raimondo[2] & Mohamed Rejdali[3]*

[1]Institut scientifique, Université Mohammed V, Avenue Ibn Batouta, B.P 703, Rabat, Morocco.
[2]Department STEBICEF, University of Palermo, via Archirafi 38, I-90123, Palermo, Italy.
[3]Institut Agronomique et Vétérinaire Hassan II, Madinat Al Irfane, B.P. 6202, Rabat, Morocco.
* Corresponding author: m_rejdali@hotmail.com

Keywords: Quercus suber*, conservation, North Africa.*

The Maamora forest (Morocco) is by far the largest existing cork oak forest in one stand throughout the world distribution area of *Quercus suber*. During centuries, it has played major ecological, economic and social roles, staring in stable from the wide expanse of sandy soils, prone to wind erosion, there by stopping the spillage of sand (sandstorms to Europe). For this reason, as well as for the many beneficial effects on the stabilisation of local population and the improvement of the economy of the region, it becomes necessary to launch an effective recovery action and reforestation through interventions funded and supervised by the national and international organizations.

The world largest cork oak Maamora forest is located at the Moroccan Atlantic plain between Rabat and Kenitra cities. It has a potential area of around 300.000 hectares of cork oak trees, that turned nowadays to a low density tree cover of less than 50.000 hectares, with a very disturbed or even absent climax environment. Research programs and scientific articles related to this magnificent forest are various and deal with all its aspects: ecologic, floristic, faunistic, socio-economic, and cultural. The future of the Maamora forest, however, causes much concern despite the many initiatives and efforts made to protect, conserve and rehabilitate its ecosystems. Both decision makers and managers failed to refrain this rapid regression and decline of this forest caused mostly by heavy and anarchic human pressure.

The authors try to present an outcome of the current situation and presume that nature by itself and through fencing as well as assisted regeneration might be the appropriate way to meet the challenge. Our contribution is a synthetic review of some of the work done about the Maamora forest and the initiatives made to safeguard this important forest ecosystem with many habitats and an excellent biodiversity.

Assessing forest logging soils disturbance by multi-temporal analysis of ground high resolution model derived by Portable Laser Scanner and physical parameters sampling

Martina Cambi*, Francesca Giannetti, Davide Travaglini, Gherardo Chirici & Enrico Marchi

Università di Firenze, Italy, Firenze, via San Bonaventura 13, Firenze, Italy.
* Corresponding author: martina.cambi@unifi.it; Phone: +393331467155

Keywords: forest logging, soil disturbance, precision forestry, PLS, Terrestrial Laser Scanner.

Forest operations may lead to negative consequences in terms of compaction and rutting, which may result in soil degradation processes such as erosion, mudflow and landslides. The damage depends on type of vehicle, number of passes, ground morphology, soil properties and slope. The aim of this research was to investigate the impact on soil caused by logging operations through ground survey and with terrestrial portable laser scanner (PLS). Samplings were carried out in two trails that differed for the numbers of machine passes and slope. The data collection where performed before and after works to analyze the impact on soil of forest operations. The specific objectives were: (i) to analyze how forest operations have influenced soil compaction and rutting; (ii) to assess soil compaction with traditional techniques; iii) to determine logging caused rutting with high-resolution ground surface models generated by PLS scans; iv) to assess the differences in the soil disturbances in two different trials. Significant impacts were detected with both investigation

methods, i.e. physical parameters and multi-temporal analysis of high resolution ground surface models derived by PLS. Therefore, in order to limit the damage to the soil, it is important to apply extraction methods and machines in relation with the specific site conditions, especially when a high mechanization level is used.

Innovating forest plantation practices: science, technical development and knowledge exchange

Catherine Collet[1]*, Claudine Richter[2], Erwin Ulrich[2] & Marieke Blondet[1]

[1]INRA, INRA, LERFOB, Champenoux, France.
[2]ONF, Fontainebleau, France.
* Corresponding author: catherine.collet@inra.fr; Phone: 33383394043

Keywords: plantation, barrier to innovation, mechanical site preparation.

Forest plantation is a major tool to adapt forest ecosystems to global change and to restore damaged forest ecosystems. However, several barriers to a wide use of plantation to regenerate or restore forests have been identified:

1. Recurrent failure of plantation under certain site conditions (dry sites, sites with high vegetation competition,…).
2. High financial plantating costs.
3. Potential negative environmental impacts of planting (soil compaction, biodiversity loss,…).
4. Hard working conditions for tree planters.

The different barriers need to be removed, in order to promote the use of plantation as an adaptation tool. New plantation practices, with enhanced technical, economic, environmental and social performances must be developed and promoted among forest practitioners.

Mechanical tools have been developed in recent years, that improve the different performances of plantation practices. Examples of such innovation will be shown. The analysis of the innovation process highlights the weaknesses of regional and national socio-technical networks, in relationship with poor knowledge exchange practices, and poor economic collaboration among stakeholders within the local forest sector. Developing stronger socio-technical networks, based on information and financial collaboration, is a key to the development and diffusion of new planting methods.

Geobotanical foundations and diversity patterns in the Mediterranean forests

Francesco Spada

Department of Environmental Biology, University of Rome "La Sapienza", Botanical Garden of Rome, Largo Cristina di Svezia 24, 00165 Rome, Italy. E-mail: francesco.spada@uniroma1.it

Keywords: Mediterranean forests, lauriphyllous dendroflora, specie adaptations, community structure.

Mediterranenean forests are very diverse ecosystens, ranging from sclerophyllous evergreen thickets and woodlands, to stands of warm-temperate deciduous forests and non-boreal conifer forests at higher altitudes.

Since they host most of the woody species of the European flora, their assessment is highly suggestive for the structure and long term history of the whole Mediterranean biota.

Nearly all are home to a changing amount of modern sclerophyllous derivatives of the lauriphyllous dendroflora of the subtropical forest biomes spread over the southern part of Paloeurope at the onset of the Neogene. This suggests an overall high degree of abaptation and relictuality in their structural assessment, a pattern mirrored , among others, by the complex genetical structure of the present day dominating oaks, whose intriguing incongruence between molecular signatures and morphological traits reveal reiterated paleo-range pulsations and late-Neogene adaptation events to the present day seasonal, warm, dry Mediterranan-type climatic regime.

Here focus on this legacy on coenology is emphasized in order to explain in terms of historical events features usually misinterpreted as result of human impact, disruption theories, the role of fire and a general reductionistic actualism in the interpretation of species adaptations and community structure in the Mediterranean regions.

The controversial direction of sucession in Mediterranean forests is outlined on this basis, in order to contribute to a florogenetically and biogeographically consistent descriptive model for their restauration.

MEDFORVAL, the Mediterranean network of forested areas of high ecological value: restoration, protection or management of woodlands sites

Magda Bou Dagher Kharrat[1]*, Marine Lovero[2]*, Valentine Pleiss[2], Pedro Regato Pajares[3] & Alain Chaudron[2]

[1]MEDFORVAL, France, Marseille, 14 rue Louis Astouin, 13002 Marseille.
[2]Association internationale forêts méditerranéennes (AIFM), France, Marseille, rue Louis Astouin, 13002 Marseille.
[3]AIFM consultant, Spain, Madrid, General Ampudia 4, 28003 Madrid.
* Corresponding author: marine.lovero@aifm.org; Phone: 009613468260

Keywords: network, ecological value, Mediterranean region, international, forest restoration.

The high ecological value of some Mediterranean forest and wooded areas results from the interaction between many natural and human factors, following a very complex dynamic. The MEDFORVAL project is financed by MAVA Foundation for Nature and is managed by AIFM (International Association for Mediterranean Forests) as part of the Collaborative Partnership on Mediterranean Forests (CPMF) and the Strategic Framework on Mediterranean Forests (CGFS). It aims to create collaboration between practitioners and policy makers from different sectors of the Mediterranean on concrete measures to protect, manage or restore the ecological values of their respective sites, through network-ing. After the two first years, the network is rich of 19 sites spread over the entire Mediterranean basin and grouped into four ecological clusters. These sites, helped by the network Secretariat, have started working together, through regular meetings, learning exchange visits and the development of joint project proposals. This presentation will feature experiences on ecological restoration shared by MEDFORVAL network members such as: Shouf biosphere reserve restoration plan - Lebanon; Participation of private owners to the restoration of the Guadiana watershed - Portugal; Juniper landscape restoration in Prespa national park - Greece; Rehabilitation of the Jordan river valley - Jordan and Restoring the Ticino valley ecological connectivity - Italy. Challenges encountered in different ecological restoration of Mediterranean forests projects will also be discussed. Some thoughtful scientific questions are raised aiming to optimize economically and technically the restoration outcomes: explore and restore the below-ground biodiversity, promote the use of native species, clarify the effect of nurse-plants and their "facilitation" role, select the appropriate genetic resources to be used for reforestation, evaluate the effect of fencing on restored site biodiversity and finally the deciphering the effect of animal wildlife on the long-term sustainability of restored forests.

Spatio-temporal patterns and drivers of secondary succession in a Mediterranean landscape

Rafael Da Silveira Bueno[1]*, Daniel Garcia[2], Mauro Galetti[3] & Tommaso La Mantia[1]

[1]University of Palermo, viale delle Scienze, Ed. 4, Palermo, Italy.
[2]University of Oviedo, E-33071 Oviedo, Asturias, Spain.
[3]Sao Paulo State University, Av. 24A, Rio Claro, Brazil.
* Corresponding author: rafabrc@yahoo.com.br; Phone: +39 3347422239

Keywords: herbivory, GIS, Mediterranean, natural regeneration, secondary succession.

In recent years, many Mediterranean agricultural lands have been abandoned, reforested, rewilded and ecologically restored, creating different templates and trajectories for the development of secondary succession. Our objective was to verify whether past legacies of woody vegetation (remnant forest and shrub patches and reforestations) influenced the current spatial pattern of woody cover in a midsuccessional Mediterranean area, identifying spatial cold and hotspots (i.e: low/slow or high/fast cover increase) and looking for footprints of seed-disperser and herbivore-mediated processes at landscape and local scales. The study took place in three 500x200 m plots in a formerly managed and partially reforested pastureland in the Ficuzza Natural Reserve (Palermo, PA), the last large forest remnant in western Sicily. We sampled woodland and shrubland cover over a 24-year interval (from abandonment to the present), by combining current field sampling and a GIS-based interpretation of sequential high resolution satellite images and greyscale aerial photographs. The overall woody vegetation cover almost doubled through the studied period, with a balanced increase of woodland and shrubland patches. *Fraxinus angustifolia* reforestation contributed marginally to woodland expansion, while the major increase was due to the natural regeneration consisted mainly of five fleshy-fruited and one dry-fruited species, all of them well protected against herbivory. Most of woody cover expansion was correlated with initial cover, although some hotspots presented 100% of cover increase from bare areas even further than 100 m away from any woody patch. Our results reveals that the composition and spatial configuration of past vegetation legacies can influence the secondary succession evolution, as well as the specific contribution of natural regeneration, human-made reforestation, herbivory and animal seed dispersal in creating these patterns, setting a template for further investigations regarding mechanisms and functional traits driving these patterns.

The contribution of forest restoration to the conservation of woody endangered species in Sicily

Cristina Salmeri[1]*, Francesco Maria Raimondo[1] & Gianniantonio Domina[2]

[1]Dept. of Biological, Chemical and Pharmaceutical Sciences and Technologies, University of Palermo, via Archirafi 38, I-90123 Palermo, Italy.
[2]Dept. of Agriculture and Forest Sciences, via Archirafi 38, I-90123 Palermo, Italy.
* Corresponding author: cristinamaria.salmeri@unipa.it; Phone: +3909123891228; +393388381177

Keywords: forest biodiversity, endangered species, nursery production, restoration, Sicily.

Sicilian forest ecosystems are, in general, numerically poor in terms of their floristic composition. As many studies on Sicilian dendroflora have highlighted, such poorness is not intrinsic to forest formations, but it is due to the millenary human pressures. Repeated passage of fire, continuous wood usage and reforestations by single or few species dramatically reduced the plant biodiversity of Sicilian forest ecosystems, often suffering of monodominance. The Sicilian dendroflora includes several endangered species, such as *Abies nebrodensis, Betula aetnensis, Celtis tournefortii* subsp. *asperrima* and subsp. *aetnensis*, as the wild pears, which in Sicily are represented by 4 endemic species, in addition to the commonly known *Pyrus spinosa* and *P. pyraster*. Similarly, the genus *Salix* counts 8 different species instead of the given 4. Thus, higher attention toward all these taxa, which strongly improve the forest heritage of specific areas, is needed. Throughout their knowledge, survey, propagation and extensive use, the risk of local and general biodiversity loss can be limited. These actions necessarily require a targeted nursery program aimed to produce plantlets with high genetic variability starting from local propagation material.

Radial increment of Taxodium distichum from Veliko ratno ostrvo area (Belgrade-Serbia) at two different heights of the trunk

Dusan Danilo Jokanovic*, Dragica Milan Vilotic, Vesna Milan Nikolic & Dragica Stankovic

Faculty of Forestry, Kneza Viseslava 1, Belgrade, Serbia.
* Corresponding author: dusan.jokanovic@sfb.bg.ac.rs; Phone: 065-6969-846

Keywords: Veliko ratno ostrvo, Taxodium distichum*, radial increment, soil characteristics.*

Taxodium distichum is exotic species that is mainly recommended for afforestation of lowland areas in Serbia, such as Veliko ratno ostrvo. This area has been characterized by flat orography with an average height of about 72 meters above the sea level. In the paper, there were analyzed growth rings characteristics of three trunks that have been chosen as representatives, due to their dimensions, physiological and healthy looking, position in the population and due to lack of any technical deformation. Radial increment was measured at two heights - on the base and on 1.3 meters (breast height). On the base of the obtained results, it was deduced that growth rings were a bit wider on the base than on the breast height. It was also concluded that an average width of the growth rings by *Taxodium distichum* (about 3.5 mm) was a bit bigger than by the other conifers in Serbia. It is very important to emphasize that radial increment of *Taxodium distichum* depends a lot on soil characteristics. As for Veliko ratno ostrvo area, it belongs to alluvium with different texture. Big water capacity related to suitable soil texture and significant content of nutrients, as well, caused relatively wide growth rings. The most important conclusion could be related to following: minimal growth rings width is situated in juvenile wood zone, that includes the first 10 growth rings; maximal growth rings width was in the last a few growth rings, close to the bark; culmination of radial increment is remarkable at about age of 30.

Mapping and monitoring in protected natural areas: the use of the FAO LCCS as an effective tool for habitat mapping and change detection

Valeria Tomaselli[1]*, Giuseppe Veronico[1], Cristina Tarantino[2] & Palma Blonda[2]

[1]CNR IBBR, via G.Amendola 165/A, Bari, Italy.
[2]CNR IIA, via G. Amendola 165/A, Bari, Italy.
* Corresponding author: valeria.tomaselli@ibbr.cnr.it; Phone: 3393137493

Keywords: mapping, monitoring, change detection.

Effective and timely biodiversity monitoring within protected sites and their surroundings is critical for detecting landscape changes which might impact site's conservation status, quality and resources and to evaluate the effectiveness of conservation policies in protecting biodiversity and ecosystems from human activities. The most commonly used Land Cover/Land Use (LC/LU) or habitat classification systems are limited in their ability to read all aspects of the landscape. The Food and Agricultural Organization (FAO) Land Cover Classification System (LCCS) taxonomy (Di Gregorio and Jansen, 2005) was identified as the most appropriate for providing a common language for harmonizing different LC/LU legends. One of the basic principles of this system is that a given land-cover class is defined by a dynamic combination of classifiers, thus allowing the more complex semantics of each land-cover class may be described. FAO/LCCS has been also found to be effective for translating EO-derived LC/LU classes to habitat types (Tomaselli et al., 2013; Adamo et al 2014), since it allows a better description of natural habitats in comparison to other classification systems. Furthermore, LCCS has proven to be a valid tool in change detection, both at the level of conversion and modification. In fact, changes become immediately identifiable by a difference in classifier, or through the use of additional classifiers, although maintaining the same class type. In this contribution LC and habitat mapping have been performed on a site belonging to the Natura 2000 and located in Southern Apulia (Italy), characterized by coastal environments, Mediterranean maquis and extensive pine forests. The mapping was performed by means of photo interpretation and on-site survey, in years 2007 and 2015. Different LC and habitat classification systems were used and results compared. The LCCS turned out to be the most effective in detecting changes in forest types, highlighting changes such as height and density which were not evidenced with other classification systems.

Changes of forest communities surface in the Murge of Taranto (Puglia - Southern Italy) in the last 60 years

Roberto Greco*, Maria Immacolata Marzulli, Manuela Persia & Patrizia Tartarino

DiSAAT - Università degli Studi di Bari Aldo Moro, via Orabona 4, Bari, Italy.
* Corresponding author: roberto.greco@uniba.it; Phone: +393347408035

Keywords: Forest communities, Murge, Southern Italy.

The Planning of Forest Community Management must be necessarily based on the knowledge of the functioning of present ecosystems, but also of relations that exist or that occurred in the past with the surrounding area and that led to the current disposition.

In this study, changes of forest vegetation surfaces occurred in the last 60 years were examinated in an area extended on about 55.000 ha, located in the Murge of Taranto in Puglia (Southern Italy). It consists of the river basins that underlie the “Gravine” (ie. deep cuts in the limestone and calcarenite units in the area) of Ginosa, Laterza, Montecamplo and Castellaneta.

The study began with the GIS based photo-interpretation activity of ortophotos dating back to 2006-2011, validated by field surveys, aimed at the vectorization of the different classes of Land Cover (Directive 2007/2/EC - artificial surfaces, agricultural areas, woods and forests) in the studied area. For the forest vegetation it was used a classification of physiognomic-type composition, considering a unit digitalisation of 0,2 ha.

Subsequently, the vector database obtained was compared with the aerial photo frame of 1954-55, orthorectified and georeferenced with the software Pix4dMapper. Therefore, it was possible to vectorize differences on surfaces observed, and evaluate, also on a statistical basis, factors that have determined them.

Quercus suber in the Iberian Peninsula: ecological characteristics and cork exploitation

Javier López-Tirado[1]*, Federico Vessella[2] & Pablo J. Hidalgo[1]

[1]Department of Integrated Sciences, Faculty of Experimental Sciences, University of Huelva, Avda. Tres de Marzo s/n, 21071 Huelva, Spain.
[2]Department of Agriculture and Forestry (D.A.F.N.E.), Università degli Studi della Tuscia, via San Camillo de Lellis, snc, 01100, Viterbo, Italy.
* Corresponding author: javier.lopez@dbasp.uhu.es

Keywords: Quercus suber, *Iberian peninsula, ecology, cork, Species Distribution Models.*

The current distribution of cork oak (*Quercus suber* L.) is located westwards in the Mediterranean Basin: from Portugal to Italy in Europe and Morocco, Algeria and Tunisia in North Africa. The largest stands are distributed in the Iberian Peninsula, especially in Portugal and Southwestern Spain. The ecology of cork oak is characterised by thermophilous areas ranging from sub-humid to hyper-humid environments. Acid soils are also particularly linked to this oak. The abovementioned conditions altogether make cork oak more competitive than *Q. ilex* subsp. *ballota* (Desf.) Samp. (holm oak). By contrast, the latter shows a greater ecological plasticity like indifference to edaphology and withstanding both more arid and colder conditions as well.

Human-induced disturbances and management since several centuries ago has led to an alteration of the land use. Cork oak has suffered opposite shifts on its distribution. For instance, in Southern Spain holm oak has been favoured to the detriment of cork oak in savannah-like pasturelands (locally called *dehesas* in Spanish or *montados* in Portuguese), due to the sweet acorn of the former for feeding porks. More recent business like eucalypt (*Eucalyptus globulus* Labill.) plantations has devastated potential areas for cork oak –eucalypts are needed of a high amount of annual rainfall–. On the other hand, in the surroundings of the Strait of Gibraltar, Algerian oak (*Q. canariensis* Willd.) has been disadvantaged with respect to cork oak. In this case, it seems that cork has prevailed because there is no a clear exploitation resource from Algerian oak. Nowadays, Portugal is the first producer of cork in the world.

Recent studies on Species Distribution Models (SDMs) point out a gradual decrease of the potential distribution of cork oak in Southern Spain. This methodology is highly useful for being aware about the trend of this species in a context of global change. Suitable spots can be detected aiming to carry out conservation programmes. Thus, ecologic and economic issues could be achieved to this significant Mediterranean oak.

Toward sustainable forest management in Morocco: restoration, certification and regional program as cases

Said Lahssini[1], Mustapha Naggar[2]* & Said Moukrim[2]

[1]ENFI, Bp 511, Tabriket, Sale Morocco, Rabat, Morocco.
[2]HCEFLCD, 3 Rue Haroune Rachid, Agdal-Rabat, Rabat, Morocco.

* Corresponding author: munaggar@yahoo.fr; Phone: +212663666596

Keywords: forest management, forest restoration, sustainability.

Morocco's ecological contexts are diverse. As such, altitude varies from sea level to 4100 m, the geology is diverse, and rainfall ranges from less than 30 mm $year^{-1}$ in the south to more than 2000 mm $year^{-1}$ in the north. As consequence, Morocco is one of the most diverse countries of the Mediterranean region in terms of plant species. It houses the most species in North-Africa with 4200 floral-taxa, including 1282 subspecies, representing 920 genera and 130 families (Fennane & al. 2012). The most important part of such biodiversity are hold in mountainous area and mainly in forest domains which covers 9 million ha. In order to ensure the sustainability of the goods and services provided by forest lands, forest management adopted by Moroccan forest administration has been widely adapted to cope with the multiple uses of Moroccan forests. Moreover, under climate change perspective on which Morocco is expected to be severely impacted, sustainability of forests and its associated resources are a key factor for ensuring inhabitants' survival and adaptive capacity and requires to improve approach for managing forests. Then a holistic approach to address the various components of Moroccan forests and to ensure their suitability while taking into account the effects of climate change that includes tree regeneration and reforestation efforts and the livelihood of the local community depending on it, is needed. This communication, through the analyses of three Moroccan context aiming to implement sustainable forest management [(1) regional forest program (regional planning of Rifs' forests), (2) forest management certification (certification FSC of Itzer's forest management process), (3) forest restauration as main driver of forest management (case of Maamora)], try to underpin the main changes adopted to forest management practices and the main challenges to forest suitability while taking into account the effects of climate changes.

The coastal communities of Junipers in Sicily: conservation status and perspectives of management and restoration

Pietro Minissale[1]* & Saverio Sciandrello[2]

[1]Department of Biological, Geological and Environmental Sciences, University of Catania, via A. Longo, 19, Catania, Italy.
[2]Centre for the Conservation and Management of Nature and Agroecosystems (CUTGANA), University of Catania, via Santa Sofia, 98, Catania, Italy.
* Corresponding author: p.minissale@unict.it; Phone: 3404175175

Keywords: Juniperus *sp. pl., threatened habitats, restoration actions, Mediterranean dunal environments.*

Juniperus sp. pl. plant communities represent one of the most threatened habitats of the Mediterranean area. Notably they are *Juniperus oxycedrus* subsp. *macrocarpa* coastal vegetation, growing on the highest and stable dunes, and *Juniperus turbinata* plant community, which colonizes the inner dunes. Especially in northern Mediterranean this psammophilous vegetation suffered a strong decrease due to the intense coastal urbanization and agricultural activities which/and sometimes have expanded to the coast occupying dune environments. These wooded plant communities, climax-vegetation of dune environments, are included in Annex I (2250* code) of the European Habitats Directive 92/43. Their importance is related also to the vulnerability of the species which show slow growth and limited renovation capacity. The creation of protected areas has favored the conservation, of these habitats, even though delayed. Regarding this topic Sicily represents a case study, because the disappearance and transformation of extensive dune systems have occurred in a period of just half a century. Dramatic examples are the coastal dunes of Catania and Gela. Another threat and alteration in coastal dunes were the reforestation actions with alien species, such as *Acacia.*

Poster presentations

The longevity and resilience of *Pinus leucodermis*: a long tree-ring chronology to investigate the Mediterranean climate

Anna Dinella[1]*, Ingo Heinrich[2], Alfredo Di Filippo[3], Michele Baliva[3], Aldo Schettino[4], Giuseppe De Vivo[4] & Gianluca Piovesan[3]

[1]Faculty of Science and Technology, Free University of Bolzano-Bozen, piazza Università, 5 39100 Bolzano, Italy.
[2]GFZ German Research Centre for Geosciences, Telegrafenberg, 14473 Potsdam, Germany.
[3]Department of Agriculture and Forestry Science (DAFNE), Università della Tuscia, via San Camillo de Lellis, 01100 Viterbo, Italy.
[4]Pollino National Park, Complesso monumentale Santa Maria della Consolazione, 85048 Rotonda, Italy.
* Corresponding author: anna.dinella@natec.unibz.it: Phone: +39 3315008388

Keywords: Bosnian pine, longevity, resilience, tree-ring, climate change.

Bosnian pine (*Pinus leucodermis* Antoine) is one of the longest-lived species of Europe. This biological feature allows building long tree-ring chronologies. The aim of this study is to analyze the growth responses of long-lived trees of Bosnian pine that grows at higher altitude limit of the Monte Pollino and Serra Dolcedorme (Pollino National Park, Southern Italy). We used the dendrochronological method to measure both ring-width and wood anatomical parameters. Dendrochronological results show that the reduced growth rates promote the longevity of Bosnian pine. Despite their old age, trees do not show a growth decline, but an increasing trend of growth in the last decades. The recent positive growth trend represent an important deviation from the sigmoid model of tree growth. A positive correlation has been obtained by comparing the growth of trees, in terms of basal area increment (BAI), and the trend of temperature measured in the last 150 years. It follows then an absence of the tree growth reduction in the oro-Mediterranean pine forests in response to global warming. The same comparison has been carried out using the main wood anatomical parameters (e.g. lumen area, lumen diameter) which point out a strong relationship with climatic trend. The Bosnian pine behavior in relation to temperature variations allowed to investigate the climatic events which characterized Mediterranean region in the last decades and it represents an effective indicator of the current climate change. Furthermore, this study underlines the remarkable acclimatization and resilience of the pioneer Bosnian pine, which makes it suitable for forest restoration of mountain Mediterranean degraded areas. In the context of mitigation strategies for carbon sequestration, restored Bosnian pine stands, thanks to the high tree longevity of the species, will sequester carbon for centuries.

Analysis vegetation of *Juniperus oxycedrus* subsp. *badia* microforests in the Iberian Peninsula: increasing their knowledge for a better restoration

Carmelo Maria Musarella[1]*, Ana Cano Ortiz[2], José Carlos Piñar Fuentes[2], Sara Del Río[3], Carlos José Pinto Gomes[4], Giovanni Spampinato[1] & Eusebio Cano[2]

[1]Department of AGRARIA - "Mediterranea" University of Reggio Calabria, Loc. Feo di Vito, 89122 Reggio Calabria, Italy.
[2]Department of Animal and Plant Biology and Ecology, Section of Botany - University of Jaén, Campus Universitario Las Lagunillas s/n - 23071 Jaén, Spain.
[3]Department of Biodiversity and Environmental Management (Botany), Faculty of Biological and Environmental Sciences - University of León, Campus de Vegazana s/n, E-24071, León, Spain.
[4]Department of Landscape, Environment and Planning; Institute for Mediterranean Agrarian and Environmental Sciences (ICAAM); School of Science and Technology - University of Évora, Rua Romão Ramalho, nº 59, P-7000-671 Évora, Portugal.
* Corresponding author: carmelo.musarella@unirc.it; Phone: +39 09651694374

Keywords: Junipers*, conservation, edaphoxeric conditions, restoration, livestock.*

Juniperus oxycedrus L. is widely distributed throughout the Mediterranean region. In the Iberian Peninsula three subspecies are recognized: subsp*. macrocarpa* (Sm.) *Ball* on coastal sandy dunes, subsp. *badia* (H. Gay) *Debeaxu* and subsp. *oxycedrus* in internal territories.

Our studies show that the latter two subspecies grow on hard substrates, both acidic and basic, and they coexist in the same territories. Communities of *J. oxycedrus* subsp. *badia* occur in a wide territory in the centre and south of the Iberian Peninsula, prefer rocky substrates and are favoured by forest fires and more xeric environments. These communities host many endemic species that are important for biodiversity conservation.

The study highlighted several types of plant communities linked to different ecological conditions. Many of these communities are significantly degraded. The current grazing management is leading to a reduction of these communities. High livestock pressure of cervids and lagomorphs increases the content of organic matter: all this causes an involution of this vegetation type. However, only a grazing control it is not sufficient and other measures must be taken for forest restoration. When xericity of substrate is changed, *Pinus halepensis* , *Quercus rotundifolia* and *Quercus coccifera* compete with *Juniperus oxycedrus.* Therfore, selective cuts could be planned to enhance juniper wood, following forest restoration patterns proposed by Valle & al. (1990: 1ª Reunión sobre el Medio Ambiente en Andalucía.) and Cano & al. (1994: Naturalia Baetica 6: 7-112). They propose a dynamic pattern based on a first diagnosis of: initial vegetation stages, objectives pursued, methods of management and actions. This pattern allows to get the final stage which is a plant community of *Juniperus oxycedrus* subsp. *badia* with an edaphoxerophylous character.

Strategies for the re-naturalization of reforestation: the case study of the Sicilian clay hills

Tommaso La Mantia[1], Donato Salvatore La Mela Veca[1], Giulia Casamento[2], Angelo Dimarca[2], Giuseppe Giaramida[2], Giovanni Landini[3], Giuseppe Pace[3] & Rafael Da Silveira Bueno[1]*

[1]Dipartimento Scienze Agrarie e Forestali, Università di Palermo, viale delle Scienze, Edificio 4, Ingresso H, Palermo, Italy.
[2]Legambiente Sicilia - Gestione Riserve Naturali, via Tripoli, 3, Palermo, Italy.
[3]Regione Siciliana, Dipartimento Sviluppo Rurale e Territoriale, Ufficio di Trapani, via Vallona, 6, Trapani, Italy.
* Corresponding author: rafaeldesilveirabueno@unipa.it

Keywords: Mediterranean reforestation, Eucalyptus *plantations,* Pinus *plantations.*

On the IX century there was a massive reforestation effort in Sicily aiming to contrast increasing hydrogeological problems. Most of these reforestation were made using conifers or exotic species, and despite the overall cover increase, nowadays several of these areas still remaining in the past regarding richness and density of natural regeneration. Our objective was to evaluate the effectiveness of a naturalization intervention in the Natural Reserve "Grotta di Santa Ninfa", located in western Sicily. The first step was structurally characterize the 30 year eucalyptus reforestation, composed by *Eucaliptus camaldulensis*. The sampling areas consisted of circular plots ranging from 567 m^2 up to 1270 m^2 and densities ranging from 238 up to 673 trees ha^{-1}. Moreover, all woody plants of other species were identified and quantified. In winter, after the characterization, within sampling area, all eucalyptus trees were cut and 904 seedlings from 18 species were planted along the cleared areas. Each seedling was classified accordingly to its general integrity before planting. The first verification of planting success was made after 5 months, and was registered an average mortality of 6%, with species specific mortality ranging from 0% up to 33.3%. One year later another verification was made, and the average mortality reached 52.6%, ranging from 11.1% up to 90%. The negative initial conditions of the seedlings were positively correlated with post plantation mortality, demonstrating that for some species there is low probability of correcting initial problems like inappropriate size, age or deformations of the root system. The low density of natural regeneration demonstrating that in some areas active interventions are needed to enhance the naturalization speed of reforested areas. Results of this test together with results of previous tests at Santa Ninfa provide important information on ways to proceed with the re-naturalization of reforestation in Sicily.

Genetic variability of Austrian pine (*Pinus nigra*) seedlings in response to water deficit and its important to reforestation in arid terrain

Vasilije Isajev[1]*, Milan Mataruga[2]*, Rakonjac Ljubinko[1], Vera Lavadinovic[1] & Aleksandar Lucic[1]

[1]Institute of Forestry, Kneza Viseslava 3, Belgrade, Serbia.
[2]Faculty of Forestry, University of Banja Luka, Bulevar Vojvode Stepe Stepanovica 75a, Banja Luka, Bosnia & Herzegovina.
* Corresponding author: veralava@eunet.rs; Phone: +381113553454

Keywords: indicators of drought, Pinus nigra*, properties of seedling.*

Knowledge of genetic adaptation to environmental factors can help develop strategies for successful reforestation in arid terrain. In this study, Austrian pine (*Pinus nigra* Arnold) seedlings grown from seed collected from 40 open-pollinated families from five Balkan Peninsula provenances were evaluated for survival and growth under imposed drought. Within each provenance, seed was collected from an extremely harsh habitat and from a favorable habitat. One-year-old seedlings, from each provenance, habitat type and open pollinated family were transplanted into three "stress-beds", each designed to simulate different levels of water availability by filling with varying ratios of crushed stone and soil. Seedling height growth and survival were recorded every 20 days from April-September. In all provenances, seedlings grown from seed originating from the harsh habitats had lower survival regardless of stress-bed treatment compared to those grown from seed collected from favorable habitats. Cluster analyses of survival data showed that populations from a similar habitat generally grouped together, regardless of provenance. The lowest and highest survival values were found in seedlings from harsh habitats, while those from the favorable habitats clustered in the mid-range. These results suggest that higher seed quality from productive stands may be the most influential factor determining seedling vigor under drought stress and that genetic adaptation to drought was not detected in adjacent populations having different habitat conditions.

In defence of biodiversity and Mediterranean landscape: the "Carta dei Comuni custodi della macchia mediterranea"

Aurelio Angelini[1], Francesco Cancellieri[2], Renato Carella[3], Giuseppe Lo Paro[4], Vincenzo Piccione[5], Francesco Maria Raimondo[6] & Salvatore Scuto[7]

[1]Department of Architecture, University of Palermo, viale delle Scienze, Ed. 14, 90128 Palermo, Italy.
[2]Associazione Centro Educazione Ambientale (CEA) Messina onlus - c.da Castellaccio Le Terrazze snc - 98122 Messina, Italy.
[3]Associazione Ramarro Sicilia, Via A. Ferrari 2, 95041 Caltagirone, Italy.
[4]Department CHIMBIOFARAM, University of Messina, via Stagno d'Alcontres, 98166 Messina, Italy.
[5]Department of Biological, Geological and Natural Sciences, University of Catania, via Longo, 95100 Catania, Italy.

[6]Department STEBICEF/Section of Botany and Plant Ecology, University of Palermo, via Archirafi 38, I-90123 Palermo, Italy.
[7]Soprintendenza per i Beni culturali e ambientali di Caltanissetta, Caltanissetta, Italy.
* Corresponding author: aurelio.angelini@libero.it

Keywords: Mediterranean maquis, nature protection, municipalities, Sicily.

In Sicily, the "macchia mediterranea" extending 110,000 hectares, i.e. 21% of the whole woody area, is the most emblematic and representative plant coenosis. In the world, it is also an important biodiversity reserve because, in front of its low territorial extention - just 2% - the macchia, together chaparral, fymbos and other similar coenoses, includes more than 20% of total plant and animal species to date observed.

The charter of guardian municipalities of Mediterranean maquis was conceived by a group of Sicilian scholars and environmentalists for years engaged in the protection of nature. The goal is to form a network of municipalities that become "guardians" of the Mediterranean maquis, committing to develop programs to protect the rich naturalistic heritage present in Sicily. The safeguard comes from the need to make a prevention sylviculture to stop the anthropic exploitation, the land consumption, contrast the fires, mainly arsons, abuses related to pasture and to incompatible uses with the preservation of its landscape and biodiversity. To date, 30 municipalities have decided to adhere to the project. Among them, there are Caltagirone – the place of the first presentation of the project and signing of the first 11 adhesions – Bagheria, Buccheri, Caltanissetta, Comiso, Gela, Messina, Palermo, Palazzolo Acreide, Syracuse, etc. Other 10 municipalities have ongoing the deliberative acts for their adhesion; among them, Catania.

This is an initiative destined to cross the regional borders and it has already generated interest also in other municipalities of southern Italy and Sardinia.

In addition to the text of the project and the overview of the potential and real extension of the Mediterranean maquis in Sicily, the relevant plant associations, a summary of the main floristic prominences, as well as the mapped role as an important factor with respect to mitigation and resilience to climatic changes (drought and desertification) are presented. Moreover, the list of participant municipalities and the graphical representation of the areas of their respective competence are reported. The list of the events organized by the promoting group for the diffusion of the project and for public awareness complete the presentation.

Vegetation dynamics within afforested coastal areas: regeneration by native species or invasion by alien species?

Emilio Badalamenti[1]*, Olimpia Campo[2], Rafael Da Silveira Bueno[1], Martina Gallo[1], Donato Salvatore La Mela Veca[1], Salvatore Pasta[3], Giovanna Sala[1] & Tommaso La Mantia[1]

[1]Università degli Studi di Palermo - Dipartimento SAF, Viale delle Scienze, Palermo, Italy.
[2]Dipartimento Regionale dello Sviluppo Rurale e Territoriale, Viale Regione Siciliana, 4600 – 90145 Palermo, Italy.
[3]Université de Fribourg - Departement de Biologie, Chemin du Musée, 10, Fribourg, Switzerland.
* Corresponding author: emilio.badalamenti@unipa.it; Phone: +39-3291078849

Keywords: Mediterranean and dune ecosystems, Acacia saligna*, forest Management,* Pinus pinea.

During the last century, massive reforestation projects along dunes of the southern Sicily have been carried out. Such interventions, far from being in line with current trends of close-to-nature silviculture, are, however, particularly interesting to assess vegetation dynamics in afforestation areas. Our research was conducted within "*Foce del Fiume Platani"* Oriented Natural Reserve, where afforestation interventions were carried out in the second half of the last century. The study area is now affected by substantial renaturalization processes, also as a consequence of the selective thinning performed in time. Such interventions aimed at reducing the density of dominant canopy species, mainly *Pinus* sp.pl. and *Acacia saligna* (Labill.) H.L. Wendl., while fostering the spread and establishment of native woody species. However, *Acacia*, a well recognized invader of Mediterranean-type ecosystems, started to reproduce naturally and quickly spread in the understory. The dynamics of woody vegetation within *Pinus pinea* L. afforestation were evaluated by comparing results of surveys carried out in 2001 with new surveys carried out on January 2017 over three 441 m^2 square plots. *Acacia* density has more than quintupled in just sixteen years, reaching 10,800 individuals per hectare. However, native species such as *Pistacia lentiscus* L. and *Olea europaea* var. *sylvestris* Mill. also displayed a notable density increase. *Pistacia* density increased up to 6 times, reaching a maximum density of 9,700 individuals per hectare, whereas *Olea* density increased as much as 800 times, with a maximum density of 120,000 individuals per hectare. Canopy cover was one of the main factors explaining the observed pattern. This study case may be emblematic for the management of afforested area in the Mediterranean where thinning aimed at favoring the renaturalization by native woody species could trigger the possible spread of invasive alien species that may counterbalance positive effects of necessary interventions.

Nuclear and chloroplast variability of *Ulmus laevis* populations near Belgrade (Serbia): prospects for conservation

Jovana Devetakovic[1]*, Vladan Ivetic[1], Mirjana Tihomir Šijačić-Nikolić[1] & Jelena M. Aleksic[2]

[1]University of Belgrade - Faculty of Forestry, Kneza Viseslava 1, Belgrade, Serbia.
[2]University of Belgrade - Institute of Molecular Genetic and Genetic Engineering, Vojvode Stepe 444a, Belgrade, Serbia.
* Corresponding author: jovana.devetakovic@sfb.bg.ac.rs

Keywords: Ulmus laevis*, genetic variability, nuclear microsatellites, chloroplast DNA, conservation.*

European white elm (*Ulmus laevis* Pall.) is a broadleaved deciduous tree found at riparian habitats across central and Eastern Europe. However, it is nowadays considered as a rare and endangered species in Europe because of the habitat destruction and detrimental effects of the Dutch elm disease. Its conservation is urgent, and such actions require knowledge on genetic status of remnant populations. Although European white elm populations from Europe have been studied genetically, knowledge on levels of genetic diversity and genetic structure of populations from the Balkans is still lacking. We genotyped

93 trees from two neighboring populations of European white elm found on river islands near Belgrade, Serbia (Sava and Danube rivers) using nuclear microsatellites (nSSRs) and chloroplast DNA (cpDNA) non-coding regions. Out of the ten tested nSSRs, only two were successfully amplified. Levels of nuclear genetic diversity were high in both populations (He > 0.555) and comparable to those observed in populations from the Iberian Peninsula and central and western Europe. Two populations, distant c. 5 km, were not genetically differentiated (Fst = -0.0062) due to the extensive gene flow (Nm = 27.72 migrants per generation). They did not experience recent bottlenecks, and their effective population sizes were 48 and three. However, contrary to previous reports on low levels of cpDNA diversity in European white elm, our preliminary results (based on the analysis of eight cpDNA regions of which four were successfully amplified in four individuals) demonstrate that variability is present in the *rps*16 - *trn*K region, while a duplication of a 4 bp motif in *trn*L - *trn*F region may be used for distinguishing diploid and triploid individuals (these considerations, however, require further analyses). In conclusion, both studied European white elm populations are good candidates for *in situ* conservation, and further studies of the cpDNA variability of this species may be promising.

Production of European beech cultivars by grafting on different rootstocks

Marina Zeljko Nonić* & Mirjana Tihomir Šijačić-Nikolić

University of Belgrade - Faculty of Forestry, Kneza Viseslava 1, Belgrade, Serbia.
* Corresponding author: marina.nonic@sfb.bg.ac.rs; Phone: +38163551581

Keywords: Fagus sylvatica*, European beech cultivars, grafting, nursery production, planting material.*

European beech (*Fagus sylvatica* L.) is one of the main species in deciduous forests in Europe, which is widespread - from Sicily in Southern Italy to Bergen in Southern Norway. Along with its significance as a forest species, European beech is renowned due to its numerous cultivars, which are planted and well adapted in various green spaces. This research was performed in order to improve the production of planting material of ornamental beech cultivars, which could be grown in urban park-forests and other green spaces. Beech seedlings of different ages from natural offspring and seedlings produced in the nursery, originating from four populations in Serbia, were used as rootstocks for grafting. Three rootstocks types were used: rootstocks directly produced and planted in nursery beds, rootstocks in containers and bare root rootstocks. Scionwoods were collected from ten adult trees: three ornamental beech cultivars (*Fagus sylvatica* 'Purpurea', *Fagus sylvatica* 'Tricolor' and *Fagus sylvatica* 'Purpurea Tricolor') and one Moesian beech from Serbia (Belgrade area). Grafting was done in the nursery of the Faculty of Forestry, in 2011 and 2013. Two methods of copulation were applied - splice grafting and wedge grafting. After grafting performed in 2011, using rootstocks in containers, a high grafts success rate (70-80%) was noted, but the percentage of survival at the end of the first year was lower (30-60%). In the case of grafting on rootstocks which have been produced directly in the nursery beds, the average success of survival was 58.9% at the end of 2011, and constantly kept the value of >50% in the next three successive years. Grafting on bare root rootstocks originating from the nursery and natural offspring did not show satisfactory results, as low survival rates (<40%) were noted. Conducted research confirms the importance of appropriate choice of grafting components, which is, along with their genetic similarity, an essential precondition for the successful production of European beech cultivars.

Online survey on forest adaptation and restoration under global change - an approach to gathering expert knowledge and local experiences worldwide

Markus Hoehl* & Andreas Bolte

Thünen Institute of Forest Ecosystems, A.-Möller-Str. 1, 16225, Eberswalde, Germany.
* Corresponding author: markus.hoehl@thuenen.de; Phone: +49 3334 3820-364

Keywords: forest adaptation, forest restoration, best practices, online survey.

Climatic and societal changes affect forest ecosystems and confront forest managers worldwide with the challenge to increase the adaptive capacity of forests. However, sound management decisions have to be information-based, therefore the compilation of expert knowledge on local experiences with forest adaptation and restoration under global change from all parts of the world will form a profound basis for decisions on the local, regional, and international level. Both forestry practitioners and decision makers can use this information in order to develop best practice approaches that can support decision-making processes.

For this purpose, we present a novel online survey approach that gathers information on real world forest adaptation and restoration projects. This includes fundamental data on location, environmental- and forest conditions, management regimes, and actors. Furthermore, in-depth information on the targets, implementation, and success factors of the forest adaptation and restoration activities in the face of climate- and societal change will be gathered to form the basis for developing best practice approaches. The online survey is designed for multilingual use and collects standardized data that is stored in a spatial database to facilitate global application, regionalized analysis of results, and the integration with additional geodata. This survey is a core activity within the IUFRO Task Force *Forest Adaptation and Restoration under Global Change* and the presentation will introduce our approach to global information gathering.

We expect to motivate attendees to participate, give feedback, and learn about our research activities but also to induce new ideas for their own projects regarding the use of surveys for information gathering.

Is the use of seeds for the restoration of the Grecian juniper wood (*Juniperus excelsa*) stands in the Prespa National Park a good practice?

Giorgos Varsamis[1], Petros Kakouros[2]*, Annita Logotheti[3] & Theodora Merou[1]

[1]Forestry Department, TEI EMT, 1st km Drama-Mikrohori, 66100, Drama, Greece.
[2]Greek Biotope/Wetland Centre, 14th km Thessalonikis-Mihanionas, PO Box 60394 57001 Thermi, Thessaloniki, Greece.
[3]Society for the Protection of Prespa, Agios Germanos, 53077, Prespa, Greece.
* Corresponding author: petros@ekby.gr; Phone: +302310473320

Keywords: Juniperus excelsa*, seeds, Prespa National Park, JunEx, old growth forests.*

Greek juniper (*Juniperus excelsa* M. Bieb.) is distributed from Albania to Western India and from the Arabian Peninsula (Oman) to Kyrgyzstan and Ukraine. In Greece, it is located in Western Macedonia, at Nestos Gorge, in various locations of Eastern Rhodope and on the islands of Thasos, Samos and Evia. In several of these locations, it forms stands of the priority habitat type "Endemic forests with *Juniperus* sp." 9560. The oldest and more extensive area of this habitat type in Greece is located in Prespa National Park (PNP) at the borders with Greece, FYROM and Albania. This habitat type is gradually degrading due to the abandonment of grazing and to the dominance of highly competitive broadleaved species that suppress the Juniper trees and reduce natural regeneration. One of the restoration measures implemented in PNP, under the EU LIFE- Nature project (LIFE12 NAT/GR/539 - JunEx) was direct sowing of pre-treated seeds. The seedling survival was measured both in the laboratory and in the field. In the laboratory 5 months after germination, 15% of the seeds survived. In the field, one year after plot installation alive seedlings were found in 3% of the 5,000 plots. placed. Taking into account that a) in the 2,192 ha of the habitat type at PNP, natural regeneration has been recorded as almost absent and b) *Juniperus excelsa* seeds collected from PNP hold 95% empty or damaged embryos, while only 1.75 to 5% of the embryos have been shown to be viable, the use of pre-treated seeds as a restoration measure for the Juniperus stands (*Juniperus excelsa*) should be considered as a good practice.

Dynamics and vulnerability of a mountain forest ecosystem: case of the cedar forest of Tikjda (Djurdjura National Park, Algeria)

Rachid Meddour*, Radia Larbi & Ouahiba Meddour-Sahar

Université Mouloud Mammeri, Hasnaoua 2, BP 17 RP, 15000 Tizi Ouzou, Algeria.
* Corresponding author: rachid_meddour@yahoo.fr; Phone: +213 790159376

Keywords: dynamics, anthropogenic pressure, Cedrus atlantica*, restoration, Algeria.*

The authors aim to study the dynamics of vegetation and to estimate the intensity of anthropogenic disturbances in a mountain forest ecosystem, classified as a protected area (national park and biosphere reserve).
This study was carried out at the level of 5 forest fragments, distributed over an altitudinal amplitude of 1300 to 1800 m, of the Tikjda cedar, located on the southern slope of Djurdjura. The floristic, ecological and structural elements of this cedar tree were analyzed by the realization of 90 floristic surveys (plots of 100 to 200 m²), according to the phytosociological method and a structural and dynamic approach of the stand by

the measurement of the dbh and the height (40 plots of 400 to 500 square meters). Results revealed the presence of six forest species with dominance of *Cedrus atlantica* (average density of 230.81 trees/ha, height ranging from 2.7 to 21.7 m) and *Quercus rotundifolia* (mean density of 55.23 individuals/ha, height from 4 to 11 m). Other high woody species (*Pinus nigra* subsp. mauretanica, *Juniperus oxycedrus*, *Taxus baccata*, *Acer obtusatum* and *Ilex aquifolium*) have densities of 21 stems or less per hectare. On the other hand, 33% of survey sites are subjected to overgrazing of medium or high intensity, 39% to medium or high intensity woodcutting and 17% to pollution of medium or high intensity. In post-fire forest fragments, fire intensity was generally estimated to be nil or low for 88% of the plots surveyed.
These various anthropogenic disturbances on natural environments result in the massive destruction of ecosystems, in particular forests, of the national park of Djurdjura. A medium-term plan for the ecological restoration of the Tikjda forest must be undertaken in order to restore this degraded forest to its natural state.

Effects of soil and plant species competition on sward restoration and plantations eight years after restoration

Sara Martelletti[1]*, Fabio Meloni[1], Renzo Motta[1], Michele Lonati[1], Marco Pittarello[1], Michele Freppaz[1], Andrea Paone[1], Massimiliano Ferrarato[2] & Antonio Nosenzo[1]

[1]University of Turin - Department of Agricultural, Forest and Food Sciences, Largo Paolo Braccini, 2 -10095 Grugliasco (TO), Italy.
[2]Regional Agency for Protection of the Environment - Department of Geology and Geological Instability, Via Pio VII, 9 - 10135 Turin, Italy.
* Corresponding author: sara.martelletti@unito.it; Phone: 0039 011 6708865

Keywords: sward restoration, plantation, anthropogenic soils.

The construction and the use of infrastructures (e.g. high-speed railways) entail the loss, the fragmentation and the degradation of habitats. However, these facilities are crucial connector between countries and they will be implemented to meet human needs. As required by the current environmental regulation, environmental compensations have to be achieved to mitigate the ecological impacts. Sward restoration and plantations represent two compensation practices largely adopted, but the operation success rarely is monitored in the medium-term period.

In 2014, we assessed the effectiveness of sward restoration and plantations, eight years after their implementation, by considering pedological factors and competition among plant species. The research took place in northwestern Italy, in 32 areas set along a segment of the "Mediterranean Corridor", a high-speed railway that will link the Iberian Peninsula with the Hungarian-Ukrainian border. We collected data on herbaceous vegetation (e.g. cover of sown, non-sown, exotic and ruderal species), tree growth and soil (e.g. physical and chemical parameters).

In general, in eight years, sward restoration was satisfying. Herbaceous cover was always higher than 60 % with sown species that prevailed over non sown ones and perennial species that prevailed over annual ones. Moreover sown species limited exotic and ruderal ones ($p<0.05$). On the contrary the mean height of trees and shrubs indicate a very slow growth rate affected above all by harsh soil conditions.

Even if sward restoration was successful, these degraded areas are not completely restored, in spite of high costs of the projects. Anthropogenic soils with low organic matter content and high compaction, questionable planting techniques and lack of monitoring are among the main causes of partial failure. Therefore there is the need to look for new planting and site preparation methods, which will improve the success of restoration, and to monitor restored areas in the medium long-term period to confirm the suitability of applied techniques.

Woodlands of Sicily: biodiversity, conservation and future perspectives

Saverio Sciandrello[1]*, Salvatore Brullo[2], Pietro Minissale[2], Carlo Prato[1], Giovanni Signorello[1], Giovanni Spampinato[3] & Gianpietro Giusso Del Galdo[2]

[1]Centre for the Conservation and Management of Nature and Agroecosystems (Cutgana), University of Catania, via S. Sofia 98, 95123 Catania, Italy.
[2]Department of Biological, Geological and Environmental Sciences, University of Catania, via A. Longo 19, 95125 Catania, Italy.
[3]Department of Agriculture, Mediterranean University of Reggio Calabria, Feo di Vito, 89122 Reggio Calabria, Italy.
* Corresponding author: sciandrello.s@hotmail.it

Keywords: floristic composition, ecology, fragmentation, altitudinal range.

Mediterranean woodlands are dynamic and complex ecosystems, able to provide a wide range of environmental and socio-economic benefits. Sicily is the biggest Mediterranean island and, due to its long-lasting human influence and to the high variability of environmental features, represents one of the most important center of plant diversity in the whole Mediterranean area. For millennia, Sicily has been subjected to human pressure which severely modified, fragmented and destroyed the pristine forest landscape. Sicily occupies an area of about 25,700 km^2 with only 2,215 km^2 (8% of the total regional land) covered by natural woodlands, to which 850 km^2 of tree plantations have to be added. Main objectives of this research are to: 1) identify and quantify the natural wood plant communities occurring in Sicily, 2) analyze their floristic composition, ecology, chorology and conservation status, 3) defining their altitudinal range, 4) evaluate their degree of fragmentation, and lastly 5) their future perspectives, especially in terms of conservation and management of the most threatened ones.

Our study, based on literature and field surveys and supported by GIS analyses, shows: a) high diversity of woodland types represented by climatophilous plant communities (*Quercetea Ilicis* and *Querco - Fagetea sylvaticae*), edapho-xerophilous plant communities (*Cisto-Lavanduletea* , *Junipero-Pinetea sylvestris*), and edapho-hygrophilous plant communities (*Nerio-Tamaricetea*, *Salici-Populetea nigrae*); b) which are the most important environmental factors explaining such diversity; c) how much of the Sicilian woodlands falls within N2000 network, Regional Parks or Nature Reserves; and lastly d) their fragmentation degree. Given the current woodland cover, species composition, conservation status and fragmentation, it would be desirable to implement action plans aiming at preserving the extant natural forests and, most important, at renaturalizing the artificial plantations.

Restoration practices in Mediterranean habitats using native woody species

Tommaso La Mantia[1]*, Mario Azzarello[1], Emilio Badalamenti[1], Angelo Dimarca[2], Domenico Fontana[2], Daniele Gucciardo[2], Salvatore Livreri Console[3], Elena Prazzi[2], Salvatore Tirrito[1] & Paola Quatrini[1]

[1]Università degli Studi di Palermo, viale delle Scienze Ed. 4, Palermo, Italy.
[2]Legambiente Sicilia - Gestione Riserve Naturali, via Tripoli, 3, Palermo, Italy.
[3]Area Marina Protetta "Isola di Ustica", via Petriera snc, Ustica, Italy.
* Corresponding author: tommaso.lamantia@unipa.it

Keywords: biodiversity, protected areas, management, microbial inoculation.

Since the beginning of the XXI century, Legambiente, supported by the University of Palermo, has launched several naturalization actions within Sicilian natural reserves (NR). Interventions were carried out on bare lands with the aim to restore native woody vegetation. Differently from the classical approach, consisting in the use of preparatory species usually Pines, in our approach, native shrubs and trees were used. In the NR "*Isola di Lampedusa*", once widely covered by woodlands and now almost desertified, a massive intervention planted 4000 plants belonging to 43 taxa (including *Periploca angustifolia* and *Pistacia lentiscus*). The combination of bio-engineering techniques and the use of local genotypes led to a significant increase in vegetation cover and reduction of erosion. The NR "*Lago sfondato*" (Cl) was established to preserve a peculiar karstic lake and the surrounding vegetation, hosting a number of species of conservation value, including many orchids. Interventions aiming at restoring natural woody vegetation were carried out with native species. The NR "Macalube di Aragona", a small reserve with great environmental value and high biological diversity, was intensively impacted by intensive farming and grazing. One of the main results of the interventions here was the restoration of *Lygeum spartum* perennial grassland, a species-rich vegetation providing notable protection against soil erosion. The re-establishment of prairies is the first step to create conditions to establish woody species. In all NR, woody plants were inoculated with symbiotic microrganisms (plant growth promoting bacteria and mycorrhizal fungi) enhancing their chance of survival and establishment after transplanting. Moreover seeds of woody legumes, were also inoculated with selected nitrogen fixing rhizobia. Such interventions suggest that the use of native species, especially local genotypes, should be the best way to restore native Mediterranean habitats, where specific propagation techniques are also recommended.

The forest portal of Majella National Park

Teodoro Andrisano

Majella National Park Authority. Badia Morronese, Via Badia 28 – 67039 Sulmona (Aq), Italy. E-mail: teodoro.andrisano@parcomajella.it

Keywords: innovative information tool, forest portal, Majella National Park, WebGIS, forest restoration.

Innovation in forest restoration does not need of new technological equipment and of new methods of intervention on field.

Even an innovative information tool can effectively contribute to the work of the planners.

The forest portal of Majella National Park is an informatics tool born to support the authorization procedures management in the silvicultural field in the National Parks and it is a new tool for Italy that can support also the plan of restoration work in the protected area.

The system architecture consists of four general interdependent areas:

- authorization procedure of interventions;
- plan technical support;
- WebGIS and associated database;
- Statistics and ecosystem services secured from the forests.

The WebGIS database consists of many maps (orthophotos; topographic, geological, soil and landscape map; Regional Landscape Plan) and georeferenced layers (Digital Terrain Model, slope, exposure, inclinations, land cadastre, toponymy, road network, paths and fruition facilities, skiing, forest categories, forest types, monumental trees and forests, fires, geological constraint, the Official List Protected Areas, park zonation, SIC and ZPS, habitat Directive, grid protected species and forest parcel of management plans).

Technical support provides a single cartographic open source platform, the traditional layers, the information contained in the plans (e.g. forest parcel of management plans and also copies of forestry projects and plots), layers and naturalistic/environmental information (e.g. habitats map and grid of presence of flora and fauna protected species, for each ones predictions of the SIC and ZPS Management Plan are detailed).

The information and the data produced by the projects and the actions taken, are used by the system, after their approval, to update automatically cartographic, territorial and natural layers, and the data contained in the databases.

Synchronized masting across Atlas cedar forest patches of the Djurdjura

Nadia Abdelkrim[1], Fazia Krouchi[1], Yassina Amirat[1], Francois Lefevre[2], Djaffer Aitsidhoum[1], Federico Vessella[3] & Arezki Derridj[1]

[1]Faculty of Biological &Agronomic Sciences, UMMTO, BP 17 RP 15000 Algeria.
[2]INRA, UR 629 Ecologie des Forêts Méditerranéennes, URFM Domaine Saint Paul, site AgroParc, 84914 Avignon Cedex9 – France.
[3]Department of Agricultural and Forestry Science (DAFNE),Università della Tuscia, Via S. Camillo de Lellis, snc, 01100 - Viterbo, Italy.

* Corresponding author: krfaz@yahoo.com

Keywords: Cedrus atlantica*, synchronization, reproductive effort, cones, regeneration, Djurdjura.*

Cedrus atlantica is a major tree species on high elevations of Saharan and Tellian Atlas in Algeria. Its regeneration relies exclusively on seeding. Therefore, periodicity and importance of reproductive events play a key role in such process. The reproductive potential of the species regarding seed production and germination capacity as well year to year variation in reproductive efforts at a local scale are documented in previous studies but synchronization in reproductive events across distant stands is less documented.

Here we investigated the reproductive output of the species across cedar forest patches of the Djurdjura mountain, including the most distant ones (Azroun'thor and Tala-guilef) over a linear distance of 36kms, on the northern side, as well as a southern forest patch (i.e.Tikjda) at an intermediate position between the two previous ones along the mountain chain.

Cone records were made for two consecutive years (2014 and 2015) on 16 plots of 25x25m or 25x50m each. At Tikjda and Azro'nthor, only two plots were sampled per site. At Tala-guilef, 12 plots were considered across a distance of 4kms covering different situations of cover, slopes and elevation. Tree size parameters (total tree height and DBH, height and diameter of the crown) were associated to such records.

Results suggest a general trend consisting in a synchronized effort across stands a given year, resulting in alternatively good and low seeding years in combination with a within-stand variation explained only partially by tree size. The synchronization observed across this mountain may be driven by an extrinsic factor (i.e. climate), but inference of climatic influence on such trend may only rely on extrapolated data from neighboring sites in the absence of on-site meteorological stations. The present investigation across a single mountain could gain in accuracy through a long term survey of the same sites. It may also be extended to other ranges of Atlas cedar in Algerian for a deeper understanding of the regeneration processes and its driving factors.

Analysis of the influence of the silvicultural treatments on ecosystem services in black pine (*Pinus nigra*) stands in Central Italy

Paolo Cantiani[1]*, Isabella De Meo[2], Alessandra Lagomarsino[2], Maurizio Marchi[1] & Alessandro Paletto[3]

[1]CREA SEL, viale Santa Margherita 80, Arezzo, Italy.
[2]CREA ABP, via di Lanciola 12/A, Firenze, Italy.
[3]CREA MPF, Viale Nicolini 6, Villazzano (TN), Italy.
* Corresponding author: paolo.cantiani@entecra.crea.gov.it; Phone: 3478825826

Keywords: selective thinning, Pinus nigra*, forest multifunctionality, Tuscany region.*

Ecosystem services are considered the conditions and processes through which natural ecosystems sustain and fulfill human life. According to the Millennium Ecosystem Assessment (2005) ecosystem services can be classified in four main categories: provisioning, regulating, cultural, and supporting services. Concerning forests ecosystem services, their provision is influenced by site and stand characteristics and forest management practices.

The aim of the present study is to analyze the ecosystem services provided by black pine stands under different silvicultural treatments. In order to analyze the influence of silvicultural treatments on the relationships between ecosystem services, three stands located in Central Italy were chosen. These forests have been established in the sixties of twentieth century for protection purpose but not managed during the rotation period. The study areas are characterized by a similar genesis but a different current structure and future perspective. In order to enhance the multifunctionality of these forests two different silvicultural treatments (selective and traditional thinning) were applied. While the traditional thinning consists in a classical thinning from below, the selective is a localized action performed on the most promising trees per hectare, characterized by easy applicability and replicability. The innovative thinning was applied to compare its effects (economical, ecological and social) with the traditional thinning and with unmanaged areas.

Five main ecosystem services were selected and assessed: timber and bioenergy production, climate change mitigation, hydrogeological protection and biodiversity conservation. For each silvicultural treatment the biophysical assessment of selected ecosystem services was performed by using primary data and calculating one or more indicators ecosystem services. First results highlight that selective thinning enhances the majority of ecosystem services compared to the traditional thinning which has a positive influence on some components of the biodiversity.

The role of forest management practices to increase the provision of forest ecosystem services: the experiences of two LIFE projects in Central Italy

Elisa Bianchetto[1]*, Paolo Cantiani[2], Ugo Chiavetta[2], Isabella De Meo[1], Alessandra Lagomarsino[1], Alessandro Paletto[3], Stefano Mocali[1], Silvia Landi[1] & Elena Salerni[4]

[1]Council for Agricultural Research and Economics, Research Centre for Agrobiology and Pedology (CREA-ABP), via di Lanciola, 12/a - 50125 Firenze, Italy.
[2]Council for Agricultural Research and Economics, Forestry Research Centre (CREA-SEL), viale Santa Margherita, 80 - 52100 Arezzo, Italy.
[3]Council for Agricultural Research and Economics, Research Unit for Forest Planning and Monitoring (CREA-MPF), piazza Nicolini, 6 - 38100 Trento, Italy.
[4]Dipartimento di Scienze della Vita - Università degli Studi di Siena, via P.A. Mattioli, 4 - 53100 Siena, Italy.
* Corresponding author: elisa.bianchetto@crea.gov.it; Phone: +39 055 2492238

Keywords: black pine stand, forest management practices, thinning, Apennines, Tuscany region.

LIFE Projects SelPiBio (LIFE13 BIO/IT/000282 “Innovative silvicultural treatments to enhance soil Biodiversity in artificial black Pine stands”) and FoResMit (LIFE14 CCM/IT/000905 “Recovery of degraded coniferous Forests for environmental sustainability Restoration and climate change Mitigation”) are two Italian projects aimed at testing and verifying the effectiveness of forest management options on black pine stands in the Apennines

(Italy). The main objective of silvicultural treatments realized in the frame of both projects is to increase the provision of some ecosystem services (climate change mitigation, biodiversity conservation, soil protection, bioenergy and timber production) ensuring sustainable forest management. Study areas are located in Central Italy: two in the Apennines (Pratomagno and Val d'Orcia) and the third in the hill of the Florence town (Monte Morello). Forest stands are black pine plantations established throughout the Apennines after the Second World War with the purpose of re-establishing forest cover. Black pine stands already achieved the land restoration purpose and today silvicultural treatments have the aim to enhance forest multifunctionality, trying to balance various ecosystem services. Both projects are based on testing an innovative thinning (selective thinning) which seems to be one of the most promising and interesting approach for dense artificial plantations. The thinning is a localized action performed on the most promising trees per hectare, characterized by easy applicability and replicability and known to improve the mechanical stability of trees, the growth rates and the timber production in artificial black pine plantations in the Italian Apennines chain. Furthermore, this thinning is effective in increasing soil biodiversity and improving the ecological equilibrium and climate change mitigation potential of stands. Preliminary results show that the selective thinning increases the net primary production, contains GHG emissions from deadwood decomposition, and increases bioenergy production.

Protection and conservation of the manna ash landscape in Sicily

Pietro Mazzola[1]*, Francesco Maria Raimondo[2] & Vivienne Spadaro[2]

[1]Department of Agricultural and Forest Sciences, University of Palermo, via Archirafi 38, I-90123 Palermo, Italy.

[2]Department of Biological, Chemical and Pharmaceutical Sciences and Technologies (STEBICEF) / Section of Botany and Plant Ecology, University of Palermo, via Archirafi 38, I-90123 Palermo, Italy.

* Corresponding author: pietro.mazzola@unipa.it

Keywords: Fraxinus*, landascape management, green economy, relictual agriculture, Madonie territory.*

Known as manna ashes, some local varieties of *Fraxinus ornus* L. and *F. angustifolia* Vahl (*Oleaceae*) are cultivated for extracting the manna, a product rich in mannose which is useful under both pharmaceutical and nutraceutical aspects. As wild plants in Sicily these ashes participate in diversifying evergreen and deciduous oak woods as well as other forest communities at the watercourse borders, together with several species of *Salix*, *Populus* and *Ulmus*, particularly in the hills. Cultivation of manna dates back to ancient times in Sicily and elsewhere and ash groves were increasingly spread up to the half of last century. Then, the culture had a progressive decline due to the abandonment of land and its gradual replacement by other crops. Most of the surface formerly occupied by ashes is now uncultivated and therefore also exposed to recurrent fires. As a consequence even the rich varietal heritage, documented by detailed monographs, went partially lost, although recently have not missed a revival of the local scientific community.

In the face of the many thousands hectares occupied by these crops in the past, now residual plantations are confined in just a few hundred hectares in the territories of Castelbuono and Pollina (province of Palermo), in the northern side of the Madonie mountains. In this area the plant landscape had been strongly characterized by the ash groves, that besides acted an efficacious hydrogeological protection. At present, despite the progressive loss, the cultivation of manna ashes could still play an important role in the local economy. Therefore, in order to preserve all social, cultural and even biological values as well the landscape, it was proposed to establish a natural reserve of the manna ashes some decades ago; but that suggestion was later abandoned after the Madonie natural Park was estasblished. Nevertheless the Park has not, over the years, affected concretely the further abandonment of ash groves and the protection and conservation of the related landscape.

Recently, the Sicilian Regional government has adopted some measures aimed at supporting farmers for replanting ash groves: these are active conservation initiatives for the production of manna. Here we find it useful to propose even passive measures such as reforestation like those implemented elsewhere in the province of Palermo with good results for the environment and landscape. Other initiatives, that could not be postponed, concern vocational training as well as research and conservation of ash varieties germplasm to be grown in specific arboretums such as those already implanted in the fields of the agricultural schools at Castelbuono (Palermo) and Mussomeli (Caltanissetta) and in the experimental plantations at Sparacia (Caltanissetta), SAF Department of the Palermo University.

Sustainable use of Mediterranean forest resources: the collection and recycling of cork stoppers

Francesco Maria Raimondo*, Filippo Scafidi & Emilio Di Gristina

Department of Biological, Chemical and Pharmaceutical Sciences and Technologies (STEBICEF) / Section of Botany and Plant Ecology, University of Palermo, via Archirafi 38, 90123, Palermo, Italy.
* Corresponding author: francesco.raimondo@unipa.it; Phone: +39091623891243

Keywords: Quercus suber, *cork*, *botanical gardens*, *green economy, Mediterranean area.*

Among the organic materials produced by the forest plants, in addition to the wood for the various uses, the cork is mainly used to derive the stoppers for the bottling of wines and sparkling wines. The cork oak (*Quercus suber* L.) is the main source of production of this material. A close connection exists between the wine growing and distribution area of this forest species. Around the world - except the Islamic and underdeveloped countries - wine and therefore also cork is consumed. The intensive use of cork is causing the decline of the cork forest and its supply for the industry. In addition, the recurring fires and the decrease of forest areas by expansion of urban centers is involving the loss of product quality. A comparable example occurring in the cork oak Maamora forest (Morocco). In the past, the efforts promoting the recycling of cork stoppers to send to the industries for the production of new cork stoppers and especially of insulating panels, have been few. Collections for these purposes have been implemented in some northern regions of Italy. Some years ago, the first author, as president of the Italian Botanical Society, exhorted the directors of the botanical gardens to organize the recycling of cork stoppers as a way of self-financing of the activities of the same botanical gardens, using their equipments and volunteers; the citizens can contribute submitting to the botanical gardens the cork stoppers collected and stored. In Italy, due to the high consumption, it would be possible to recover a considerable amount of cork for the benefit of the perpetuation of a timeless winemaking tradition and therefore also safeguarding the small cork processing industries.

Forest restoration for disaster risk reduction. Success stories in Italy

Riccardo Boschetto[1], Carmela Cascone[1], Lorenzo Ciccarese[1]*, Piera Pellegrino[2] & Valerio Silli[1]

[1]Istituto Superiore per la Protezione e la Ricerca Ambientale, ISPRA, Roma, Italy.
[2]Sapienza Università di Roma, piazzale Aldo Moro 4, Roma, Italy.
*Corresponding author: lorenzo.ciccarese@isprambiente.it

Keywords: disaster risk reduction, resilience, ecosystem services, sustainable local development.

The UN adopted the Sendai Framework for Disaster Risk Reduction (2015-2030) aiming to "reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries". Among its priorities the one "Investing in disaster risk reduction for resilience" is related to ecosystem-based approach to disaster risk reduction and the enhancement of ecosystem functions.

Forest restoration, that has its major focus on restoring the relation between biodiversity and forest ecosystem functioning, may represents a key approach to mitigate risks related to natural disaster and to foster resilience of ecosystems post disasters, in natural and semi-natural habitats.

Advantages and benefits of Ecosystem-based Disaster Risk Reduction (Eco-DRR) measures include: (i) various effects becoming evident both at the time of disaster and during post-disaster rehabilitation period; (ii) effectiveness against various types of hazards; (iii) possible cost savings in initial investment and operation and maintenance using existing local natural resources; (iv) provide ecosystem services during non-disaster times; (v) involvement of local stakeholders. These advantages are emphasized by the 2030 Agenda for Sustainable Development and related sustainable development goals. In Italy, significant and replicable success stories show that Eco-DRR measures, aimed at strengthening the ecosystems' resilience and to the recovery of degraded areas, thus oriented to the biodiversity protection, are more effective and economically more affordable compared to the measures based on conventional and 'hard' structures. During the presentation we will introduce case studies of forest restoration initiatives in Italy with a DRR component. The case studies comprise establishment of short-rotation plantations on abandoned or degraded soils, tree plantings in secondary forests and other restoration projects based on controlling pressures (such as fires, invasive species, etc.) on forests.

Sentinel-2 imagery for mapping Cork oak (*Quercus suber*) distribution in Calabria (Italy): capabilities and quantitative estimation for forest restoration activities

Giuseppe Modica*, Angelo Merlino & Francesco Solano

Agriculture Department "Mediterranea" University of Reggio Calabria, 89122 Reggio Calabria (Italy).
*Corresponding author: giuseppe.modica@unirc.it

Keywords: Sentinel-2 (S-2), Landsat 8 OLI, Spectral signature, cork oak woodlands, Calabria (Italy), Red-edge position (REP).

The objectives of this research refers to the potential in using new Sentinel-2 (S-2) remote sensing imagery and *in situ* surveying for mapping and monitoring Cork oak (*Quercus suber* L.) woodlands in Calabria region, for restoration purposes. Considering that S-2 spectral bands are particularly suitable for estimating different vegetation cover characteristics, we propose a methodology for mapping the actual consistence of this habitat, using the Red-edge position (REP) in the vegetation spectral reflectance to evaluate cork oak spectral response and classify this vegetation type. A set of different S-2 and L8 OLI scenes where freely downloaded and pre-processed (topographic and atmospheric correction, band anomaly detection) in order to better investigate cork oak spectral signature. The selected sensor bands where used to perform spectral signature separability and the results where compared. Normalized Difference Red Edge Vegetation Index (NDRE) and Normalized Difference Vegetation Index (NDVI) where calculated to obtain a high spectral resolution vegetation mask. Then a Digital Elevation Model (DEM) was used as threshold of altitude ecological limit to clip the vegetation mask where to run the classification. Signature training sets, GCP and ancillary data where used to perform a supervised classification of both S-2 and L8 OLI imagery. Furthermore an accuracy assessment was applied to the classified images in order to evaluate the user's and the producer's accuracy. S-2 provides a great opportunity for global vegetation monitoring due to its enhanced spatial, spectral and temporal characteristics compared with Landsat. Results confirm the importance of the red-edge bands on Sentinel-2 for vegetation applications, because of the combination with its high spatial resolution of 20 m and the possibility to use peculiar vegetation indices to analyze vegetation behaviour. The performed images classification of cork oak distribution suggested that, when these images integrate with other ancillary data, it becomes possible to map species as well as to carry out other studies at regional scale with a high overall accuracy. Derived vegetation indices proved to be an accurate tools in detecting and monitoring cork oak woodlands health for restoration activities.

Main types of forest, macchia and garigues of Sardinian island

Ignazio Camarda*, Antonello Brunu, Luisa Carta, Gabriella Vacca & Giuseppe Brundu

Department of AGRARIA, University of Sassari, Viale Italia 39 07100 Sassari-Italy.
*Corresponding author: icamarda@hotmail.it

Keywords: *forest, macchia, garigues, Sardinia.*

The evergreen sclerophyllous vegetation represents the main forest type of Sardinia. Floristic composition, physiognomy and structure are extremely variable, depending both on geology, climate and human impacts since ages. Main types of vegetation and the dominant species in forest, macchia and garigues are taken into account in relation to the processes of degradation. More than two hundred physiognomic types of vegetation are included in the 5 phyto-climates given for Sardinia.
The evergreen forest vegetation are dominant with *Quercus ilex* L., *Olea europaea* var. *sylvestris* (Mill.) Brot., *Ceratonia siliqua* L., *Ilex aquifolium* L., the coniferous trees of the genus *Pinus* (*Pinus pinea* L., *P. halepensis* Mill., *P. pinaster* Ait., *Juniperus* (*J. phoenicea* L., *J. oxycedrus* L., *J. oxycedrus* subsp. *macrocarpa* (Sm.) Ball, *J. communis* L.) and *Taxus baccata* L. A particular condition is given by the forests of *Quercus suber* L., whose origin is typically anthropic. Among the species of the deciduous species, oaks forests (*Quercus pubescens* Willd., s. l.) are frequent from hilly areas to the limit of 1500 m, while rare forests are formes by *Ostrya carpinifolia* (L.) Scop, *Acer monspessulanum* L. and *Fraxinus ornus* L. Shrubs as *Phillyrea latifolia L., Arbutus unedo* L., *Pistacia lentiscus L. P. terebinthus* L., *Quercus coccifera* L., *Laurus nobilis* L., *Myrtus communis* L., *Rhamnus alaternus* L., *Erica arborea* L., *Erica scoparia* L., *Phillyrea angustifolia* L., *Cytisus villosus* (L.) Pourret, *Chamaerops humilis* L., *Juniperus sibirica* Burgsd. and decidous thermophylous species as *Calycotome villosa* L., *Anagyris foetida* L., *Euphorbia arborea* L. are the fundamental elements of the macchia. The degradation of the macchia leads to garigues, where small shrubs (*Teucrium marum* L., *Helichrysum italicum* subsp. *microphyllum* (Willd.) Nyman, *Euphorbia spinosa* L., *Genista* sp. pl., *Cistus* sp.pl., *Lavandula stoechas* L., *Santolina* sp. pl. and *Rosmarinus officinalis* L.) are prevalent. These species are provided with aromatic substances, toxic or thorny as a defense from excessive insolation, aridity and by grazing animals. The garigues widespread above all in coastal and high-mountain areas, generally represent a degradation stage of the Mediterranean shrubs and woodlands.
The evergreen vegetation of the rivers is mainly represented by the formations of *Nerium oleander* L. and *Tamarix africana* Poir., while the hygrophilous forests of *Alnus glutinosa* (L.) Gaertner, *Populus alba* L., *Ulmus minor* Mill., *Fraxinus oxycarpa* Willd. and *Salix* sp. p.l, are common from sea level up to 1600 m above the sea level. The forest vegetation for productive purposes are limited to *Castanea sativa* Mill. and *Corylus avellana* L., while the reforestation measures in the island started in the last decades with conifers, either spontaneous (*P. pinaster, P. halepensis* and *P. pinea*) and exotic as the *Pinus nigra* Arnold, *P. brutia* Ten, *P. canariensis* Sprengel, *Abies alba* Mill., and in recent times *Pinus radiata* D. Don, *Abies cephalonica* Loudon, *A. nordmanniana* (Steven) Spach, *Cedrus atlantica* (Endl.) Carrière, *Cupressus sempervirens* L., *C. arizonica* A.L. Greene, *C. macrocarpa* Hartweg. Among the decidous species the most commonly used in reforestation are *Eucalyptus camaldulensis* Dehnh. and *Acacia cyanophylla* Lindley s. l. which now represent a significant part of the island landscape.

Environment, human impact and the role of trees on the Po plain during the Middle and Recent Bronze Age: Pollen evidence from the Terramara of Santa Rosa di Poviglio (SUCCESSO-TERRA)

Anna Maria Mercuri*, Assunta Florenzano & Paola Torri

Laboratorio di Palinologia e Paleobotanica, Dipartimento di Scienze della Vita, Università di Modena e Reggio Emilia.
*Corresponding author: annamaria.mercuri@unimore.it

Keywords: palynology, cultural landscape, Bronze Age, wood management, Po plain.

The national-funded project SUCCESSO-TERRA *(Human societies, climate-environment changes and resource exploitation/sustainability in the Po Plain at the Mid-Holocene times: the Terramara)* focuses on an interdisciplinary geoarchaeological and archaeobotanical investigation on the Terramare Middle Bronze Age culture, which developed in the central-southern Po Plain from around 1550 to around 1170 years BC (Cremaschi et al. 2016, Climate change versus land management in the Po Plain (Northern Italy) during the Bronze Age: new insight from the VP/VG sequence of the Terramara Santa Rosa di Poviglio. Quat. Sci. Rev. 136: 153-172). The land transformations that occurred at the onset, duration, and end of the Terramare culture has been investigate through the study of several terramare villages (T) and necropolis (N) including T Montale, T Baggiovara, N Casinalbo, T Santa Rosa di Poviglio. The Terramare wew banked and moated villages that developed in the central sector of Po River alluvial plain during the Middle and Late Holocene. The relationships between the Late Holocene regional environmental and land-use changes have been investigated to obtain a detailed comprehension of adaptive strategies of the Terramare people during the Middle/Recent Bronze ages. The palynological research demonstrated that the wood had a key role in the development of this cultures characterized by a sophisticated dynamic agricultural economy. The latter was expressly practiced on the basis of wood management and cereal/legume fields. At the top of the sequence of Santa Rosa di Poviglio, in correspondence with the drying of the moat system, a dramatic decrease of woods may had a twofold causation: increased aridity (natural factor) and intensive land-use (anthropic factor) might have played a fairly synchronous action on vegetation.

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I. Camarda, L. Carta, G. Vacca & A. Brunu

Les plantes alimentaires de la Sardaigne: un patrimoine ethnobotanique et culturel d'ancienne origine*

Abstract

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The traditional practice of collecting wild edible plants is still active especially in small communities and has a great interest today at the scientific and cultural level. The revaluation of wild plants is of considerable importance not only for nutrition, but also to meet the "desire for nature", which appears increasingly marked, especially in large cities. This research on Sardinian food plants takes into account the existing literature from the first mentions by Greek and Latin authors and the ancient medieval *Condaghes*, a kind of ecclesiastical register of businesses, in the early centuries of the second millennium. In times closer to us, thanks to Fara, Manca dell'Arca, Moris we have important information about the use of cultivated and wild plants in the past. Especially at the end of the last century and in recent years, a large amount of very detailed data on the use of plants in the whole of Sardinia, offers the opportunity to attempt a synthesis of this field. 223 species are considered according to the parts used (bulbs, rhizomes, tubers, tuberous roots, basal leaves, stems, inflorescences, flowers, fruits, seeds, biological forms). In addition, a local name for each species is seleced. Of the 41 plant families included, the most important are: *Asteraceae*, *Rosaceae*, *Brassicaceae*, *Phaseolaceae*, *Liliaceae* (including *Alliaceae*, *Asparagaceae*, *Asphodelaceae*, *Ruscaeae*), *Apiaceae* and *Lamiaceae*. The grasses (annuals and perennials) constitute 57% of the total. The richness of local names and their variants has a great cultural significance that ranges from plant geography to systematics, ethnography to history and human migration, plant names to the evolution of languages, the domestication of plants to the regional cuisine and to the traditional medicine of a region. That is why food plants of Sardinia are a distinctive cultural heritage of this region, but strictly linked to the common history of the Mediterranean countries.

Key words: flora, endemic species, food plants, ethnobotany, Sardinia.

Introduction

L'importance de l'utilisation des plantes sauvages pour aide à celles cultivées à été déjà souligné depuis longtemps par Targioni-Tozzetti (1764) et il semble superflu d'insister sur cet aspect. Au cours du siècle dernier, en particulier en Europe, les grandes transformations sociales et la concentration de la population dans les grandes villes, a conduit à la dispari-

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tion d'une grande partie des connaissances et de la pratique traditionnelle de recueillir les plantes spontanées d'intérêt alimentaire. Cependant, nous assistons aujourd'hui dans le monde entier à la «redécouverte» des plantes médicinales et alimentaires sauvages en général, un phénomène qui est devenu quelque chose de plus qu'une mode de notre époque lié au "désir de nature", impliquant en particulier les habitants des grandes villes. La connaissance des plantes alimentaires sauvages vit encore principalement dans les petites communautés qui préservent les usages traditionnels, non seulement en cas de besoin, mais aussi dans la pratique quotidienne et surtout pendant les fêtes traditionelles.

Matériels et Méthodes

En Europe, il est connu l'usage alimentaire d'environ 1600 espèces sauvages, ce qui représente 13% de toute la flore (Couplan 1995, 2009) et autant d'espèces sont connues dans la région méditerranéenne (Le Floch 1983; Ertug 2000, 2004; Dogan & al. 2004; Della & al. 2006; Pardo de Santayana & al. 2007; Hadjichambis & al. 2008). Le nombre d'espèces alimentaires (GFPs sensu Rivera & al. 2006) dans le partour mèditerranéen est estimé en 2.300 et forment le cœur d'un système traditionnel de connaissances pan-méditerranéennes qui vont au-delà de l'aspect nutritionnel, en impliquant l'histoire, la démographie, les costumes, l'alimentation, la valeur nutraceutique et la santé humaine (Rivera & al. 2006, Leonti & al. 2006). En Italie, pour un usage alimentaire, aromatique et pour liqueur, le nombre se tient à une valeur de 828 (environ 12%) entités comestibles y compris aussi diverses plantes cultivées (Aliotta & Salerno 1987; Picchi & Pieroni 2005; Guarrera 2006; Tomei & al. 2006). Les enquêtes sur les différentes régions ou sur des territoires plus limités (Appi & al. 1979; Corsi & Pagni, 1979; Sella 1992; Arcidiacono & Peacock 1994; Guarrera 1994; Aliotta & Salerno 1995; Manzi 1999; Bianco & Macchackova 2002; Taffettani 2005; Lentini & Venza 2007; Guarrera & al. 2009) donnent une connaissance assez acceptable sur la connaissance de la flore alimentaire. Même quelques plantes potentiellement toxiques pour l'accumulation de nitrite ou pour la présence d'alcaloïdes sont consommés mais en suivant une pratique culinaire traditionnelle qui affaiblit les effets nocifs pour la santé humaine par l'ébullition. Par ailleurs, la confusion des plantes comestibles avec des espèces toxiques similaires (par exemple. *Apium nodiflorum/Oenanthe crocata, Foeniculum vulgaris/Ferula communis, Asparagus acutifolius/Tamus communis, Beta vulgaris/Arum pictum*) est souvent un péril pour les "chasseurs de plantes du dimanche".

La Sardaigne, à partir de l'âge du bronze, était une importante route commerciale des peuples méditerranéens et elle a partagé l'histoire et la culture, comme en témoignent les sources écrites et les découvertes archéologiques (Mastino & al. 2005). Les plantes alimentaires ont un intérêt important même pour l'introduction de plantes exotiques naturalisées.

Les premières nouvelles que nous avons sur les plantes de la Sardaigne sont grâce à des auteurs grecs, tel que Pseudo-Aristote et Diodore de Sicile (Perra 1997) qui donnent de références génériques, bien qu'ils considèrent l'île très riche d'arbre à fruits. Dans Plinie (Conte 1984) nous avons peu de citations (ex. *Castanea sativa, Quercus coccifera*) et le célèbre *Risus sardonicus* se référant vraisemblablement à une plante toxique (*Oenanthe crocata*) ayant effets mortels par confusion avec *Apium nodiflorum* (Camarda 1986; Paulis

1992; Ortoleva 2014). Rutilius Palladius, qui possédait dans l'île des fermes, dans son traité *De Agricultura* (V siècle, après J.C.), en plus des pratiques agronomiques, donne un'indication sur la présence d'agrumes (Mastino & Zucca 2011; Camarda & al. 2015). Dans les anciens *Condaghes* médiévaux, une sorte de registres d'église, dans les premiers siècles du deuxième millénaire, environ 100 plantes surtout cultivées sont nommés (blè, orges, vignobles, olivier, poirer etc.) et d'autres espèces sauvages couramment utilisées.

Dans les temps plus près de nous, Fara (1570) et Manca dell'Arca (1780) donnent des informations importantes sur les plantes cultivées et sauvages. Moris (1837-1859) a été auteur du premier recensement de la flore de l'île avec une grande attention aux plantes cultivées. Après, beaucoup d'autres auteurs (ex. Mola 1916; Camarda 1984, 1990; Camarda & Valsecchi 1990, 2008; Atzei & al. 1991, 2004; Camarda & Satta 1996a, 1996b; Bruni & al. 1997; Rau & Satta 1998; Camarda & Piras 2003; Viegi & al. 2006; Arrigoni 2006-15; Ghirardini & al. 2007; Campus & Campus 2008; Signorini & al. 2009; Campanini 2009; Ballero & Hanger 2011) complètent le tableau des connaissances botaniques et de leurs utilisations. De plus une synthèse sur les espèces d'importance officinale a été rédigé par Atzei (2003) avec une grande quantité d'informations très detailleées sur l'utilisation populaire des plantes dans la Sardaigne entière. Dans son travail Atzei prend en compte à la fois des plantes alimentaires spontanées, soit cultivée d'origine ancienne (par exemple *Cucumis melo* L., *Triticum* sp. pl.) ou exotiques (par exemple, *Zea mays* L., *Helianthus annuus* L.) et les champignons (par exemple *Boletus sp.pl.*) sur la base d'environ 650 données bibliographiques, dont certains, malheureusement, ne sont pas pris en charge par une interprétation taxonomique appropriée, à la suite d'enquêtes menées par des chercheurs non-botanistes. En fait, il est difficile d'accepter comme alimentaires des plantes très toxiques tel que *Arum pictum* L. fil., *Anagyris foetida* L. ou des espèces telles *Ptilostemon casabonae*, avec tige très dure et épineuse dans toutes ses parties. Même l'Auteur (page XVII) considère la nécessité d'une vérification. Tout cela ne permet pas d'avoir un nombre entièrement exact des espèces alimentaires ainsi que le nombre de 257 espèces, cité par Rivera & al. (2006), doit être considéré comme approximatif.

Aspects archéo-botaniques e noms vernaculaires des plantes

L'identification correcte des plantes pendant les entrevues avec les informateurs ont révélé des difficultés considérables car la nomenclature locale, en Sardaigne, possède une articulation extrêmement variée avec de synonymes qui sont parfois bien différentes même dans villages trés proches et les indications fournies sont souvent difficiles à vérifier.

Les premières recherches archéo-botaniques menées dans les sites archéologiques des Nuraghes Toscono et Urpes dans le centre de la Sardaigne (Webster 1996), et dans les récentes fouilles en localité «Sa Osa», et autres localités ont révélé en couches attribuées à la période nuragique (1.500-1.200 av. J.C.) de nombreuses espèces, soit de plantes ligneuses que herbacées cultivées (*Castanea sativa, Pinus pinea, P. halepensis*, *Juglans regia, Pistacia lentiscus, Prunus spinosa, Olea europaea, Vitis vinifera*, *Cucumis melo*, *Hordeum* sp., *Lathyrus* sp. *Rumex* sp., *Sylibum marianum, Triticum durum*, *etc.*) (Ucchesu & al. 2014). La découverte de graines et de fruits de châtaignier, de noyer et de graines de pin pignon et pin d'Aleppe de cette âge semble donner du crédit à leur statut d'espèces indigènes, comme cette période précède la première colonisation de l'île par les Phéniciens (900 av. J.C.). Même la présence de graines de la vigne (si sera confirmée son appartenance à des cultivars de la variété *sativa* plutôt que à la variété *sylvestris*) peut supposer un'introduction beaucoup plus ancienne et antérieure de cette période, ou bien confirmer comme biotypes autoctones. La présence de *Quercus coccifera* dans les alentours de ruines phénico-puniques semble indiquer un'introduction de cette espèce par ces peuples, à fin d'obtenir selon Plinie le colorant rouge au moyen de galles produites par l'insect *Kermococcus ilicis* (Camarda & Valsecchi 2008), étant la couleur rouge de la robe symbole de noblesse.

Les événements historiques à travers les siècles ont vu en Sardaigne la présence d'autres peuples qui ont laissé leurs traces même sur les noms des plantes utilisées, que ce soit comestibles, aromatiques, médicinales et autres encore, mais il y a des espèces encore désignées par des noms (a*danu*=G*enista aetnensis*, *ghìrthari*=*Lathyrus latifolius*, *mudécru*=*Cistus monspeliensis*, *udduru*=*Conium maculatum*) attribuables à l'ancienne langue des Sardes (Paulis 1992; Camarda 2006, 2010). Le terme *còdoro*=*Pistacia terebinthus* vien de la langue grecque. Certains noms des plantes (*Zìppiri*=*Rosmarinus officinalis*) sont d'origine phénico-punique (Wagner 1960; Cossu 1960; Paulis 1992) et leur utilisation précède la conquête et la colonisation de l'île par les Romains en 238 av. J.C.). A côté de noms les plus anciens, ils persistent même les noms d'origine latine.

Actuellement les noms locaux des plantes dans la langue sarde, quelle que soit leur origine, sont également important pour définir dans certains cas, les dialectes des différentes zones géographiques. A suivre quelques exemples. Le nom sarde de poirier sauvage dérive du latin *pyraster* et dans le sud de la Sardaigne est répertorié comme *pirastu* et seulement la lettre «r» dans la syllabe finale (*pirastru*) le distingue dans le nord, tandis que le terme *perastru* à Sassari a été influencé de la langue italienne. Les variantes locales de l'aubépine dans les divers villages, malgré les transformations phonétiques, montrent un'origine commune: *calabriche, calavriche, calabrigu, calabrighe, calarighe, calafrihu, calariggiu, calaviru, calabria, calavri'e, calavrighe, callavrigu, cararigi, coarviu, coavigu, croaxiu*. Dans le romarin on observe deux groupes de noms qui correspondent même à une subdivision géographique nette. Le premier se réfère à la Sardaigne centre-méridionale jusqu'à la ville côtière de Bosa qui a eu l'influence phénico-punique: *cipari, sippiri, thippiri, tipiri, zipari*, tandis que les variantes du romarin dans le centre-septentrionale de la Sardaigne: *arromaniu, ramasinu, romanì, romasinu, rosmarinu, rumasinu, rusmarinu, romaninu, rumazzinu, rumosinu,* sont de claire dérivation latine. De même, dans le mastic, il y a deux conditions de base dans la Sardaigne centre-nord avec le terme c*hessa,* tandis que *moddizzi* prévaut au centre-sud. Ils font exception le nom *cose-neigre* au sud, d'origine génoise à Carloforte, et *astringol* au nord, d'origine catalane à Alghero.

En synthèse, les noms des plantes alimentaires, dans une très large mesure (environ 75%), sont de dérivation latine (p. ex. *cardu*=*carduus, chercu*=*quercus, figu*=*ficus, filighe*=*filix, frassinu*=*fraxinus, ghiniperu*=*juniperus, isparagu*=*asparagus; murta*=*myrtus; porru*=*porrum, rubu*=*rubus, juncu*=*juncus, suberiu*=*suber, veda*=*beta* etc.). Ne manquent pas de noms d'origine ibérique (*margallò*=*Chamaerops humilis*, z*ibba*=*Atriplex portulacoides*) étant l'influence espagnole en Sardaigne durée plus de quatre siècles. Beaucoup de noms, bien sûr, ont une claire dérivation italienne, surtout les espèces introduites de longue date et cultivées (*lazzarola*=*Crataegus azarolus; mairana*=*Origonum majorana, salvia*=*Salvia officinalis*). Le nom sarde *regalissia*=*Glycirrhiza glabra,* plante de récent introduction se rapproche du français *réglisse*. Il est singulier le cas de *Helianthus tubero-*

sus, espèce nord-américaine, dont le nom *topinambour* est transformé en *napu-tamburru* dont l'origine est évidente. En tout cas, les espèces sauvages ou cultivées qui ont un nom dans la langue sarde actuelle (les plus souvent avec de nombreuses variantes locales qui peuvent souligner leur origine différente) sont environ 1.000, et parmi celles-ci les plus communes sont celles d'intérêt alimentaire. Une exacte correspondance entre le nom local des plantes et le nom scientifique peut donner aux linguistes une base de réflexions sur leur correct sens et origine.

Resultats

La recherche prend en compte les études citées et examinées sur la base des enquêtes sur le terrain, que nous avons mené pendant plusieurs décennies dans les différents localités de la Sardaigne. Le tableau attaché (Fichier Électronique Supplémentaire 1) tient compte des plantes qui ont un intérêt dans l'alimentation humaine et leurs différentes parties: bulbes, rhizomes, tubercules, racines tubéreuses (partie souterraine); feuilles basales, feuilles de la tige et tiges (partie aèrienne); inflorescences, fleurs, fruits, graines (indiqués ici comme partie reproductive); le type biologique (TB). De plus on a considéré un nom vernaculaire local parmi d'autres. La nomenclature des espèces suit la *Flore de l'île de Sardaigne* (Arrigoni 2006-2015).

Les plantes alimentaires et leurs familles

On a considéré seulement les plantes indigènes ou exotiques introduites de longtemps et aujourd'hui spontanées, sans tenir compte de ceux qui se trouvent parfois aux côtés des cultures de l'année précédente, comme la tomate (*Solanum esculentum* L.) ou le pomme de terre (*Solanum tuberosum* L.) et de toutes on a analysé les parties utilisées et consommées de différentes façons.

De la famille des composées, les parties plus recherchées et utilisées sont les feuilles en rosette basales consommées toutes seules comme légume cuit ou en omelette. *Crepis vesicaria* est l'espèce la plus recherchée parmi les herbes sauvages en hiver et au printemps. A suivre les autres espèces du genre *Crepis*, et surtout l'artichaut sauvage (*Cynara cardunculus*) dont on utilise les feuilles et avant la floraison les capitules, cuisinés ou bien conservés dans le vinaigre et l'huile. De *Aetheorhyza bulbosa* on recueille et on mange les tubercules souterrains crus. *Cichorium intybus* est bien appréciés pour les feuilles basales tandis que de *Chondrilla juncea* et de *Andryala integrifolia* on mange la tige et les feuilles. Presque de tous les chardons on mange la tige tendre; les espèces les plus appréciées sont *Sylibum marianum*, dont dans de sites archéologiques on a trouvé aussi une grande quantité de graines stockées dans des pots en terre cuite, *Onopordon illyricum* et *Cirsium scabrum*. L'endémique *Lactuca longidentata* est connue par les bergers, elle est de goût amer mais agréable. *Crysanthemum segetum* est considéré aphrodisiaque et est mangé cru. Tous les garçons savent *Hyoseris radiata* dont on mange la tige florale aussi que la plus rare endémique *Hyoseris taurina*. Une autre espèce très connue est *Reichardia pichroides*.

Parmi les crucifères les feuilles basales des espèces du genre *Brassica* et du genre *Raphanus* sont consommées toutes seules bouillies, en omelette ou dans la soupe, tandis que *Nasturtium officinale* est utilisé comme condimentale, aussi que *Diplotaxis tenuifolia*.

Parmi les ombrellifères l'espèce la plus appréciée est sans doute le fenouil pour ses feuilles basales et les jeunes tiges, mais aussi pour les graines comme condimentale ou pour faire des liqueurs. La férule est une plante toxique, en particulier dans les feuilles vertes, mais la tige, lorsque est encore tendre, est consommée grillée par les berger au fin superstitieux de préserver le bétail de l'empoisonnement. Même la tige de *Conium maculatum* est consommée, bien que l'espèce est connue comme toxique. *Apium nodiflorum* étè une fois très apprecié, mais actuellement peu utilisé. *Oenanthe pimpinelloides* devient partie d'un soupe caractéristique.

Parmi les légumineuses sont utilisées particulièrement les espèces du genre *Pisum* et *Lathyrus* dont on mange les fruits, tandis que de *Vicia villosa* et de *Vicia cracca* on mange l'inflorescence (appelée *pane e casu* c'est à dire *pain et fromage*).

Les labiacées ont surtout un'utilisation condimentale et aromatique (*Mentha aquatica, Mentha pulegium, Mentha insularis, Origanum heracleoticum*, *Rosmarinus officinalis, Salvia officinalis, Salvia desoleana*) ou bien pour de liqueurs (*Mentha* sp. pl., *Thymus catharinae*).

Les rosacées sont recherchées surtout pour les fruits, mures du ronces et cynorrhodons des églantiers, également comestibles et riches en vitamine C. On les consomme sous forme de confitures ou de gelées. Aussi les fruits de l'aubépine, de l'amandier, du cerisier, du poirier, du prunier, de l'alisier et du pommier sauvages sont collectés pour faire confitures, gelées, liqueurs, fruits secs, sirop et bonbons tels ceux typiques aux amandes amères.

Parmi les iridacées le safran est cultivé soit pour donner couleur et saveur au riz, mais aussi pour des bonbons traditionnels. On ne connait pas l'usage de *Crocus minimus* (Réq.) DC espèce endemique très commune.

Les autres familles sont représentées par un plus petit nombre d'espèces, mais elles ne sont pas moins importantes; telles sont l'asperge (*Asparagus acutifolius*), sans aucun doute la plante la plus populaire, qui donne lieu à un commerce assez intéressant, comme dans le cas de la betterave (*Beta vulgaris*) et du fenouil sauvages (*Foeniculum vulgare*). L'asperge blanc (*Asparagus albus*) est très amer mais aussi récolté lorsque il est encore bien tendre. Presque toutes les espèces du genre *Rumex,* en particulier *R. thyrsoides,* sont comestibles en particulier leurs aigres feuilles basales. Parmi les liliacées *Allium triquetrum* est consommé en salade ou en omelette avec les œufs, tandis que *Allium subhirsutum* est choisi pour donner arome et conserver les saucisses. Il est plus rare l'usage d'autre ailles sauvages.

Châtaigne, chêne pubescent, chêne vert et chêne-liège donnent des fruits pour les hommes et pour les animaux. Il est caractéristique, dans la région Ogliastra, le pain de glands (pain de la période de famine) mélangée avec de l'argile, qui est préparé oujourd'hui seulement pour des occasions spéciales (Atzei 2003; Pinna 2015). Les baies de myrte ont été commercialisés dans le passé par les pays des côtes à ceux de l'intérieur, aussi pour faire une liqueur traditionnelle qui est actuellement produit en quantité remarquable à partir des baies ou des feuilles.

Le raisin sauvage n'est pas très apprécié, mais est parfois utilisé pour faire du vin. Les samares pourvues d'une aile membraneuse et groupées en bouquets de l'orme (*Ulmus minor*) sont mangées par les garçons, qui aiment aussi les petits fruits de micocoulier (*Celtis australis*). Parmi les fougères seulement le rhizome de *Polypodium australe* au goût de réglisse est quelque fois consommé.

Une place spécial attende la figue de Barbarie (*Opuntia ficus-indica*), qui est devenue spontanée et répandue dans les zones côtières et collinaires, utilisée comme clôture des champs dans les formes très épineuses, et dans tous les cas elle est très recherchée pour le fruit, qui est également utilisé pour la préparation d'une mélasse et, quelques fois, de liqueur.

Dans d'autres régions d'Italie sont généralement consommées espèces comme *Chenopodium bonus-henricus*, *Leopoldia comosa, Portulaca oleracea, Papaver roheas, Silene vulgaris, Stellaria media, Urtica dioica* et *Centranthus ruber*, mais dans l'île ont peu d'intérêt au point de vue alimentaire. Gheradini & al. (2007) citent aussi pour la Sardaigne *Galactites tomentosa*, une plante mellifère très important pour le miel dit de chardon, mais avec feuilles très épineuses et tige bien dure; *Dipsacus fullonum* est difficilement comestible parce que toutes les parties de la plante sont pourvues de très nombreuses épines extrèmement dures. Nous n'avons pas retrouvé usages alimentaires de *Ruta graveolens* et *Bellis perennis*.

Les familles botaniques sont 41 et celles avec le plus grand nombre d'espèces alimentaires utilisées sont les *Asteraceae* (23%), les *Brassicaceae* (*12%*), les *Rosaceae* (9%), les *Lamiaceae* (9%), les *Phaseolaceae* (7%), les *Liliaceae* (5%), les *Apiaceae* (*5%*), les *Boraginaceae* (*2%*), les *Polygonaceae* (*2%*) et à suivre les autres. Ce sont surtout les hemicriptophytes (32%) et plantes annuelles (*25%)* les plus communes utilisées, à suivre les phanerophytes (22%), les géophytes (11%) et comme dernières les chamephytes (10%). Les fruits des arbres et des arbustes tels que *Arbutus unedo*, *Celtis australis, Ficus carica* var. *caprificus*, *Myrtus communis, Olea oleaster, Pistacia lentiscus, Prunus spinosa, Quercus pubescens, Pyrus spinosa, Rubus ulmifolius* sont recherchés pour être consommés directement ou transformés de plusieurs manières. Les fougères, à l'exception du rhizome de *Polypodium australe*, n'ont pas un intérêt alimentaire.

La comparaison de la flore comestible italienne (Camangi & al. 2013) avec celle de la Sardaigne montre une homogénéité substantielle au point de vue des familles les plus rappresenatives qui devient encore plus prononcé par rapport à celui de l'Italie du Sud (Gheradini & al. 2007).

Les plantes sauvages deviennent aussi partie de la Diète Méditerranéenne, qui en Novembre 2010, a été reconnu par l'UNESCO patrimoine culturel immatériel de l'humanité. Un patrimoine qui combine les habitudes alimentaires des peuples du bassin méditerranéen (Italie, Espagne, Grèce, Maroc, Portugal, Croatie et Chypre), établie au cours des siècles et est resté pratiquement inchangé jusqu'aux années Cinquante, et qui va bien au-delà d'un simple liste d'aliments, mais concerne la culture de la vie, les pratiques sociales, traditionnelles et agricoles.A l'occasion de l'Exposition Universelle de 2015 de Milan "Nourrir la planète, énergie pour la vie" Dédiée à l'alimentation humaine, avec le sous-thème «Nourriture au sein des cultures du monde et des groupes ethniques" a eu une grande importance le thème de la longévité liée à la diète méditerranéenne. En Sardaigne, en particulier dans les pays d'intérieur de l'Ogliastra vit une pourcentage élevée de centenaires (Deiana & al. 1999; Deiana & Vaupel 2006; Poulain & al. 2004; Carru & al. 2003), mais un lien entre la longévité et l'utilisation des plantes sauvages, sinon impossible, doit être scientifiquement prouvé.

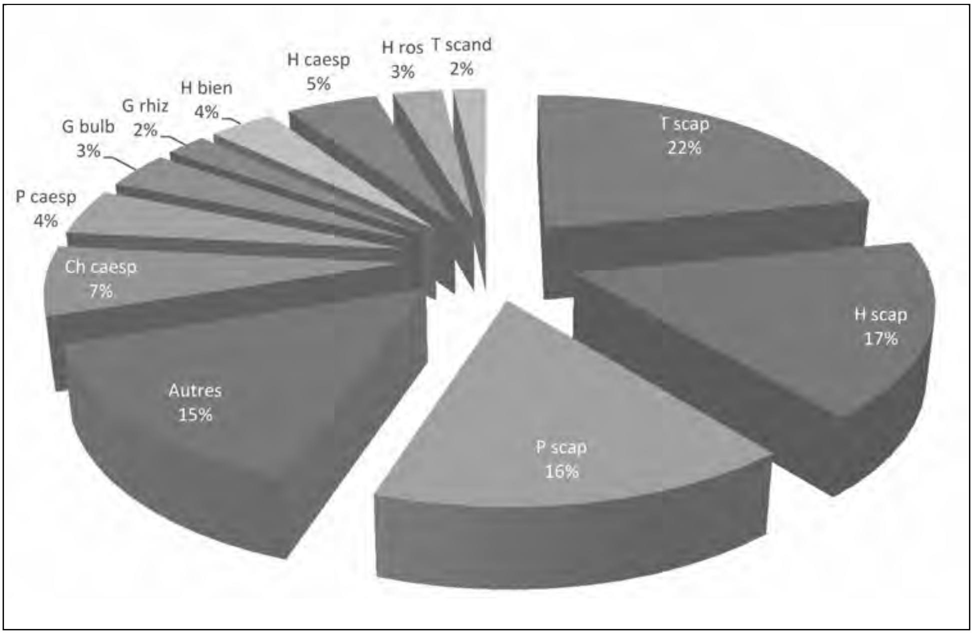

Fig. 1. Pourcentage des types biologiques des plantes alimentaires de la Sardaigne.

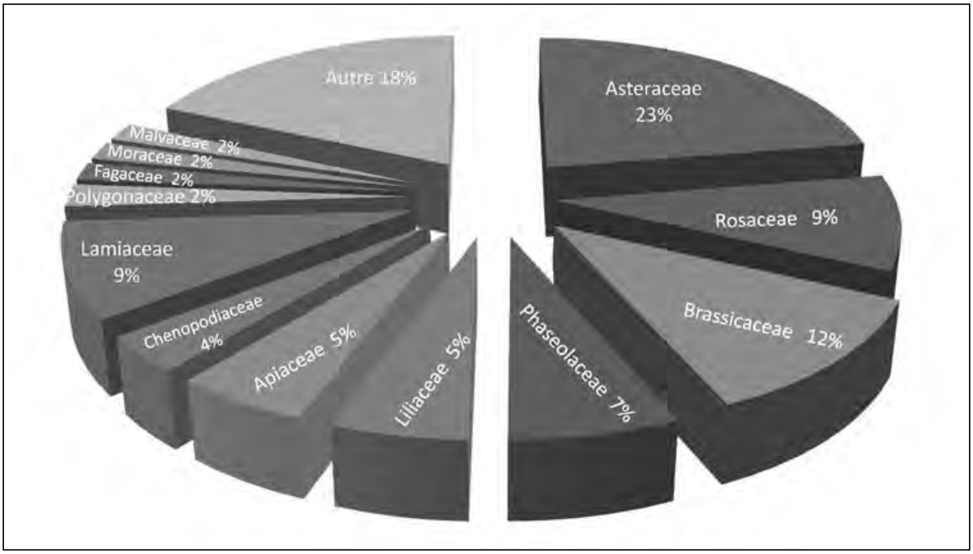

Fig. 2. Pourcentage des familles des plantes alimentaires de la Sardaigne.

Table 1. Comparaison entre les et sous-espéces des familles plus represéntées de la flore alimentaire italienne et sarde.

Famille	nr. italiennes	% italiennes	nr. sardes	% sardes
Asteraceae	156	19	50	23
Cruciferae	62	7	26	12
Lamiaceae	55	7	21	9
Phaseolaceae	49	6	15	7
Apiaceae	47	6	12	5
Polygonaceae	18	2	5	2
Autres	441	53	94	42
Total	828	100	223	100

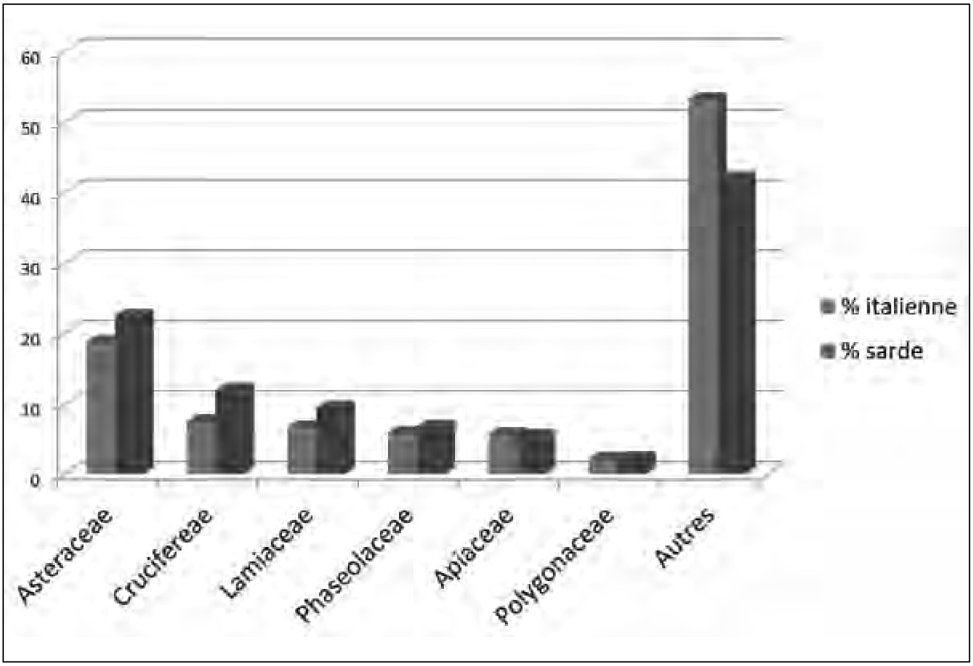

Fig. 3. Comparaison entre les espéces et sous-espéces des familles plus represéntées de la flore alimentaire italienne et sarde.

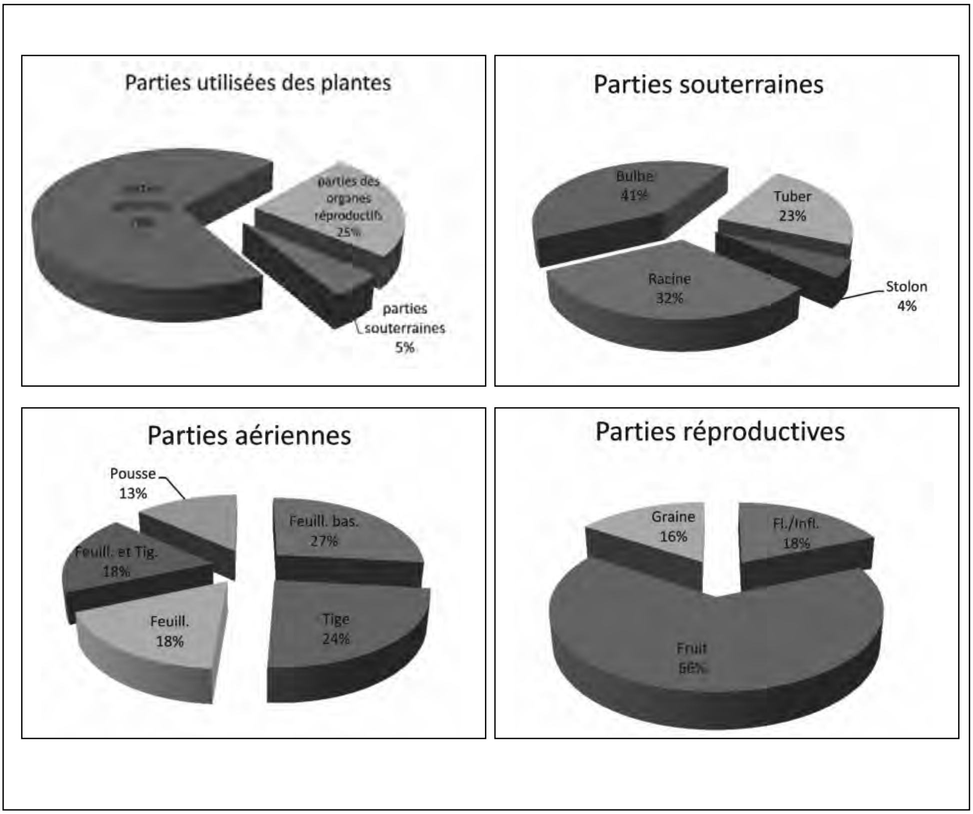

Fig. 4. Parties utilisées selon les différentes parties des plantes alimentaires en pourcentage.

Conclusions

La documentation sur l'utilisation des plantes alimentaires sauvage en Sardaigne remonte au premier millénaire a.J.C. et les nouvelles découvertes dans les fouilles archéologiques révèlent une remarquable connaissance par les anciens habitants de l'île. Les 223 plantes utilisées en Sardaigne représentent environ 10% de la flore spontanée, un percentage tout à fait semblable au niveau national, européen et méditerranéen. Cela aussi montre une grande connaissance des plantes par les populations locales sur leurs proprietés, effets et biologie. D'autre part, les nombreuses implications que l'utilisation de plantes alimentaires présentent, ont un particulier attrait qui amène de la phytogéographie à la systématique, de l'ethnographie à l'histoire et aux migrations humaines, de noms de plantes à la linguistique et à l'evolution des languages, de la domestication des plantes à la cuisine régionale et à la médicine traditionelle. De cette manière l'analyse des plantes alimentaires, à partir de plusieurs points de vue, monte au centre de la vie sociale, non seulement pour la satisfaction des besoins de base de l'homme, mais aussi pour tous les aspects culturels qui en découlent et qui deviendront de plus en plus clairs, à partir d'une évaluation de l'ensemble de la flore d'une région.

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Adresses des auteurs:
Ignazio Camarda, Luisa Carta, Gabriella Vacca & Antonello Brunu,
Département d'Agriculture, Université de Sassari, viale Italia, 39 – 07100-Sassari, Italie. E-mail: anbrunu@tiscali.it

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G. Astuti, F. Roma-Marzio & L. Peruzzi

Traditional karyomorphological studies: can they still provide a solid basis in plant systematics?*

Abstract

Astuti, G., Roma-Marzio, F. & Peruzzi, L.: Traditional karyomorphological studies: can they still provide a solid basis in plant systematics? — Fl. Medit. 27: 91-98. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

Chromosomes are helpful tools for systematic purposes, but their use has not always been rigorous. In this contribution, we review and discuss the use of karyomorphological data from the beginning of cytotaxonomy to present day. We highlight the use of incorrect karyomorphological parameters and the erroneous merging of different parameters in some case studies. In addition, we suggest complementing the karyological data with information from other independent sources to infer systematic reconstructions.

Key words: chromosome number, karyotype asymmetry, multivariate analysis, phylogeny.

Background

Since early works (e.g. Strasburger 1882, 1910), chromosomes have played an important role in plant systematics, because their changes in number and structure has always been linked to plants evolution and speciation (Greilhuber & Speta 1978; Greilhuber 1982; Cerbah & al. 1998; Weiss-Schneeweiss & Schneeweiss 2003; Guerra 2012).

Traditional techniques, such as Feulgen staining, for evaluating phenotypic aspects of chromosome complement revealed to be some of the most used techniques for the purpose of studying relationships among taxa. In addition, they are quite cheap and easy to apply. For these reasons, a big amount of data has been collected during times (Stace 2000; Bedini & al. 2010 onwards, 2012; Garbari & al. 2012; Rice & al. 2014; Peruzzi & al. 2014).

Phenotypic features of chromosome complements, i.e. karyotype, mainly deals with number, size and position of centromere in chromosomes of a given complement. These karyomorphological features are not simply taxonomic characters, such as the number of petals or the leaf shape, used for taxonomic issues, but they can be crucial for depicting evolutionary scenarios involving systematic relationships (e.g. Levin 2002, Doyle & al. 2004; Leitch & Leitch 2008; Mandáková & Lysak 2008; Siljak-Yakovlev & al. 2008; Weiss-Schneeweiss & al. 2009; Siljak-Yakovlev & Peruzzi 2012).

* Extended and enriched version of the oral presentation given at the XV OPTIMA meeting in Montpellier, 6-11 June 2016.

One of the most important concepts in karyomorphology is the karyotype asymmetry: a concept introduced by Levitsky (1931) and later developed by Stebbins (1971), who for first proposed a classification of chromosome complements based on both inter-chromosomal and intra-chromosomal asymmetry. According to these authors, inter-chromosomal asymmetry is a measure of the heterogeneity of chromosome lengths within a single complement. Hence, a symmetrical complement is characterized by having chromosomes more or less of the same length. Instead, intra-chromosomal asymmetry depends on the position of centromere along single chromosomes. A metacentric chromosome is considered symmetric while a telocentric chromosome is considered asymmetrical. Therefore, an asymmetrical karyotype is mostly constituted by telocentric chromosomes, whereas a symmetrical complement is mostly constituted by metacentric chromosomes.

The problem of describing karyotype features

During times, many indices have been proposed for measuring karyotype asymmetry, starting from the quali-quantitative indices proposed by Stebbins (1971). In place of these quali-quantitative indices, many quantitative ones have been proposed by later authors, some of them combining both inter- and intra-chromosomal aspects. Much more indices of intrachromosomal asymmetry have been proposed with respect to interchromosomal ones. Indeed, as stated by Paszko (2006), the Coefficient of Variation of Chromosome Length (CV_{CL}) has been commonly considered the best choice for describing interchromosomal asymmetry, while less accordance exists concerning intrachromosomal asymmetry. The contribution of Paszko (2006) represents the first critical review dealing with conceptual and statistical reliability of these indices and she proposed to use, along with CV_{CL}, the Coefficient of Variation of Centromeric Index (CV_{CI}), for measuring intrachromosomal asymmetry. In addition, she introduced the Asymmetry Index (AI), an index combining both the aforementioned indices.

Five years later, Zuo & Yuan (2011) criticized the use of CV_{CI}, because it does not measure the intrachromosomal asymmetry sensu Levitsky (1931), but it only evaluates the variation of centromeric position in a complement, instead of evaluating the frequency of telocentric chromosomes (asymmetrical chromosomes). Based on these considerations, Peruzzi & Eroğlu (2013) confirmed the use of CV_{CL} and rejected the use of CV_{CI}, replaced by M_{CA}. The latter parameter corresponds to the A index proposed by Watanabe & al. (1999), but expressed in percentage. M_{CA} index is consistent with the intrachromosomal asymmetry concept and has a solid statistic basis. In addition, Peruzzi & Eroğlu (2013) discouraged the use of combined indices and supported the use of scatter plots of the two asymmetry indices plotted one against the other, for a better comparison of taxa. Indeed, merging such different concepts may cause an important loss of information leading to an underestimation of the differences among taxa.

A year later, further suggestions came from Peruzzi & Altinordu (2014), who proposed the use of six parameters, of general applicability and uncorrelated each other, in multivariate analysis based on karyological data. These parameters are the following: the chromosome number (2*n*), the basic chromosome number (*x*), the total haploid length (THL), the interchromsosomal CV_{CL}, MCA and CVCI. This last index could be useful as additional parameter, measuring the heterogeneity of centromere position. However, if CV_{CI} is correlated to M_{CA} it should be discarded from the analysis. More recently, a tool for measuring karyotypes and automatically calculating these parameters has also been released (Altinordu & al. 2016).

A critical survey of the karyomorphological literature

Despite the criticisms moved against the use of biased karyotype asymmetry indices, they are still used today (Fig. 1). The indices proposed by Romero Zarco (1986) and the TF% (Huziwara 1962) are the most used, but we can see that in the last years their use is decreasing, probably due to the critical reviews of Paszko (2006) and Peruzzi & Eroğlu (2013). The use of an index instead of another appears often related to the geographical location of manuscripts' authors (Fig. 2), or to their affiliation's working group (not shown). For instance, in India and Iran the TF% (Huziwara 1962) seems the first choice, while in South America the indices by Romero Zarco (1986) are definitely the most frequently used, and in Italy in the last 10 years the most used are those proposed by Paszko (2006).

One of the reasons why old (incorrect) parameters are highly represented is because in the last 10 years, these indices were used altogether in many studies, often in a multivariate

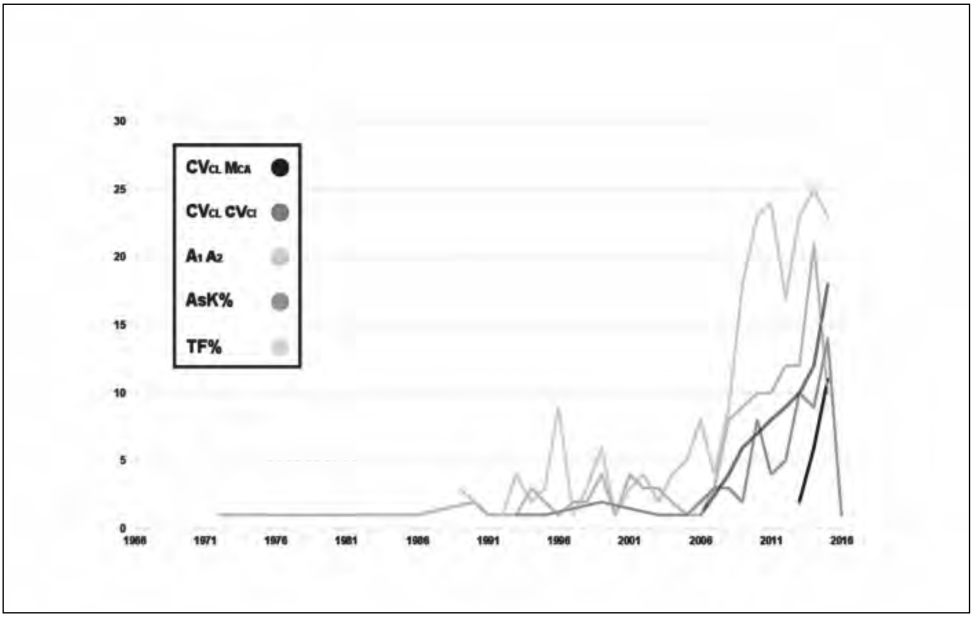

Fig. 1. Plot showing how frequently (number of papers found on ISI Web of Science) karyotype asymmetry indices were used during times, at May 31st 2016. Only the five most popular methods are shown, i.e. CV_{CL} & M_{CA} (Peruzzi & Eroglu 2013); CV_{CL} & CV_{CI} (Paszko 2006); A_1 & A_2 (Romero Zarco 1986); AsK% (Arano 1963); TF% (Huziwara 1962).

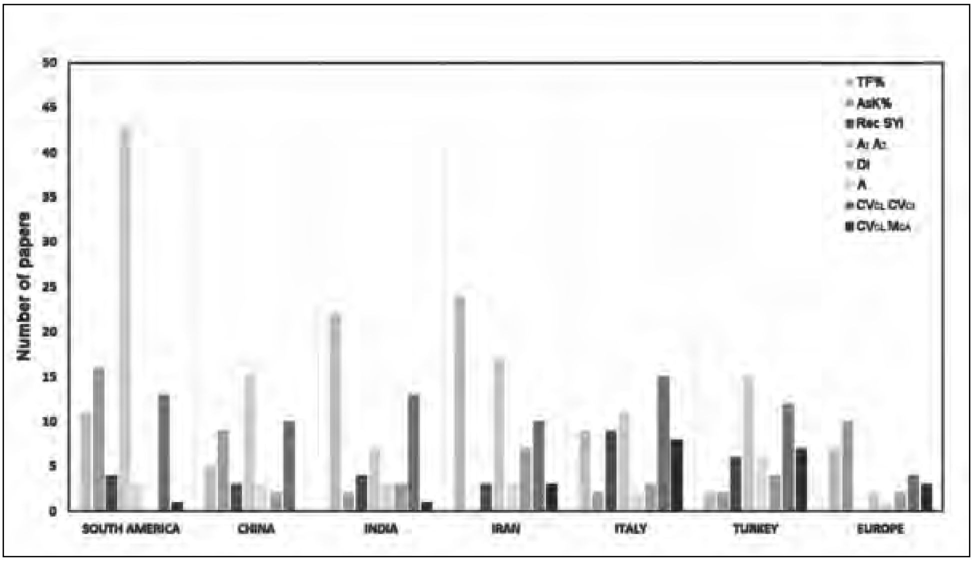

Fig. 2. The frequency (number of papers found on ISI Web of Science) of karyotype asymmetry indices and the geographical affiliation of the authors who included these indices in their papers, at May 31st 2016. For references on indices, see the caption of Fig. 1. For the remaining indices: Rec & SYi (Greilhuber & Speta 1976); DI (Dispersion Index; Lavania & Srivastava 1992); A (Watanabe & al. 1999).

approach. Being these indices correlated to each other (see Paszko 2006; Peruzzi & al. 2009; Peruzzi & Eroğlu 2013), such an approach may be affected by redundancy and may thus provide unreliable results. Indeed, as summarized in the case regarding tribes within *Liliaceae*, when performing a PCoA with six uncorrelated parameters (see Fig. 2 in Peruzzi & Altinordu 2014), a better separation of groups than using 11 mostly correlated parameters (Fig. 3) can be obtained. In addition, using these six parameters in *Crocus* L. series *Verni* B.Mathew (Peruzzi & Altinordu 2014), we can see that resolution of groups is better with respect to the simple scatter plot with the two asymmetry indices (Harpke & al. 2015). For instance, if we look at *C. tommasinianus* Herb. and *C. heuffelianus* Herb., they mostly overlap in the scatter plot, whereas they are well-separated in the PCoA with six parameters. A further problem regarding many studies with multivariate analyses is that often parameters not of general applicability are included, such as the absolute lengths of chromosome arms, satellite numbers and positions, etc. It is obvious that these can be useful only when comparing closely related taxa.

Another kind of misleading result can be found when phylogenetic relationships are inferred exclusively using karyological data. For example, in the study of Caputo & al. (2013), a dendrogram from a cluster analysis was produced, using karyological data of species within *Vicia* L. subgen. *Vicia*. In addition, the authors of this study also used molecular data to clarify the relationships among taxa. Conflicting results between the two different analyses were found, but despite these incongruences, they tried to draw some conclusions merging the two kinds of data in a single matrix, from which a phylogenetic tree was obtained. One of the authors' conclusions is that a trend of increasing asymmetry can be found in this group of plants, with plesiomorphic condition represented by more symmetrical karyotypes, typical of *Vicia* sect. *Atossa* (Alef.) Stank. However, the two species belonging to this section (i.e. *V. sepium* L. and *V. oroboides* Wulfen) cluster with two different sections (i.e. *V.* sect. *Narbonensis* (Radzhi) Maxted and *V.* sect. *Vicia*, respectively) having different overall karyotype asymmetry. Moreover, the authors hypothesized that *V.* sect. *Narbonensis* retains more plesiomorphic characters, because a part of it (four species) diverges earlier in the cluster analysis. Nevertheless, a cluster analysis is not properly a phylogenetic tree, and cannot be used for depicting evolutionary trends. In fact, in the ITS tree *V.* sect. *Narbonensis* is monophyletic and its position among other sections is unresolved. Moreover, it is worth to stress again the possible biases introduced by redundancy: in this analysis on subgenus *Vicia*, 37 karyological parameters were used, most of them being redundant. This redundancy might have led to a loss of signal of karyotype asymmetry information and to an increase of weight of the character "*chromosome number*". An example of this, could be found considering the cluster in the dendrogram corresponding to species with $2n = 10$, which instead are scattered throughout the ITS tree.

On the contrary, in the study on *Liliaceae* by Peruzzi & al. (2009), karyological data were superimposed upon a reliable phylogenetic framework, in order to evaluate direction of changes involving karyotype features in an evolutionary perspective. In this case, we can only visually appreciate karyotype changes, for instance those concerning the basic chromosome number x, without having a statistical support of what we can perceive or hypothesize by eye. A more advanced way to infer trends in the evolution of karyological traits is to perform phylogenetic regression analyses. For instance, in the study on the subgenera within *Allium* L. by Peruzzi & al. (2017), plesiomorphic character-states concern-

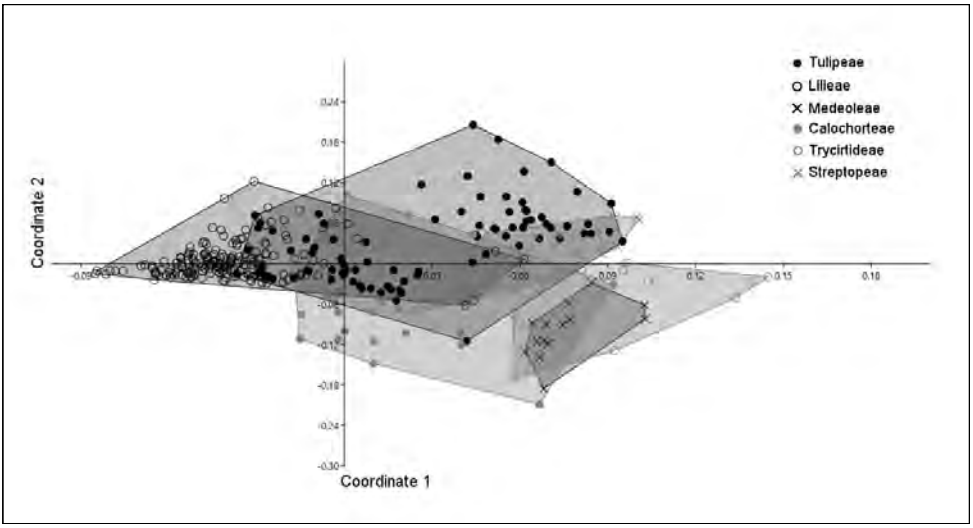

Fig 3. PCoA with Gower's distance performed on the tribes within *Liliaceae*, using 11 karyological parameteres. Original karyomorphological data derived from Peruzzi & al. (2009).

ing CV_{CL} and M_{CA} were inferred by a statistical model. Indeed, in the phylogenetic tree, M_{CA} resulted changing with a trend going from asymmetrical to more symmetrical karyotypes, confirming that the common assumption that symmetrical karyotypes are plesiomorphic (Stebbins 1971) is often wrong.

Concerning modern cytotaxonomy, molecular cytogenetics has reached great advances, for example in tracing karyotype evolution in *Brassicaceae* through chromosome painting techniques using BAC (Lysak & Lexer 2006; Lysak & al. 2007; Schranz & al. 2007; Mandáková & Lysak 2008; Mandáková & al. 2010; Mandáková & al. 2012; Lysak 2014). In addition, in the near future Next Generations Sequencing technique could implement the construction of BAC libraries (Dolezel & al. 2014) for chromosome painting comparison, and could facilitate the development of probes for comparative FISH analysis (Soltis & al. 2013). However, this kind of analysis cannot completely replace traditional karyomorphology. Indeed, molecular cytogenetics is often limited to comparisons of very closely related taxa (e.g., comparisons of 45S and 5S positions using FISH, investigations of recent hybridization events using GISH, etc.; see also Siljak-Yakovlev & Peruzzi 2012). Moreover, molecular cytogenetic data are still poor in terms of number, lacking a wide coverage of plant diversity, with respect to the vast amount of basic karyological data (Peruzzi & Bedini 2014). For example, up to now comparative chromosome painting has been widely applied almost exclusively within *Brassicaceae* family.

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Addresses of authors:
Giovanni Astuti, Francesco Roma-Marzio & Lorenzo Peruzzi,
Dipartimento di Biologia, Università di Pisa, Via Derna, 1 – 56126 Pisa, Italy. E-mail: gastuti@biologia.unipi.it

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M. Karadelev, K. Rusevska, G. Venturella & M. L. Gargano

An insight into the presence of lignicolous fungi in Sicily (southern Italy)

Abstract

Karadelev, M., Rusevska, K., Venturella, G. & Gargano M. L.: An insight into the presence of lignicolous fungi in Sicily (southern Italy). — Fl. Medit. 27: 99-110. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

Thirty-six lignicolous fungal species (4 *Ascomycota* and 32 *Basidiomycota*), included in 16 families and 28 genera have been recorded in different natural and reforested areas of Sicily. *Amylostereum laevigatum*, *Ceriporia excelsa*, *Phlebia lilascens,* and *Stereum insignitum* represent new records for Sicily. Notes on some rare species are also here reported.

Key words: fungal diversity, ecology, distribution, forest fungi, Mediterranean area.

Introduction

Fungi as heterotrophes represent one of the most important organisms in forest ecosystems (Carroll & Wicklow 1992; Zhu & al. 2015). Fungi that not only grow on wood but cause process of wood decaying are included in the category “lignicolous fungi” (Mueller & al. 2004). They degrade different plant host materials and colonise different environmental niches by producing different enzymes (Petre & al. 2014). According to the type of decay that they cause the lignicolous fungi are brown rot, soft rot, and white rot (Fukasawa & al. 2011). Lignicolous fungi are one of the key player organisms in the forest ecosystems due to the following issues: they are essential for the functioning of forest ecosystems since they contribute to the wood decomposition and nutrient recycling, soil formation and the general carbon budget (Lonsdale 2008; Županić & al. 2009). The residual products of decomposition from fungal action have variable pH, solubility and redox potentials thus can have a noticeable effect on the environment of the specific area. In particular, these products can be incorporate in the soil and sediment over time (Dashtban & al. 2010).

Some species of wood-decay fungi attack dead wood, such as brown rot, and some, such as *Armillaria* species, are parasitic and colonize living trees. Lignicolous fungi possess high decay ability on different living forest trees (Worral & al. 1997; Fukasawa

& al. 2011; Angelini & al. 2016) as well as on many other woody plant species such as tree fruit and ornamental trees (Adaskaveg & al. 1993; Auetragul & al. 2015).

Biodiversity studies of these fungi have been carried out in Italy over the last decades (Venturella 1991; Bernicchia 2005; Venturella & al. 2011; Landi & al. 2015). New sets of data including both ecological (Angelini & al. 2016; Venturella & al. 2015) and distributive data (Karadelev & al. 2017) are constantly appearing during regular examination and investigation of this area.

The aim of this paper was to improve the knowledge of the ecological and distribution data on lignicolous fungi from Sicilian forest ecosystems and to highlight the presence of some rare and interesting species for the examined southern region in Italy. A special attention was paid to natural reserves and regional parks of Sicily within which fall different forest types of particular biogeographic importance such as woods of *Fagus sylvatica* L., mixed woods of *Quercus petraea* (Matt.) Liebl. and *Ilex aquifolium* L., *Taxus baccata* L., *Abies nebrodensis* (Lojac.) Mattei, and *Chamaerops humilis* L.

Materials and Methods

Observation on different forest ecosystems in the Nebrodi Regional Park (province of Messina), the Zingaro Oriented Natural Reserve (province of Trapani), and the Madonie Regional Park (province of Palermo) and in areas planted with *Acacia karoo* Hayne were carried out during spring in 2016.

For identification of species standard methods were used, implying microscoping, application of reagents (Melzer reagent, Sulphovanilin, Cotton blue, KOH, etc.) and consulting the following keys and monographs as resources for determination of the collected fungi: Eriksson & Ryvarden (1973); Eriksson & al. (1978, 1984); Breitenbach & Kränzlin (1981, 1986); Jülich (1984); Hjortstam & al. (1987); Hansen & Knudsen (1992, 1997, 2000); Ryvarden & Gilbertson (1993-1994); Bernicchia (2005) and Bernicchia & Gorjon (2010).

The nomenclatural notes are referred to Index Fungorum (http://www.indexfungorum.org/names/names.asp) while the nomenclature of vascular plants follow The Euro+Med PlantBase - The Information Resource for Euro-Mediterranean plant diversity (http://www.emplantbase.org/home.html).

The herbarium samples were prepared in the airdryer and kept in the Macedonian Collection of Fungi of the Institute of Biology at the Faculty of Natural Sciences and Mathematics in Ss. Cyril and Methodius University in Skopje in the Republic of Macedonia (MCF) and in the Herbarium SAF of the Department of Agricultural, Food and Forest Sciences in the University of Palermo (Italy).

The species are reported in a taxonomical order including both phylum (Ascomycota and Basidiomycota) and family name in the list. Data pertaining to geographical distribution, altitude, forest association, and data source are provided under each fungal species.

List of species

Ascomycota

Bertiaceae Smyk

***Bertia moriformis* (Tode) De Not.**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *Fagus sylvatica* L. and *Taxus baccata* L., on fallen branches of *F. sylvatica*, 18 May 2016, *Karadelev & Venturella s.n.*, SAF100.

Diatrypaceae Nitschke

***Diatrype disciformis* (Hoffm.) Fr**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen branches of *F. sylvatica*, 18 May 2016, *Karadelev & Venturella s.n.*, SAF101.

Xylariaceae Tul. & C. Tul.

***Annulohypoxylon cohaerens* (Pers.) Y.M. Ju, J.D. Rogers & H.M. Hsieh**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen branches of *F. sylvatica*, 18 May 2016, *Karadelev & Venturella s.n.*, MCF-16299.

***Biscogniauxia nummularia* (Bull.) Kuntze**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen branches of *F. sylvatica* and *Acer campestre* L., 18 May 2016, *Karadelev & Venturella s.n.*, MCF-16285.

Basidiomycota

Amylostereaceae Boidin, Mugnier & Canales

***Amylostereum laevigatum* (Fr.) Boidin**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*,, on bark of living trees of *T. baccata*, 18 May 2016, *Karadelev & Venturella s.n.*, SAF102.

Auriculariaceae Fr.

***Auricularia mesenterica* (Dicks.) Pers.**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen trunks and stumps of *T. baccata*, 18 May 2016, *Karadelev & Venturella s.n.*, SAF103.

***Eichleriella deglubens* (Berk. & Broome) Lloyd**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen branches of *T. baccata*, 18 May 2016, *Karadelev & Venturella s.n.*, MCF-16284; Collesano (Madonie Regional Park, province of Palermo), 460 m, mixed forest of *Quercus suber* L. and *Q. virgiliana* (Ten.) Ten., on fallen branches of *Q. suber* L., 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16297; Isnello, Contrada Montaspro (Madonie Regional Park, province of Palermo), 800 m, mixed forest of *Quercus ilex* L. and *Q. virgiliana*, on fallen branches of *Q. ilex*, 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16286; Petralia Sottana, Piano Pomieri (Madonie Regional Park, province of Palermo), 1200 m, mixed forest of *Quercus petraea* (Matt.) Liebl. and *Ilex aquifolium* L., on fallen branches of *I. aquifolium* L, *Karadelev & Venturella s.n.*, MCF-16283.

***Exidia glandulosa* (Bull.) Fr.**
Petralia Sottana, Piano Pomieri (Madonie Regional Park, province of Palermo), 1200 m, mixed forest of *Q. petraea* and *I. aquifolium*, on fallen branches of *Q. petraea, Karadelev & Venturella s.n.*, SAF104.

***Exidiopsis effusa* Bref.**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen branches of *F. sylvatica* and *A. campestre*, 18 May 2016, *Karadelev & Venturella s.n.*, MCF-16298.

Corticiaceae Herter

***Vuilleminia comedens* (Nees) Maire**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on dry branches of living trees of *F. sylvatica*, 18 May 2016; *Karadelev & Venturella s.n.*, *s.n*., Petralia Sottana, Piano Pomieri (Madonie Regional Park, province of Palermo), 1200 m, mixed forest of *Q. petraea* and *I. aquifolium*, on dry branches of living trees of *Q. petraea*, *Karadelev & Venturella s.n.*, MCF-16289.

***Vuilleminia coryli* Boidin, Lanq. & Gilles**
Isnello, Contrada Montaspro (Madonie Regional Park, province of Palermo), 800 m, mixed forest of *Q. ilex* and *Q. virgiliana*, on dry branches of living tree of *A. campestre*, 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16301; Polizzi Generosa, SP 119, near Vallone Madonna degli Angeli, (Madonie Regional Park, province of Palermo), 1100 m, reafforestation of *Castanea sativa* Miller and *A. campestre*, on fallen branches of *A. campestre*, 20 May 2016, *Karadelev & Venturella s.n.*, SAF105.

***Vuilleminia cystidiata* Parmasto**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on dry branches of living trees of *Crataegus monogyna* Jacq, 18 May 2016; *Karadelev & Venturella s.n.*; Isnello, Contrada Montaspro (Madonie Regional Park, province of Palermo), 800 m, mixed forest of *Q. ilex* and *Q. virgiliana*., on dry branches of living tree of *C. monogyna*, 20 May 2016, *Karadelev & Venturella s.n.*, SAF106.

Hydnodontaceae Jülich

***Subulicystidium longisporum* (Pat.) Parmasto**
Collesano (Madonie Regional Park, province of Palermo), 460 m, mixed forest of *Q. suber* and *Q. virgiliana*, on fallen branches of *Q. suber*, 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16305.

Hymenochaetaceae Donk

***Trichaptum biforme* (Fr.) Ryvarden**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen trunks of *A. campestre*, 18 May 2016, *Karadelev & Venturella s.n.*, SAF107.

Lachnocladiaceae D.A. Reid

***Scytinostroma hemidichophyticum* Pouzar**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen branches of *F. sylvatica*, 18 May 2016, *Karadelev & Venturella s.n.*, MCF-16300.

Meruliaceae P. Karst.

***Junghuhnia nitida* (Pers.) Ryvarden**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen trunks of *F. sylvatica*, 18 May 2016, *Karadelev & Venturella s.n.*, SAF108.

***Phlebia lilascens* (Bourdot) J. Erikss. & Hjortstam**
Isnello, Contrada Montaspro (Madonie Regional Park, province of Palermo), 800 m, mixed forest of *Q. ilex* and *Q. virgiliana*, on fallen branches of *Q. virgiliana*, 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16296.

***Steccherinum ochraceum* (Pers.) Gray**
Isnello, Contrada Montaspro (Madonie Regional Park, province of Palermo), 800 m, mixed forest of *Q. ilex* and *Q. virgiliana*, on fallen branches of *Q. virgiliana*, 20 May 2016, *Karadelev & Venturella s.n.*, SAF109.

Peniophoraceae Lotsy

***Peniophora incarnata* (Pers.) P. Karst.**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on dry branches of living trees of *F. sylvatica*, 18 May 2016, *Karadelev & Venturella s.n.*, SAF110.

Peniophora lycii **(Pers.) Höhn. & Litsch.**
Zingaro Oriented Natural Reserve (province of Trapani), 50 m, Mediterranean maquis with *Spartium junceum* L. and *Chamaerops humilis* L., on dry branches of *S. junceum*, 19 May 2016, *Karadelev & Venturella s.n.*, MCF-16279; ss 113, near Città del Mare-Perla del Golfo (Terrasini, province of Palermo), 20 m, planted *Acacia karoo* Hayne, on fallen branches of *A. karoo*, 19 May 2016, *Karadelev & Venturella s.n.*, MCF-16287

Peniophora meridionalis **Boidin**
Isnello, Contrada Montaspro (Madonie Regional Park, province of Palermo), 800 m, mixed forest of *Q. ilex* and *Q. virgiliana*, on dry branches of living trees of *Q. ilex*, 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16294.

Peniophora nuda **(Fr.) Bres.**
ss 113, near Città del Mare-Perla del Golfo (Terrasini, province of Trapani), 20 m, planted *A. karoo* Hayne, on fallen branches of *A. karoo*, 19 May 2016, *Karadelev & Venturella s.n.*, MCF-16295

Peniophora pini **(Schleich.) Boidin**
Polizzi Generosa, SP 119, near Vallone Madonna degli Angeli, (Madonie Regional Park, province of Palermo), 1100 m, reafforestation of *Pinus nigra* J.F. Arnold, on dry branches of *P. nigra*, 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16282.

Peniophora quercina **(Pers.) Cooke**
Petralia Sottana, Piano Pomieri (Madonie Regional Park, province of Palermo), 1200 m, mixed forest of *Q. petraea* and *I. aquifolium*, on dry branches of living trees of *Q. petraea*, *Karadelev & Venturella s.n.* MCF-16292; on dry branches of living trees of *Q. ilex, Karadelev & Venturella s.n.*, MCF-16293.

Phanerochaetaceae Jülich

Byssomerulius corium **(Pers.) Parmasto**
Isnello, Contrada Montaspro (Madonie Regional Park, province of Palermo), 800 m, mixed forest of *Q. ilex* and *Q. virgiliana*, on dry branches of living trees of *A. campestre* L., 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16302.

Ceriporia excelsa **S. Lundell ex Parmasto**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen branches of *F. sylvatica*, 18 May 2016, *Karadelev & Venturella s.n.*, SAF111.

Phlebiopsis ravenelii **(Cooke) Hjortstam**
Collesano (Madonie Regional Park, province of Palermo), 460 m, mixed forest of *Q. suber* and *Q. virgiliana*, on fallen branches of *Q. suber*, 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16290; Isnello, Contrada Montaspro (Madonie Regional Park, province of

Palermo), 800 m, mixed forest of *Q. ilex* and *Q. virgiliana*, on fallen branches of *Q. ilex*, 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16288.

Porostereum spadiceum **(Pers.) Hjortstam & Ryvarden**
Zingaro Oriented Natural Reserve (province of Trapani), 50 m, Mediterranean maquis with *S. junceum* and *C. humilis*, on dry branches of *S. junceum*, 19 May 2016, *Karadelev & Venturella s.n.*, MCF-16291.

Polyporaceae Fr. ex Corda

Cerioporus varius **(Pers.) Zmitr. & Kovalenko**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen trunks of *F. sylvatica*, 18 May 2016, *Karadelev & Venturella s.n.*, SAF112.

Picipes badius **(Persoon) Zmitr. & Kovalenko**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen trunks of *A. campestre*, 18 May 2016, *Karadelev & Venturella s.n.*, MCF-16304.

Daedaleopsis nitida **(Durieu & Mont.) Zmitr. & Malysheva**
Isnello, Contrada Montaspro (Madonie Regional Park, province of Palermo), 800 m, mixed forest of *Q. ilex* and *Q. virgiliana*, on trunks of *Q. ilex* L., 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16303.

Trametes versicolor **(L.) Lloyd**
Collesano (Madonie Regional Park, province of Palermo), 460 m, mixed forest of *Q. suber* and *Q. virgiliana*, on fallen branches of *Q. suber*, 20 May 2016; *Karadelev & Venturella s.n.*; Isnello, Contrada Montaspro (Madonie Regional Park, province of Palermo), 800 m, mixed forest of *Q. ilex* and *Q. virgiliana*, on logs of *Q. ilex* and *Q. virgiliana*, 20 May 2016, *Karadelev & Venturella s.n.*, SAF113.

Schyzoporaceae Jülich

Schizopora paradoxa **(Schrad.) Donk**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on fallen branches of *F. sylvatica*, 18 May 2016, *Karadelev & Venturella s.n.*, SAF 220; Collesano (Madonie Regional Park, province of Palermo), 460 m, mixed forest of *Q. suber* and *Q. virgiliana*, on fallen branches of *Q. virgiliana*, 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16281; Isnello, Contrada Montaspro (Madonie Regional Park, province of Palermo), 800 m, mixed forest of *Q. ilex* L. and *Q. virgiliana*, on stem of *Q. ilex* L., 20 May 2016, *Karadelev & Venturella s.n.*, MCF-16280.

Stereaceae Pilát

Stereum hirsutum **(Willd.) Pers.**
Isnello, Contrada Montaspro (Madonie Regional Park, province of Palermo), 800 m, mixed forest of *Q. ilex* and *Q. virgiliana*, on logs of *Q. ilex*, 20 May 2016; *Karadelev & Venturella s.n.*, *s.n.* Piano Battaglia, (Madonie Regional Park, province of Palermo), 1600 m, *F. sylvatica* forest, on fallen branches of *F. sylvatica*; *Karadelev & Venturella s.n.*; Petralia Sottana, Piano Pomieri (Madonie Regional Park, province of Palermo), 1200 m, mixed forest of *Q. petraea* and *I. aquifolium*, on fallen branches of *Q. petraea*; *Karadelev & Venturella s.n.*; Polizzi Generosa, SP 119, near Vallone Madonna degli Angeli, (Madonie Regional Park, province of Palermo), 1100 m, reafforestation of *C. sativa* and *A. campestre*, on fallen branches of *C. sativa*, 20 May 2016, *Karadelev & Venturella s.n.*, SAF114.

Stereum insignitum **Quél.**
Bosco della Tassita (Nebrodi Regional Park, province of Messina), 1347 m, mixed forest of *F. sylvatica* and *T. baccata*, on dry branches of living trees of *F. sylvatica*, 18 May 2016, *Karadelev & Venturella s.n.*, SAF115.

Tremellaceae Fr.

Tremella mesenterica **Retz.**
Petralia Sottana, Piano Pomieri (Madonie Regional Park, province of Palermo), 1200 m, mixed forest of *Q. petraea* and *I. aquifolium*, on fallen branches of *Q. petraea*, *Karadelev & Venturella s.n.*, SAF116.

Discussion and Conclusions

In the Mediterranean forests, a high level of diversity for plants and fungi can be recognized (Scarascia-Mugnozza & al. 2000). In the last years, this diversity is subjected to a massive anthropic pressure, to wrong silvicultural treatments and to the effect of climatic changes. In particular, the interruption in the practice of removal of woody material into the forests has favored the permanence of common lignicolous species, which typically grow on small branches and wood residues of different sizes.

In different natural and reafforested areas of Sicily, we recorded thirty-six lignicolous fungi species (4 *Ascomycota* and 32 *Basidiomycota*), included in 16 families and 27 genera. Most of the specimens were collected in *Fagus sylvatica* and *Taxus baccata* mixed forests (19 records) and *Q*uercus *ilex* and *Q. virgiliana* mixed forests (12 records). A lower number of specimens arise from *Q. petraea* and *Ilex aquifolium* mixed forest (6 records) and from *Q. suber*, *Q. virgiliana,* and *Q. petraea* mixed forest (5 records). Three specimens were recorded in *Castanea sativa* and *A*cer *campestre* mixed forest, on plant of *A. campestre* and two in the maquis with *Spartium junceum* and *Chamaerops humilis*, respectively. On isolated plants of *Pinus nigra* and *F. sylvatica* were instead collected only a specimen per each trees.

All lignicolous species belongs to the ecological category Sw (saprotroph on wood): they mainly colonize fallen branches, barks, trunks, stumps, and logs both of dead or living trees.

Species like *Auricularia mesenterica*, *Byssomerulis corium*, *Bertia moriformis*, *Diatrype disciformis*, *Exidia glandulosa*, *Peniophora incarnata*, *P. lycii*, *P. meridionalis*, *P. quercina*, *Stereum hirsutum*, *Steccherinum ochraceum*, *Schizopora paradoxa*, *Trichaptum biforme*, *Tremella mesenterica,* and *Trametes versicolor* are very common and widely distributed in the Italian forest ecosystems. Referring to the survey of Bernicchia & al. (2008), *Vuilleminia comedens* is a widely distributed lignicolous species in the forests of the Italian territory. *V. coryli* is an uncommon species in Italy previously recorded for Friuli Venezia Giulia, Emilia Romagna, Lazio, Sardinia, and Tuscany (Bernicchia & al. 2008). *Acer campestre* is a new substratum here reported for *V. coryli*. Finally, the very rare *V. cystidiata* confirms, even in the Sicilian forests, its preference for the wood of members of family *Rosaceae* and in particular for that of shrubs of the genus *Crataegus* L.

Annulohypoxylon cohaerens, introduced in Italy with trade, is a conspicuous cause of rot disease on beech trees and it is included in the European Database of the Invasive Forest Pathogens (IFPs) (Schumacher & al. 2006; Santini & al. 2013).

In *Fagus sylvatica* woods of Italy, in recent times, the biotic and abiotic stresses have determined an increase of attacks by pathogenic fungi and particularly by *Biscogniauxia nummularia*, a xylariaceous fungus associated with severe beech-decline events (Luchi & al. 2006). The presence of *B. nummularia* in Bosco della Tassita confirms the stress conditions of beech trees in Sicily.

Eichleriella deglubens is a very rare saprotroph previously recorded in Sicily on trunks of *Quercus ilex* L. (Venturella & al. 2007). Its distribution in Italy is limited to scattered localities of few regions, i.e. Sardinia, Trentino Alto Adige and Veneto (Onofri & al. 2003). *T. baccata*, *Q. suber,* and *I. aquifolium* are new substrata here reported for *E. deglubens*.

The distribution of *S. longisporum* in Italy is limited to few regions (Onofri & al. 2003). In this paper, we report the second findings of this species in Sicily on a different substratum, i.e. fallen branches of *Q. suber*.

The presence of *Scytinostroma hemidichophyticum* and *Junghuhnia nitida* on fallen branches of *F. sylvatica*, in a mixed forest of *F. sylvatica* and *T. baccata* is confirmed in this paper.

The infrequent *P. spadiceum* is reported on a unusual substratum, the Spanish broom (*S. junceum*), at the sea level in the Mediterranean maquis.

Phlebiopsis ravenelii previously recorded for Italy in the maquis of *Arbutus unedo* L. (Pérez Gorjón & al. 2006) it has been collected on different substrata, i.e. fallen branches of *Q. ilex* and *Q. suber*.

As also reported for other geographic areas by Zmitrovich & al. (2016), *Cerioporus varius*, confirms its presence and its ecological role with old-growth broadleaf trees. The presence of *D. nitida* in mixed forests of the Mediterranean southern regions is also confirmed (Pisani & al. 2016).

The following species *Amylostereum laevigatum*, *Ceriporia excelsa*, *Phlebia lilascens,* and *Stereum insignitum* represent new records for Sicily. In particular, *S. insignitum* is a thermophilous species with a rather restricted distribution in southern Europe (Winterhoff 1992). Furthermore, *C. excelsa*, *Exidiopsis effusa* and *Vuilleminia coryli* are rare species, recorded on different deciduous susbtrata, in Italy (Onofri 2005). *Phlebia lilascens*, infrequent in Italy and locally frequent in some European countries (Pérez Gorjón & al. 2009), is reported for the first time on *Quercus virgiliana*. In addition, *P. badius* has a scattered distribution in Italy (Onofri & al. 2003).

Specific record is that of *Peniophora nuda* on planted *Acacia karoo*. This species was previously reported only for the region of Lombardia and Veneto on different substrata (Onofri 2005). Furthermore, *Peniophora pini* is reported for the first time in southern Italy on *Pinus nigra* since it was previously recorded only in Piedmont and Trentino Alto Adige (Onofri 2005).

In conclusion, the Sicilian forests express a high level of lignicolous fungi diversity, some of them very rare in Europe (Karadelev & al. 2017) and this data is also confirmed by the presence of *Ceriporia excelsa*, a taxon included among the sets of Indicator (Signal) species for cryptogams biodiversity (Nordėn & al. 2007). Besides many of the recorded polyporoid taxa are important producers of substances having immunomodulatory, antitumoral, antiviral, and antihyperlipidemic effect and represent a very important genetic resource, which should be mantained for different applications in the near future (Zmitrovich & Kovalenko 2016).

Acknowledgments

The authors contributed equally to this work.

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Addresses of the authors:
Mitko Karadelev[1], Katerina Rusevska[1], Giuseppe Venturella[2] & Maria Letizia Gargano[2],
[1]Ss. Cyril and Methodius University, Institute of Biology, blvd. Goce Delcev 9, 1000 Skopje, Republic of Macedonia. E-mail mitkokaradelev@gmail.com
[2]Department of Agricultural, Food and Forest Sciences, University of Palermo, Viale delle Scienze, Bld. 5, I-90128 Palermo, Italy. E-mail: giuseppe.venturella@unipa.it, marialetizia.gargano@unipa.it

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Anders Langangen

The disappearance of *Chara hellenica* (*Characeae*) from the only one known locality, Lake Bertonou in Corfu (Greece)

Abstract

Langangen, A.: The disappearance of *Chara hellenica* (*Characeae*) from the only one known locality, Lake Bertonou in Corfu (Greece). — Fl. Medit. 27: 111-116. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

The charophyte collected in Lake Bertonou in 2008 was later described as a new species, *Chara hellenica* (*Characeae*). It was also found in 2014, but not in 2015 and 2016. The reason for its disappearance is most probably runoff soluble such as phosphorus and nitrogen from Temploni landfill.

Key words: Charophytes, Temploni, water pollution, Greece.

Introduction

Corfu is situated in the Ionian Sea, close to the border of Albania. The island has several eutrophic fresh water lakes, especially in the central parts, and also some salt lakes and brackish water localities (Langangen 2010).

In 2008 a new species, *Chara hellenica,* from Lake Bertonou, near the village of Temploni, was found growing in dense stands and covering the bottom in shallow water (Fig. 1) (Langangen 2010). My observations were from land, in the northwestern part of the lake. The bottom in this lake is brown clayish soil. The lake has a rich bird life.

Chara hellenica has some unique characters which separate it from other species, especially the dioecious condition of a diplostichous species. The spine-cells also exhibit a key character, varying from single to pair and three together, and are commonly longer than the stem diameter. Also features of the bract-cells are special as the anterior are long and the posterior are rudimentary.

Material and methods

The island of Corfu was visited in 2008 (Langangen 2010), in June 2014, two times in 2015 and again in spring 2016 (see Table 1). The specific conductivity of the water was

Table 1. The measured abiotic parameters; specific conductivity, calcium, tot-P, phosphate, tot-N and nitrate.

Date	Specific conductivity µS/cm	Ca^{2+} mg/L	Tot-P mg/L*	$PO_4{}^{3-}P$ mg/L	Tot-N mg/L**	$NO^{3-}/NO^{2-}N$ mg/L
26.05.2008	**1200**	**170**	**-**	**-**	**-**	**-**
30.06.2014	**1380**	**200**	**0.23**	**-**	**17.2**	**-**
08.04.2015	**1400**	**236**	**0.12**	**-**	**5.0**	**-**
02.10.2015	**2380**	**140**	**0.39**	**-**	**64.1**	**-**
04.05.2016	**1200**	**200**	**0.12**	**0.085#**	**23.6**	**18.8##**

* uncertainty ±10%, **uncertainty ±15%, # uncertainty ±20%, ## uncertainty ±15%

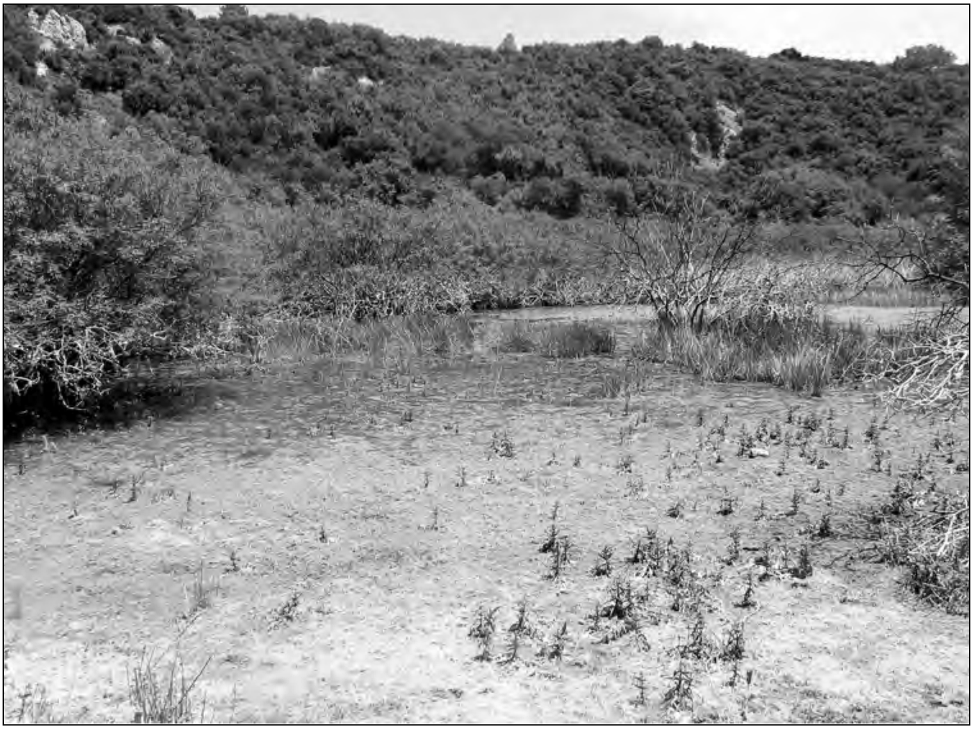

Fig. 1. Lake Bertonou. In shallow water the bottom is covered with *Chara hellenica.* Photo 26.05.2008.

measured with a Milwaukee SM 301 EC meter, range 0-1990 µm/cm. Calcium was measured with Aqua Merck test kit.

Analyzes of phosphorus and nitrogen have been done by VestfoldLAB AS (www.vestfoldlab.no).

Geology

According to the geological map of Corfu (Higgins & Higgins 1996) the bedrock around Lake Bertonou is Triassic breccias. This kind of rock is a mixture of Triassic limestone and dolomites as well as gypsum. A similar area has been extensively examined on the mainland, south of Corfu between Gulf of Arta and Gulf of Patras (Zagana & al. 2011). This was a karstified area, which also is the case for the area around Templоni. Lake Bertonou is situated in a blind valley, 42 meters above sea level, with Temploni landfill to the west. The lake has, according to locals, an underground outlet which drains eastwards to Gouvia at the coast.

Results

Lake Bertonou is a highly eutrophic lake, surrounded by shrubs and with various aquatic plants.

In 2014 the water-level was low and no charophytes were found in the water, but on land, the dry bottom was covered with white, dried specimens of *C. hellenica*. The specimens were richly fertile with ripe, black oospores. These were the remains of stands of *C. hellenica* from the spring this year. Stones on the bottom were covered with filamentous green algae.

In 2015 I visited the lake two times, in April and in October. In April 2015 the water level was relatively high, but had been higher earlier in the year (Fig. 2). The shores were more or less covered with dense mats of filamentous green algae, partly hanging on the vegetation and floating in the surface. No charophytes were found. The brook coming in from northwest, in the area around the landfill, was flowing very high.

The green algae found were: *Ulothrix* sp., *Microspora* sp., and *Desmidium swartzii*.

In October 2015 the water level was very low (Fig. 3). The level was at least 2-2.5 m lower than in April. The water was turbid, brownish green and no plants or charophytes were found in the water or on the bottom. Along the shore there were several places with green/brown cover of *Microcystis viridis*, *Euglenia* sp., *Monomorphina* (*Phacus*) sp. The dryer parts were more or less covered by dense vegetation of *Cyperus michelianus* (L.) Link. and *Alopecurus aequalis* Sobol. The growth of these plants was very fast as the area was under water in April. Shrubs and small trees which earlier grew in the water are now without leaves. On shrubs and trees around the lake there are still remains of brown, dried green algae hanging meters above the ground (e.g. *Microspora* sp.) The inlet brook is now dry.

On May 2016 the water level was high. The water was turbid, and the surface along the shores were more or less covered with cushions of algae, e.g. *Tribonema* sp. No charophytes were found.

Fig. 2. Lake Bertonou. Shore on the eastern part of the lake. The watersurface and vegetation is covered with filamentous green algae. Photo 08.04.2015.

Fig. 3. Lake Bertonou and the landfill. Photo 02.10. 2015.

Discussion

As can be seen from figure 1 *Chara hellenica* formed dense stands in the northwestern part of the lake in 2008. This was presumably also the situation in June 2014 when I found large areas on land with white, dried specimens of the charophyte. In 2015 and 2016 there were no finds of any charophytes, not in the water or on land. The water was now turbid and brownish green in colour.

The lake is situated in a lime rich area as can be seen from the measured values of calcium (Table 1). In Sweden the average *Chara*-lake (calcareous lake) had an average calcium value of 62 mg/L (Forsberg 1965). In Lake Bertonou the values were 2-4 times higher.

Specific conductivity is a measure of the total content of electrolytes in the lake. Swedish calcareous lakes reported by Forsberg (1965) had conductivity values between 200-550 µS/cm. In calcareous lakes in the island of Evia (Greece) the measured values were 500-1320 µS/cm (Langangen 2010a). In lake Bertonou these values varied from 1200-2380 µS/cm.

The water level of the lake varied through the year due to precipitation, evaporation and drainage through an underground outlet. In Lake Bertonou the water level was low in fall. This variation in water level will affect the ecology of the lake and the growth of charophytes which developed during the spring and early summer.

Nitrogen and phosphorus are important major elements for normal metabolism in plants and animals. Phosphorus is necessary for the growth of water plants and algae in the lake. Forsberg (1965) found that charophytes grew luxuriant in lakes with tot-P values below 20 µm/L. In highly eutrophic lakes with a high content of phosphorus he found no charophytes. Blindow (1988) found that *Chara hispida* and *C. tomentosa* grew well in phosphorus concentration at 1 mg/L. Instead she proposed light limitation as a reason for decline of charophytes during eutrophication. Eutrophication is most often caused by runoff from agriculture, fertilizer and garbage. The high values of phosphorus and phosphate-P in Lake Bertonou is most probably caused by runoff from Templοni landfill (see below).

In Lake Bertonou the tot-P values are 0,12-0,39 mg/L, values within tolerance limits for charophytes.

Nitrogen is found in many forms in lakes - nitrate, nitrite and ammonia. Total-N is the sum of these constituents and organically bounded nitrogen. In the Norwegian guide to environmental conditions (WDF 2015), the lake type *lime rich, dystrophic (humic?)* is most similar to Lake Bertonou. In such lakes the ecological conditions are good if the value of tot-N is below 1325 µg/L. If the value is above 2025 µg/L the conditions are very unfavorable for charophytes. In Lake Bertonou these values were much higher, between 5,0-64,1 mg/L (5000 µg/L – 64100 µg/L). In 2016 the value of nitrate-N was 18.8 mg/L (18800 µg/L). These high values must be due to runoff from the Templοni landfill.

It has been generally understood that phosphorus has been the cause of the decline of charophytes in fresh waters. In contrast to this Lambert & Davy (2011) found that the concentration of nitrate -N strongly affected the growth of charophytes. In the field they found that a concentration of 0.5 mg/L NO_3-N gave optimal growth, which also was supported in growth experiments with *Chara globularis*. At values above 8 mg/L the plants became red and necrotic. In my one observation from 2016, the value of nitrate-N was 18.8 mg/L, well above the necrotic concentration.

The disappearance of *Chara hellenica* from Lake Bertonou is most probably caused by runoff from Temploni landfill, as indicated by the increased values of nitrogen and phosphorus. This runoff has resulted both in the high concentration of nitrate -N and turbid brown green water in both 2015 and 2016.

The visible change of the water quality is most likely the reason why *Chara hellenica* is no longer found. It is to be hoped that if the heavy pollution of the lake is stopped, the lake can be restored, and if oospores have survived in the bottom sediments, that the charophyte will return.

The Temploni landfill has been registered as illegal by the European Commission (EU) since at least 2007 (EU 2015a, 2015b).

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Address of the author:
Anders Langangen,
Hallagerbakken 82b, 1256 Oslo, Norway. E-mail: langangen@hotmail.com

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L. Peruzzi, S. Bagella, R. Filigheddu, B. Pierini, M. Sini, F. Roma-Marzio, K. F. Caparelli, G. Bonari, G. Gestri, D. Dolci, A. Consagra, P. Sassu, M. C. Caria, G. Rivieccio, M. Marrosu, M. D'Antraccoli, G. Pacifico, V. Piu & G. Bedini

The Wikiplantbase project: the role of amateur botanists in building up large online floristic databases

Abstract

Peruzzi, L., Bagella, S., Filigheddu, S., Pierini, B., Sini, M., Roma-Marzio, F., Caparelli, K. F., Bonari, G., Gestri, G., Dolci, D., Consagra, A., Sassu, P., Caria, M. C., Rivieccio, G., Marrosu, M., D'Antraccoli, M., Pacifico, G., Piu, V. & Bedini, G.: The Wikiplantbase project: the role of amateur botanists in building up large online floristic databases. — Fl. Medit. 27: 117-129. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

The Wikiplantbase project, started in 2013, provides a framework where the full set of georeferenced floristic records of Tuscany and Sardinia can be entered, stored, updated and freely accessed through the Internet. Mainly thanks to the collaboration of amateur botanists, data have accumulated quickly. All records entered by collaborators are submitted to the project coordinators, who are enabled to accept, modify, or reject them. As of 22 November 2016, Wikiplantbase #Toscana holds 116,402 verified floristic records (90% based on published literature, 5% on unpublished herbarium specimens, 5% on field observations), and Wikiplantbase #Sardegna 40,043 (77% published literature, 18% unpublished herbarium specimens, 5% on field observations). The records include over 90% of the specific and subspecific taxa known for Tuscany and about 70% – but rapidly growing – of those known for Sardinia. The most recorded species are *Quercus ilex* L. (*Fagaceae*) for Tuscany and *Pistacia lentiscus* L. (*Anacardiaceae*) for Sardinia. With minor software tweaking, the online platform Wikiplantbase might be adopted in other contexts, resulting in a well connected network of regional floristic databases suited to exploit the involvement – still largely untapped – of non-academic collaborators, as advocated by citizen science.

Key words: citizen science, Italy, online platform, Sardinia, Tuscany.

Introduction

Online databasing of plant diversity data became one of the major issues in biodiversity informatics in recent years. An increasing number of databases is now available concerning nomenclature and taxonomy, herbarium specimens, invasive alien plant monitoring, plant traits, ecology, vegetation, chromosome numbers, plant rDNA sites, genome size,

* Extended and enriched version of the oral presentation given at the XV OPTIMA meeting in Montpellier, 6-11 June 2016.

DNA sequences. On the contrary, there are still few publicly available databases storing detailed information on plant distribution, especially at local level. Floristic records provide baseline data for researches in plant biology, linking a certain systematic unit to the localities where it is known to occur. As printed sources – like e.g. floras – are quickly outdated, researchers must look for updated data in the scientific literature and herbarium specimens (Bedini & al. 2016, and literature cited therein).

In consideration of this, in June 2013 we have started the project “Wikiplantbase #Toscana” (Peruzzi & Bedini 2015 onwards) to provide a framework where the full set of georeferenced floristic records of Tuscany can be entered, stored, continuously updated and freely accessed through the Internet (Bedini & Peruzzi 2013). Mainly thanks to the collaboration of amateur botanists, in few months thousands of data accumulated (more than 4,000 floristic records in September 2013, 54,233 in September 2014, see Bedini & al. 2014) and in the fall of year 2014 also “Wikiplantbase #Sardegna” (Bagella & al. 2015-onwards) went online and was quickly populated with floristic records (Bagella & al. 2015; Peruzzi & al. 2015). Shortly after, the project data were merged in a single database, whilst maintaining two distinct web addresses for accessing the data for Tuscany and Sardinia. All records entered by collaborators are submitted to the project coordinators, who are enabled to accept, modify, or reject them. Based on the data stored in Wikiplantbase #Toscana at the beginning of 2015, we officially presented our project to the international scientific community (Bedini & al. 2016).

Materials and methods

Botanical nomenclature follows Conti & al. (2005, 2007) and subsequent updates issued as “Notulae alla checklist della Flora vascolare Italiana” on Informatore Botanico Italiano from 2007 to 2015 and on Italian Botanist from 2016 onwards. Plant names are associated to higher taxa following Peruzzi (2010a) and APG IV (The Angiosperm Phylogeny Group, 2016). Names of herbaria follow Thiers (2007-onwards). Bibliographical references documenting floristic records in Italian regions, and covering the period 1950-2005, were obtained by Scoppola & Magrini (2005).

Georeferenced toponyms were mostly obtained from public databases maintained online by Regione Toscana (http://sira.arpat.toscana.it/sira/Toponomastica/COMUNI.htm) and Regione Sardegna (http://webgis.regione.sardegna.it/ricercatoponimi/).

Data management is powered by the open source relational DBMS Postgresql version 8.3, installed on a server maintained by the IT services of Pisa University. The same server provides storage space for the whole system. The database was designed around the concept of floristic record, i.e. the association of a valid plant name to a point in time and space via an accepted documentation. An Entity-Relationship (ER) model (Chen 1976) was developed to describe floristic records - so as to find an acceptable trade-off between the reduction of data redundancy and the practical management of database tables – and then used as a blueprint to create database tables.

The interface was written with custom HTML, CSS, Javascript and PHP coding, with the aim to provide easy and fast access to data and a practical, reliable procedure for entering new data. Georeferenced records are mapped to Google Maps. As Google Maps accepts only WGS84 coordinates, while the Postgresql version used in the project supports only plane coordinates, a software conversion from geographic to metric systems and *vice-versa* was performed via proj4php, a library providing a PHP class for geographic coordinates transformation using proj4 definitions (https://github.com/proj4php/proj4php).

Critical issues about the interface design were discussed in public conferences and solved based on the recommendations and suggestions stemming from the discussion. Further suggestions were provided directly by collaborators after the start of the project, based on the experience gained while entering floristic records in Wikiplantbase.

Access to interface is provided through the project's website.

The number of site visitors is monitored through Google Analytics.

Results

Data structure and interface

The logical ER scheme is shown in Fig. 1.

The data are stored in seven tables, linked via 0:m or 1:m relationships and are arranged in three groups:

1. Georeferenced floristic records: two tables are included here, linked by a 0:m relationship connecting one record of "georeferenced toponyms" to one or many records of "floristic records". This relationship allows each floristic record to be unequivocally georeferenced. The tables are constantly updated by project collaborators via the web interface.
2. Taxonomic database: three tables provide updated plant names in a taxonomic framework. Note the recursive relationship of "plant_names", modelling synonyms and included names. The database is constantly updated by one of us (L. Peruzzi) via a dedicated interface. The taxonomic database is connected to floristic records via a 0:n relationship.
3. Bibliographic database: two tables provide bibliographical lists arranged by region of interest. The tables are constantly updated by project collaborators via the web interface.

Before going online, the tables "plant_names", "bibliographical_references", and "toponyms" were populated with data sourced as shown in Table 1, and were then added to as indicated above.

We developed thirteen interface pages to access different functions of the project, as shown in Table 2. Most pages are public except data entry pages – open to registered collaborators only – and data verification page, open solely to qualified system administrators. Taxonomic tables are updated via a separate interface type, not accessible from Wikiplantbase pages.

Besides the standard searches and reports accessible from the interface through the search, stats, and record density pages, further searches can be run by the database managers through the standard database front-end software – in this case psql – providing a native interface to the database via SQL.

Drop-down menus, autocomplete fields, and radio buttons are implemented in search and data entry pages to enhance ease of use by minimizing the number of keystrokes required to insert a new record or to look for stored records. The current layout of the interface results from the stimulating discussion raised in public conferences (held in Rosignano Marittimo (LI), 15 June 2013; Pisa, 30 April 2015) and from subsequent interaction with users. Therefore, in the data entry page, default values are provided in as many

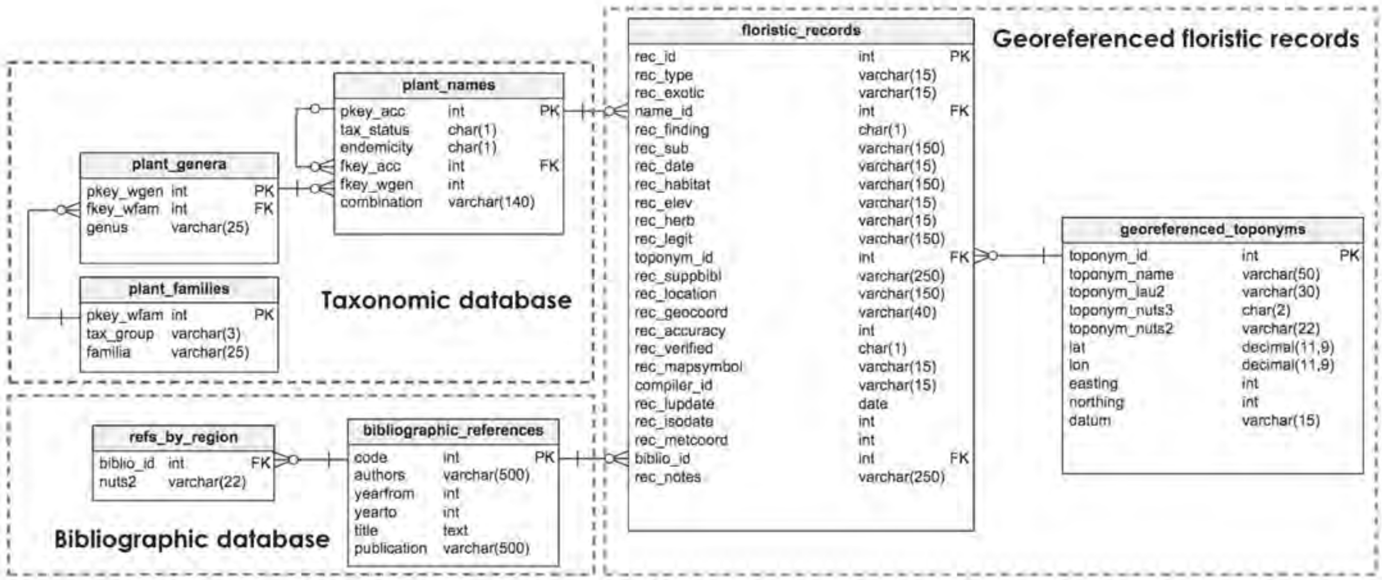

Fig. 1. Structure of the database, showing tables (solid-line rectangles) with their names (in the grey area on top), fields (left column in each table) and field types (right column). Tables are arranged in three groups (dashed-line rectangles). PK = primary key; FK = foreign key.

fields as practical, based on the commonest value for the field; while performing sequential data entry operation, data are carried over in most fields from previously inserted values; plant names and bibliographic references can be entered by typing the first four letters and then selecting from an autocomplete list; georeferencing can be accomplished just by clicking on a map, triggering the automatic fill-in of coordinates, nearest toponym, municipality (lau-2), and province (nuts-3) fields.

When users click on the "Record data" button, fields are checked for syntax and a message is displayed should any issue arise at this stage; if check is passed, data are recorded in the database along with user's credentials and a confirmation message is displayed.

All records are submitted to validation by a project editor prior to being admitted online. Editors are empowered to change items, especially the accepted name for the record. Collaborators in fact do not need to enter an accepted name, but are requested to enter a "sub" name either chosen from an autocomplete list linked with the "plant_names" table or manually typed in the field. In the first case, the accepted name field will be automatically filled, while in the second case it will be left blank: in this case, users can choose a name from an autocomplete list or leave the field blank. The accepted name field cannot be filled with free typing, but only by selecting from a list.

Public engagement

Besides four academic editors, sixty-five collaborators are currently registered in the project, mostly non-academic. They have provided a continuous input to the database since its inception.

While some collaborators are not yet active (i.e. have not yet entered records in the database), the contributions of active collaborators range from 1 to 41,964 records (mode = 180). Besides data, collaborators have contributed valuable feedback about the interface; in some instances, they have pointed out unresponsive or erratic procedures at data entry or search page that needed to be fixed; in others, their suggestions were instrumental in streamlining data entry and improving the search page of Wikiplantbase. In the data entry page, users' suggestions focused on the procedures to enter a plant name, the record location, and the associated bibliographic reference. Experienced users are now able to enter up to two records per minute.

Four events were organized to disseminate Wikiplantbase to actual and potential collaborators as well as to people with a generic interest to know about Wikiplantbase:

- Rosignano Marittimo (15 June 2013, Wikiplantbase #Toscana: verso un catalogo collaborativo, online e gratuito delle piante vascolari di Toscana)
- Pisa (30 April 2015, La nuova versione di Wikiplantbase #Toscana in vista del traguardo delle 100000 segnalazioni: nuove potenzialità per l'inserimento e l'analisi dei dati)
- Sassari (25 November 2015, Piant@Là)
- Monte San Savino (24 luglio 2016, Wikiplantbase #Toscana in azione. Un'escursione alla scoperta della flora vascolare dell'unico "punto bianco" di Wikiplantbase #Toscana. See D'Antraccoli & al. (2016)

Wikiplantbase is connected with two Facebook pages, one for Wikiplantbase #Toscana ("Flora della Toscana"), one for Wikiplantbase #Sardegna ("Flora della Sardegna"), enabling an informal interaction with collaborators and the general public.

In addition, the most active collaborators have been involved in the drafting of papers, including the present one.

Floristic records

As of 22 November 2016, Wikiplantbase holds 156,872 floristic records for Tuscany and Sardinia, and approximately as many records in the ancillary tables "plant_names", "bibliographical_references", "toponyms".

The records for Tuscany include 3,958 specific and subspecific taxa, 1,044 genera and 158 families, referring to a total of 6,930 distinct localities and 808 bibliographic references; by taking into account only "presence" and "doubtful" records (therefore discarding "exclusion" records) of native and exotic taxa (therefore excluding cultivated plants), the number of specific and subspecific taxa drops to 3909, still over 95% of the specific and subspecific taxa known for Tuscany (Pierini & Peruzzi 2014). As regards Sardinia, the records include 2001 specific and subspecific taxa, 660 genera and 128 families, referring to a total of 2,219 different localities and 134 bibliographic references. After selecting presence and doubtful records of native and exotic taxa, the taxonomic coverage is still about 68%, based on Peruzzi (2010b).

The provinces hosting the highest number of floristic records are Grosseto (for Tuscany) and Sassari (for Sardinia) (Fig. 2a, b). In June 2016, a new function was added which

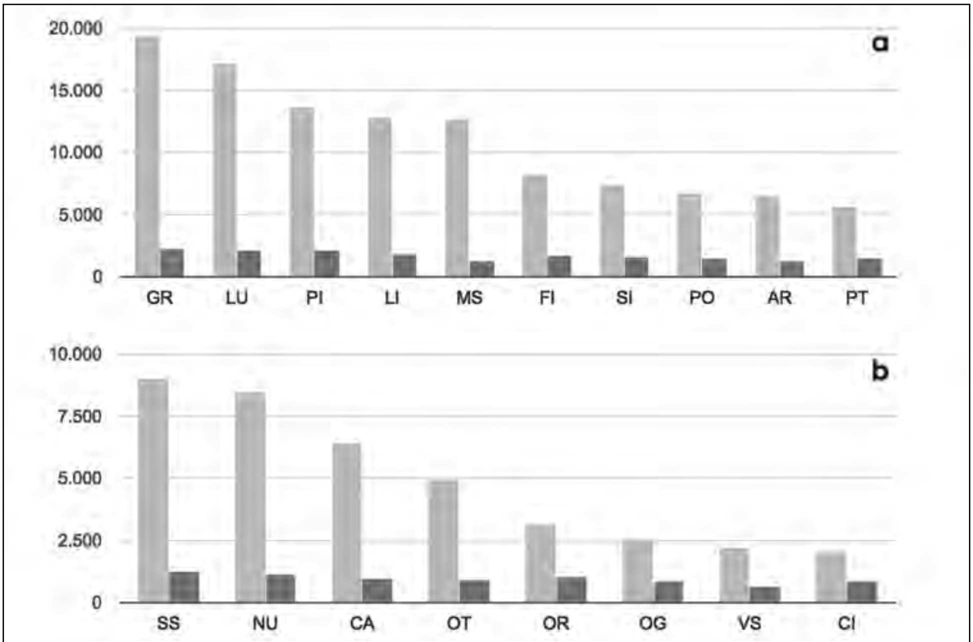

Fig. 2. Number of floristic records (light grey) and species/subspecies (dark grey) per administrative province in Tuscany (a) and Sardinia (b), as of 5 October 2016. GR = Grosseto; LU = Lucca; PI = Pisa; MS = Massa Carrara; LI = Livorno; FI = Firenze; SI = Siena; PO = Prato; AR = Arezzo; PT = Pistoia; SS = Sassari; NU = Nuoro; CA = Cagliari; OT = Olbia-Tempio; OR = Oristano; OG = Ogliastra; VS = Medio Campidano; CI = Carbonia-Iglesias. The updated graphs can be obtained in real time from the webpages http://bot.biologia.unipi.it/wpb/toscana/stats.html and http://bot.biologia.unipi.it/wpb/sardegna/stats.html, respectively.

allows the elaboration – in real time – of a map showing the sampling intensity (in terms of floristic records) for each municipality of the regions. All 280 municipalities in Tuscany have at least one floristic record (Fig. 3), while in Sardinia there are still many municipalities to fill with records (Fig. 4).

Stored floristic records in both regions are based on published literature (about 90% in Tuscany, 77% in Sardinia), herbarium specimens (about 5% in Tuscany, 18% in Sardinia), and unpublished field observations (about 5% in both regions) (Fig. 5a, b). The most recorded species are *Quercus ilex* L. (*Fagaceae*) for Tuscany (427 records from 283 distinct localities; Fig. 5), and *Pistacia lentiscus* L. (*Anacardiaceae*) for Sardinia (333 records from 217 different localities; Fig. 6a, b).

Starting from their availability online, Wikiplantbase pages have been visited 41,979 times by approximately 2800 visitors from 13 countries.

Discussion

The online platform Wikiplantbase is providing a framework where the full set of georeferenced floristic records of Tuscany can be entered, stored, continuously updated and freely accessed through the Internet. While other platforms exist to store biodiversity occurrence data, Wikiplantbase proved to be a very effective tool in this respect. Indeed, a query on plant records run on GBIF (www.gbif.org) returned 3,364 records in a polygon drawn around Tuscany borders and 5,665 around Sardinia, i.e. two and one order of magnitude – respectively – lower than Wikiplantbase for the same territories. Another Italian project, An Archive for Botanical Data (Lucarini & al. 2015), gives free online access to floristic records obtained from 113,457 herbarium specimens and 34,542 relevés in the whole country, mostly related to central Italy. Unfortunately, its interface does not allow to extract the full occurrence data on a regional basis, so that it cannot be directly compared with Wikiplantbase project. However, in terms of order of magnitude, the two systems seem to stand on the same level, but Wikiplantbase achieved this result in a much shorter time span, considering that An Archive was started in 2000 (Lucarini & al. 2015), Wikiplantbase in 2013, mainly thanks to the commitment of the project collaborators.

So far, most records come from published literature. This source impacts the overall quality of the stored data, which is about as good as that of the original papers, mostly subjected to peer-review, and books. Another significant source of data is represented by herbarium specimens, whose labels have been transcribed with no change except taxonomic updates if needed – but in any case, keeping also the original name. Field observations are a minor component of the database; while otherwise undocumented, observations records are carefully checked by the editors at validation step. In doubtful cases, they can request more information to contributors as an aid to their decision to accept or reject the record.

The fast rate of data entry is likely due to the care exerted in designing the user interface, aimed at reducing as far as possible and practical the number of keystrokes required to complete data entry for a floristic record. This design has been appreciated by collaborators, including those who were not accustomed to work with online databases and those who were outright uneasy with filling up an online form. While the user-friendly interface

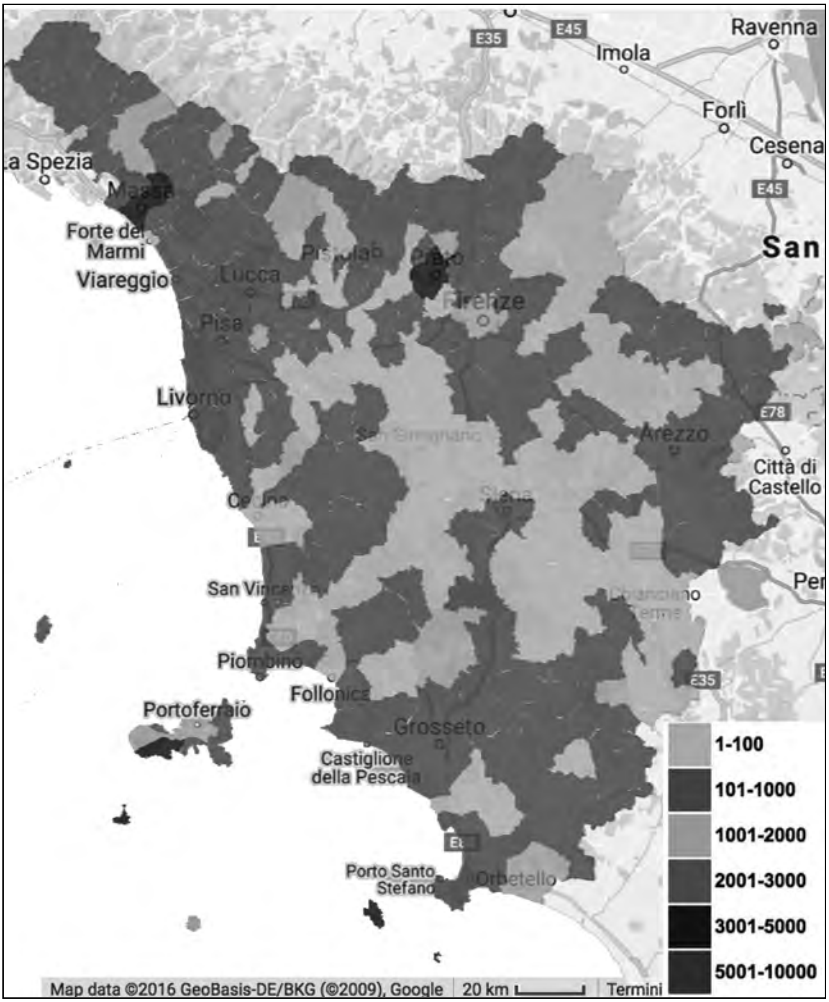

Fig. 3. Sampling intensity (in terms of floristic records) for each municipality of Tuscany, as of 5 October 2016. The different colors in the legend on the right refer to different range numbers of floristic records. The updated map can be obtained in real time from the webpage http://bot.biologia.unipi.it/wpb/toscana/dens_segn.html.

design is a bonus for data entry operators, it is also an effortless way to increase data integrity and semantic coherence. In this context, we were especially concerned about the correct use of plant names and solved the issue by enforcing a selection from a closed list of correct plant names – linked to the "plant_names" table – to fill the accepted name field. As the list in plant_names is constantly updated by the editors, its integrity and taxonomical coherence is ensured upstream of data entry and no responsibility about it is left with users. The selection from closed lists is enforced also in toponym and bibliographical ref-

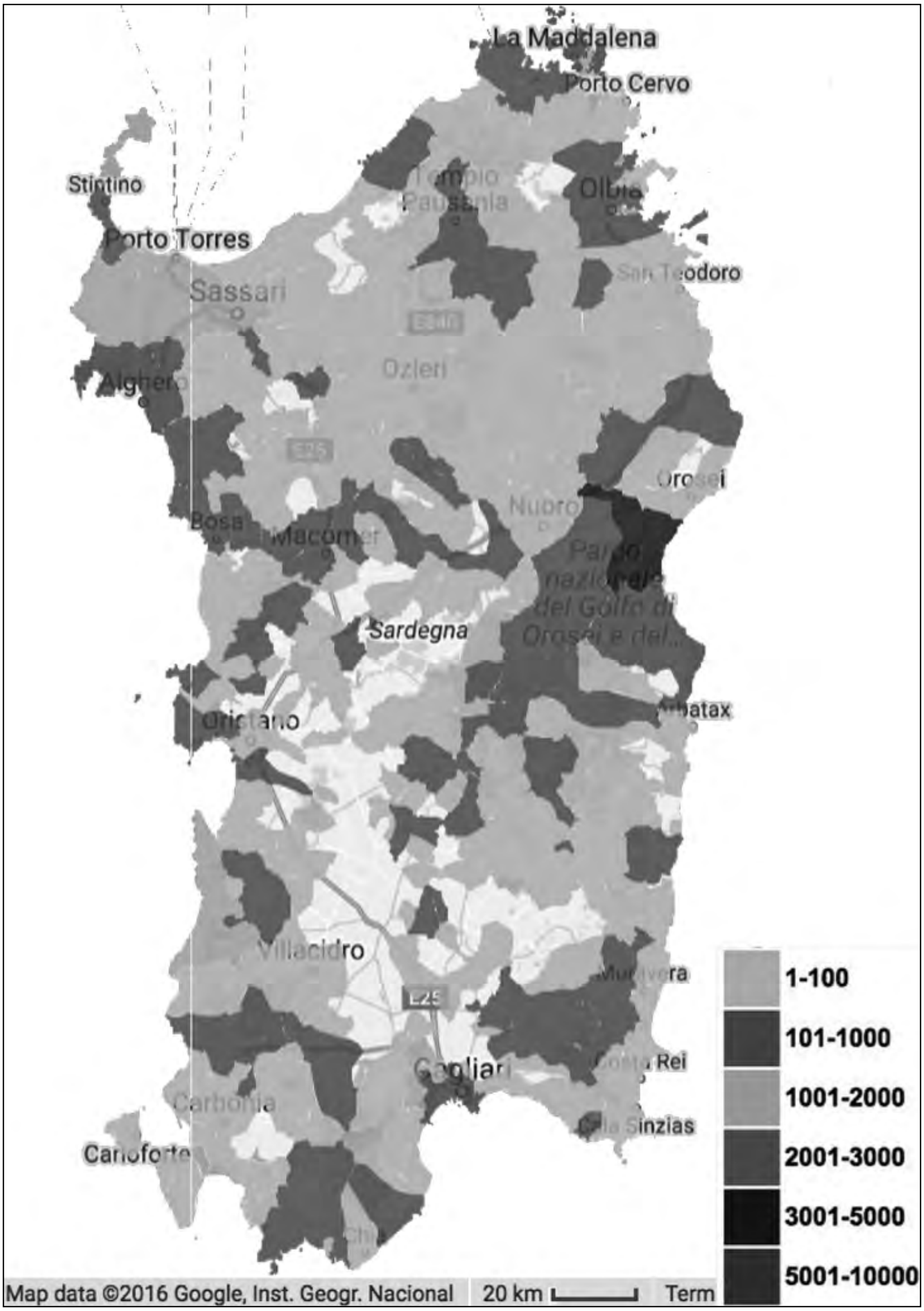

Fig. 4. Sampling intensity (in terms of floristic records) for each municipality of Sardinia, as of 5 October 2016. The different colors in the legend on the right refer to different range numbers of floristic records. The updated map can be obtained in real time from the webpage http://bot.biologia.unipi.it/wpb/sardegna/dens_segn.html.

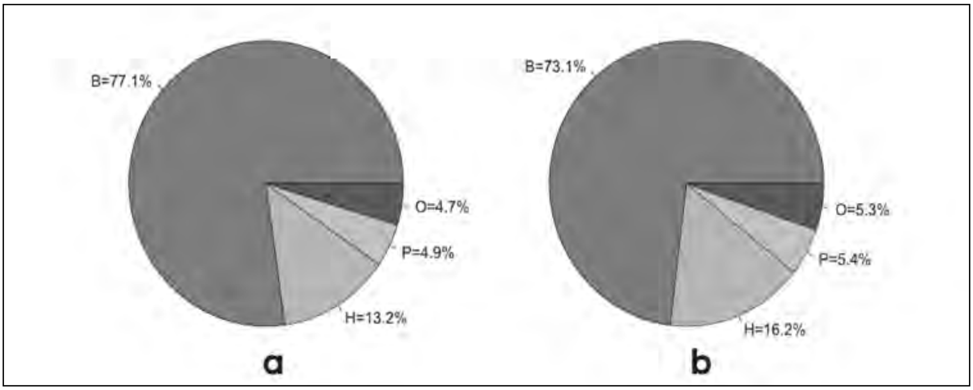

Fig. 5. Typology of floristic records stored in the databases for Tuscany (a) and Sardinia (b), as of 5 October 2016. O = field observations; P = published herbarium records; B = bibliographic records; H = unpublished herbarium records. The updated graphs can be obtained in real time from the webpages http://bot.biologia.unipi.it/wpb/toscana/stats.html and http://bot.biologia.unipi.it/wpb/sardegna/stats.html, respectively.

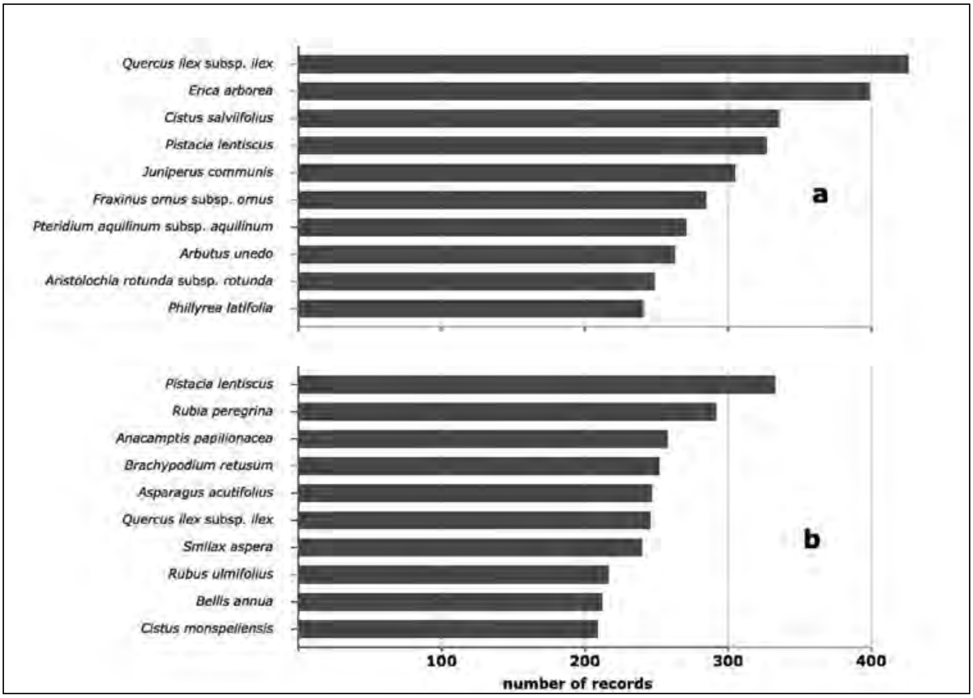

Fig. 6. The ten most recorded species/subspecies in Tuscany (a) and Sardinia (b), as of 5 October 2016. The updated graph can be obtained in real time from the webpage http://bot.biologia.unipi.it/wpb/toscana/stats.html and http://bot.biologia.unipi.it/wpb/sardegna/stats.html, respectively.

erence fields, for the sake of limiting keystrokes and syntactical / semantical errors. Although desirable, this feature comes with a major drawback: if a plant name, a toponym or a bibliographical reference is not included in the list, the appropriate fields cannot be filled and any attempt to record the data will be rejected.

To overcome this hurdle, specific pages have been added for collaborators, where they can add the missing data using appropriate forms and controls, except for plant names as mentioned above.

After about three years of use, feedbacks and adjustments, data entry is now in a mature stage and does not seem to need any major revision. The public search interface, on the other hand, might benefit from several new features, as suggested by users, including:

1. export search results as csv or other formats;
2. query the database by clicking on a map, to retrieve records within a given radius from any point in the map or within a polygon drawn by users;
3. query the database by sending an SQL string, to provide competent users with full flexibility in searching the database, beyond the standardized search types available in the interface.
4. connection with taxon-oriented databases, to integrate taxonomic information and distribution data.
5. integration in large biodiversity data portals such as GBIF (www.gbif.org).

Some of the above points are already in a preliminary phase: as regards item 4, a static link to the taxon-oriented database Acta Plantarum (2007 onward-a) has been added in the homepage of Wikiplantbase and a dynamic link to Acta Plantarum search page has been added to the info window that appears upon clicking on the map symbols representing the records retrieved in a search operation; furthermore, Wikiplantbase is now enabled to accept queries from Acta Plantarum species pages (Acta Plantarum, 2007 onward-b), to power an effective two-way connection between the two systems.

As regards item 5, the connection with BIOCASE and GBIF is now in the testing stage and should go online by the end of 2016 to make Wikiplantbase records accessible through a BIOCASE web service.

In conclusion, Wikiplantbase's current design is the result of iterative interaction with a wide base of mostly non-academic collaborators willing to share their time and passion in a common project. Through subsequent refinements, Wikiplantbase is now a user-friendly system allowing people to feel comfortable about entering data; in turn, this resulted in a fast rate of data entry. Furthermore, Wikiplantbase is designed to be easily adopted in other contexts, resulting in a well-connected network of regional floristic databases suited to exploit the involvement – still largely untapped – of non-academic collaborators, as advocated by citizen science. Indeed, while contacts have been made to extend the project to Liguria, Sicily, any other Italian and foreign territory will be welcome. Given the fast rate of data entry, we foresee Wikiplantbase to furnish a substantial contribution to the floristic knowledge of several Italian territories.

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Addresses of the authors:
Lorenzo Peruzzi[1], Simonetta Bagella[2], Rossella Filigheddu[2], Brunello Pierini[3], Maria Sini[4], Francesco Roma-Marzio[1], Katia Francesca Caparelli[5], Gianmaria Bonari[6], Giovanni Gestri[7], David Dolci[1], Angela Consagra[1], Patrizia Sassu[8], Maria Carmela Caria[2], Giovanni Rivieccio[9], Marco Marrosu[10], Marco D'Antraccoli[1], Giuliano. Pacifico[11], Valeria Piu[12] & Gianni Bedini[1],
[1]Dipartimento di Biologia, Università di Pisa, Italy, e-mail: lorenzo.peruzzi@unipi.it.
[2]Simonetta Bagella, Rossella Filigheddu, Maria Carmela Caria, Dipartimento di Scienze della Natura e del Territorio, Università di Sassari, Italy, e-mail: bage@uniss.it.
[3]via Zamenhof 2, 56127 Pisa, Italy.
[4]Strada Vicinale Li Giosi Nobi 6, 07100 Sassari, Italy.
[5]P.za G. Guerra 28, 50053 Empoli, Italy.
[6]Dipartimento di Scienze della Vita, Università di Siena, Italy.
[7]via Bonfiglioli 30, 59100, Prato, Italy.
[8]Via Amundsen 6, 07100 Sassari, Italy.
[9]Via Balai 72, 07046 Porto Torres, Italy.
[10]SC Platamona 32, 07100 Sassari, Italy.
[11]via Ponte del Vescovo 32/D, 54100 Massa, Italy.
[12]Via Regione Salighes snc, 07014 Ozieri, Italy.

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Ch. Kyriakopoulos, E. Liveri & D. Phitos

Campanula kamariana (section *Quinqueloculares*), a new species from S Peloponnisos, Greece

Abstract

Kyriakopoulos, Ch., Liveri, E. & Phitos, D.: *Campanula kamariana* (section *Quinqueloculares*), a new species from S Peloponnisos, Greece. — Fl. Medit. 27: 131-135. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

In the framework of the first author's Ph.D. dissertation on the study of the flora of Mt. Taigetos (south Peloponnisos) and surrounding areas, as well as the molecular phylogenetic study of *Campanula* (section *Quinqueloculares*) by the second author, a new species, *C. kamariana*, was discovered in the surrounding area of Mt. Taigetos and hereby described. The chromosome number is provided, together with a discussion on the main morphological differences with the seemingly closely related *C. topaliana* s. l., as well as with other taxa in section *Quinqueloculares*. The appropriate conservation status for this species is also recommended.

Key words: *Campanulaceae*, Greek flora, endemism, conservation.

Introduction

In a recent publication on species of *Campanula* in section *Quinqueloculares* (Phitos 2016), as well as in a previous publication by Phitos (1965), it was particularly emphasized the need for a broader study focusing on the strong morphological polymorphism exhibited by this group in order to generate a more informed classification. This ongoing effort is under the guidance of Prof. D. Phitos and Prof. G. Kamari, and the second author, Ms. E. Liveri, is undertaking the molecular study of section *Quinqueloculares* in collaboration with Assoc. Prof. N. Cellinese (Florida Museum of Natural History, University of Florida, USA). This research, combined with the study of the rare and endemic species on Mt. Taigetos and surrounding areas (Kyriakopoulos, in prep.), have resulted in the discovery of a new species, *Campanula kamariana*, in southern Peloponnisos.

Material and methods

Living plants of *Campanula kamariana* were examined in the field. A few specimens are kept under cultivation at the University of Patras. The description of the new species was based on both dry specimens and living material. For the morphological analysis we consulted dry herbarium material kept in *Herb.-Phitos & Kamari* (UPA). For the karyological investigations we used the classical squash technique by Östergren & Heneen (1962) and Kamari (1976), with some small modifications (Phitos & Kamari 1988).

Results

Campanula kamariana Kyriak., Liveri & Phitos **sp. nov.** (Figs. 1 & 2).

Diagnosis: *Campanula kamariana* belongs to section *Quinqueloculares*. It differs from all other *Campanula* taxa in this section, especially from the seemingly closely related *C. topaliana* Beauverd (which is mainly distributed in central and western Peloponnisos), by having strongly lacerate, sparsely pubescent to glabrescent rosette leaves with long, sparsely lobed petioles. Additionally, it differs by having small, triangular, rarely ovate, appendages, not covering the ovary.

Typus: S Peloponnisos (Greece), Nomos Lakonias: Areopolis area, west entrance of Limeni, 36° 40’ 45.71” N, 22° 22’ 31.89” E, ca. 20-30 m a.s.l., limestone rocks, N-NW orientation, 30 Apr. 2017, leg. *Ch. Kyriakopoulos 2321* (Holo: *Herb.-Phitos & Kamari*!). Isotypi: UPA!, ACA!, and PAL-Gr!

Description: Biennial or monocarpic perennial, with stout, woody tap-root. Basal leaves in a rosette, ± 17 cm long, long-petiolate with sparsely lobed petioles; blade of rosette leaves ± 7 × 4.5 cm, longitudinal lanceolate and strongly lacerate, sparsely pubescent to glabrescent. Flowering stems several, up to 30 cm long, procumbent, appressed to the rock, simple or sparingly branched. Lower cauline leaves long petiolate, oblanceolate, laciniate; the uppermost leaves short petiolate, oblanceolate, serrate. Flowers short pedicellate. Calyx lanuginous, with teeth long triangular, acuminate, ± half as long as corolla tube; calyx appendages small, triangular rarely ovate, not covering the ovary. Corolla relatively small, 9-12 mm long, tubular, sparsely puberulent, pale violet-blue; lobes obovate. Capsule (4-)5-locular, stigmas (4-)5.

Karyology: Plants from the *locus classicus* of *Campanula kamariana*, were analyzed karyologically. Results showed a chromosome number $2n = 34$ and a symmetrical karyotype with mostly metacentric (m) chromosomes. The chromosome number and karyotype morphology of *C. kamariana* is congruent with most *Campanula* species in section *Quinqueloculares*, especially with the *C. topaliana* species complex.

Phenology: Flowering from April to the middle of May. Fruiting from May to the middle of June.

Specimens seen: Greece: S Peloponnisos, Nomos Lakonias: Areopolis area, west entrance of Limeni, 36° 40’ 45.71” N, 22° 22’ 31.89” E, ca. 20-30 m a.s.l., limestone rocks, N-NW orientation, 30 Apr. 2017, leg. *Ch. Kyriakopoulos 2321* [Herb.-Phitos & Kamari (UPA)]; ibidem: ca. 50-80 m a.s.l., 10 June 2017, leg. *Ch. Kyriakopoulos 2332* [Herb.-

Fig. 1. Individuals in full flowering and rosette leaves of *Campanula kamariana* from its *locus classicus*.

Fig. 2. Flowering stems of *Campanula kamariana* from its *locus classicus.*

Phitos & Kamari (UPA); ibidem: 17 June 2017, leg. *E. Liveri & V. Ketsilis-Rinis 236* [Herb.-Phitos & Kamari (UPA)].

Distribution and habitat: *Campanula kamariana* is a chasmophytic species growing usually on limestone rocks, like most other species in section *Quinqueloculares*. It was found in the peninsula between the Messinian and Lakonian bay in S Peloponnisos. More precisely, in Limeni, a small village closes to the town Areopolis (Messinian Bay). Other chasmophytic species found growing in association with *Campanula kamariana* include: *Scaligeria moreana* Engstrand, *Stachys canescens* Bory & Chaub., *Onosma graeca* Boiss., etc.

Conservation status: *Campanula kamariana* is apparently a rare endemic species. It is known as of now only from the type locality. However, within the broader area of its distribution range, it is possible that some small isolated subpopulations also exist. The population consists of approximately 150-200 mature individuals. Therefore, this species should be classified as Critically Endangered (CR) according to the IUCN (2016) criteria.

Etymology: The species is named after Georgia Kamari, Professor Emeritus of Plant Systematic and Phytogeography at the University of Patras, graduate supervisor of the first two authors.

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Adresses of the authors:
Charalampos Kyriakopoulos, Eleni Liveri & Dimitrios Phitos,
Botanical Institute, Department of Biology, University of Patras, 265 00 Patras, Greece. E-mails: hakyri@yahoo.gr; eleni-liveri@hotmail.com; dphitos@upatras.gr

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Michele Aleffi

Contribution to the knowledge of the Bryophyte Flora of the Vatican City State: The Pontifical Villas of Castel Gandolfo (Rome, Italy)

Abstract

Aleffi, M.: Contribution to the knowledge of the Bryophyte Flora of the Vatican City State: The Pontifical Villas of Castel Gandolfo (Rome, Italy). — Fl. Medit. 27: 137-150. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

For the first time, the bryoflora of the Pontifical Villas of Castel Gandolfo (Vatican City State) has been studied. Research led to the identification of 87 bryophytes (1 hornworts, 15 liverworts and 71 mosses), among which one liverwort and six moss species are new reports for the Lazio Region. *Zygodon forsteri*, epiphyte species considered Vulnerable in Europe, *Anthoceros agrestis* and other species rare for Italy, were found in the study area. In addition, the life-form of each species was taken into consideration, in order to compare with the ecological and climatic characteristics of the territory examined. The study contributes to the knowledge of a territory of the Vatican City State that until now had been almost unexplored from the bryological point of view and provides important information for the realization and definition of the European and Mediterranean Red List of Bryophytes.

Key words: Bryophytes, *Anthoceros agrestis*, *Zygodon forsteri*, Life-forms, Lazio Region.

Introduction

This work, conducted in the Pontifical Villas of Castel Gandolfo, completes the research carried out on the bryological flora of the Vatican Gardens (Aleffi 2015), providing more detailed information for the production of the Check-List and country status of European Bryophytes.

Previously, numerous studies of the vascular and cryptogamic flora of the city of Rome have been carried out but they did not include this small country. The information about bryophytes in Vatican City was provided only by Bizot (1965) who collected some species from the Dome of Saint Peter's Basilica, and recently by Aleffi (2015), who identified 121 *taxa* mostly concentrated in the Vatican Gardens.

Study area

The Pontifical Villas of Castel Gandolfo comprise about 55 hectares: 30 ha make up a garden, while 25 ha are used for farming. The latter is carried out with full regard for the aesthetics proper to countryside gardening. The Pontifical Villas complex includes the Papal Palace, the Barberini Palace and Villa Cybo, and extends from the top of the hill of Castel Gandolfo (41°44'48.65" N – 12°38'56.79" E), where the Papal Palace is located, as far as the residential area of Albano (41°43'53.21" N – 12°39'30.34" E), along the south-western edge of the crater that forms Lake Albano, in a dominating position facing the Tyrrhenian Sea, at an altitude between 400 m and 450 m a.s.l.

The Pontifical Villas were built on the ruins of the central part of the summer residence of the Emperor Domitian (81-96 AD), which covered about 14 km^2 from the Appian Way to the shores of Lake Albano. After the death of Domitian, the imperial villa quickly began to deteriorate. It was only in July 1596, under the pontificate of Clement VIII, that the Apostolic Chamber took possession of the villas. Pope Clement XIV further enlarged the palace in March 1773 by acquiring the adjacent Villa Cybo. The Pontifical Villas took on their current dimensions after the Lateran Pacts of 1929, with the acquisition of the Villa Barberini complex, where gardens of a new design were established. Worthy of particular mention among these gardens is the Belvedere Garden. Pius XI completed the residence with the acquisition of some gardens toward Albano to create a farm (Fig. 1).

The area of the Pontifical Villas is part of the Roman Castles, an area of volcanic nature that originated with the collapse of the Latium Volcano several hundreds of thousands of years ago. The main opening of the Latium Volcano occupied the entire area of the inner belt of the Castles: its subsequent collapse gave rise to various secondary openings, the most important of which is the current Mont Cavo (949 m a.s.l.). The other minor openings of the Volcano became

Fig. 1. The extensive area of farmland planted with olive trees is characterized by an interesting bryoflora.

lacustrine basins during the hydromagmatic phase of the Latium Volcano through the encounter between magma and subsoil water between 100,000 and 20,000 years ago, the most important of which are Lake Albano and Lake Nemi; most of the other basins have been drained over the course of the centuries (Funiciello & Parotto 1978; Giordano & al. 2006).

According to the classification data of the National Geological Service (1961), most of the territory of the Roman Castles is composed of material from the final eruptions, which gave rise to the famous *peperino*, a material widely used in the construction of many buildings, including all of the Pontifical Villas.

From the climatic point of view, according to the classification of the ecoregions of Italy (Blasi & al. 2014), the studied area is part of the Mediterranean Division (Northern and Central Tyrrhenian Section of the Tyrrhenian Province) with mild winters, autumn temperatures higher than the spring ones, and breezy summers. Average annual precipitation is around 900-1000 mm with a reduction from January-February to July-August and a sharp increase in September.

The Alban Hills are marked by a phenomenon called the *stau*: the water vapor diminishes as the land elevation increases. Thus the greatest rainfall occurs on the first highlands of the Alban Hills, facing the Sea. Normally the area is subject to winds from the southwest, namely the *scirocco* and *libeccio*. Instead, during the winter there are the strong cool winds from the north and northeast, the *tramontana* and *grecale* winds.

The sub-Mediterranean climatic conditions, which fall between the strictly Mediterranean and Temperate ones, and are determined by a moderate drought in the summer period (Blasi & al. 1999; Blasi & Michetti 2005), influence the cryptogamic flora.

Material and Methods

The research was conducted between September 2014 and May 2015 in several phases. The first examined the entire area of the Pontifical Villas, while the later ones concentrated on areas with microclimatic and floristic characteristics of greater bryological interest, such as tree trunks (Fig. 2), archaeological sites and flowerbed soils where there is persistent humidity, with particular regard to the following sites:

the Avenue of Holm Oaks which is adjacent to the entrance of Villa Barberini and reaches the square bordered by the Roman Amphitheatre; an analogous avenue, formed of centuries-old holm oaks, is located between the olive grove of the farm and the Belvedere gardens; *Domitians's Amphitheatre*: built on the pre-existing structures of the Villa of Domitian (81-96 A.D.), characterized by a series of steps originally covered with polychrome marble, and by a theatre building in packed earth;

the Avenue of the Nympheums: starting from the Amphitheatre, currently form the backdrop for the centuries-old trees that compose the Italian-style garden;

Belvedere Gardens: divided into three parterres, the historic gardens are the heart of Villa Barberini, and extend beyond the 300 meters of length of the cryptoporticus that runs alongside them; the gardens are bordered by an avenue of aromatic herbs where numerous officinal plants are cultivated (Fig. 3).

The following list of bryophytes collected during this research gives each *taxon* in alphabetical order, with the location and environment where it was collected. Nomenclature follows Ros & al. (2007) for liverworts and Ros & al. (2013) for mosses. The chorotypes and

Fig. 2. The holm oaks gallery presents special moisture conditions that favor the growth of bryophytes on tree trunks and rocks.

Fig. 3. The Belvedere Gardens is the traditional Italian garden: the first level reproduces the design of a coffered ceiling.

the ecological features are drawn from Dierβen (2001); the life forms from Hill & al. (2007). The samples are kept in the Herbarium of University of Camerino (CAME).

The new *taxa* for the Lazio Region (the geographic region within which the Castel Gandolfo Villas are located) are marked with asterisk (*).

Results

The research conducted in the Pontifical Villas of Castel Gandolfo identified 87 bryophytes: 1 hornwort, 15 liverworts and 71 mosses (Table 1). Of these, 1 hornwort, 4 liverworts and 23 mosses are additions to the bryoflora of the Vatican City State (Aleffi 2015). According to Aleffi & al. (2008), one liverwort and seven mosses are new records for the Lazio Region.

List of *taxa*

Hornworts and Liverworts

**Anthoceros agrestis* Paton: on shaded humid soil of the Roman Amphitheatre.
Cephaloziella baumgartneri Schiffn.: on shaded humid stones of *Opus reticulatum*.
Cololejeunea rossettiana (C. Massal.) Schiffn.: on bark of *Quercus ilex.*
Conocephalum salebrosum Szweyk., Buczkowska & Odrzykoski: on shaded humid stones of *Opus reticulatum*.
Fossombronia angulosa (Dicks.) Raddi: on shaded humid soil of the Roman Amphitheatre.
Fossombronia caespitiformis Rabenh.: on shaded humid soil of the Roman Amphitheatre.
Frullania dilatata (L.) Dumort.: on bark of *Arbutus unedo*, *Cedrus atlantica*, *Quercus ilex*.
Lejeunea cavifolia (Ehrh.) Lindb.: on bark of *Quercus ilex*; on stones of *Nymphaeum* and Roman Amphitheatre.
Lunularia cruciata (L.) Lindb.: on soil of flowerbeds, *Nymphaeum* and Roman Amphitheatre; on stones of *Opus reticulatum*.
Marchantia polymorpha subsp. *ruderalis* Bischl. & Boisselier: on humid soil of the *Nymphaeum* and flowerbeds.
Metzgeria furcata (L.) Dumort.: on bark of *Arbutus unedo*, *Cedrus atlantica*, *Cupressus sempervirens*, *Quercus ilex*; on shaded stones of the *Nymphaeum*.
Pellia endiviifolia (Dicks.) Dumort.: on shaded humid stones of *Opus reticulatum.*
Porella platyphylla (L.) Pfeiff.: on bark of *Olea europaea* and *Quercus ilex*.
Radula complanata (L.) Dumort.: on bark of *Quercus ilex*.
Sphaerocarpos michelii Bellardi: on shaded humid soil of the Roman Amphitheatre.
Targionia hypophylla L.: on shaded stones of *Opus reticulatum*; on damp slope.

Mosses

Alleniella besseri (Lobarz.) S. Olsson, Enroth & D. Quandt: on shaded stones of the *Nymphaeum*.
Alleniella complanata (Hedw.) S. Olsson, Enroth & D. Quandt: on bark of *Quercus ilex*.
Aloina rigida (Hedw.) Limpr.: on soil of the Roman Amphitheatre.
Amblystegium serpens (Hedw.) Schimp.: on shaded stones of *Opus reticulatum*.
Barbula convoluta Hedw.: on shaded humid soil of the Roman Amphitheatre and on flowerbeds.

Barbula unguiculata Hedw.: on soil of flowerbeds.
Brachythecium rutabulum (Hedw.) Schimp.: on soil of flowerbeds.
Brachythecium salebrosum (F. Weber & D. Mohr) Schimp.: on soil of flowerbeds.
Bryum argenteum Hedw.: on soil of the vineyard.
**Bryum elegans* Nees: on humid soil of the Roman Amphitheatre.
Ceratodon purpureus (Hedw.) Brid.: on soil of flowerbeds; on stone benches.
**Cynodontium bruntonii* (Sm.) Bruch & Schimp.: on shaded volcanic stones.
Dicranella howei Renauld & Cardot: on soil of the Roman Amphitheatre.
Didymodon insulanus (De Not.) M. O. Hill: on stone benches.
Didymodon luridus Hornsch.: on stone benches; on soil and stones of the Roman Amphitheatre and *Nymphaeum.*
Didymodon rigidulus Hedw.: on stones of the Roman Amphitheatre.
Didymodon sinuosus (Mitt.) Delogne: on stone benches; on stones of *Nymphaeum*; on stones of the path of live oaks.
Didymodon vinealis (Brid.) R. H. Zander: on soil and stones of the Roman Amphitheatre; on stones of flowerbeds; on stones of the path of live oaks.
Enthostodon convexus (Spruce) Brugués: on stones of the Roman Amphitheatre.
Eucladium verticillatum (With.) Bruch & Schimp.: on stones of the Roman Amphitheatre; on shaded stones of *Opus reticulatum*.
Eurhynchiastrum pulchellum (Hedw.) Ignatov & Huttunen var. *pulchellum*: on stone benches; on stones of the path of live oaks.
Eurhynchium striatum (Hedw.) Schimp.: on shaded stones of *Opus reticulatum.*
Fabronia pusilla Raddi: on bark of *Cupressus sempervirens* and *Quercus ilex.*
Fissidens crispus Mont.: on stones of the Roman Amphitheatre; humid soil of the path of live oaks.
Fissidens exilis Hedw.: on stones of the *Nymphaeum*; on stones of the path of live oaks.
Fissidens ovatifolius R. Ruthe: on damp slope.
Fissidens viridulus var. *incurvus* (Röhl.) Waldh.: on shaded stones of *Opus reticulatum*; on soil of flowerbeds.
Fissidens viridulus (Sw.) Wahlenb. var. *viridulus*: on humid soil of the path of live oaks.
Funaria hygrometrica Hedw.: on soil of flowerbeds and the vineyard.
Grimmia laevigata (Brid.) Brid.: on the volcanic stones of the balcony of the Italian Garden.
Grimmia pulvinata (Hedw.) Sm.: on stone benches; on the volcanic stones of the balcony of the Italian Garden.
Grimmia trichophylla Grev.: on the volcanic stones of the balcony of the Italian Garden.
Gymnostomum calcareum Nees & Hornsch.: on stones of the Roman Amphitheatre.
Gyroweisia tenuis (Hedw.) Schimp.: on stones of the Roman Amphitheatre.
Habrodon perpusillus (De Not.) Limpr.: on bark of *Arbutus unedo*, *Cupressus sempervirens*, *Olea europaea* and *Quercus ilex.*
Homalothecium sericeum (Hedw.) Schimp.: on bark of *Olea europaea* and *Quercus robur.*
Hypnum cupressiforme Hedw. var. *cupressiforme*: on bark of *Olea europaea*, *Quercus ilex and Q. robur*; soil of the flowerbeds.
Hypnum cupressiforme var. *filiforme* Brid.: on bark of *Arbutus unedo.*
Kindbergia praelonga (Hedw.) Ochyra: on stones of *Opus reticulatum*; on soil of flowerbeds.

Leptodon smithii (Hedw.) F. Weber & D. Mohr: on bark of *Arbutus unedo*, *Olea europaea*, *Quercus ilex and Q. robur*; on stones of the *Nymphaeum.*
Leucodon sciuroides (Hedw.) Schwägr.: on bark of *Olea europaea*, *Quercus ilex and Q. robur.*
Microbryum rectum (With.) R. H. Zander: on soil of the Roman Amphitheatre.
Microeurhynchium pumilum (Wilson) Ignatov & Vanderp.: on soil of flowerbeds; on stones of *Opus reticulatum*; on damp slope.
Nogopterium gracile (Hedw.) Crosby & W. R. Buck: on bark of *Olea europaea* and *Quercus ilex.*
Orthotrichum diaphanum Schrad. *ex* Brid.: on bark of *Arbutus unedo.*
Orthotrichum lyellii Hook. & Taylor: on bark of *Olea europaea.*
Orthotrichum tenellum Bruch *ex* Brid.: on bark of *Arbutus unedo*, *Olea europaea*, *Quercus ilex.*
Oxyrrhynchium speciosum (Brid.) Warnst.: on stones of *Opus reticulatum.*
**Oxystegus tenuirostris* (Hook. & Taylor) A. J. E. Sm.: on basaltic stones.
Plagiomnium elatum (Bruch & Schimp.) T. J. Kop.: on soil of flowerbeds.
Plagiomnium medium (Bruch & Schimp.) T. J. Kop.: on soil of flowerbeds.
Plasteurhynchium meridionale (Schimp.) M. Fleisch.: on soil of flowerbeds.
**Pottiopsis caespitosa* (Bruch *ex* Brid.) Blockeel & A. J. E. Sm.: on soil of the Roman Amphitheatre.
Pseudocrossidium revolutum (Brid.) R. H. Zander: on soil of the Roman Amphitheatre.
Pseudoleskeella nervosa (Brid.) Nyholm: on bark of *Quercus ilex.*
**Ptychostomum boreale* (F. Weber & D. Mohr) Ochyra & Bednarek-Ochyra: on soil of flowerbeds; on basaltic stones.
Ptychostomum capillare (Hedw.) Holyoak & N. Pedersen: on stones of *Opus reticulatum*, Roman Amphitheatre and *Nymphaeum*; on soil of flowerbeds and on the vineyard.
Ptychostomum imbricatulum (Müll. Hal.) Holyoak & N. Pedersen: on soil of flowerbeds and on the vineyard; on stones of *Opus reticulatum.*
Rhynchostegiella tenella (Dicks.) Limpr.: on stones of *Opus reticulatum*, Roman Amphitheatre and *Nymphaeum*; on damp slope; on stones of the path of live oaks.
Rhynchostegium confertum (Dicks.) Schimp.: on soil of flowerbeds; on basaltic stones.
Rhynchostegium megapolitanum (Blandow *ex* F. Weber & D. Mohr) Schimp.: on soil of flowerbeds.
Scorpiurium circinatum (Bruch) M. Fleisch. & Loeske.: on soil and stones of the flowerbeds, Roman Amphitheatre, *Opus reticulatum* and *Nymphaeum*.
Syntrichia laevipila Brid.: on bark of *Arbutus unedo*, *Cedrus atlantica*, *Quercus ilex* and *Q. robur*; on basaltic rocks.
Syntrichia papillosa (Wilson) Jur.: on bark of *Olea europaea.*
Tortula atrovirens (Sm.) Lindb.: on rocks of the flowerbeds.
Tortula inermis (Brid.) Mont.: on bark of *Quercus ilex*; on stones of *Nymphaeum.*
Tortula marginata (Bruch & Schimp.) Spruce: on stones of *Nymphaeum.*
Tortula muralis Hedw.: on stones of the *Opus reticulatum*; on the volcanic stones of the balcony of the Italian Garden.
Tortula subulata Hedw.: on stones of the *Opus reticulatum* and Roman Amphitheatre.
**Zygodon forsteri* (Dicks.) Mitt.: on bark of *Olea europaea* and *Quercus ilex.*
Zygodon rupestris Lorentz: on bark of *Arbutus unedo*, *Cedrus atlantica*, *Cupressus sempervirens*, *Olea europaea, Quercus ilex.*

Discussion and conclusions

Among the species collected the finding of *Anthoceros agrestis*, is particularly interesting, since it is a Mediterranean temperate species, previously reported only for Campania (Thyssen 1965), Calabria (Aleffi & Puntillo 1998), Sicily (Lübenau R. & Lübenau K. 1970; Raimondo & Dia 1981; Privitera & Puglisi 1996; Privitera & al. 2008) and Sardinia (Frahm & al. 2008). This acidophytic-subneutrophytic species grows on open, compacted clay and loam and is known from the Algeria, Canary Islands, Crete, France, Madeira, Macedonia, Morocco and Portugal (Ros & al. 2007).

Another interesting finding is *Cynodontium bruntonii*. This species was reported for the regions of northern Italy and for Sicily (Blockeel 1995; Privitera & Puglisi 1996, 2002) and Sardinia (Aleffi & al. 1995; Frahm & al. 2008) and this is the only report for continental south-central Italy. It is a suboceanic-montane species that grows on siliceous rocks, with known locations in Europe, North Africa and Macaronesia (Dierβen 2001).

Pottiopsis caespitosa is a rare species in Italy, recently recorded only for some regions of south Italy: Apulia (Aleffi & al. 2009), Campania (Thyssen 1965; Mazzoleni & al. 1993), Calabria (Privitera & Puglisi 1999), Sicily (Lübenau R. & Lübenau K. 1970; Aiello & al. 2001; Carratello 2001, 2004) and Sardinia (Cortini Pedrotti & Aleffi 1994). This suboceanic-montane species is widespread in the Mediterranean basin and grows on bare and exposed soil.

Zygodon forsteri in Italy was recently recorded only in the Marche (Aleffi & al. 2005), Campania (Cipollaro & Colacino 2005), Sicily (Dia & Lo Re 2005) and Sardinia (Frahm & al. 2008). It is an oceanic-submediterranean *taxon* distributed in the European continent in Bulgaria, Croatia, France, Greece, Montenegro, Portugal, Serbia, Spain, and Turkey; outside Europe it is present in Cyprus, Israel, Madeira and Syria (Ros & al. 2013). The species grows on the trunks and exposed roots, in well-lighted sites and in conditions of moderate moisture. It is considered Vulnerable (V) in Europe (ECCB 1995); in the United Kingdom it has been included in the "*UK Biodiversity Action Plan*" and in the "*English Nature's Species Recovery Programme*" with the purpose of conservation and increase of the populations *in situ*. Though the pattern of distribution of this species is on the whole fairly widespread, in fact its presence is limited to only a few locations with very small populations.

The bryoflora of the Pontifical Villas of Castel Gandolfo is characterized by the presence of a substantial number of species with Oceanic-Mediterranean tendency, which are about 50% of the species collected in the study area, against 35% of temperate species and a nonetheless significant 15% of species with boreal tendency. This fact is doubtlessly related to the particular ecological and microclimatic conditions in the Pontifical Villas, due to diversity of habitats and the permanent conditions of humidity present in the entire area. Concerning the substratum, the volcanic nature of the entire territory causes conditions of marked acidity, both in the soil and in the outcropping rocks. This has a decisive influence on the composition of the species, about half of which are acidophilous and 35% subneutrophilous species, while typically basiphilous species are only 15% of the total species observed (Dierβen 2001).

The particular structure of the Pontifical Villas, characterized not only by traditional Italian-style gardens, but also by a fairly extensive area of farmland (olive groves, vineyards, fruit groves) and the substantial presence of archaeological ruins of the ancient Villa of Domitian (Amphitheatre, nymphaeums, etc.) have a significant influence on the bryophyte diversity and richness. Therefore, the bryophyte biodiversity of the Pontifical Villas is numerically high

Table 1. List of *taxa* found in both studied areas, indicating for each of them, chorotypes, growth substrate and life form. Life forms abbreviations: At: aquatic trailing; Cu: cushion; De: dendroid; Fa: fan; Mr: mat, rough; Ms: mat, smooth; Mt: mat, thalloid; Sc: solitary creeping; St: solitary thalloid; Tf: turf; Tp: turf, protonemal; Ts: turf, scattered; We: weft.

Taxa	Vatican Gardens	Pontifical Villas	Chorotypes	soil	rocks	epiphytes	Life Forms
Hornworts and Liverworts							
Anthoceros agrestis Paton		•	Temperate	•			St
Cephaloziella baumgartneri Schiffn.	•	•	Oceanic Mediterranean		•		Sc
Cephaloziella divaricata (Sm.) Schiffn.	•		Temperate		•		Ms
Chiloscyphus polyanthos (L.) Corda	•		Subboreal		•		At
Cololejeunea rossettiana (C. Massal.) Schiffn.		•	Submediterranean Montane			•	Mr
Conocephalum salebrosum Szweyk., Buczkowska & Odrzykoski	•	•	Subboreal Montane		•		Mt
Fossombronia angulosa (Dicks.) Raddi		•	Oceanic Mediterranean	•			Ms
Fossombronia caespitiformis Rabenh.	•	•	Oceanic Mediterranean	•			Sc
Frullania dilatata (L.) Dumort.	•	•	Temperate			•	Ms
Lejeunea cavifolia (Ehrh.) Lindb.		•	Suboceanic Montane		•	•	Ms
Lunularia cruciata (L.) Lindb.	•	•	Oceanic Mediterranean	•			Mt
Marchantia polymorpha subsp. *ruderalis* Bischl. & Boisselier	•	•	Temperate	•			Mt
Metzgeria furcata (L.) Dumort.	•	•	Temperate			•	Mt
Pellia endiviifolia (Dicks.) Dumort.	•	•	Temperate		•		Mt
Pellia epiphylla (L.) Corda	•		Temperate		•		Mt
Porella platyphylla (L.) Pfeiff.	•	•	Temperate			•	Fa
Radula complanata (L.) Dumort.	•	•	Temperate			•	Ms
Sphaerocarpos michelii Bellardi	•	•	Suboceanic Submediterranean	•			St
Targionia hypophylla L.		•	Oceanic Submediterranean	•	•		Mt
Mosses							
Alleniella besseri (Lobarz.) S. Olsson, Enroth & D. Quandt		•	Subcontinental Montane		•		Fa
Alleniella complanata (Hedw.) S.Olsson, Enroth & D.Quandt		•	Temperate			•	Fa
Aloina rigida (Hedw.) Limpr.		•	Temperate	•			Ts
Amblystegium serpens (Hedw.) Schimp.	•	•	Temperate	•			Mr
Anomodon viticulosus (Hedw.) Hook. & Taylor	•		Temperate	•			Mr
Barbula bolleana (Müll. Hal.) Broth.	•		Submediterranean		•		Tf
Barbula convoluta Hedw.		•	Temperate	•			Tf
Barbula unguiculata Hedw.	•	•	Temperate	•	•	•	Tf
Brachythecium rivulare Schimp.	•		Subboreal		•		Mr
Brachythecium rutabulum (Hedw.) Schimp.	•	•	Temperate		•	•	Mr
Brachythecium salebrosum (F. Weber & D. Mohr) Schimp.		•	Subboreal	•			Mr
Bryum argenteum Hedw.	•	•	Temperate	•			Tf
Bryum dichotomum Hedw.	•		Temperate	•			Tf
Bryum elegans Nees		•	Boreal Montane	•			Tuft
Bryum gemmiparum De Not.	•		Suboceanic Submediterranean		•		Tuft
Bryum radiculosum Brid.	•		Suboceanic Mediterranean		•		Cu
Bryum ruderale Crundw. & Nyholm	•		Suboceanic	•			Tuft
Calliergonella cuspidata (Hedw.) Loeske	•		Temperate	•			We
Ceratodon purpureus (Hedw.) Brid.	•	•	Temperate		•		Tf
Cinclidotus aquaticus (Hedw.) Bruch & Schimp.	•		Submediterranean Montane		•		At
Cinclidotus fontinaloides (Hedw.) P. Beauv.	•		Submediterranean Montane		•		At
Ctenidium molluscum (Hedw.) Mitt.	•		Temperate	•			Mr
Cynodontium bruntonii (Sm.) Bruch & Schimp.		•	Suboceanic Montane		•		Cu
Dialytrichia mucronata (Brid.) Broth.	•		Submediterranean Suboceanic			•	Tuft
Dicranella howei Renauld & Cardot		•	Oceanic Mediterranean	•			Tuft
Dicranella varia (Hedw.) Schimp.	•		Temperate	•			Tf
Didymodon fallax (Hedw.) R. H. Zander	•		Temperate		•		Tf
Didymodon ferrugineus (Besch.) M. O. Hill	•		Temperate Montane		•		Tf
Didymodon insulanus (De Not.) M. O. Hill	•	•	Submediterranean Suboceanic		•		Tf
Didymodon luridus Hornsch.	•	•	Submediterranean	•	•		Tf
Didymodon rigidulus Hedw.		•	Temperate		•		Tuft
Didymodon sinuosus (Mitt.) Delogne	•	•	Suboceanic Submediterranean		•		Tf
Didymodon spadiceus (Mitt.) Limpr.	•		Temperate Montane		•	•	Tf
Didymodon tophaceus (Brid.) Lisa	•		Temperate	•	•		Tf
Didymodon vinealis (Brid.) R. H. Zander	•	•	Submediterranean	•	•		Tuft
Drepanocladus aduncus (Hedw.) Warnst.	•		Temperate		•		We
Enthostodon convexus (Spruce) Brugués		•	Mediterranean		•		Ts
Eucladium verticillatum (With.) Bruch & Schimp.	•	•	Submediterranean		•		Tuft

Table 1. continued.

Eurhynchiastrum pulchellum (Hedw.) Ignatov & Huttunen	●	●	Subboreal Montane	●		●	Mr
Eurhynchium striatum (Hedw.) Schimp.		●	Suboceanic		●		We
Fabronia pusilla Raddi	●	●	Submediterranean			●	Mr
Fissidens crassipes Bruch & Schimp.	●		Suboceanic Submediterranean		●		Tf
Fissidens crispus Mont.	●	●	Oceanic Mediterranean	●	●		Tf
Fissidens exilis Hedw.		●	Temperate		●		Ts
Fissidens ovatifolius R. Ruthe		●	Mediterranean Suboceanic	●			Tf
Fissidens pusillus (Wilson) Milde	●		Temperate Montane	●			Ts
Fissidens serrulatus Brid.	●		Oceanic Submediterranean	●			Tf
Fissidens viridulus (Sw.) Wahlenb. var. *viridulus*	●	●	Submediterranean		●		Tf
Fissidens viridulus var. *incurvus* (Röhl.) Waldh.	●	●	Submediterranean	●	●		Tf
Funaria hygrometrica Hedw.	●	●	Temperate	●			Tuft
Grimmia laevigata (Brid.) Brid.		●	Submediterranean Suboceanic		●		Cu
Grimmia lisae De Not.	●		Mediterranean Oceanic		●		Tf
Grimmia pulvinata (Hedw.) Sm.	●	●	Temperate		●		Cu
Grimmia trichophylla Grev.	●	●	Temperate Montane		●		Cu
Gymnostomum calcareum Nees & Hornsch.	●	●	Submediterranean Montane		●		Tf
Gymnostomum viridulum Brid.	●		Submediterranean Montane		●		Tf
Gyroweisia tenuis (Hedw.) Schimp.	●	●	Submediterranean Suboceanic		●		Tp
Habrodon perpusillus (De Not.) Lindb.	●	●	Mediterranean Oceanic			●	Mr
Hedwigia stellata Hedenäs	●		Subboreal Montane			●	Mr
Homalothecium lutescens (Hedw.) H. Rob.	●		Temperate	●			We
Homalothecium sericeum (Hedw.) Schimp.	●	●	Temperate		●	●	Mr
Hygroamblystegium fluviatile (Hedw.) Loeske	●		Suboceanic Montane		●		Mr
Hygroamblystegium tenax (Hedw.) Jenn.	●		Temperate		●		Mr
Hypnum cupressiforme Hedw. var. *cupressiforme*	●	●	Temperate	●	●	●	Ms
Hypnum cupressiforme var. *filiforme* Brid.	●	●	Temperate			●	Ms
Isothecium alopecuroides (Dubois) Isov.	●		Temperate	●			De
Kindbergia praelonga (Hedw.) Ochyra	●	●	Temperate		●		Mr
Leptodon smithii (Hedw.) F. Weber & D. Mohr	●	●	Oceanic Mediterranean		●	●	Fa
Leptodyctium riparium (Hedw.) Warsnt.	●		Temperate		●		Mr
Leucodon sciuroides (Hedw.) Schwägr.	●	●	Temperate			●	Mr
Microbryum rectum (With.) R. H. Zander		●	Oceanic Submediterranean	●			Ts
Microeurhynchium pumilum (Wilson) Ignatov & Vanderp.	●	●	Suboceanic Submediterranean	●	●		Mr
Nogopterium gracile (Hedw.) Crosby & W. R. Buck	●	●	Suboceanic Submediterranean			●	Mr
Orthotrichum acuminatum H. Philib.	●		Submediterranean Montane			●	Cu
Orthotrichum affine Schrad. *ex* Brid.	●		Temperate			●	Cu
Orthotrichum diaphanum Brid.	●	●	Temperate		●	●	Cu
Orthotrichum lyellii Hook. & Taylor	●	●	Euoceanic Montane			●	Tuft
Orthotrichum speciosum Nees	●		Temperate			●	Cu
Orthotrichum stramineum Brid.	●		Suboceanic			●	Cu
Orthotrichum tenellum Bruch *ex* Brid.	●	●	Submediterranean Suboceanic			●	Cu
Oxyrrhynchium hians (Hedw.) Loeske	●		Temperate	●			Mr
Oxyrrhynchium speciosum (Brid.) Warnst.	●	●	Temperate		●		Mr
Oxystegus tenuirostris (Hook. & Taylor) A. J. E. Sm.		●	Suboceanic Montane		●		Tf
Philonotis calcarea (Bruch & Schimp.) Schimp.	●		Subboreal		●		Tf
Philonotis fontana (Hedw.) Brid.	●		Subboreal		●		Tf
Philonotis marchica (Hedw.) Brid.	●		Submediterranean		●		Tf
Philonotis rigida Brid.	●		Oceanic Mediterranean		●		Tf
Plagiomnium elatum (Bruch & Schimp.) T. J. Kop.	●	●	Boreal	●			Tf
Plagiomnium medium (Bruch & Schimp.) T. J. Kop.	●	●	Subarctic Alpine	●			Ms
Plagiomnium rostratum (Schrad.) T. J. Kop.	●		Temperate	●			Ms
Plagiomnium undulatum (Hedw.) T. J. Kop.	●		Temperate	●			Tf
Plasteurhynchium meridionale (Schimp.) M.Fleisch.		●	Suboceanic Mediterranean	●			Mr
Pohlia melanodon (Brid.) A. J. Shaw	●		Temperate		●		Tf
Pohlia wahlenbergii (F. Weber & D. Mohr) A. L. Andrews	●		Subboreal		●		Tf
Pottiopsis caespitosa (Bruch *ex* Brid.) Blockeel & A. J. E. Sm.		●	Submediterranean Suboceanic	●			Ts
Pseudocrossidium revolutum (Brid.) R. H. Zander		●	Oceanic Submediterranean	●			Tf
Pseudoleskeella catenulata (Brid. *ex* Schrad.) Kindb.	●		Boreal Montane			●	Mr
Pseudoleskeella nervosa (Brid.) Nyholm	●	●	Boreal Montane		●	●	Mr
Pseudoscleropodium purum (Hedw.) M. Fleisch.	●		Temperate	●			We
Ptychostomum boreale (F. Weber & D. Mohr) Ochyra & Bednarek-Ochyra		●	Temperate	●	●		Tuft
Ptychostomum capillare (Hedw.) D. T. Holyoak & N. Pedersen	●	●	Temperate	●	●	●	Tf
Ptychostomum donianum (Grev.) D. T. Holyoak & N. Pedersen	●		Oceanic Mediterranean		●		Tf
Ptychostomum imbricatulum (Müll. Hal.) D. T. Holyoak & N. Pedersen	●	●	Temperate		●		Tf
Ptychostomum pallens (Sw.) J. R. Spence	●		Boreal		●		Tf
Ptychostomum pseudotriquetrum (Hedw.) J. R. Spence & H. P. Ramsay	●		Temperate		●		Tf
Ptychostomum torquescens (Bruch & Schimp.) Ros & Mazimpaka	●		Oceanic Mediterranean	●			Tf
Rhynchostegiella curviseta (Brid.) Lindb.	●		Submediterranean Suboceanic		●	●	Ms

Table 1. continued.

Rhynchostegiella tenella (Dicks.) Limpr.	•	•	Submediterranean Suboceanic	•	•	•	Mr
Rhynchostegium confertum (Dicks.) Schimp.	•	•	Submediterranean Oceanic	•	•		Mr
Rhynchostegium megapolitanum (F. Weber & D. Mohr) Schimp.	•	•	Suboceanic Mediterranean	•	•		Mr
Rhynchostegium riparioides (Hedw.) Cardot	•		Temperate		•		Ms
Sciuro-hypnum plumosum (Hedw.) Ignatov & Huttunen	•		Suboceanic			•	Mr
Scorpiurium circinatum (Bruch) M. Fleisch & Loeske	•	•	Oceanic Mediterranean	•	•	•	Mr
Syntrichia laevipila Brid.	•	•	Oceanic Submediterranean	•	•	•	Tf
Syntrichia papillosa (Wilson) Jur.	•	•	Temperate			•	Tuft
Syntrichia ruralis (Hedw.) F. Weber & D. Mohr var. *ruralis*	•		Temperate		•		Tf
Tortella inflexa (Bruch) Broth.	•		Oceanic Mediterranean		•		Tp
Tortella nitida (Lindb.) Broth.	•		Oceanic Mediterranean	•	•		Cu
Tortula atrovirens (Sm.) Lindb.		•	Submediterranean		•		Tf
Tortula bolanderi (Lesq. & James) M. Howe	•		Oceanic Mediterranean		•		Tf
Tortula canescens Mont.	•		Suboceanic Mediterranean		•		Tf
Tortula inermis (Brid.) Mont.		•	Submediterranean Montane		•	•	Tf
Tortula marginata (Bruch & Schimp.) Spruce	•	•	Oceanic Mediterranean		•		Tf
Tortula muralis Hedw.	•	•	Temperate		•		Tf
Tortula subulata Hedw.	•	•	Subboreal Montane	•			Tuft
Trichostomum brachydontium Bruch	•		Suboceanic Mediterranean	•			Tf
Trichostomum crispulum Bruch	•		Temperate	•	•		Tf
Weissia condensa (Voit) Lindb.	•		Suboceanic Mediterranean		•		Tf
Zygodon forsteri (Dicks.) Mitt.		•	Euoceanic Submediterranean			•	Cu
Zygodon rupestris Lorentz	•	•	Suboceanic Mediterranean		•	•	Tf

when compared with the data emerged from similar studies conducted in the gardens and parks of the urban area of Rome (Carcano 1989) and in some cities of Sicily (Dia & al. 2003).

Considering the area of the Vatican Gardens, which covers about 44 hectares, and that of the gardens of the Pontifical Villas of Castel Gandolfo, which extends for about 55 hectares, the study of the bryoflora of the territory of the Vatican City State covers about 100 hectares. Taken together, the two studies noted 149 *taxa* which are about 12.5% of the Italian flora, a significant percentage if one considers the modest extension of the territory studied. Of these, 1 hornworts, 1 liverworts and 16 mosses are new records for the Lazio Region.

On the basis of the substratum most of the species were collected on rocks (87 species), followed by terricolous species (57 species), while the epiphytes are 40. Most of the latter are species that grow exclusively on the bark of trees, such as *Fabronia pusilla*, *Habrodon perpusillus*, *Nogopterium gracile* and the species of the *Orthotrichum* genus.

Finally, it was considered the overall distribution of life-forms of the species (Hill & al. 2007), showing a clear dominance of turf (35%) and mats (32%), while tufts and cushion respectively represent around 10% of the total. It also reveals a clear distinction between exposed sites (e.g. flowerbeds and exposed rocks), characterized by high insolation and drier conditions, where life-forms as cushions (e.g. *Grimmia* and *Orthotrichum* species), tufts and turfs (e.g. *Didymodon*, *Philonotis*, *Ptychostomum* and *Tortula* species) dominate, and shaded sites, (e.g. the fountains and the archaeological remains, or areas with high tree cover), where rough mats (e.g. *Brachythecium* species and *Homalothecium sericeum*), smooth mats (e.g. *Frullania dilatata* and *Hypnum cupressiforme*), thalloid mats (e.g. *Conocephalum salebrosum* and *Metzgeria furcata*), fans (e.g. *Alleniella besseri*, *A. complanata*, *Leptodon smithii*, *Porella platyphylla*) and wefts (e.g. *Calliergonella cuspidata* and *Pseudoscleropodium purum*) prevail, thus clearly confirming the results of other studies (Kürschner 2004; Sérgio & al. 2014; Puglisi & al. 2013, 2014, 2015; Dia & Campisi 2015).

The study of the bryoflora of the Vatican City State contributes significantly to the knowledge of a territory which until now had been scarcely explored from the bryological point of view, and provides important floristic information for the realization and definition of the Checklist and country status of European Bryophytes (Rossi & al. 2014; Sérgio & al. 2014; Hodgetts 2015).

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Address of the author:
Michele Aleffi,
School of Biosciences and Veterinary Medicine, Plant Diversity & Ecosystems Management Unit, Bryology Laboratory and Herbarium, University of Camerino, Via Pontoni 5 I-62032 Camerino (MC), Italy. E-mail: michele.aleffi@unicam.it

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D. Cusimano, R. Guarino & V. Ilardi

Discovery of a second locality for the narrow endemic *Anthemis ismelia* (*Asteraceae*) in NW Sicily

Abstract

Cusimano, D., Guarino, R. & Ilardi, V.: Discovery of a second locality for the narrow endemic *Anthemis ismelia* (*Asteraceae*) in NW Sicily. — Fl. Medit. 27: 151-158. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

A new population of *Anthemis ismelia* (*Asteraceae*) has been discovered on Mt Pecoraro (Cinisi, NW Sicily), a limestone headland at about 14 km from Mt Gallo (Palermo), the *locus classicus et unicus* of this species described in 1884. Taxonomic framework, distribution update, habitat characterisation, ecology and phytosociological framework are provided, as well as meta-population numerical estimates and risk status assessment.

Key words: chasmophyte, endangered flora, IUCN Direct Threats and assessment, phytosociology.

Introduction

In spring 2014, floristic field sampling in the mountains surrounding Palermo (NW Sicily) yielded the discovery of a new population of *Anthemis ismelia* Lojac. on the western side of Mt Pecoraro near the town of Cinisi. This species, ascribed to *Anthemis* sect. *Hiorthia*, was hitherto known only for the shady, north-facing limestone cliffs of Mt Gallo near Palermo, about 14 km far from the newly discovered population [Lojacono-Pojero 1884 (sub *A. punctata* Vahl), 1903; Bartolo & al. 1981]. In spring 2015 and 2016, some scattered plants were found in the northern side of Mt Pecoraro during field work to confirm and assess the consistency of the newly discovered population (Fig. 1).

The aim of the present contribution is to elucidate the taxonomic framework of the species, to update its distribution range, to provide information on the growing sites (habitat, geology, bioclimate, and phytosociological affiliation), to document the so far known metapopulations and to assess the risk status according to the IUCN criteria.

Materials and methods

The species was identified based on the diagnostic characters reported in the original description and in the Flora Sicula (Lojacono-Pojero 1888-1909), Flora d'Italia (Pignatti 1982),

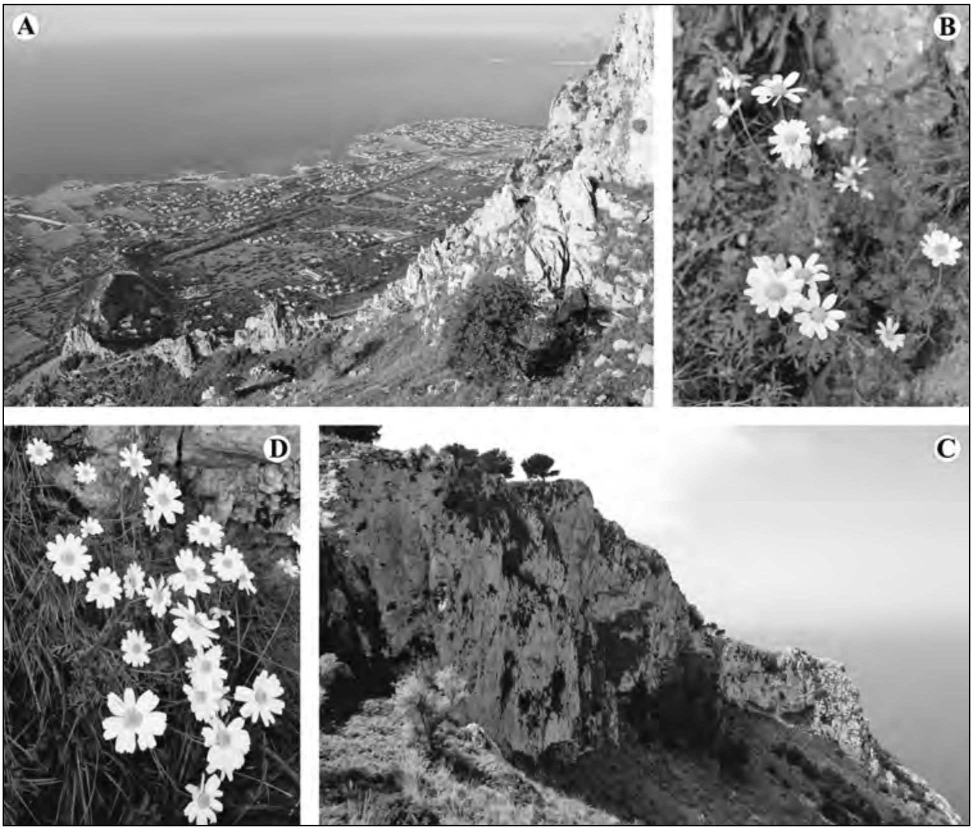

Fig. 1. Natural habitat and flowering stems of *Anthemis ismelia*: **A-B** at Mt Pecoraro (from which on the horizon right you can glimpse Mt Gallo); **C-D** at Mt Gallo.

and Flora Europaea (Tutin & al. 1976), as well as on the comparative analysis of herbarium specimens and of living plants collected in Mt Pecoraro and Mt Gallo. The specimens collected during the field research have been dried and stored in the *Herbarium Mediterraneum Panormitanum* (PAL). Taxonomic nomenclature follows Giardina & al. (2007).

For the climatic characterization of the growing sites, reference was made to rainfall and temperature measurements of weather stations next to the surveyed sites, according to the data provided by the Hydrographic Service of the Sicilian Region (Ministero dei LL. PP. 1926-85) and processed by Duro & al. (1996). The bioclimatic classification follows Rivas-Martínez (2008), and the spatial analysis of the bioclimatic units of Sicily reported in Bazan & al. (2015) and in the Climatological Atlas of Sicily (Drago 2005).

In order to update the risk status of the species, after the discovery of this new population at Mt Pecoraro, the entire surface of the sites was surveyed for current threats (IUCN-CMP 2012), extent of occurrence (EOO) and area of occupancy (AOO) – calculated by the 1 × 1 km Universal Transverse Mercator (UTM) grid – and effective AOO, according to the IUCN Red list category and criteria (IUCN Standards and Petitions Subcommittee 2017).

Results

Taxonomic framework and morphological traits

The *Anthemis punctata* group was recorded in Sicily already by pre-Linnaean botanists, such as Cupani [1696: 48 (sub *Chamaemelum montanum*, *flore magno*, *Absinthii vulgaris foliis et odore*, *licet remisso*); 1713, vol. 1: plate 195 (sub *Chamaemelum Absinthii folio*, *Parthenii odore*); 1713, vol. 3: plate 12 (sub *Buphtalmum argenteum flore albo*)] and Boccone [1697: 120 (sub *Bellis incana Chrysanthemi cretici foliis*)]. The first post-Linnaean botanist mentioning *A. punctata* in Sicily was Presl (1826), followed by Gussone (1843), who confirmed the occurrence in Sicily of two varieties of *A. punctata*: a typical, glabrous one, and the variety "b" *incana*, therefore confirming the Cupani's recognition of two forms of "*Chamaemelum*" from W Sicily. Later on, these two varieties were interpreted by Lojacono-Pojero (1884) as expressions of the morphological variability of *A. cupaniana* Nyman. The same author (Lojacono-Pojero 1884) discovered the *A. ismelia* population of Mt Gallo, near Palermo, which was provisionally referred to *A. punctata* Vahl ("Symb. bot. 2, p. 9, non Guss. nec Alior.! Desf. fl. Atl. 2, p. 285, tab. 239!!"), providing evidence that this population was different from *A. cupaniana*, particularly in the morphologic features of the achenes (continuous corona and markedly tuberculate ribs).

To circumvent interpretation problems arising from the comparison with the diagnosis provided by Gussone (1843), Lojacono-Pojero (1884) wrote a taxonomic *notula* on the interpretation and nomenclatural vicissitudes of *Anthemis punctata* s.l. from Sicily here translated: "On this beautiful species, that should not be confused with the forms of *A. Cupaniana* Tod. (*A. punctata* Guss.), and on the group of *A. montana*, I have written extensively in a monographic work still unpublished. I say for now that Gussone has wrongly referred the Sicilian species of our more or less high mountains to this northern African species, which I discovered few years ago in the aforecited places, where it luxuriates in a singular way and grows copious in grassy and shaded places among the ledges of Mount Gallo overlooking the sea. If Gussone had known this species, he would have better clarified the specific forms of the Sicilian *Anthemis* species, since it is from the knowledge of *A. punctata* that the connection between *A. cupaniana* and *A. montana* can be figured out; it is very intimate in a few cases, but never to the point of making ambiguous the knowledge of the two types, because it can be said that in Sicily, except for the high mountains of Nebrodi, the subspecies *cupaniana* occurs everywhere with its innumerable forms, whereas *A. montana* assumes that form I have seen common in all of Italy, which is *A. columnae* Ten.".

Based on Lojacono-Pojero's (1884) notula and on his direct knowledge of the morphological traits of the North African populations of *A. punctata* Vahl, Fiori (in Fiori & Paoletti 1903) highlighted the distinctive and peculiar characters of the Sicilian population of Mt Gallo and dedicated it to the Sicilian botanist Lojacono-Pojero through the nomenclatural combination *Anthemis punctata* Vahl var. b *Lojaconi* Fiori in Fiori & Paoletti. Almost simultaneously, Lojacono-Pojero (1903), in his *Flora Sicula*, described as a new species, *Anthemis ismelia*, the population of the "... northern slopes overlooking the sea in wild shady and stony places on arable stony soil or on the cliffs at Mount Gallo, on the side of Sferracavallo at Malo Passo". Afterwards, Fiori (1926) refers *Anthemis ismelia* Lojac. to *Anthemis punctata* var. γ *Lojaconi* Fiori.

Anthemis ismelia Lojac., Flora Sicula 2(1): 78 (1903) [Syn.: *Anthemis punctata* Vahl, Symb. Bot. 2: 91 (1791); *Anthemis punctata* f. b *lojaconi* Fiori in Fiori & Paoletti, Fl. Analitica Ital. 3: 258 (1903)]. Lectotype [designated by Aghababyan & al. (2008: 517)]: "Flora selecta exsiccata, Publié par Ch. Magnier. 1463. – *Anthemis Ismelia* Lojacono Sp. nova. – *A. punctata* Loj olim in contrib. fl sic. in Nat. sic. (Guss. ex parte! an Vahl ??) – *A. Cupaniana* Tod. ex parte! Sicile: rochers ombragés, mont Gallo. Avril-Mai 1887. M. Lojacono.".

Currently, according to Greuter (2008), the *Anthemis punctata* aggregate includes *A. cupaniana*, *A. ismelia*, and *A. punctata* [with subsp. *punctata* and subsp. *kabylica* (Batt.) Oberpr.], to which is to be added *A. pignattiorum* Guarino, Raimondo & Domina, an isolated species recently described for the Hyblean Plateau (SE Sicily) by Guarino & al. (2013).

According to the chromosomal analysis, *A. ismelia* is diploid ($2n$ = 18; Bartolo & al. 1981), and, therefore, it could be a possible ancestor of *A. cupaniana* that is tetraploid (Brullo & al. 1978). All representatives of the *A. punctata* aggregate are suffruticose or herbaceous perennials with very limited vegetative reproduction, typically forming scattered populations of caespitose individuals up to 70 cm tall, with dissected leaves and showy inflorescences (Oberprieler 1998). Plants flower from April to June, but extra-seasonal flowering of few individuals from September to December is not a rare event. Capitula are pollinated mainly by native bees and are likely to be self-incompatible, even if incompatibility was not tested. The fruits, epappus achenes, are dispersed by gravity and through mirmecochory.

Distribution and habitat

Anthemis ismelia is a rare endemic chasmophyte restricted to two sites in NW Sicily (Fig. 2), where it grows on north- to west-facing vertical cliffs at an elevation of 10–500 m a.s.l. at Mt Gallo, near Palermo, and 400–650 m a.s.l. at Mt Pecoraro, near Cinisi. Both sites fall within Meso-Cenozoic calcareous rocks of the Panormide Units, a carbonate platform constituting the skeleton of the northernmost sector of Palermo Mountains. These are part of the Sicilian "Fold and Thrust Belt", which, at the boundary between the African and the European plates, links the African Maghrebides to the Calabrian arc subduction complex and to the Southern Apennines (Catalano & al. 2013).

Both growing sites fall into the Mediterranean pluviseasonal oceanic bioclimate (Rivas-Martínez & al. 2004), with lower subhumid ombrotype and upper thermomediterranean (Mt Gallo) and lower mesomediterranean (Mt Pecoraro) thermotype (Bazan & al. 2013). These bioclimatic conditions, however, are buffered and cooled by a daily moisture condensation, often forming a very dense fog, due to the humid sea breeze arising from the Tyrrhenian Sea, right off the limestone cliffs where *A. ismelia* grows. The outstanding floristic value of the huge vertical cliffs of Mt Gallo and Mt Pecoraro is emphasised by a long list of endemic or subendemic species like *Brassica rupestris* Raf., *Centaurea panormitana* Lojac. (see Domina & al. 2016, 2017 for the use of the name), *Cymbalaria pubescens* (C. Presl) Cufod., *Dianthus rupicola* Biv. subsp. *rupicola*, *Euphorbia bivonae* Steud., *E. melapetala* Gasparr., *Galium pallidum* C. Presl, *Glandora rosmarinifolia* (Ten.) D.C. Thomas, *Helichrysum panormitanum* Guss. subsp. *panormitanum* (on Mt Pecoraro) and subsp. *stramineum* (Guss.) C. Brullo & Brullo (on Mt Gallo), *Iberis semperflorens* L., *Lomelosia cretica* (L.) Greuter & Burdet, *Micromeria graeca* subsp. *fruticulosa* (Bertol.) Guinea, *Odontites bocconei* (Guss.) Walp. subsp. *bocconei*, *Pseudoscabiosa limonifolia*

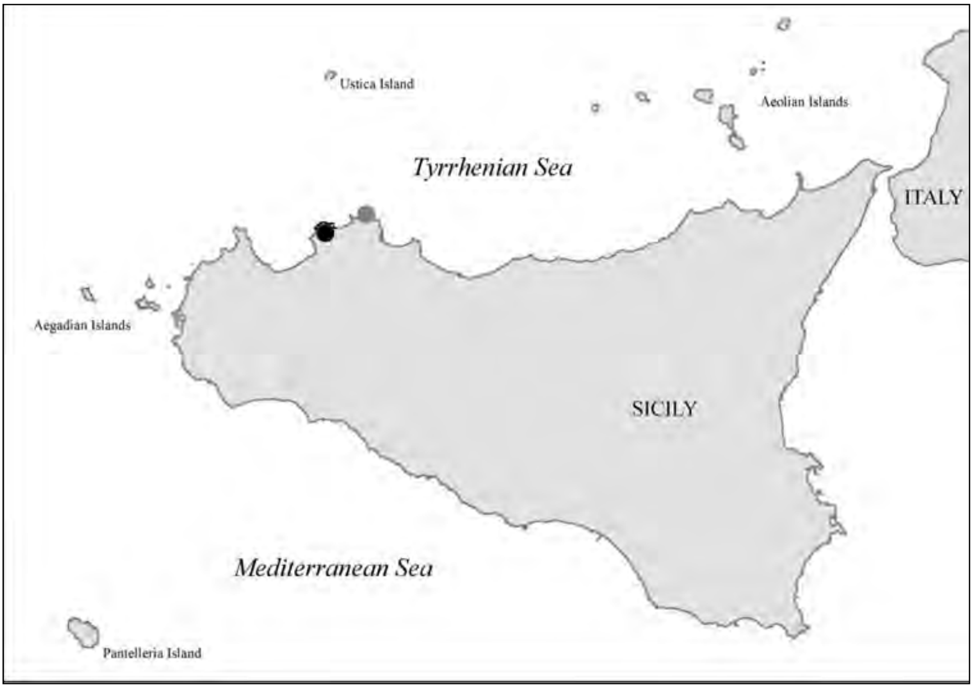

Fig. 2. Geographical range of *Anthemis ismelia*: the new population at Mt Pecoraro (black dot) and the single hitherto known location at Mt Gallo (grey dot) in NW Sicily.

(Vahl) Devesa, *Seseli bocconei* Guss., *Silene fruticosa* L. Besides of these species, occurring on both sites and exhibiting a broader distribution range, other ones are narrowly endemic to one of the two sites: *Genista gasparrini* (Guss.) C. Presl, *Hieracium lucidum* Guss. subsp. *lucidum* and *Limonium panormitanum* (Tod.) Pignatti are endemic to Mt Gallo; *Limonium poimenum* Ilardi, Brullo, D. Cusimano & Giusso is endemic to Mt Pecoraro (Ilardi & al. 2014).

This endemic-rich chasmophitic vegetation has been described as *Scabioso creticae-Centaureetum ucriae* Brullo & Marcenò 1979 *anthemidetosum ismeliae* (Brullo & Marcenò 1979) Brullo, Marcenò & Siracusa 1998, belonging to the alliance *Dianthion rupicolae* Brullo & Marcenò 1979, to the order *Asplenietalia glandulosi* Br.-Bl. in Meier & Br.-Bl. 1934 and to the class *Asplenietea trichomanis* (Br.-Bl. in Meier & Br.-Bl. 1934) Oberd. 1977 (Brullo & Marcenò 1979; Brullo & al. 1998).

Conservation status

Anthemis ismelia was previously assessed as Vulnerable: VU (Walter & Gillett 1998), and after as Critically Endangered: CR (criteria B1+2c, D; Buord & Lesouëf 2006; Council of Europe 2012). Even if the habitat of the species should represent a stable environment and the discovery of a new population doubled the overall population size, when applying the IUCN-CMP Unified Classification of Direct Threats (IUCN-CMP 2012), some threats for the species were detected, mainly ascribable to the following categories: 2.3.1 *Nomadic Grazing* (especially the goat grazing in the wildness); 6.1 *Recreational activities* (especially rock climbing); 7.1.1 *Increase in Fire Frequency/Intensity* (arsons affect both sites almost yearly, especially that of Mt Gallo); 12.1 *Other Threat* (risk factors intrinsic to the species are related to the relictual nature of the sites, to the habitat fragmentation and to the exiguous numerical consistency of the metapopulations). Overall, these threats represent undoubtedly a barrier to the dispersal of the species, affecting its current distribution and the number of mature individuals. Therefore, although the two metapopulations fall within Sites of Community Importance (SCI ITA 020006 "*Capo Gallo*" and SCI ITA 020021 "*Montagna Longa e Pizzo Montanello*"), a Special Protection Area (SPA ITA 020049 "*Monte Pecoraro e Pizzo Cirina*") and a regional wildlife preserve (Oriented Natural Reserve "*Capo Gallo*"), their exiguity (the population size is in both cases fewer than 100 mature individuals), restricted localization (extent of occurrence estimated in 22 km^2, with an area of occupancy of 9 km^2 and an effective area of occupancy of about 0.38 km^2) and fluctuation in the number of mature individuals, allow, according to the IUCN Red list category and criteria (IUCN Standards and Petitions Subcommittee 2017), to confirm *Anthemis ismelia* as Critically Endangered: CR [criteria B1ab(iii,v)c(iv)+2ab(v)c(iv); C2b], as also stated by other authors (Raimondo & al. 2011).

In both sites the protection measures are not effective in preserving the integrity of this species, because nothing is known about its reproductive fitness and seed bank status, nor about its genetic variability within and among populations. These factors are very important for defining functional populations (those with members that exchange genes), for identifying potential targets to ensure the conservation of the species domains and evaluating opportunities for *in situ* and *ex situ* conservation programs. Reduced pollen exchange due to inbreeding, localized pollination, very limited dispersal of seeds are likely to affect the two existing populations, but nothing has been done so far to assess it properly.

Even if the population size is monitored *in situ* and some living specimens are grown in the Botanical Garden of Palermo, this species requires intensive investigation efforts and stronger conservation measures, including specific and more effective *in situ* and *ex situ* conservation programmes.

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Addresses of the authors:
Dario Cusimano[1], Riccardo Guarino[2] & Vincenzo Ilardi[3],
[1]Department SAAF, University of Palermo, Viale delle Scienze Ed. 4, I-90128 Palermo, Italy. E-mail: dario.cusimano@unipa.it
[2]Department STEBICEF - Botanical Unit, University of Palermo, Via Archirafi 38, I-90123 Palermo, Italy. E-mail: riccardo.guarino@unipa.it
[3]Department DISTEM, University of Palermo, Via Archirafi 26, I-90123 Palermo, Italy. E-mail: vincenzo.ilardi@unipa.it

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F. Covelo, F. Sales, M. M. V. G. Silva & C. A. Garcia

Vegetation on limestone versus phyllite soils: a case study in the west Iberian Peninsula

Abstract

Covelo, F., Sales, F., Silva, M. M. V. G. & Garcia, C. A.: Vegetation on limestone versus phyllite soils: a case study in the west Iberian Peninsula. — Fl. Medit. 27: 159-173. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

The influence of soil on plant cover was investigated in two different soil types, on limestone and on phyllite, in the Coimbra peri-urban area. Two areas were selected in each soil type. Soil was analysed for colour, pH, electrical conductivity, moisture, organic matter content, mineralogy, texture and chemical composition. Floristic composition was assessed and abundance was calculated using DAFOR methodology. Data were statistically analysed in Canoco for Windows 4.5. The two soil types have distinct texture and distinct mineralogical, physical and chemical properties. Soil on limestone had pH, electrical conductivity and moisture content higher than soil on phyllite; the latter had higher organic matter content. Soil on limestone had silt clay loam texture and the most abundant minerals were calcite and quartz. The texture of soil from phyllite is sandy loam, loam and silt loam and the most abundant minerals were quartz and mica. Also, most common oxides and trace elements are different. A total of 288 taxa in 61 families (*Fabaceae*, *Asteraceae,* and *Poaceae* are predominant) were identified, showing the enormous diversity of the peri-urban vegetation of Coimbra. A clear distinction was found between the vegetation of the areas of limestone and phyllite; the main environmental factors influencing the ordering of species are pH, mineralogy and anthropic impact.

Key words: multivariate analysis, Portuguese vegetation, soil on limestone, soil on phyllite, soil properties vs vegetation.

Introduction

Soils are natural bodies and their properties derive from the combined effect of physical, chemical and biological processes acting on the parent rock material over time. The resulting mineral and organic material is essential to living beings (Blum & al. 2006). Often, soil provides a satisfactory environment for plant growth and long term establishment of plant populations. Root growth, development and distribution across the soil profile are affected by soil chemical composition (Gregory 2006). There is evidence that in the process of land colonisation, plant lineages adapted differently to the variety of soils (Osaki & al. 2003; Kenrick & Strullu-Derrien 2014).

Plants prefer simple elements, easy to absorb by osmosis. N, P, K, Ca, Mg are the main nutrients and Fe, Mn, Zn, Cu, Mo and B are essential micro nutrients (Johnston 2005). Soil with high clay content is more fertile because of its ability to adsorb nutrients; sandy soil is well drained and tends to have higher temperature. Organic matter corrects nutrient deficiencies, but in high concentration can lower the soil pH due to increase in organic acids during decomposition (Rheinheimer & al. 2000). Soil pH indicates the activity of the ion hydrogen in solution. Low pH (<4.5) promotes the dissolution of elements such as Al, Fe, Mn that may attain toxic concentrations for plants; high pH (>8.0) turns other elements less absorbable, e.g. Fe, Mn, Zn. Salts in high concentration are also toxic and their content is assessed by determination of the electric conductivity (Brady & Weil 2012).

In the area of Coimbra (central Portugal, c. 40 km from the Atlantic coast) (Fig. 1), there are two different types of soil exceptionally close to each other: (1) one developed in the Jurassic carbonate sediments (limestone, marls, marly limestone, limy marls) belonging to the Mesocenozoic Lusitanian Basin, and (2) the other developed in the phyllite of Coimbra – Espinhal – Alvaiázere sector of the Ossa Morena zone, of Neoproterozoic age, belonging to the Iberian Massif (Serviços Geológicos de Portugal 1992). These carbonate sediments and phyllite run NNW-SSE almost parallel to each other and are separated by a narrow strip (400 – 1300 m wide) of a Triassic sandstone (Grés de Silves) that widens south of Coimbra (Serviços Geológicos de Portugal 1992). The soils in the area are poorly developed (C-horizon is about 40-50 cm deep) and they are classified as calcaric cambisols in the limestone areas and chromic cambisols in the phyllite areas (Soil Atlas of Europe 2005).

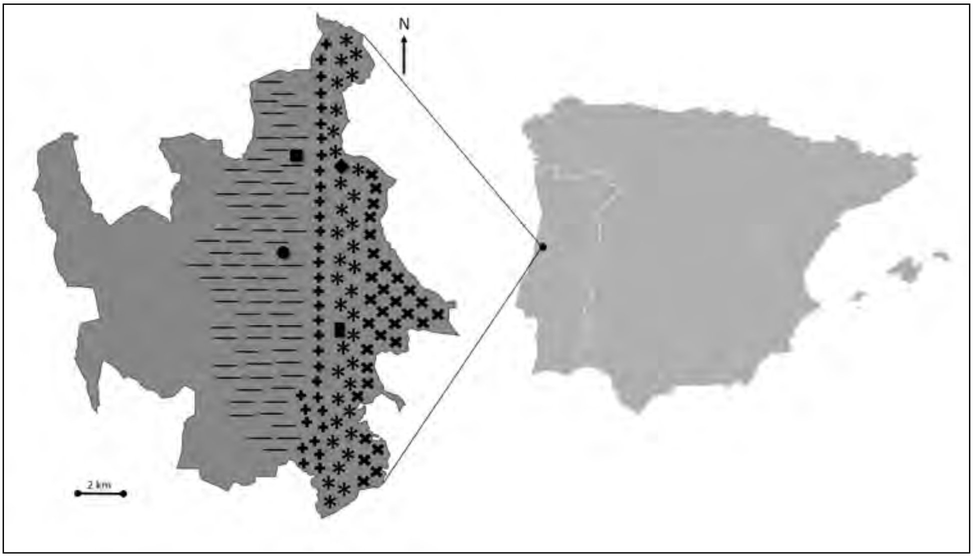

Fig. 1. Location of the areas investigated and soil types in Coimbra district. ■: Relvinha; ●: Souselas; ◆: Bostelim; ▮: Torres do Mondego. ▁▁: Jurassic carbonate sediments (limestone, marls, marly limestone, limy marl); ✚: Triassic sandstone (*Grés de Silves*); ✱: Neoproterozoic phyllite of the *Coimbra–Espinhal–Alvaiázere* sector of the *Ossa Morena* zone; ✖: Neoproterozoic–Cambrian *Grupo das Beiras*.

The climate of the area is within the Csb of the Köppen-Geiger climate classification (warm temperate with dry and warm summer; Pell & al. 2007; AEMET & IPM 2011). The vegetation falls within the Western Mediterranean sub-region, Mediterraneo-iberoatlantic superprovince of Rivas-Martinez (1987).

The main objective of this investigation was to compare the floristic composition in two soil types, on limestone and on phyllite, by selecting sites as near as possible to the spatial limit between the soils. Due to their proximity, climate should not be a factor causing variation in the floristic composition. Therefore, this area constitutes a model to study the influence of soil type on plant cover. The area also has a rich native flora in spite of locally anthropic.

Materials and methods

Area selection

The criteria to select the areas for the study in limestone and phyllite were: proximity between the two soil types and similar altitude in both soil types. In addition, the choice had to fall on sites with the least possible anthropic disturbance. Four areas (Fig. 1) were selected and they total 33,600 m2 for each of the two soils: on limestone, (1) Relvinha (13,600 m2; altitude: 52-91 m; Lat.: 40°13'57.28"N, Long.: 8°26'2.88"W), well-developed herb, shrub and arboreal strata; long-abandoned olive grove; and (2) Souselas (20,000 m2; alt. 62-106 m; Lat.: 40°16'50.59"N, Long.: 8°24'49.28"W), herb and small shrub strata; on phyllite, (3) Bostelim (13,600 m2; alt. 200 m; Lat.: 40°16'34.21"N, Long.: 8°23'19.76"W), herb, shrub and arboreal strata present with the latter very well-developed height-wise; crossed by a path and partially occupied by a fallow-field; and (4) Torres do Mondego (20,000 m2; alt. 53-88 m; Lat.: 40°11'16.91"N, Long.: 8°23'40.22"W), very dense shrub and well-developed arboreal strata.

Soil sampling and analysis

In each of the four areas, three soil samples were collected (e.g. Relvinha 1, Relvinha 2 and Relvinha 3), each being a composite sample of 4 sub-samples. The proceeding was as follows: the O-horizont in an area of about 1m^2 was removed and 4 small excavations were performed, at about 20-30cm depth, to access the B-horizon, which was sampled. These 4 sub-samples were mixed to create a composite sample.

The weight of each composite sample was c. 3 kg. The samples were oven dried at 40 ºC, sieved through a 2 mm nylon mesh sieve and quartered to obtain the laboratory samples, with c. 200 g each. The samples were analysed for methodologies readily available at the Earth Sciences Department, University of Coimbra: (1) colour, (2) pH, (3) electrical conductivity, (4) soil moisture, (5) organic matter, (6) mineralogy by X-ray diffraction, (7) chemical composition by X-ray fluorescence and (8) texture.

Soil colour was determined comparing with the Munsell Soil Color Chart (1994). Assessment of pH was in a 2:5 suspension of soil:water. Electric conductivity was determined in the supernatant liquid of a 1:5 mixture of soil:water. The humidity content was determined by weighing the sample before and after drying at 105 ºC for 24 hours. The organic matter content was determined by loss-on-ignition in a muffle furnace at 360 ºC (Salehi & al. 2011). Replicas of one sample per area were analysed for assessment the analytical error using the methodology of Gill & Ramsey (1997). For all these methodologies, errors were better than 4%.

The portable X-ray techniques are now used by researchers in soil sciences, archaeology and biology, environment and geology (Gazley & al. 2014; Lemiere & al. 2014) and in this study the chemical composition of the <125 µm fraction of soil samples was determined with a portable Niton XL3t, XRF spectrometer, Thermo Scientific. In each sample three X-ray "shots" were made and the final result was the average of these, therefore the sample chemical composition is better constrained. The analytical error was estimated with replicas using the methodology of Gill & Ramsey (1997) and it was better than 14 %.

Soil texture was determined according to the data from granulometric analysis, which was performed by laser granulometry using a Coulter LS 230 granulometer. The granulometric analysis was performed after the dissolution of the organic matter and carbonates by H_2O_2 and HCl, respectively.

For the mineralogy two samples were analysed per area and was determined by X-ray diffraction using a Philips PW 3710 diffractometer, with a Cu tube and 40 kV and 20 mA as operating conditions. The software APD 3.6J from Philips was used for peaks identification.

Floristic surveys

Surveys took place every month during 2014 with two objectives: (1) a complete checklist of the vascular plants present in the total size of the areas studied, and (2) a statistical analysis of the vegetation. The latter was performed along three N/S random transects 20 m long drawn in each of the four areas; along each transect four squares 10 × 10 m were outlined. Taxa abundance was assessed by the DAFOR scale (Rich & al. 2005).

Plant identification/nomenclature followed Flora iberica (Castroviejo & al. 1986-2014). For families not yet published, we followed Nova Flora de Portugal: *Asteraceae* (Franco 1971-1984); *Poaceae* (Franco & Afonso 1998). Taxa nomenclature was up-dated according to WCSP (2014), for *Asteraceae* to Flann (2009). Family circumscription follows APG IV (2016).

Anthropic impact

The anthropic impact is one of the environmental variables for the statistical analysis of the vegetation and its assessment was very simple. During the surveys all impacts were identified and absence/presence was determined for each area.

Statistical analysis of the vegetation

From the 45 environmental variables considered, 19 were selected: pH, electrical conductivity, soil moisture, organic matter, sand, clay, Al_2O_3, CaO, MgO, Zn, Cu, K_2O, Fe_2O_{3t}, quartz, calcite, mica, rain fall, insolation, and anthropic impact. The criteria for this selection were: (1) relevance to plant development (Cerqueira 2001; Johnston 2005); (2) the few climate variables with variation between sites (insolation [Souselas and Bostelim: 2500 – 2600 hrs; Relvinha and Torres do Mondego: 2600 – 2700 hrs) and rainfall (Souselas: 1000 – 1200 mm; Bostelim: 1200 – 1400 mm; Relvinha and Torres do Mondego: 800 – 1000 mm) (Agência Portuguesa do Ambiente 1931-1960)].

Statistics analysis of data used CANOCO for Windows 4.5 (ter Braak & Šmilauer 2002). Analysis started with a Detrended Correspondence Analysis (DCA) (Hill & Gauch 1980). Gradient length of axis 1 was 3.788 indicating high β-diversity (McCune & al.

2000) and, therefore, it was performed a Canonical Correspondence Analysis (CCA). To better understand the stronger correlations taxa/ environmental variables, a weight range of 30% for the most abundant species was applied to the same CCA. The 19 environmental variables were analysed in a Monte Carlo test for significance $p < 0.05$ and a meaningful interpretation from the ecological point of view. The matrix of the environmental variables was created using mean values since the soil samples per area (three) were fewer than the quadrats (12). It was performed a Correspondence Analysis (CA) for species and quadrat ordination according to floristic affinity.

Results

Soil analysis

SOIL COLOUR. In Relvinha the soil is light yellowish brown (10 YR 6/4); in Souselas very pale brown (10 YR 7/3) and pale brown (2.5 Y 4/7); in Bostelim yellow (10 YR 7/6; 2.5 Y 7/6); Torres do Mondego light reddish brown (2.5 YR 7/4) and light red (2.5 YR 6/8).

PH (Table 1). The soil in the two limestone areas were strongly alkaline (Souselas 8.77 ± 0.09; Relvinha 8.59 ± 0.06) and they were moderately acid to slightly acid in the two phyllite areas (Bostelim 5.68 ± 0.49; Torres do Mondego 6.34 ± 0.39), according to the Soil pH classes of the Natural Resources Conservation Service (USDA 2016).

ELECTRICAL CONDUCTIVITY (Table 1). Both soils are non-saline soils, according to USDA (2011) and the soils on limestone areas had a higher electrical conductivity (Souselas 71.40 ± 5.63 μS/cm; Relvinha 78.65 ± 14.08 μS/cm) than the soils on the phyllite areas (Bostelim 30.63 ± 10.66 μS/cm; Torres do Mondego 51.27 ± 13.05 μS/cm).

SOIL MOISTURE (Table 1). Soils on limestone areas retained more humidity (Souselas 5.47 ± 0.84%; Relvinha 4.77 ± 0.40%) than the soils in the phyllite areas (Bostelim 2.24 ± 0.48%; Torres do Mondego 2.37 ± 0.08%).

ORGANIC MATTER (Table 1). Soil in Souselas, a limestone area, had the lowest content in organic matter (2.49 ± 0.55%), while the soil in Relvinha, another limestone area, had a higher organic matter content (4.01 ± 0.18%), approaching that of the soils in the phyllite areas (Bostelim 4.39 ± 0.33% and Torres do Mondego 4.41 ± 0.88%).

TEXTURE (Fig. 2). Soil texture of the limestone areas is silty clay loam. The soil texture in the phyllite areas is more variable, with high sand content and little clay, being sandy loam, loam and silt loam.

OXIDES (Table 1). The most abundant oxide in the soil of Souselas is CaO (31.96 ± 6.47%), but the most abundant oxide in Relvinha is SiO2 (42.93 ± 2.61%). SiO_2 is also the most abundant oxide in the soils of the phyllite areas, being higher than in the soil of Relvinha (Bostelim 43.78 ± 0.48%; Torres do Mondego 47.63 ± 3.70%). Other oxides, e.g. TiO_2, Al_2O_3, Fe_2O_{3t}, K_2O and P_2O_5, follow the pattern of SiO_2.

TRACE ELEMENTS (Table 1). The soil in the two limestone areas are also distinct in trace elements. The most abundant trace elements in Souselas soil are Sc (302.36 ± 121.98 mg/kg) and Sr (262.50 ± 49.98 mg/kg) but in Relvinha soil are Zr (237.97 ± 20.11 mg/kg) and Cr (175.99 ± 9.97 mg/kg). In the phyllite soil, the most abundant trace

Table 1. Results of soil physico-chemical analysis; three samples were collected in each area. - data below the detection limit of the chemical elements.

Investigation area		Relvinha			Souselas			Bostelim			T. Mondego			Error (%)
Samples		Relvinha 1	Relvinha 2	Relvinha 3	Souselas 1	Souselas 2	Souselas 3	Bostelim 1	Bostelim 2	Bostelim 3	T. Mondego 1	T. Mondego 2	T. Mondego 3	
pH		8.57	8.66	8.54	8.68	8.78	8.86	5.36	6.24	5.43	6.58	6.55	5.89	0.14
Electrical conductivity (µS/cm)		92.6	64.45	78.9	67.9	77.9	68.4	30.2	41.5	20.2	58.7	58.9	36.2	2.50
Soil moisture %		4.99	5.01	4.31	4.91	6.44	5.07	2.75	2.17	1.81	2.44	2.29	2.39	4.20
Organic matter %		3.81	4.17	4.06	2.43	3.06	1.96	4.73	4.09	4.34	5.43	3.92	3.89	2.02
Texture	Clay (%)	34.74	38.78	28.08	29.27	33.96	30.9	22.12	19.14	8.88	11.75	12.94	17.27	
	Silt (%)	56.60	57.00	57.93	57.66	54.74	60.24	58.49	63.09	26.19	42.38	37.77	60.32	
	Sand (%)	8.67	4.22	13.99	13.07	11.3	8.86	19.39	17.77	64.93	45.86	49.29	22.41	
Oxides (%)	SiO_2	40.03	43.70	45.06	24.65	29.16	19.46	43.36	44.31	43.67	44.05	51.43	47.41	4.19
	TiO_2	0.83	0.87	0.89	0.39	0.53	0.32	1.29	1.39	1.31	1.11	1.12	1.05	1.33
	Al_2O_3	8.21	8.09	10.33	6.10	6.66	4.46	13.49	15.60	14.84	11.81	12.89	14.87	9.55
	Fe_2O_3total	5.64	5.44	6.20	3.63	4.51	3.10	6.98	5.36	6.69	5.60	5.97	6.96	0.80
	MnO	0.04	0.07	0.04	-	-	-	-	-	-	0.20	0.14	0.09	1.98
	MgO	1.29	1.66	-	1.86	1.93	-	0.90	1.08	1.38	-	1.05	1.18	
	CaO	8.12	5.13	3.51	34.04	24.70	37.13	0.09	0.29	0.14	0.51	0.36	0.25	8.97
	K_2O	7.09	6.79	7.34	4.79	5.47	4.22	7.33	8.87	8.18	7.71	7.26	8.29	0.96
	P_2O_5	0.19	0.30	0.33	-	-	-	0.33	0.41	0.36	0.42	0.45	0.42	
	Cl	0.06	0.06	0.05	0.05	0.06	0.05	0.05	0.03	0.04	0.05	0.04	0.06	
	S	0.07	-	-	0.08	-	0.07	-	-	-	-	-	-	13.93
Trace elements (mg/kg)	Zr	233.92	259.80	220.19	121.35	162.35	94.49	422.64	310.52	298.89	335.34	333.12	335.17	2.15
	Sr	103.90	64.40	82.63	265.10	211.26	311.12	127.22	160.84	122.65	105.93	103.75	131.43	0.69
	Rb	67.16	70.50	74.37	32.09	41.92	28.31	77.57	89.82	88.07	86.35	84.51	85.02	1.17
	Th	11.32	12.75	11.52	-	6.12	5.37	17.12	18.76	18.60	15.50	14.33	13.95	8.66
	Pb	26.28	26.14	35.67	-	11.46	-	-	32.00	31.77	47.83	31.21	35.37	6.66
	As	9.77	11.52	11.43	-	-	-	36.80	24.01	16.16	17.36	13.33	13.61	13.49
	Zn	88.80	100.82	62.52	32.19	33.17	23.54	-	36.39	39.90	44.69	31.32	45.46	7.38
	Cu	39.21	32.58	33.72	-	26.43	-	-	37.48	-	28.59	-	58.07	12.94
	Cr	187.42	171.41	169.13	-	156.93	-	211.10	91.33	214.86	165.60	146.76	203.44	8.26
	V	123.93	124.84	139.94	-	65.04	67.94	200.24	257.25	224.70	179.69	178.17	167.55	7.41
	Sc	123.28	79.56	-	363.15	323.87	381.99	-	-	-	-	-	-	3.51
	Nb	16.85	17.82	16.93	10.18	11.26	7.66	21.95	22.66	22.10	20.22	19.05	21.74	4.46
	Bi	8.75	12.43	9.71	-	-	-	17.16	19.05	18.89	-	13.79	13.21	10.03

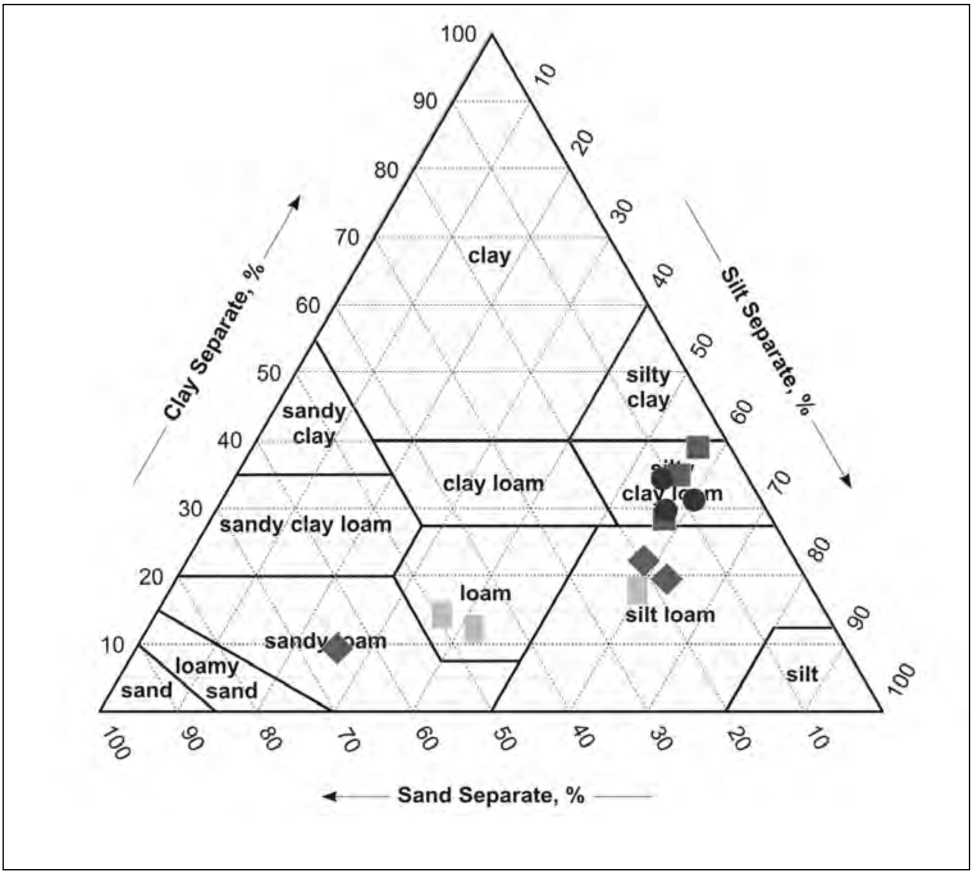

Fig. 2. Diagram of soil texture classification of the investigated areas: ■: Relvinha; ●: Souselas; ◆: Bostelim; ■: Torres do Mondego.

elements are Zr (Bostelim 344.02 ± 68.34 mg/kg; Torres do Mondego 334.54 ± 1.24 mg/kg) and V (Bostelim 227.40 ± 28.60 mg/kg; Torres do Mondego 175.14 ± 6.62 mg/kg). The content in Zr, Rb, Th, Pb, V, Nb, Bi follows the pattern of the oxides SiO_2, TiO_2, Al_2O_3, Fe_2O_{3t}, K_2O and P_2O_5, i.e., being higher in soils of the phyllite areas than in the soils of the two limestone areas; here they are lower in Souselas.

MINERALOGY (Table 2). The main minerals in the four areas were quartz, mica and clay minerals in different degrees; feldspar was detected in the phyllite and in Relvinha. Soil in the limestone area of Souselas is rich is calcite and it has some quartz and mica. In contrast, soil in Relvinha has a mineralogy similar to that of the soils in the phyllite areas, in that it has high content of quartz and mica, but it has calcite and dolomite. The soils in the phyllite areas don´t have calcite. The soil in Bostelim also has a small content of hematite, and the soil in Torres do Mondego has traces of titanium oxides and iron sulphides.

Table 2. Results of soil X-ray diffraction analysis; two out of three samples per area were analysed. X –refers to 1.000 counts/second at peak mineral, x –refers to 500 counts/second at peak mineral.

Investigation area		Relvinha		Souselas		Bostelim		T. Mondego	
Samples		Relvinha 1	Relvinha 2	Souselas 2	Souselas 3	Bostelim 1	Bostelim 2	T. Mondego 1	T. Mondego 2
Minerals	Quartz	XXXX	XXXXXx	XXX	X	XXXXXx	XXXXx	XXXXXx	XXXXXXX
	Calcite	Xx		XXx	XXXX				
	Dolomite		Xx						
	Feldspar	x	x			x	x	x	X
	Hematite						x		
	Mica (muscovite, biotite)	XXXx	XXXXx	XXX	x	XXXXXx	XXXX	XXXXx	XXXXXX
	Clay minerals (chlorite, vermiculite, kaolinite)	x	x	x	x	x	x	x	x
	Ti oxides							x	x
	Fe sulphides							x	x

Checklist

Plant diversity was high with 288 specific and subspecific taxa identified in 190 genera and 61 families: Relvinha, 110 taxa; Souselas, 135; Bostelim, 143; and Torres do Mondego, 95 (Electronic Supplementary File 1). Bostelim has 49.65% of the total diversity in contrast with the other much larger area in phyllite, Torres do Mondego, this having only 32.99%. The largest plant families were *Fabaceae*, *Poaceae* and *Asteraceae*; the next most abundant were *Lamiaceae* and *Orchidaceae*. Families with more taxa in limestone were *Asteraceae* (Relvinha, 10%; Souselas, 12.59%), *Lamiaceae* (Relvinha, 5.45%; Souselas, 8.89%) and *Orchidaceae* (Relvinha, 4.55%; Souselas, 8.15%) (Table 3). Families with more taxa in phyllite were *Fabaceae* (Bostelim, 14.69%; Torres do Mondego, 16.84%), *Poaceae* (Bostelim, 13.99%; Torres do Mondego, 12.63%) and Ericaceae (Bostelim, 4.20%; Torres do Mondego, 3.16%) (Table 3).

Table 3. Analysis of plant diversity in the four areas. Only families with more than two taxa in at least two areas were selected; abundance (%) at family level in each area is indicated. Families in bold are those with the highest diversity.

Family	Relvinha (% taxa)	Souselas (% taxa)	Bostelim (% taxa)	T. Mondego (% taxa)	Total of 288 taxa (% taxa)
Apiaceae	3.64	5.19	2.10	3.16	3.47
Asparagaceae	2.73	2.96	2.10	3.16	2.08
Asteraceae	**10.0**	**12.59**	**11.19**	**8.42**	**10.42**
Caprifoliaceae	4.55	2.22	2.10	1.05	1.74
Cistaceae	2.73	2.96	2.80	3.16	2.43
Ericaceae	1.82	0.0	4.20	3.16	2.43
Fabaceae	**10.91**	**8.89**	**14.69**	**16.84**	**14.24**
Fagaceae	1.82	0.0	2.10	3.16	1.04
Gentianaceae	2.73	2.22	2.10	1.05	1.74
Lamiaceae	5.45	8.89	4.20	3.16	5.9
Orchidaceae	4.55	8.15	0.70	1.05	4.51
Plantaginaceae	0.91	2.22	2.10	1.05	2.08
Poaceae	**11.82**	**8.15**	**13.99**	**12.63**	**11.11**
Rosaceae	5.45	4.44	4.20	5.26	3.13
Rubiaceae	1.82	2.96	2.80	2.11	1.74
Total	70.92	71.85	71.36	68.42	68.06

Statistical analysis of the vegetation

The matrix of taxa abundance (DAFOR data) refers to 196 taxa in 48 squares in a total of 1.585 entries.

Table 4. Anthropic impacts identified in the areas investigated. Totals were used in the matrix of environmental variables. X: presence of anthropic impact.

Impact	Relvinha	Souselas	Bostelim	T. do Mondego
Agriculture			X	
Desflorestation			X	
Fallow field	X		X	
Grazing		X	X	
Motor traffic		X	X	
Totals	1	2	5	0

Table 5. Values of F e P (test de Monte Carlo, with 499 simulations) and inflation factor of environmental variables selected for the preparation of the CCA.

Environment variables	Inflation factor	F	P
pH	5.8541	10.05	0.0020
Mica	4.3007	6.43	0.0020
Anthropic impact	2.2951	8.05	0.0020

Table 6. CCA and CA ordination summary.

	CCA					CA				
Canonical axes	**1**	**2**	**3**	**4**		**1**	**2**	**3**	**4**	
Eigenvalues	0.604	0.399	0.280	0.389		0.618	0.455	0.344	0.294	
Species-environment correlations	**0.991**	**0.980**	0.978	0.000		0.984	0.761	0.667	0.931	
Cumulative percentage variance:										
of species data	**18.5**	30.7	39.3	51.2		18.9	32.8	43.3	**52.4**	
of species-environment relation	47.0	78.1	**100.0**	0.0		46.6	67.2	79.1	99.0	
Sum of all eigenvalues					3.268					3.268
Sum of all canonical eigenvalues					1.283					1.283

For the CCA ordination the environmental variables selected from the Monte Carlo test were pH, mica content of soil and anthropic impact (Table 4), all with p = 0.002; a selection of 10 from the remaining 16 variables was used as supplementary variables in the analysis. The inflation factor of the environmental variables that explain species ordination is < 10 which indicates a desirable low multicollinearity between them (Table 5). The CA explains 52.4% of the total floristic variation found amongst the four areas (Table 6). As the eigenvalues of CA and CCA are similar in the first four axes, the environmental variables included in the CCA explain the floristic variation found in the CA.

The CCA ordination shows different groups along the first and second axes. Along axis 1 are separated the areas of limestone and phyllite. The two limestone areas, Souselas and Relvinha, are very close to each other and are positively correlated with pH, electrical conductivity, soil moisture, calcite and clay; the two areas of phyllite, Bostelim and Torres do Mondego, are positively correlated with mica, K2O, organic matter and quartz. Along axis 2 are separated the two areas of phyllite, Bostelim having a positive correlation with both anthropic impact and rainfall (Electronic Supplementary File 2).

In the CA ordination, species and quadrats have a similar relation to that in the CCA, although the quadrats overlap in the CCA but split in the CA. The quadrats in Bostelim are clearly split in two groups in the CA (Electronic Supplementary File 3).

Discussion

Soil analysis

Soil pH and soil electrical conductivity of soil influence the amount of salts available to plants. The differences in pH found in the two soil types studied are mainly due to the mineral composition of soils, which is controlled by lithology. Electrical conductivity is proportional to the content in soluble salts. In the limestone soils, both pH and electrical conductivity are high, due to easy calcium carbonate dissolution that causes higher pH and higher content in dissolved salts.

In the two limestone areas, the soil has higher clay content (c. 32.62%). This soil type influences plant development in different ways. The little permeability of such soil leads to the accumulation of water at the surface and reduces infiltration to lower horizons. Water accumulated in small depressions explains the local presence of a few *Cyperaceae*. On slopes, overland flow takes place and the soil becomes drier, which explains the presence of *Carlina gummifera*, a species adapted to water stress (Barceloux 2012). This soil with small macro-porosity is compact and, therefore, with little oxygen.

The soils on the two phyllite areas are loamy and silt-loamy with lower clay and higher sand content (36.61%) than in the limestone areas (10.02%). Because of their higher permeability and macro-porosity, water runs through them quicker and, therefore, they are drier than the soil of Relvinha and Souselas. Soils with a silty to sandy loam texture have a cation exchange capacity (CEC) of 10-15 meg/100g, while clay loams have a CEC of 15-30 meq/100g (Donahue & al. 1977), but the soils in the phyllite areas have higher organic matter content (4.39 – 4.41 %), than the soils in the limestone areas (2.49 – 4.01 %). As organic matter has a much higher cation exchange capacity e.g. CEC of 150-500 meq/100g (Birkeland 1974), the soils in the phyllite areas will have higher contents of available nutrients. In fact, essential elements to plant development, such as Zn, K, P and Fe (Johnston 2005), are in higher concentration in the soils of the phyllite areas than in the soils of the limestone areas.

The lower content in organic matter of the soils in Souselas may result from its mildly alkaline pH, enough to favour the soil decomposers (Andrews & al. 2003). The higher content in organic matter in the soils from Relvinha and from the two phyllite areas (Bostelim and Torres do Mondego) may also be explained by the vegetation itself, here with greater development of the shrub stratum.

Soils from the phyllite areas have higher concentrations of SiO_2, TiO_2, Al_2O_3, total Fe_2O_3, K_2O and P_2O_5 and lower concentrations of CaO, than soils from the limestone areas (Table 2). These differences, evaluated with t-Student test, are statically significant and they are explained by differences in the lithology of the parent material. In these cambisols the parent material seems to be the main factor controlling the chemical composition of the soils. This is also true for trace elements as the soils from the phyllite areas have statistically higher contents of Zr, Rb, Th, V and Nb than soils from limestone areas (Table 1) and these have an average of 254.37 mg/kg of Sc, which was not detected in the soils from the phyllite.

Altogether, the results of soil analysis showed that in the two phyllite areas (Bostelim and Torres do Mondego) the soils have similar composition but that there are various differences between the soils in the two limestone areas (Relvinha and Souselas). The soil from Relvinha has a chemical composition more similar to the soils from the phyllite areas, than the soil from Souselas (Table 1). This can be explained by two factors: 1) the parent material in Relvinha has an higher marl content than in Souselas; 2) in Relvinha the soil has a transported component, derived from a terrace deposit of red sands (Areias Vermelhas do Ingote, Soares & al. 1985), located at higher altitude, above up-stream Relvinha, as quartz pebbles were identified during field work in this soil.

Checklist

The most abundant families are *Fabaceae* (14.24%), *Poaceae* (11.11%) and *Asteraceae* (10.42%), the typical pattern in the Mediterranean (Table 3), which compares very well with a nearby area (Barrico & al. 2012). An indicator used for the degree of the Mediterranean influence is the index of *Cistaceae* (Cueto & al. 1991). It is considerably high (2.43%) (Table 3) in the areas here studied, even higher than in Southern Iberian Peninsula (2.30% in Almeria; Cueto & al. 1991).

Proportionally to the size of the areas, species number in the soils from the limestone areas is quite similar, whereas it is very disparate in the soils from phyllite areas. Bostelim has the highest species number (143) of the four areas and Torres do Mondego has the lowest (95) (Electronic Supplementary File 1). Torres do Mondego has very steep topography were slope is 40% and, therefore, anthropic impact is the lowest of all areas (Table 4). Native vegetation has developed well, mainly trees and shrubs, e.g. *Arbutus unedo, Cistus salviifolius, Erica arborea, Myrtus communis, Quercus suber* (Electronic Supplementary File 2) leaving little space for annuals. The high species number in Bostelim is discussed in the sections below.

Statistical analysis of the vegetation

Species ordination is not substantially altered in presence of the environmental variables (compare CCA and CA, Electronic Supplementary File 2 and Electronic Supplementary

File 3). This means that the environmental variables in the CCA are the explanation for the floristic composition of the areas. The differences between CCA and CA result from the use of averages for each environmental variable; this leads to the observed grouping of quadrats in each area in the CCA.

The differences in mineralogy and physico-chemical composition of the soils explain the clear separation of both the limestone and phyllite areas along the axis 1 in the CCA (Electronic Supplementary File 2).

Along the axis 2 of the CCA are observed major contrasts between the soils in limestone and phyllite areas. Whereas the two limestone areas are very close to each other, the two phyllite are further apart (Electronic Supplementary File 2). Although the soil analysis showed differences between the two limestone areas greater than those between the phyllite, the vegetation composition does not seem to be affected (at least in the analysis) by such differences. The major distance along the axis 2 between the two phyllite areas does not result from the soil features (mica, K_2O, organic matter, quartz). In fact, the anthropic impact shows its highest strength in the direction of Bostelim placing it away from its counterpart, Torres do Mondego. In fact, many of the species restricted to Bostelim are ruderal taxa, e.g., *Digitalis purpurea* subsp. *purpurea*, *Medicago polymorpha*, *Raphanus raphanistrum* subsp. *raphanistrum*, *Rumex bucephalophorus* subsp. *hispanicus* and *Vicia sativa* subsp. *sativa*. In the CA ordination, it is clear the heterogeneity of Bostelim itself with one transect placed a long distance away in axis 2 (Electronic Supplementary File 3). This transect is a small fallow field and the human impact here is evident in the higher number of annuals.

The analysis showed a number of taxa with stronger affinities to particular environmental variables. These taxa are densely placed around the respective squares (Electronic Supplementary Files 2 & 3). To better understand the stronger correlations taxa/kind of soil, the same CCA is also given with a weight range of 30% for the most abundant species (Electronic Supplementary File 4).

Conclusions

Plant diversity was dissimilar in the two soil types studied, one developed from limestone, the other from phyllite. Different parent materials have determined different soil mineralogy, thus different soil proprieties that, in turn, influenced the vegetation structure and floristic composition.

The variability of soil proprieties in the limestone areas did not substantially alter the floristic composition.

The decisive environmental variable for the differences in floristic composition between the two phyllite areas was the stronger anthropic impact observed only in one of them.

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Addresses of the authors:
Filipe Covelo[1], Fátima Sales[1, 2], Maria Manuela da Vinha Guerreiro da Silva[3], César Augusto Garcia[4],
[1]Centre for Functional Ecology, Department of Life Sciences, University of Coimbra, Calçada Martim de Freitas, 3000-456 Coimbra, Portugal. E-mail: filipe.covelo@student.uc.pt
[2]Royal Botanic Garden Edinburgh EH3 5LR, Edinburgh, Scotland.
[3]Centre for Mechanical Engineering, Department of Earth Sciences, University of Coimbra, Rua Sílvio Lima, Univ. Coimbra - Pólo II, 3030-790 Coimbra, Portugal.
[4]Museu Nacional de História Natural e da Ciência, Centre for Ecology, Evolution and Environmental Changes, Universidade de Lisboa, Rua da Escola Politécnica, 58, 1250-102 Lisboa, Portugal.

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Gennadii Urbanavichus & Irina Urbanavichene

New and noteworthy records of lichen-forming and lichenicolous fungi from Abrau Peninsula (NW Caucasus, Russia)

Abstract

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98 species of lichen-forming and lichenicolous fungi are reported for the first time from Utrish Reserve, Abrau Peninsula. Fifteen species are new to the Northern Caucasus, of which ten species are reported for the first time for the Caucasus region and five are new to Russia: *Dirina fallax*, *Flavoplaca navasiana*, *Lecanographa lyncea*, *Melaspilea enteroleuca* and *Verrucaria elaeina*.

Key words: biodiversity, Utrish Nature Reserve, new records, sub-Mediterranean forests, Black Sea coast.

Introduction

To date, the lichen-forming and lichenicolous fungi of sub-Mediterranean forests of the Abrau Peninsula on the Black Sea coast of the Russian Caucasus have received only limited attention, despite the fact that this area is recognized as one of the most interesting and species rich of the Mediterranean and Mediterranean-Atlantic biogeographic elements in Russia (Otte 2005, 2007b). Some interesting lichen taxa known to occur in the areas are: *Candelariella viae-lacteae*, *Diploicia canescens*, *Koerberia biformis*, *Pertusaria ilicicola, Physconia grisea* subsp. *algeriensis*, *Ramalina canariensis*, *Roccella phycopsis*, *Teloschistes chrysophthalmus*, *Tornabea scutellifera, Waynea stoechadiana*, and the lichenicolos fungi *Abrothallus acetabuli, Arthonia diploiciae* and *Polycoccum rinodinae*. First data on the lichens of the Abrau Peninsula were published by Otte (2005, 2007a, 2007b), who reported c. 90 taxa for the Anapa-Novorossiysk coastal area in the vicinity of the projected Utrish Nature Reserve. C. 180 species were added by Urbanavichus & Urbanavichene (2015a, 2015b), and further records are added in other taxonomic and floristic studies (Vondrák & al. 2010; Zhurbenko & Otte 2012; Urbanavichus & Urbanavichene 2015c; Urbanavichus 2016a, 2016b). The present paper is a contribution to the lichenological exploration of the Abrau Peninsula and Utrish Reserve.

Study area

The Abrau Peninsula is located in the north-westernmost part of the Greater Caucasus Range. It is particularly interesting for the presence of relic arid sub-Mediterranean forests, the single occurrence of such vegetation in Russia (Seregin & Suslova 2007; Kuznetsova 2009). The climate of the Abrau Peninsula is sub-Mediterranean, with typically cool and rainy winters without persistent snow coverage, and hot dry summers. The mean annual temperature is 12°C. On the coast monthly averages range from 2.3°C in January to 23°C in July. The mean annual precipitation is ca. 600-700 mm, with a maximum in winter.

The arid sub-Mediterranean (semi-)natural forests of the lower altitudinal belt of the Navagir Ridge (0-200 m on S-facing slopes) are constituted by a pistacia-juniper community (*Juniperus excelsa, J. deltoides, J. foetidissima, Pistacia mutica, Quercus pubescens, Carpinus orientalis*), together with Christ's thorn (*Paliurus spina-christi*) and sumac (*Rhus coriaria*). The vegetation of the upper altitudinal belt (150-500 m, descending to 50 m in gorge bottoms) consists of broad-leaved forests with *Acer campestre, Carpinus betulus, C. orientalis, Fagus orientalis, Fraxinus excelsior, Quercus petraea, Tilia begoniifolia*, etc. Steep slopes are covered with *Pinus kochiana* forests. Currently 848 vascular plant and 128 bryophyte species are known to occur in the Abrau Peninsula (Ignatova & al. 2006; Seregin & Suslova 2007).

In 2011, the area was protected as a State Nature Reserve "Utrish", in order to preserve these sub-Mediterranean forests. The reserve, located in the central part of the Abrau Peninsula, between Novorossiysk and Anapa (Krasnodar Area), on the Russian coast of the Black Sea, covers 9065 ha. The rugged morphology, the variety of substrata, the climatic conditions, the abundance of old forests, with no industrial development, are responsible for a rich lichen flora.

Material and Methods

Lichen specimens were collected by the authors from typical arid sub-Mediterranean ecosystems and mesophilous broad-leaved forests within the Utrish Reserve in 2014-2015. The coordinates and altitudes of each sampling site were determined by GPS (WGS 84). Specimens were examined using standard identification methods (Smith & al. 2009; Wirth & al. 2013). Lichen substances were studied by thin-layer chromatography (TLC) using the methods of Orange & al. (2001). Reactions of the thalli with C (commercial bleach containing sodium hypochlorite), K (10% solution of potassium hydroxide), and Pd (alcohol solution of paraphenylenediamine) were also checked. All measurements were taken from material mounted in water. The specimens are kept in the private collection of G. Urbanavichus (hb. G. Urbanavichus), and duplicates of new finding, and some interesting species in the lichenological herbarium in LE (St-Petersburg). Species which were not included in the recent checklist of lichens of Russia (Urbanavichius 2010) are marked with an asterisk (*); taxa new to the Caucasus are marked with a plus (+), and those new to the Northern Caucasus a marked with two plus signs (++).

Collection sites

For all localities: Caucasus, Russia, Krasnodar Area, Abrau Peninsula, Utrish Reserve.

1 - N44°46’02.2”, E37°26’26.4”, 400 m alt., *Quercus-Fraxinus-Tilia* forest, 26.06.2014.
2 - N44°47’16.3”, E37°24’59.0”, 195 m alt., *Quercus-Carpinus* forest, 27.06.2014.
3 - N44°47’09.6”, E37°26’45.3”, 95-100 m alt., *Juniperus-Quercus-Carpinus* forest, 28.06.2014.
4 - N44°43’29.9”, E37°26’24.7”, 100-110 m alt., *Juniperus-Quercus-Pistacia* forest on S slope, 18.09.2014.
5 - N44°42’37.7”, E37°28’00.7”, 80-90 m alt., *Juniperus-Pistacia* forest with *Paliurus* on S slope, 23.09.2014.
6 - N44°44’15”, E37°27’31.1”, 205 m alt., *Quercus* forest, 24.09.2014.
7 - N44°46’17.5”, E37°27’13.6”, 325 m alt., *Fagus-Quercus-Carpinus* forest, 19.06.2015.
8 - N44°46’21.3”, E37°27’57.5”, 160 m alt., *Fagus-Carpinus-Tilia* forest, 21.06.2015.
9 - N44°46’45.5”, E37°28’25”, 190-200 m alt., *Juniperus-Quercus-Carpinus* forest, 22.06.2015.
10 - N44°46’26.9”, E37°28’22.6”, 270-280 m alt., *Quercus-Carpinus-Tilia* forest on N slope, 22.06.2015.
11 - N44°45’27.2”, E37°28’19.3”, 390-400 m alt., *Quercus-Pinus* forest on S slope, 23.06.2015.
12 - N44°47’06.3”, E37°32’15.3”, 270-280 m alt., shrubs, stony steppe, 24.06.2015.
13 - N44°47’00.6”, E37°32’05.1”, 280 m alt., shrubs, stony steppe, 24.06.2015.
14 - N44°46’45.1”, E37°32’30.8”, 315 m alt., stone steppe with solitary *Quercus* and *Carpinus* on S slope, 24.06.2015.
15 - N44°47’11.0”, E37°31’59.1”, 280 m alt., stone steppe with solitary *Quercus* on S slope, 24.06.2015.
16 - N44°45’53.9”, E37°29’17.1”, 340-360 m alt., *Fagus-Carpinus* forest, 27.06.2015.
17 - N44°42’37.4”, E37°28’51.2”, 70-120 m alt., *Quercus-Carpinus* forest on stony slope, 08.09.2015.
18 - N44°43’27.9”, E37°29’07.5”, 60-70 m alt., *Carpinus-Juniperus* forest on stony slope, 9.09.2015.
19 - N44°43’39.6”, E37°29’17.6”, 190-200 m alt., *Quercus* forest with *Paliurus* on stony slope, 9.09.2015.
20 - N44°42’30.2”, E37°31’06.2”, 350 m alt., *Quercus-Pinus* forest on E slope, 10.09.2015.
21 - N44°42’06”, E37°30’37.1”, 430-440 m alt., meadow steppe along *Juniperus-Pistacia* forest margin, 10.09.2015.
22 - N44°42’55.2”, E37°27’59.6”, 150-160 m alt., stony slope with solitary *Quercus* and *Paliurus*, 11.09.2015.
23 - N44°42’04”, E37°29’54”, 50-60 m alt., *Juniperus-Pistacia* forest on SE slope, 12.09.2015.
24 - N44°42’57.9”, E37°30’27.7”, 140-200 m alt., *Quercus-Carpinus* forest on stony slope, 12.09.2015.
25 - N44°43’16”, E37°29’24.7”, 200-240 m alt., *Juniperus-Pistacia* forest on S slope, 13.09.2015.

26 - N44°43’07.5”, E37°29’52.9”, 465-480 m alt., *Quercus-Carpinus-Tilia* forest, 13.09.2015.
27 - N44°43’01”, E37°27’33”, 95-110 m alt., *Juniperus-Pistacia* forest on S slope, 14.09.2015.

Lichenized species

Absconditella lignicola Vězda & Pišut: 10, on lignum.
Acarospora fuscata (Schrad.) Th. Fr.: 11, on sandstone.
Agonimia tristicula (Nyl.) Zahlbr.: 5, 12, on *Quercus*, *Fraxinus* and mossy sandstone.
+***Arthopyrenia cinereopruinosa*** (Schaer.) A. Massal.: 9, on *Carpinus*.
++***Athallia cerinella*** (Nyl.) Arup, Frödén & Søchting: 14, on *Carpinus*. Also reported from Armenia (Harutyunyan & Mayrhofer 2009) and Azerbaijan (Barkhalov 1983) in Transcaucasia.
Athallia cerinelloides (Erichsen) Arup, Frödén & Søchting: 25, on *Pistacia*.
Athallia pyracea (Ach.) Arup, Frödén & Søchting: 25, on *Fraxinus*, *Pistacia*.
Athallia skii (Khodos.,Vondrák & Šoun) Arup, Frödén & Søchting: 25, 27, on *Juniperus*, *Hedera*.
Bacidia circumspecta (Nyl. ex Vain.) Malme: 16, on *Quercus*.
Bacidina delicata (Larbal. ex Leight.) V. Wirth & Vězda: 8, 16, on *Quercus* and old roofing slate.
Blastenia hungarica (H. Magn.) Arup, Søchting & Frödén: 3, on *Juniperus*. New to Krasnodar Area. Also reported from the Republic of Adygeya in North-Western Caucasus (Urbanavichus & Urbanavichene 2014).
Calicium glaucellum Ach.: 16, on lignum of *Quercus*.
Caloplaca aegatica Giralt, Nimis & Poelt: 18, 23, 25, on *Juniperus*, *Pistacia*.
++***Caloplaca atroflava*** (Turner) Mong.: 11, 21, 23, 27, on sandstone. Also reported from Armenia in Transcaucasia (Harutyunyan & Mayrhofer 2009). Widespread throughout Europe and previously reported in Russia from the Voronezh region (Muchnik & al. 2014).
Caloplaca cerina (Hedw.) Th. Fr.: 21, on *Juniperus*.
Caloplaca chlorina (Flot.) H. Olivier: 23, on sandstone. Previously reported for the Abrau Peninsula by Otte (2005).
Caloplaca raesaenenii Bredkina: 15, on plant debris on calcareous soil.
Circinaria fruticulosa (Eversm.) Sohrabi: 13, on soil. New to North-Western Caucasus. Also reported for Northern Caucasus from the Republic of Dagestan (Ismailov 2015).
Circinaria hispida (Mereschk.) A. Nordin, S. Savić & Tibell: 13, on soil. New to North-Western Caucasus. Also reported for Northern Caucasus from the Republic of Dagestan (Urbanavichus & Ismailov 2013).
Cladonia parasitica (Hoffm.) Hoffm.: 11, on lignum of *Pinus*.
Coenogonium pineti (Ach.) Lücking & Lumbsch: 26, on *Tilia*.
Collema subflaccidum Degel.: 25, on *Fraxinus*, *Pistacia*.
Collema subnigrescens Degel.: 3, 17, 25, on *Quercus*.
Diplotomma hedinii (H. Magn.) P. Clerc & Cl. Roux: 15, on limestone.
*+***Dirina fallax*** De Not.: 18, 19, 22, on sandstone. This species has its main distribution in the western part of the Mediterranean Region and the Atlantic coasts of Europe and

Africa, north from Scotland and south to Morocco, with an outpost locality in the Canary Islands (Tehler & al. 2013). The current finding in Utrish Reserve significantly expand the boundaries of the known distribution of this taxon.

*+***Flavoplaca navasiana*** (Nav.-Ros. & Cl. Roux) Arup, Søchting & Frödén: 23, on sandstone. Det. J. Vondrák. A Mediterranean, recently-described and perhaps more widespread lichen found on horizontal faces of calcareous rocks in coastal situations.

Gyalecta derivata (Nyl.) H. Olivier: 1, 2, 16, on *Quercus*.

Gyalecta flotowii Körb.: 16, 17, on *Fraxinus*, *Quercus*.

Gyalolechia flavovirescens (Wulfen) Søchting, Frödén & Arup: 23, on sandstone.

Hazslinszkya gibberulosa (Ach.) Körb.: 16, on *Quercus*.

*+***Lecanographa lyncea*** (Sm.) Egea & Torrente: 23, on *Juniperus*. This a mild-temperate, mainly western species, found on acid bark of very old isolated trees.

Lecanora bolcana (Pollini) Poelt: 21, on sandstone.

+*Lecanora confusa* Almb.: 15, on lignum of *Quercus*.

Lecanora hagenii (Ach.) Ach.: 16, on *Hedera.*

Lecanora horiza (Ach.) Linds.: 25, on *Fraxinus*, *Pistacia*.

Lecanora saligna (Schrad.) Zahlbr.: 16, on lignum of *Quercus*.

Lecanora subcarpinea Szatala: 14, on *Carpinus*.

Lecidea fuscoatra (L.) Ach.: 17, on sandstone. New to North-Western Caucasus. Also reported for Northern Caucasus from the Republic of Dagestan (Ismailov & Urbanavichus 2014).

++***Lecidea grisella*** Flörke: 11, on sandstone. Also reported from Georgia in Transcaucasia (Barkhalov 1983).

+***Lecidella achristotera*** (Nyl.) Hertel & Leuckert: 15, on lignum of *Quercus*.

++***Lecidella flavosorediata*** (Vězda) Hertel & Leuckert: 20, on *Pinus*. Also reported from Armenia in Transcaucasia (Harutyunyan & al. 2011).

++***Lepraria eburnea*** J. R. Laundon: 12, on lignum. Also reported from Armenia in Transcaucasia (Harutyunyan & al. 2011).

Lepraria finkii (B. de Lesd.) R. C. Harris: 10, 16, 18, 26, on *Carpinus*, *Fraxinus*, *Quercus*, *Tilia*.

Melanohalea infumata (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch: 4, 5, 22, 23, 25, 27, on *Carpinus*, *Fraxinus*, *Quercus*.

*++***Melaspilea enteroleuca*** (Ach.) Ertz & Diederich: 16, on *Quercus*. This species has its main distribution in the Central Europe, Mediterranean Region (including of the North Africa) and in the Southern Asia (including of the Transcaucasia) (Ertz & Diederich 2015).

Micarea denigrata (Fr.) Hedl.: 16, on lignum of *Quercus*.

Micarea prasina Fr.: 10, on lignum of *Quercus*.

Nephroma laevigatum Ach.: 26, on *Tilia*.

Opegrapha niveoatra (Borrer) J. R. Laundon: 10, on *Quercus*, *Carpinus*.

Opegrapha vulgata (Ach.) Ach.: 9, on *Fraxinus*.

Parmelia serrana A. Crespo, M. C. Molina & D. Hawksw.: 21, on *Juniperus*.

Peltigera collina (Ach.) Schrad.: 26, on *Tilia*.

Pertusaria constricta Erichsen: 10, on *Fraxinus*.

Pertusaria flavida (DC.) J. R. Laundon: 4, 22, 24, on *Juniperus*, *Quercus*.

Pertusaria hymenea (Ach.) Schaer.: 1, 4, 17, 19, 25, on *Carpinus*, *Quercus*, *Tilia*.

Pertusaria rupestris (DC.) Schaer.: 11, on sandstone.

Phaeophyscia cernohorskyi (Nádv.) Essl.: 27, on sandstone. New to North-Western Caucasus. Also reported for Northern Caucasus from the Republic of Dagestan (Urbanavichus & Ismailov 2013).

Placopyrenium fuscellum (Turner) Gueidan & Cl. Roux: 12, on *Verrucaria nigrescens* on limestone.

Placynthiella dasaea (Stirt.) Tønsberg: 10, on lignum of *Quercus*.

Polycauliona phlogina (Ach.) Arup, Frödén & Søchting: 1, on *Quercus*. Also reported for the Abrau Peninsula by Vondrák & al. (2010).

Polysporina simplex (Taylor) Vězda: 6, on sandstone.

Pycnora praestabilis (Nyl.) Hafellner: 19, on lignum of *Juniperus*.

Pyrenula nitidella (Flörke ex Schaer.) Müll. Arg.: 8, on *Carpinus*.

Rhizocarpon distinctum Th. Fr.: 11, on sandstone.

Rinodina plana H. Magn.: 9, on *Carpinus*.

Rinodina teichophila (Nyl.) Arnold: 11, on sandstone.

Roccella phycopsis Ach.: 23, 27, on *Juniperus*. Previously reported for the Abrau Peninsula by Otte (2005).

Rostania occultata (Bagl.) Otálora, P. M. Jørg. & Wedin: 2, on *Quercus*. Also reported for Krasnodar Area by Himelbrant & Kuznetsova (2002).

Rufoplaca subpallida (H. Magn.) Arup, Søchting & Frödén: 1, 6, on sandstone.

+Schismatomma graphidioides (Leight.) Zahlbr.: 7, on *Fagus*.

Scoliciosporum umbrinum (Ach.) Arnold: 1, 6, 11, on *Quercus* and sandstone.

Scytinium aragonii (Otálora) Otálora, P. M. Jørg. & Wedin: 3, 18, on mossy trunk of *Quercus* and mossy soil. Additional specimens have been examined from Khosta yew-box grove, Caucasus Reserve, Krasnodar Area (herb. G. Urbanavichus): *Buxus* forest, N43°31’52”, E39°52’40”, 80 m alt., on mossy limestone, 10.10.2008. During an examination of a Caucasian *Scytinium* in herb. LE (St Petersburg), a specimen from Armenia determined by us as *S. aragonii* was discovered: “Trans Caucasus in humidis montain Murgus, 22.02.1844, leg. Dr. F. A. Kolenati”. This species was reported by G. Urbanavichus (2016) as new to Caucasus from Armenia and Krasnodar Area (as new to Russia without localities and annotation).

Scytinium leptogioides (Anzi) Otálora, P. M. Jørg. & Wedin: 5, 23, on sandstone. This species was reported by G. Urbanavichus (2016) as new to Caucasus from Krasnodar Area (as new to Russia without localities and annotation).

Scytinium palmatum (Huds.) Gray: 1, 3, on mossy soil and *Quercus*.

Scytinium schraderi (Bernh.) Otálora, P. M. Jørg. & Wedin: 3, on soil.

Scytinium subaridum (P. M. Jørg. & Goward) Otalora, P. M. Jørg. & Wedin: 5, 24, on *Juniperus*, *Quercus* and sandstone. This species was reported by G. Urbanavichus (2016) as new to Caucasus from Krasnodar Area (as new to Russia without localities and annotation).

Scytinium turgidum (Ach.) Otálora, P. M. Jørg. & Wedin: 5, on sandstone. Also reported from Armenia in Transcaucasia (Gasparyan & al. 2015).

Squamarina cartilaginea (With.) P. James: 22, on stone.

Staurothele guestphalica (J. Lahm ex Körb.) Arnold: 15, on limestone. New to Krasnodar Area. Also reported for North-Western Caucasus from the Republic of Adygeya (Urbanavichus & Urbanavichene 2014).

Teloschistes chrysophthalmus (L.) Th. Fr.: 5, 19, 22, on *Paliurus*. Previously reported for the Abrau Peninsula by Otte (2005). This species recorded from most parts of the world although lacking in Asia (but occurs in the western parts of the Arabian Peninsula), frequent in areas with Mediterranean climate (Nash & al. 2004).

+*Thelidium olivaceum* (Fr.) Körb.: 8, on limestone and old roofing slate.

Toninia opuntioides (Vill.) Timdal: 5, on soil.

Trapelia coarctata (Sm.) M. Choisy: 11, 16, on sandstone.

+***Trapelia placodioides*** Coppins & P. James: 17, 19, 24, on sandstone.

Variospora flavescens (Huds.) Arup, Frödén & Søchting: 22, on sandstone. Previously reported for the Abrau Peninsula by Otte (2005).

*+***Verrucaria elaeina*** Borrer: 8, on old bone.

++***Verrucaria hydrophila*** Orange: 8, on sandstone in a stream.

Verrucaria muralis Ach.: 8, on limestone.

+***Verrucaria praetermissa*** (Trevis.) Anzi: 8, on sandstone in a stream.

Xanthocarpia crenulatella (Nyl.) Frödén, Arup & Søchting: 11, on sandstone.

Lichenicolous fungi

Intralichen christiansenii (D. Hawksw.) D. Hawksw. & M. S. Cole: 11, on apothecia *Candelariella* sp. on sandstone.

Lichenoconium erodens M. S. Christ. & D. Hawksw.: 10, on thallus *Ramalina obtusata* on *Quercus*. New to Krasnodar Area. Also reported for Northwest Caucasus from the Republic of Adygea (Urbanavichus & Urbanavichene 2014).

+*Roselliniopsis tartaricola* (Nyl.) Matzer: 4, on thallus *Pertusaria ilicicola* on *Juniperus*. Also reported for Asiatic Russia by Hafellner & al. (2002).

Sclerococcum serusiauxii Boqueras & Diederich: 25, on thallus *Parmelina tiliacea* on *Pistacia*. This species was known in Spain and has been also reported from Portugal, France, Austria, Slovenia and Poland (Kukwa & al. 2013). It was previously reported from Russia only from Krasnodar Area in the Northwest Caucasus (Zhurbenko & Kobzeva 2016).

Vouauxiella lichenicola (Linds.) Petr. & Syd.: 25, on apothecia *Lecanora horiza* on *Pistacia*. New to Krasnodar Area. Also reported for the Northwest Caucasus from the Republic of Adygea (Urbanavichus & Urbanavichene 2014).

Xanthoriicola physciae (Kalchbr.) D. Hawksw.: 25, on apothecia *Xanthoria parietina* on *Pistacia*. New to Northwest Caucasus. Also reported for Northern Caucasus from Stavropol Area (Zhurbenko & Kobzeva 2014).

Non-lichenized species

Chaenothecopsis pusilla (Ach.) A. F. W. Schmidt: 16, on lignum of *Quercus*.

Mycocalicium subtile (Pers.) Szatala: 12, 16, on lignum of *Quercus*.

Conclusions

The above list includes 98 species of lichen-forming and lichenicolous fungi that are new to the Utrish Reserve, of which 93 are new to the Abrau Peninsula. Hence, the number of species known to occur in the area is now c. 380, about one quarter of the taxa known to occur in Northern (Russian), the Caucasus. 15 species are reported for the first time from the Northern Caucasus, 10 of which are new to the Caucasus and 5 are reported for the first time from Russia: *Dirina fallax*, *Flavoplaca navasiana*, *Lecanographa lyncea*, *Melaspilea enteroleuca* and *Verrucaria elaeina*.

The lichen flora of the Abrau Peninsula is of great phytogeographic interest because it includes both Mediterranean-Atlantic species (occurring in arid sub-Mediterranean (semi-) natural forests of the lower altitudinal belt, e.g. *Caloplaca aegatica*, *Candelariella viae-lacteae*, *Diploicia canescens*, *Dirina fallax*, *Flavoplaca navasiana*, *Koerberia biformis*, *Lecanographa lyncea*, *Pertusaria ilicicola, Physconia grisea* subsp. *algeriensis*, *Ramalina canariensis*, *Roccella phycopsis*, *Scytinium aragonii, Scytinium leptogioides*, *Teloschistes chrysophthalmus*, *Tornabea scutellifera, Waynea stoechadiana*, and the lichenicolos fungi *Abrothallus acetabuli, Arthonia diploiciae*, *Polycoccum rinodinae* and *Sclerococcum serusiauxii*) and temperate-sub-oceanic species (mainly epiphytic species from the broad-leaved mesophilic forests of the upper altitudinal belt, e.g. *Collema flaccidum*, *C. nigrescens*, *Lobaria pulmonaria*, *Nephroma laevigatum*, *Parmotrema perlatum*, *Peltigera collina*, *Pyrenula laevigata*, *P. macrospora*, *P. nitida*, *Ricasolia amplissima*).

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Addresses of the authors:
Gennadii Urbanavichus[1] & Irina Urbanavichene[2],
[1]Institute of the North Industrial Ecology Problems, Kola Science Centre, Russian Academy of Sciences, Akademgorodok 14a, 184209 Apatity, Murmansk Region, Russia. E-mail: g.urban@mail.ru
[2]Komarov Botanical Institute, Russian Academy of Sciences, Professor Popov Str. 2, 197376 St Petersburg, Russia. E-mail: urbanavichene@gmail.com

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Tarek Hamel & Amir Boulemtafes

Découverte d'une endémique tyrrhénienne *Soleirolia soleirolii* (*Urticaceae*) en Algérie (Afrique du Nord)

Abstract

Tarek Hamel, T. & Boulemtafes, A.: Découverte d'une endémique tyrrhénienne *Soleirolia soleirolii* (*Urticaceae*) en Algérie (Afrique du Nord). — Fl. Medit. 27: 185-193. 2017 — ISSN: 1120-4052 printed, 2240-4538 online.

The recent discovery in Algeria (North Africa) of *Soleirolia soleirolii* (Req.) Dandy (*Urticaceae*) endemic to the Tyrrhenian area is here reported. Due to the limited distribution area (Edough peninsula North-East Algeria), a particular conservation attention is to be paid in Algeria.

Key words: Tyrrhenian endemic, chorology, plant conservation, Western Mediterranean Basin, vascular flora.

Introduction

La région méditerranéenne possède une diversité biologique exceptionnelle, sa richesse floristique estimée à 25000 espèces des plantes vasculaires, ce qui correspond à 9.2 % de la flore mondiale, sur un territoire représentant seulement 1.5% de la surface terrestre (Médail & Quézel 1997). La moitie de ces espèces sont endémiques du pourtour et qui sont bien adaptées aux périodes sèches (Véla & Benhouhou 2007).

Cette région est le troisième hotspot le plus riche du monde en diversité végétale (Mittermeier & al. 2004). Elle est caractérisée par leur richesse spécifique et leur taux d'endémisme (Myers 1988, 1990) et par les menaces anthropiques grandissantes (Myers & al. 2000).

La grande richesse biologique de l'extrême Nord-Est algérien et du Nord-Ouest tunisien les ont fait considérer comme un point-chaud régional de biodiversité nommé «Kabylies-Numidie-Kroumirie» (Véla & Benhouhou 2007), renfermant de nombreuses zones importantes pour les plantes (Radford & al. 2011), dont la péninsule de l'Edough fait partie.

Elle comporte en effet une grande diversité floristique et une richesse certaine en taxons endémiques et sub-endémiques à aire fragmentée, rarissimes en Algérie, souvent très localisées (sténoendémiques) (Yahi & al. 2012, Hamel & al. 2013).

Cette région plutôt méconnue, à la fois riche et sauvage (Véla & de Bélair, 2013), mérite plus d'attention de la part des chercheurs. Les travaux sur la végétation sont peu nombreux nous citons (Toubal-Boumaza 1986, Toubal & Toubal 1998, de Bélair & al. 2005, Haou & al. 2011, Hamel & al. 2013, Hamel 2013, Hamel & Meddad-Hamza 2016, Hamel 2016, Hamel & al. 2017, Hamel & Boulemtafes 2017, Hamel & Boulemtafes 2017 sous presse).

Oued El Hrour un des plus longues rivières de la péninsule de l'Edough (10 km), situé sur le secteur de Seraidi (Hamel 2013), fut l'objet d'une exploration botanique le 3 mars 2017, au cours de laquelle fut découverte, pour la première fois coté algérien, l'endémique tyrrhénien *Soleirolia soleirolii* (Req.) Dandy, le thème de cette contribution.

Observations et détermination

Le réseau hydrographique de la péninsule de l'Edough constitue essentiellement par les oueds:
- Oued Maoured sur le secteur d'Ain Barbar (7 km);
- Oued Oureida sur le secteur de Bouzizi (4 km);
- Oued El Hrour sur le secteur de Seraidi (10 km).

Ce dernier cours d'eau situé sur le versant Nord-Est de la péninsule de l'Edough (Fig. 1). Il descend du Kef Sabaa (point culminant de la région à 1008m) et va se jeter à la mer après avoir traversé des forêts de *Quercus canariensis* Willd., *Q. suber* L. et les maquis à

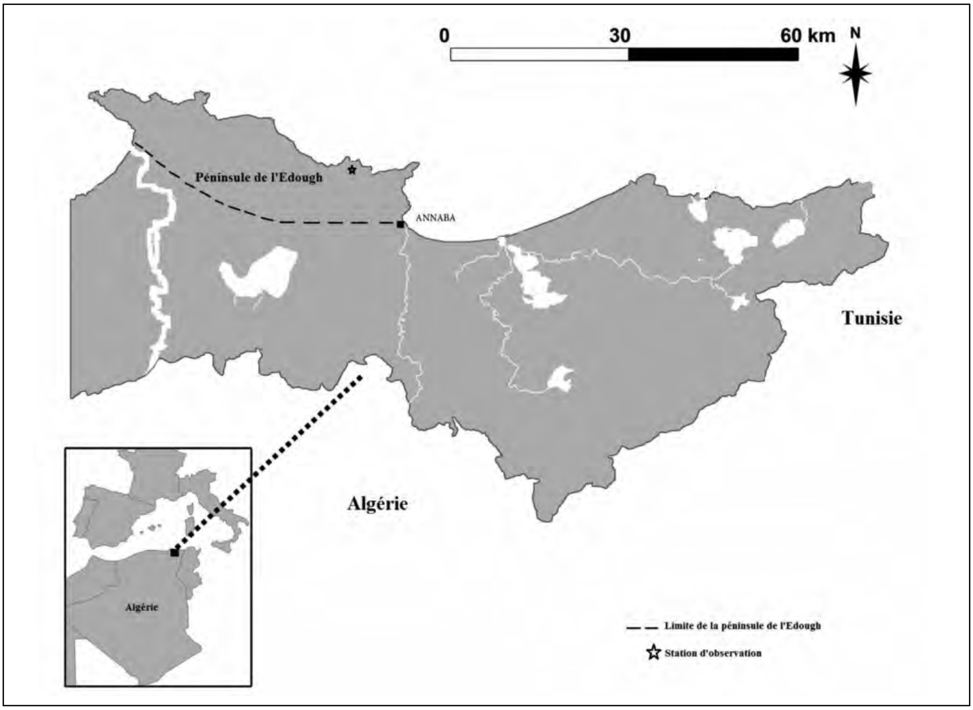

Fig. 1. Localité de la station d'observation (Oued El Hrour).

oléo-lentisque. Cet oued à une altitude de 439 m et en raison de la forte déclivité (45%), il forme la cascade des Vautours qui est un écosystème favorable au développement d'espèces endémiques et rares en Algérie ex: *Lactuca muralis* (L.) Gaertn., *Eupatorium cannabinium* L., *Sagina procumbens* L., *Carex sylvatica* Huds., *Hyacinthoides lingulata* (Poir.) Rothm., *Neotinea maculata* (Desf.) Stearn, *Hypericum afrum* Lam. (Hamel & al. 2013).

Cette réserve était idéale pour la croissance d'une population assez importante de *Soleirolia soleirolii*.

Des échantillons ont été ramassés et pris au laboratoire pour identification précise.

La définition de ce taxon, telle que présentée dans Flora d'Italia (Pignatti 1982), correspond bien aux plantes rencontrées sur la station d'observation. En résumé, plante vivace de 5 à 20 cm de longueur, feuille rondes ou ovales alternes de 1 à 3 mm de larges, et de 2 à 3 nervures. Tiges rosâtres et poilues.

En outre, la flore d'Algérie (Quézel & Santa 1962-1963) et celle d'Afrique du Nord (Maire 1952-1987) ignorent cette espèce. Il en est de même pour le Maroc (Fennane & Ibn Tattou 2005; Fennane & al. 2007) ainsi que pour la Tunisie (Poittier-Alapetite 1979-1981; Le Floc'h & al. 2010). Les travaux bibliographiques récents sur la flore d'Afrique du Nord (Dobignard & Chatelain 2010-2013) ne signalent un taxon infra spécifique qui pourrait lui être équivalent.

Soleirolia soleirolii a été décrite comme paléoendémique de l'Archipel de Toscano (Arrigoni 1976). En outre, elle est signalée comme endémique de Corse, Sardaigne, Majorque et à Caprera de l'Italie (Bacchetta & al. 2007; Sáez & al. 2015). Ces micro-espaces insulaires constituent en effet d'importants refuges pour de nombreuses espèces végétales dont l'aire de répartition est bien souvent très limitée (Médail 2008). En conséquence, elle est également considérée comme une sous-région biogéographique indépendante de la Méditerranée occidentale (Rivas-Martinez & al. 2007).

La découverte de cette espèce à la péninsule de l'Edough confirme la position géographique de la région comme presqu'île (Véla & Benhouhou 2007). Elle a subi un isolement géologique ancien, pendant le Miocène, le Nord-Est algérien présente un paysage et une structure de type de marge océanique active. Au Nord, le Tell n'est qu'une ride peu élevée qui émerge avec une île principale et des îlots avancés comme le massif de l'Edough (Marre 1992). Les phases de transgression marine du Pliocène ont pu inonder les basses terres entourant la péninsule de l'Edough et formant une île temporaire (Carranza & Wide 2004), phénomène biogéographique important décrit sous le nom d' « île fossile continentale » (Lanza 1984). De plus, la situation actuelle se double d'un isolement géologique marqué par la dominance des grès et argiles de Numidie (Joleaud 1936).

Ce qui en fait, l'espèce observée est une espèce insulaire typiquement tyrrhénienne. Elle est donc totalement nouvelle pour la l'Algérie, et par extension pour l'Afrique du Nord, bien qu'elle n'est pas citée dans l'index de Dobignard & Chatelain (2010-2013) sur le continent lui-même.

Cependant, l'écologie de la station d'observation (rochers ombragés suintants) est semblable à celle des plantes des îles de méditerranée occidentale (nesicole).

En outre, l'espèce est naturalisée dans beaucoup de pays et d'îles d'Europe atlantique car elle est très utilisée en jardinerie pour la décoration, en raison de sa capacité reconnue à éliminer les polluants gazeux (Egea & al. 2014).

Cette espèce préfère les sols relativement drainants, mais restant humides. Elle affectionne, sous climats doux, les zones fraiches et ombragées, où elle peut former de larges tapis réguliers. Dans ces conditions, elle peut coloniser rapidement des surfaces respectables, à tel point qu'elle est parfois considérée comme invasive dans certaines zones de l'Amérique du Nord (Californie) (Rejmanek & Randall 1994).

En Algérie, ce taxon reste toujours rarissime. Sa présence renforce l'intérêt de la zone importante pour les plantes «la péninsule de l'Edough» en Algérie du nord (Yahi & al. 2012).

Contexte de découverte

Lors de prospections botaniques habituelles entretenues dans les ripisylves, habitats connus par un taux d'endémisme et de rareté très élevé (Hamel & al. 2013).

Sur les bords de la station de découverte, une végétation hydrophile et hygrophile assez intéressante est présente en un nombre important (plus d'une trentaine d'espèces végétales). Ces taxons sont identifiés selon la flore de Quézel & Santa (1962-1963). La nomenclature à été actualisée selon la nomenclature de l'index de Dobignard & Chatelain (2010-2013): *Soleirolia soleirolii* (Req.) Dandy, *Adiantum capillus-veneris* L., *Allium triquestum* L., *Alnus glutinosa* (L.) Gaertn., *Lemna minor* L., *Polystichum setiferum* (Forssk.) Woynar, *Hedera algeriensis* Hibberd, *Pteridium aquilinum* (L.) Kuhn, *Hypericum androsaemum* L., *Mercurialis ambigua* L. f., *Geranium purpureum* Vill., *Lythrum junceum* Banks & Sol., *Galium rotundifolium* L. subsp. *rotundifolium*, *Iris unguicularis* Poir., *Rubus ulmifolius* Schott, *Ampelodesmos mauritanicus* (Poir.) Durand, *Polypodium cambricum* L. subsp. *cambricum*, *Cyclamen africanum* Boiss. & Reut., *Nasturtium officinale* R. Br., *Poa trivialis* L. subsp. *trivialis*, *Sedum cepaea* L., *Oxalis pes-caprae* L., *Juncus bufonius* L. subsp *bufonius*, *Scrophularia laevigata* Vahl subsp. *laevigata*, *Erica arborea* L., *Oenanthe virgata* Poir., *Schoenoplectus supinus* (L.) Palla., *Dittrichia viscosa* (L.) Greuter, *Moehringia pentandra* J. Gay., *Ruscus hypophyllum* L., *Selaginella denticulata* (L.) Spring, *Oncostema peruviana* (L.) Speta et *Senecio vulgaris* L.

Si la présence d'un taxon tyrrhénien au sens large sur la péninsule de l'Edough n'est pas surprenante. Le cas similaire de certains taxons (*Brassica insularis* Moris, *Seseli praecox* Guss., *Stachys marrubiifolia* Viv., *Tuberaria acuminata* (Viv.) Grosser, *Aristolochia navicularis* Nardi) ont déjà été signalé dans la région (Hamel & al. 2013, Hamel, de Bélair & Véla inédit).

En outre, la découverte inattendue de cette espèce, très éloignée de ses stations classiques des îles de méditerranée occidentale, augure de l'existence d'autres populations, qu'il convient de rechercher dans son aire potentielle. Il serait également utile de le rechercher ailleurs sur les côtes tunisiennes, notamment dans l'île de la Galite, où *Serapias nurrica* Corrias a été découverte par Véla & al. en 2012. Ces toutes découvertes des taxons tyrrhéniens confirment les affinités biogéographiques de presqu'île de l'Edough et l'île de Galite avec le bloc corso-sarde et/ou l'ensemble insulaire tyrrhénien (Pavon & Véla 2011).

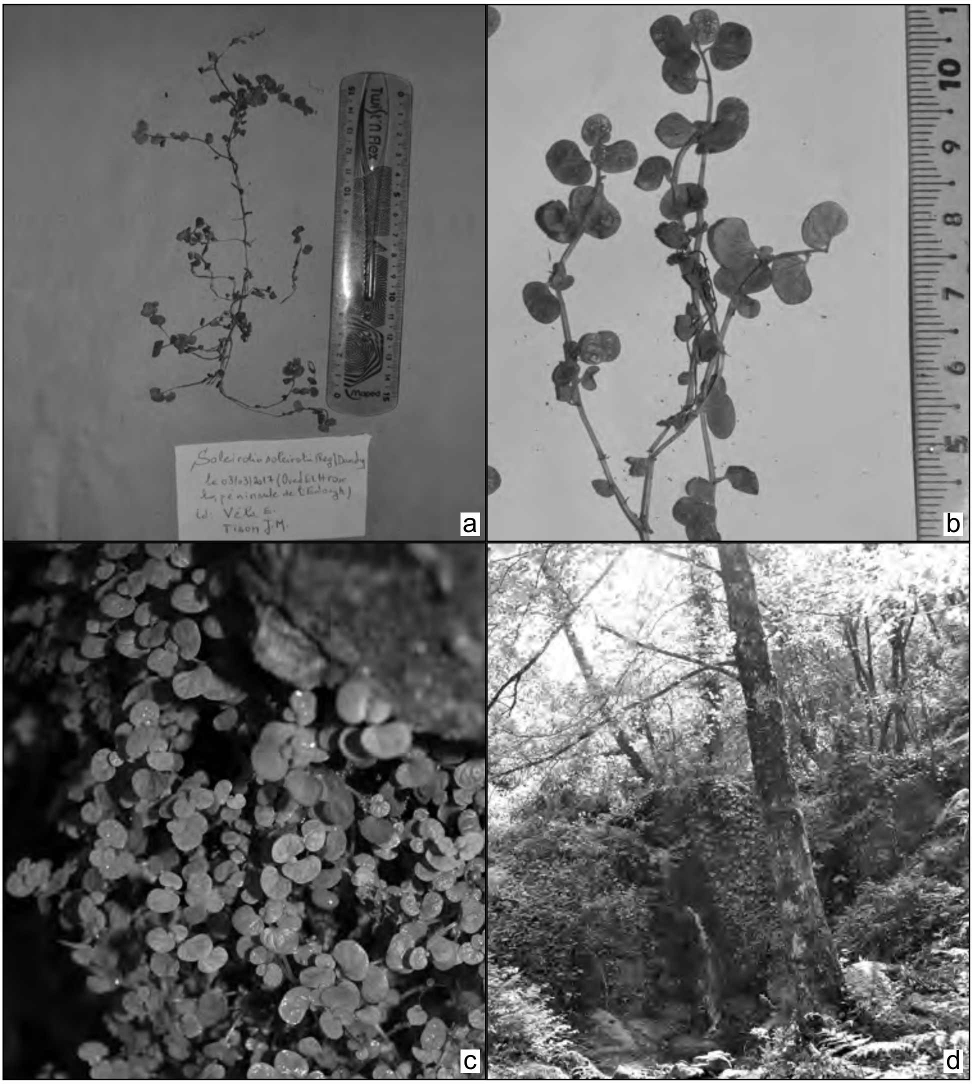

Fig. 2. **a** et **b**. Spécimens prélevés; **c.** Aspect et port de la plante dans son milieu; **d.** Habitat de la plante observée (Oued El Hrour) en 2017 (Clichés de Tarek HAMEL).

Observations complémentaires

Un effectif total de 300 individus de *Soleirolia soleirolii* a été dénombré dans la zone d'étude, incluant 240 individus matures et 60 individus immatures (Fig. 2). Sur la base des catégories de l'UICN (2001) à savoir le *Critère D1 – Population très petite,* suggère l'inclusion probable de l'espèce dans la catégorie de menace avec *En danger*, soit les individus matures de la population est inférieur ou égal à 250.

Cette découverte confirme également le fait que la péninsule de l'Edough est un carrefour biogéographique pour sa flore comme pour sa faune (de Bélair 2005; Véla & al. 2008). Cela nous encourage à une recherche encore plus méticuleuse des taxons qui pourraient avoir échappé aux investigations, comme ce fut le cas de *Sixalix farinosa* (Coss.) Greuter et Burdet découvert en mai 2013 sur les falaises maritimes de la Voile noire (Hamel & Boulemtafes 2017 sous presse). Ainsi le cas de *Oenothera rosea* Aiton observée en septembre 2015 dans le même secteur de la péninsule de péninsule de l'Edough (Hamel 2016).

Bien que l'endémisme soit limité en Algérie, les endémiques se développant dans l'aulnaie de Oued El Hrour sont relativement nombreux compte tenu du nombre des endémiques observées dans la péninsule de l'Edough, 37 taxons (Tab. 1) (Hamel & al. 2013).

Une seule espèce recensée à Oued El Hrour fait partie de la liste rouge IUCN de 1997 pour l'Algérie (Walter & Gillet 1998). Cela ne signifie pas que le reste des espèces n'y soit réellement menacées d'extinction puisque cette liste, très incomplète, n'a toujours pas été complétée ni révisée selon les nouveaux critères. En outre, 2 taxons figurent sur la liste des espèces végétales non cultivées et protégées qui en comporte 449 (J.O.R.A. 2012).

En revanche, toutes ces espèces rares et endémiques observées dans la station d'étude méritent une protection sans laquelle elles seraient menacées de disparition.

Tab. 1. Liste des espèces végétales spontanées les plus intéressantes rencontrées dans la station d'observation. Types biogéographiques selon Dobignard & Chatelain (2010-2013); rareté selon Quézel & Santa (1962-1963): P. protégé; A. assez; R. rare ; RR. très rare ; C. commun; CC. très commun.

Taxon	**Type biogéographique**	**Rareté**	Décret exécutif (2012)	**UICN (1997)**
Carex sylvatica Huds.	Européen	R		
Cyclamen africanum Boiss. & Reuter	Endémique (Maghreb)	C	P	
Eupatorium cannabinium L.	Eurasien	R		
Genista ferox Poir. subsp. *ferox*	Endémique algéro-tunisien	CC		
Geranium lanuginosum Lam.	Méditerranéen	RR		
Hedera algeriensis Hibberd	Endémique algéro-tunisien	C		
Hyacinthoides lingulata (Poir.) Rothm.	Subendémique (Maghreb)	C		
Hypericum afrum Lam.	Endémique algéro-tunisien	AC		
Hypericum androsaemum L.	Méditerranéen atlantique	R		
Iris unguicularis Poir.	Subendémique (Maghreb)	C		
Lactuca muralis (L.) Gaertn.	Européen	RR		
Montia fontana subsp. *amporitana* Sennen	Circumboréal	R		
Neotinea maculata (Desf.) Stearn	Eurasien	RR		
Oenanthe virgata Poir.	Endémique (Maghreb)	CC		
Sagina procumbens L.	Eurosibérien	RR	P	
Sambucus nigra L.	Paléotempéré	R		
Scrophularia laevigata Vahl subsp. *laevigata*	Subendémique (Maghreb)	R		
Scrophularia tenuipes Cosson & Durieu	Subendémique (Maghreb)	R		R
Sedum cepaea L.	Européen	R		
Soleirolia soleirolii (Req.) Dandy	Subendémique tyrrhénien	RR		
Solenopsis bicolor (Batt.) Greuter & Burdet	Endémique algéro-tunisien	AC	P	
Veronica montana L.	Européen	RR		
Viola riviniana Rchb.	Eurasien	R		

En termes de fragilité et de vulnérabilité, Oued El Hrour et le massif forestier qui les accompagne sont en grand péril en raison des diverses pressions exercées sur cette région de la péninsule de l'Edough: l'envahissement systématique par l'ailanthe (*Ailanthus altissima* (Mill.) Swingle) originaire de la Chine, les incendies, le surpâturage et l'agriculture (défrichement de maquis et le pompage).

Conclusion

La découverte de *Soleirolia soleirolii* à la péninsule de l'Edough confirme les affinités biogéographiques de cette presqu'île avec le bloc corso-sarde et la côte italienne et/ou l'ensemble insulaire tyrrhénien. Sa présence éventuelle en Tunisie gagnerait également à être réexaminée.

Cette découverte enrichit davantage la flore vasculaire algérienne d'origine spontanée, en deux nouveaux taxons (un genre et une espèce).

En termes de conservation, il y a lieu de rappeler la nécessité de mettre en place rapidement des mesures de protection de la station d'observation actuelles de l'espèce, notamment en encadrant les nouvelles pratiques agricoles non traditionnelles pouvant porter atteinte à l'espèce et à son habitat.

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Adresse des auteurs:
Tarek Hamel & Amir Boulemtafes,
Département de Biologie, Faculté des Sciences, Université Badji Mokhtar-Annaba-Algérie, 23000. Courriel: tarek_hamel@yahoo.fr

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Vernon H. Heywood

The nature and composition of urban plant diversity in the Mediterranean*

Abstract

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Mediterranean urban areas house substantial amounts of biodiversity – both plant and animal. Urban green spaces include (a) areas of natural or semi-natural vegetation such as ecosystem fragments, reserves, nature parks, forests, and river banks, which house varying amounts of native species; (b) urban agriculture and horticulture; (c) managed spaces with cultivated vegetation such as parks and gardens; and (d) informal urban green spaces such as wastelands or brown field sites which are largely colonized by weeds, ruderal plants and invasive species. Considerable attention has been paid to the biodiversity values of the first two categories but the last category which includes areas such as industrial wastelands, roadside verges, river and canal banks, railway line embankments, has been largely neglected. The benign climate of the Mediterranean region has permitted the cultivation of a wide range of both temperate and semitropical trees, shrubs and herbaceous plants in parks, gardens and other urban settings. The main managed elements are public parks, private and domestic gardens, botanic gardens, zoological parks, glasshouses and shade houses, planted urban forests, street trees, landscaping of office blocks, residential apartment blocks, public buildings, university and college campuses, business parks, golf courses, nurseries, garden centres, and more recently green roofs and living walls. While the diversity of species grown in urban botanic gardens is usually well documented, we have little detailed information on the overall range of species grown in public parks and gardens and, with some exceptions, even less of those grown in private gardens. Street trees are an important component of urban diversity with more than 55% of streets in a city like Madrid populated with trees, totalling altogether 300,000 specimens. Many cities have published guides to their urban street trees but there is no overall compilation. Overall, it is likely that altogether several tens of thousands of plant species are grown in Mediterranean urban areas, representing a very substantial source of biodiversity. The inventory of urban plant diversity is very uneven: for some cities such as Ioannina, Jerusalem, Montpellier, Naples, Patras, Rome, Sousse, fairly comprehensive inventories have been compiled but for most our knowledge is incomplete. Given the large growing percentage of city dwellers in the Mediterranean, it is important that much more attention should be paid to understanding and maintaining urban plant diversity which contributes substantially to human health and wellbeing.

Key words: urban biodiversity, Mediterranean, urban agriculture, green spaces.

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* Extended and enriched version of the introductory oral presentation given at the XV OPTIMA meeting in Montpellier, 6-11 June 2016.

Introduction

Ours has become a planet of urban dwellers in a very short time. Already, over half of humanity lives in urban areas. Two thirds will do so in the lifetimes of most people now living on Earth. T. Trzyna (2014)

With already half of the world population living in towns and cities, the biodiversity that they house is now widely recognized as playing an important role in enhancing the quality of life of their inhabitants whose opportunities of experience of wild nature is becoming more restricted. Although many Mediterranean cities suffer from a lack of green space for their growing populations, urban areas do house substantial amounts of biodiversity – both plant and animal. Urban green spaces are remarkably diverse (Heywood 1996) but can be grouped into the following main categories:

- areas of natural or semi-natural vegetation;
- managed spaces with cultivated vegetation such as parks and gardens;
- urban agriculture and horticulture; and informal urban green spaces such as wastelands or brown field sites which are largely colonized by weeds, ruderal plants and invasive species.

> ‘While intact natural ecosystems harbor the richest biodiversity, remnants of pristine natural landscapes (e.g. relicts of primeval forests), traditional agricultural landscapes (e.g. meadows and satoyama), restored landscapes, and managed and industrial landscapes (e.g. industrial parks, railway tracks, residential and city centers, parks, gardens, and brownfields) are increasingly becoming refugia for biodiversity in cities’. Secretariat of the Convention on Biological Diversity (2012)

Historical perspective

The vegetation of the Mediterranean region has undergone massive changes over the past few thousand years, with much of the forest cover of oaks and pines replaced by subseral communities of various types of scrubland such as maquis, garrigue, phrygana, matorral, which today form a conspicuous part of the Mediterranean landscapes. Successive waves of civilization have not only shaped the past and present landscapes through clearing of the land for crops, the use of fire, and the felling of forests to provide timber for shipbuilding but by through their introduction of numerous plants for agriculture, horticulture and ornament. The period of Al Andalus had a major influence on gardens as well as horticulture and agriculture (Heywood 2012) and the wide range of plant introductions included several ornamentals such as *Melia azedarach* (García Sánchez & Hernández Bermejo 2007). Later the introduction of ornamental shrubs, trees, palms and climbers, from many parts of the world, notably from the neotropics, has transformed the urban landscapes of the Mediterranean.

Inventory of urban plant diversity

Although urban spaces lose biodiversity, as measured by numbers of species, as urbanization expands and destroys habitats, many plant [and animal species], including threatened and endangered species, are able to grow and flourish in cities. Overall, it is likely that altogether several tens of thousands of plant species are grown in Mediterranean urban and periurban areas, representing a very substantial source of biodiversity.

Most research on urban biodiversity has focused on the inventory and composition of plant diversity within individual cities. The inventory of urban plant diversity in the Mediterranean is very uneven: for some cities such as Ioannina, Jerusalem, Montpellier, Naples, Patras, Rome, Sousse, fairly comprehensive inventories have been compiled but for most our knowledge is incomplete. This lack of inventory prevents making a proper assessment of the consequences of urbanization on changing patterns of biodiversity in the Mediterranean region and differences between east and west and north and south.

Vascular flora of Rome

Of the total 1581 spontaneous vascular plant species that make up the flora of Rome at present, 1300 species were recorded in the urban sector and 1294 species in the suburban sector. There are 228 non-native species, of which 161 are neophytes and 67 are archaeophytes. The number of species shared by the urban and suburban floristic pools are 1013, accounting for 64% of the total municipal species pool. The species that occur exclusively in the urban sector are 287 (163 native and 124 non-native) while those that occur exclusively in the suburban sector are 281 (273 native and 8 non-native).
Source: Capotorti & al. (2013)

Urban areas of natural or semi-natural vegetation

A wide array of **natural or semi-natural vegetation** which houses varying amounts of native species is found in Mediterranean cities:
- ecosystem fragments,
- urban protected areas and reserves,
- nature parks,
- urban and peri-urban forests, and
- river banks,

Some cities in the Mediterranean have invested in planning structures that preserve the biodiversity at landscape level such as the Infraestructura Verde del Área Metropolitana de Valencia: Corredor del Rio Turia, Huerta, Albufera y Mar Mediterráneo which a vast green space between eight municipalities bordering the sea. The aim is to avoid fragmentation of the ecosystems, both natural and agricultural, and the urban barriers around the river Turia, improving access to the landscape (Cantó López 2014). 'Lisbon Biodiversity 2020' aims to protect and enhance Lisbon's biodiversity. 18% of the city's area is covered with semi-natural vegetation. Of the 2,800 plant species recorded in the metropolitan area, fewer than 10 percent are native. Lisbon is also part of the 'Green Surge' project on urban green infrastructure planning and governance in 20 European cities (Box 1).

Box 1. Green Surge

Green Surge is a transnational research project funded through the European Union's Seventh Framework Programme. GREEN SURGE is an acronym for Green Infrastructure and Urban Biodiversity for Sustainable Urban Development and the Green Economy.
The project is identifying. developing and testing ways of connecting green spaces, biodi-

versity, people and the green economy, so as to meet the major urban challenges related to land use conflicts, climate change adaptation, demographic changes, and human health and well-being.
Of the 20 countries included in the project, five were Mediterranean: Bari and Milan (Italy), Barcelona (Spain), and Lisbon and Almada (Portugal).

Source: http://greensurge.eu/filer/GREEN_SURGE_Report_of_City_Portraits.pdf

Fig. 1. Canal vegetation, Nervi, near Genova, Italy (Photo V. H. Heywood).

Urban protected areas

Urban protected areas are defined by IUCN as 'protected areas situated in or at the edge of larger population centres'. They meet IUCN's definition of a protected area and can be in any of its six Management Categories. They do not include conventional urban parks with lawns, flowerbeds and sports fields (Trzyna 2014). Urban protected areas have no formal recognition as such internationally, nor is there a global inventory of urban protected areas and they are not identified separately in the World Database of Protected Areas. Most urban protected areas are recognized either as Category II (national park) or Category V (protected landscape or seascape). However, there are urban protected areas in all categories.

Urban protected areas can be managed by national governments, state or provincial governments in federal systems, local governments, nongovernmental organizations, local community groups, or businesses.

Box 2. Urban protected areas
Urban protected areas are distinctive in several ways. They: — Receive large numbers of visitors, including many who visit frequently, even daily. Many of these visitors lack experience of wilder forms of nature. They tend to be much more diverse ethnically and economically than visitors to more remote protected areas. — Relate to numerous actors in the urban arena, including government decision-makers, communications media, opinion leaders, and key educational and cultural institutions. — Are threatened by urban sprawl and intensification of urban development. — Are disproportionately affected by crime, vandalism, littering, dumping, and light and noise pollution. — Are subject to such urban edge effects as more frequent and more severe fires, air and water pollution, and introduction of invasive alien species. Source: Trzyna (2014).

Examples of urban protected areas are the Calanques National Park (Category II, 8,500 ha of land and 43,500 ha of the Mediterranean Sea, plus buffer zones) located on the outskirts of Marseilles. It was created in 2012 as France's tenth national park and may be the only national park in Europe that adjoins a city and is both terrestrial and marine. Rocky inlets, headlands, and islands heavily influenced by human activity over millennia. Managed by an administrative council composed of representatives of national and regional agencies and local governments, various interest groups, residents of the park, and park staff.

At the edge of the city are the Ljubljana marshes in the Ljubljana Marsh Nature Park, located in the area of Ljubljansko barje, in Central Slovenia, in the southernmost part of the Ljubljana Basin. It has a protected area of some13,505 ha. The Park covers Slovenia's largest complex of wet grasslands with hedges and forests, shrubs and watercourses. The area is well-known for its rich biodiversity, which is the result of specific cultivation practices (extensively-mowed meadows).
http://www.ljubljanskobarje.si/?lang=en

The Parco Nazionale delle Cinque Terre, with its 3,868 hectares wide surface, is one of Italy's smallest National Parks and the most populated at the same time, with about 4,000 inhabitants distributed in five small towns. For more than a 1000 years humans have modified the natural environment by cutting into the steep slopes of the hills to obtain stretches of land and cultivate them, the so called "ciàn", supported by kilometers-long dry-stone walls. They are the most characteristic feature of the Cinque Terre that has recognized by UNESCO as a World Heritage site as a cultural landscape[i].

Fig. 2. Ljubljana marshes (Slovenia).

Natural Parks and Nature Parks

The terms National Park and Nature Park are frequently used in some Mediterranean countries to describe landscapes protected through long-term planning, use and agriculture. They are maintained in their present state and may be promoted for the purposes of tourism. They are often subject to varying degrees of local or national legislation. Their formal definition varies from country to country. In France, a Regional Nature Park (*parc naturel régional*) is a body under the aegis of the local and the national government, covering an inhabited rural area of outstanding beauty, established in order to protect the scenery and heritage as well as setting up sustainable economic development in the area[ii]. In Spain, a natural park(*parque natural*) is a natural space protected for its biology, geology, or landscape, with ecological, aesthetic, educational, or scientific value whose preservation merits preferential attention on the part of public administration. The regulation of the activities that may occur there attempts to assure its protection[iii].

Natural and Nature parks are not National Parks although some of them may achieve such a designation. In Europe, they come under the 'EUROPARC Federation', the network for Europe's natural and cultural heritage which was established in 1973. 'the collective voice for all nature and landscape areas'.

Examples of Mediterranean Natural Parks that are urban or peri-urban are:

- Collserola Natural Park in Spain, which has been called the 'World's biggest urban Natural Park', Comprising more than 8.000 ha of Mediterranean forest, it has 10 million trees, 1,000 species of plants and almost 190 species of animals. The park forms Barcelona's natural border to the west.
- The vast Regional Natural Park of Narbonne in Mediterranean France (Parc naturel régional de la Narbonnaise en Méditerranée) covers 80,000 hectares. It includes a diver-

sity of features and landscapes, from lagoons and fine sandy beaches on the Mediterranean coast, to vineyards and garrigue[iv].

- The 1,600 hectare Regional Park of Molentargius Park (Parco Regionale Naturale Molentargius-Saline)[v]**,** located in the urban area of Cagliari, the capital of Sardinia , Italy. The abandoned industrial landscape of a former salt works has been transformed into an urban park, due to the intervention of environmental organizations and after a civil mobilization (Ruju 1998: 952).

Urban and peri-urban forests (UPF)

It is a long-standing tradition in many European towns and cities to maintain forests or woodlands in or around the inhabited area. **Urban and peri-urban forestry** (UPF) is the practice of managing forests, groups of trees or even individual trees in and around urban areas so as to maximise their economic livelihood social, cultural environmental and biodiversity values (Davies & al. 2017; Jorgensen 1986). Although long established in the USA and Europe (Kenney 2014) it is a relatively novel discipline especially in Mediterranean countries.

Although there is a diversity of definitions of what constitutes an urban forest (Calvo & al. 2914; Kenney 2014), **Urban forests** are defined by FAO (2016) as 'networks or systems comprising all woodlands, groups of trees, and individual trees located in urban and peri-urban areas; they include, therefore, forests, street trees, trees in parks and gardens, and trees in derelict corners. Urban forests are the backbone of the green infrastructure, bridging rural and urban areas and ameliorating a city's environmental footprint'. They divide then into four main types (Table 1) although some of these such as city parks and street trees overlap with other typologies and are covered separately in this paper. Thus, urban forests may be components of urban protected areas, nature and natural parks, municipal parks and gardens and private gardens.

A first attempt to develop a State of Mediterranean Urban and Peri-urban Forestry was carried out by a Working Group and published as part of the 'State of Mediterranean Forests' compiled by FAO (2013). It recognizes four approaches to Urban and peri-urban forestry (UPF) forestry:

- **Focus on management-oriented woodlands in and around towns** (central-northern European approach)
  Slovenia, Croatia, Romania & Turkey; to some extent: Israel & Morocco
- **Focus on less management-oriented urban parks and gardens**
  Algeria, Bulgaria, Cyprus, France, Lebanon, Malta, Spain & Tunisia; to some extent: Egypt, Greece and Morocco
- **Focus on the development of an ecological network of protected areas**
  Croatia, France, Greece, Italy, Portugal, Slovenia & Spain
- **Focus on the integration of all UPF approaches and related disciplines**
  France, Italy & Portugal; to some extent: Croatia, Greece, Slovenia & Turkey

It noted that 'the diversity of cultures, languages, societies, histories and policies in the Mediterranean region suggests that it will be challenging to find a common definition of urban forest and to amplify the concept to include peri-urban woodlands and open spaces. Moreover, on the one hand there are many studies on UPF in Mediterranean countries, and on the other there is a reluctance to adopt UPF as a scientific discipline and as a strategic factor in the future development of cities. To date there is no up-to-date regional overview of the experiences gained and expertise acquired; no action plans or national strategies for meeting the long-term challenges of cities that take into account the potential contributions of forests and trees; and no specialized UPF network focusing on the Mediterranean region'.

It also found that quantitative data on urban and peri-urban forests in the Mediterranean are generally very poor. For example, data on the area of green space per person (the "per capita green space provision") is highly incomplete but from the evidence available, the lowest values in Europe were found in the south and east (Fuller & Gaston 2009). A survey of 75 urban forests in major cities in Turkey reported an average size of 377 hectares with a very wide range (from 1 hectare to more than 11 000 hectares) while the Guides des forets urbaines et périurbaines (Haut Commissariat aux Eaux et Forêts et à la Lutte Contre la Désertification 2010) reported an area of 2.5 m2 of green space per inhabitant in Moroccan cities.

This guide defined urban forest as a "forest inside the urban texture", and peri-urban forest as a "forest area influenced by an urban context" (according to a range of requested services, especially recreation and tourism) located less than 30 km from the urban area.

Table 1. Main types of urban forest

Peri-urban forests and woodlands. Forests and woodlands surrounding towns and cities that can provide goods and services such as wood, fibre, fruit, other non-wood forest products, clean water, recreation and tourism. **City parks and urban forests (>0.5 ha)**. Large urban or district parks with a variety of land cover and at least partly equipped with facilities for leisure and recreation. **Pocket parks and gardens with trees (<0.5 ha).** Small district parks equipped with facilities for recreation/leisure, and private gardens and green spaces. **Trees on streets or in public squares**. Linear tree populations, small groups of trees, and individual trees in squares and parking lots and on streets. **Source:** FAO (2016)

An assessment of urban and peri-urban forests in Greece, is given by Christopoulou & al. (2007). They describe the various historical stages in the development of these forests, from numerous reforestation programmes on most of the mountainous terrain around the Greek capital by the end of the 19^{th} century, initially planted on aesthetic, health or protection grounds or on a combination of the above and subsequently, declared as 'protective' forests, an institution that was spread nationwide to encompass also forests and is still in operation today. Later, between 1973 and 1980, 19 woodland areas were declared 'Aesthetic Forests' (forests with special natural beauty) such as the Mount Hymettus Aesthetic Forest (Such is the Vai Palm Forest in eastern Crete, the Aesthetic Forest in Rodopi Mountains in Thrace and the Kaisariani Forest in Athens.

The role of urban and peri-urban forests on the provision of ecosystem services is gradually being recognized, as in the Barcelona Green Infrastructure and Biodiversity Plan 2020 (Hàbitat Urbà 2013). This notes that Barcelona has 3,611 hectares of green infrastructure covering 35.3% of the city land (according to 2009 data). Of this area, 1,076 hectares are strictly urban greenery, 1,795 pertain to the municipal district within Collserola Nature Park and 740 are private greenery generally in the highest part of the city.

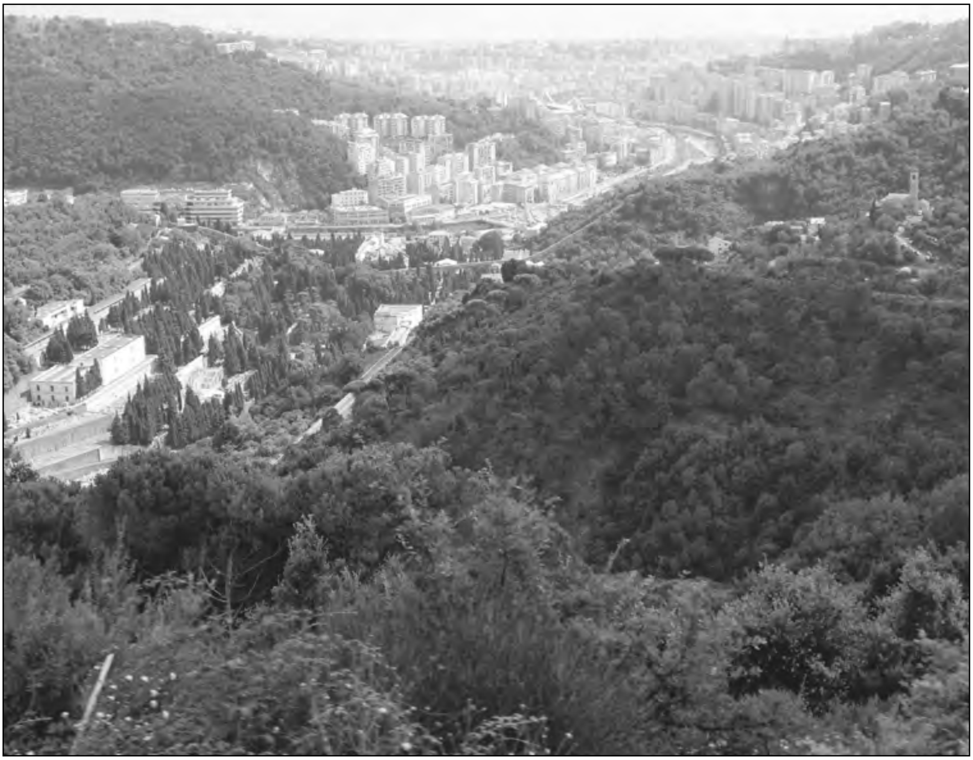

Fig. 3. Genova, Italy, wildland-urban interface (Photo V. H. Heywood).

Managed spaces with cultivated vegetation

The main managed elements of cultivated vegetation in Mediterranean cities are remarkably diverse and house large amounts of plant and animal diversity (Heywood 1996), notably :

- Urban and peri-urban parks
- Municipal/public parks and gardens
- Private and domestic gardens
- Botanic gardens and arboreta
- Zoological parks and gardens
- Landscaping of office blocks, residential apartment blocks, public buildings, university and college campuses, business parks,
- Golf courses
- Cemeteries
- Nurseries, garden centres
- Street trees
- Green roofs and living walls.

Fig. 4. River bed Jardines del Turia, Valencia, Spain (Photo V. H. Heywood).

Urban and peri-urban parks

As Mediterranean towns and cities have expanded, the role of urban parks in providing areas for culture, recreation, community development, heritage, health and wellbeing, economic development, connecting people to nature, conserving biodiversity, natural environment, education has been increasingly recognized. A wide diversity of such parks may be found, ranging from traditional urban municipal parks and gardens to vast areas of green space including both natural and seminatural vegetation and landscaped and cultivated areas, such as the Bois de Vincennes (995 ha) and the Bois de Boulogne (845 ha), in Paris the Casa de Campo in Madrid (1,722 ha) and the Parc de Collserola in Barcelona which has an area of 84.65 km^2, the largest metropolitan park in the world.

In Marseilles, half of the city's area is made up of natural spaces, with over 400 hectares of public parks and gardens, including 54 parks with an area greater than 1 ha and 15, five of them over 15ha. These are complemented by a network of 270 squares and gardens. Montpellier has 954 ha of public green spaces and parks. Madrid has 3300 ha of parks and gardens, distributed throughout more than 40 parks within the urban limits, including the Casa de Campo, the 120 ha Parque del Buen Retiro on the centre of the city, the Parque del Oeste, the Campo del Moro and the Jardines de Sabatini, the 60 ha Parque de la Dehesa de la Villa.

In addition to these parks, there are countless smaller gardens and green spaces in virtually all Mediterranean towns and cities.

Several Mediterranean countries, such as Greece, France, Italy, Spain and Portugal are members of a European federation of urban parks (Fedenatur). There are 28 such parks in the Mediterranean, most of them in Spain.

Peri-urban parks

The peri-urban space represents a transition between the city and the countryside and parks located in such areas are a key element of the green infrastructures system associated with urban areas and play a key role in the provision of ecosystem services. Peri-urban parks may be defined as:

'areas of ecological, landscape and cultural interest located on the outskirts of or in close proximity to urban settlements, but inherently interwoven with the urban environment, where environmental protection, recreational, cultural, educational, economic and development related functions can coexist, with the support of public policies, plans and actions and with full citizen involvement' (Junta de Andalucía 2012)

The Interreg 4c Periurban Project – Periurban Parks Improving Environmental Conditions in Suburban Areas[vi] identified four typologies:

a. Protected Nature Park

This type of park consists of areas with a high natural, biological and landscape or cultural related values. Generally, these parks are characterised by a high level of plant and animal biodiversity. Regulations and restrictions for the use of this type of territory exist at European level (NATURA 2000), at national level and / or at regional and local level. Legislation on nature protection often provides direct rules and frameworks for activities. The prohibition of certain uses can have significant impact on the development process.

b. Semi-Natural Agro-Ecological Park

This type of park is composed of a mixture of natural and artificially created lands, which may include ecological areas, such as green corridors, or agricultural lands, such as crop fields, woods and wetlands. This type of park is not subject to particular European regulation (though it has been taken into consideration at EU level, particularly in the 2004 EESC commentary on Agriculture in Periurban Areas), but is subject to a range of legislation and policies at national and local level.

c. Green City Park

This type of park represents a green area located in very close proximity to or within the urban area, with a series of functions related to local use and addressed to local residents. Given that it can express various forms of environmental features and values, it is subject to a range of legislations and policies at national and local level (e.g. Forest Management Plans, Local Plans on Green Spaces, Urban Development Plans).

d. Re-naturalised Park

This type of park represents a landscape, which had previously been artificially denatured or deteriorated to some extent, including ex-industrial areas, or dumping grounds, but has now been partly or fully recovered.

Private and domestic gardens

The benign climate of the Mediterranean permits the cultivation of a wide array of plants from around the world and this has encouraged the development of garden creation by private individuals. In most countries on the northern shores, there are many important private gardens, especially in Italy, France and Spain, some of which hold important collections of plants, a tradition that goes back at least to the days of Cosimo I de Medici (Heywood 2015). In 16th century Italy, many of the most important plant collections were to be found in private gardens in Rome which became a leading centre of botanical study and research (Attlee 2006).

Some of these private villa gardens were built by wealthy families, nobility or the crown. Examples include the Boboli gardens in Florence, the Villa d'Este, Tivoli, near Rome, the Giardino Giusti, Verona, in Italy, the Jardins du château de Versailles, in France, and the Jardin del Palacio de Aranjuez and the Parque de Maria Luisa, Sevilla, in Spain. A useful account of some of the main villa gardens in the Mediterranean is given by Bradley Hole (2006). In addition, there are numerous accounts of the parks and gardens of the Mediterranean, especially in France, Italy, Spain and Portugal that may be consulted. The tradition of creating gardens in the region continues and there are many innovative examples in the northern shores of the Mediterranean and to a lesser extent in some North African cities such as Rabat and Marrakesh.

Botanic gardens and arboreta

Urban botanic gardens are unique green spaces with high concentrations of plant diversity. They play a major role in plant conservation, education and public outreach. The Mediterranean was the birthplace of botanic gardens of the western tradition, and from 16th century onwards in Italy and other countries the first academic university botanic gardens were founded such as those of Pisa (1544), Padua (1545), Firenze (1545), Bologna (1547), Ferrara (?1577), Zurich (1560), Leiden (1577), Paris (1579), Leipzig (1597), Montpellier (1598) and Valencia (1567). Many further botanic gardens were created in the European Mediterranean zone in the following centuries.

In a recent review of Mediterranean botanic gardens (Heywood 2015), I noted that today, the Mediterranean region houses a large number of botanic gardens but their distribution across the region and their range of facilities are very uneven. The total number is approximately 170 of only those gardens that occur in the Mediterranean climate zone of the countries concerned are included. By far the largest number (57) are found in Italy where most of the country occurs in the Mediterranean climate zone and although France as a whole has as many if not more botanic gardens than Italy, most of them are in the non-Mediterranean zones where only some 20 occur. In Spain, most botanic gardens occur in the Mediterranean zone which covers much of the country: 21 out of a total number of 29. In contrast, with few exceptions, botanic gardens have not played an important role in the countries of the southern and eastern Mediterranean: the number of botanic gardens in North Africa and the Levant is relatively small, and often with limited resources and facilities and with species- poor living collections; and in the countries of SW Asia, with few exceptions, botanic gardens have not been developed either as scientific or educational establishments. More than half of the countries have one or two botanic gardens or none and most of those that do exist are small and report few activities (Heywood 2015).

In most cases, the plants accessions grown in botanic garden are recorded in catalogues and/or databases. Mediterranean botanic gardens house collectively some tens of thousands of species and innumerable cultivars.

A range of structures to enable a wide range of exotic species to be grown successfully and survive the winter cold is found in Mediterranean gardens, especially in botanic gardens. These include cold frames, stanzone per i cidri, limonaie and orangeries, greenhouses and shade houses (umbracula). There has also been a trend to construct biodomes or biospheres and similar glass structures to grow a diversity of plants and simulate natural habitats for the benefit of the local population and children (Fig. 5).

Inventory of plants diversity in Mediterranean parks and gardens.

It is evident that the estate of Mediterranean parks and contains an enormous diversity of plant species but we have little detailed information on the overall range of species grown in them and, with some exceptions, even less of those grown in private gardens. Some of them have been inventoried such as the Parc de Collserola, where over a thousand higher plants and around thirty plant communities have been catalogued, but most of them do not have a complete or even partial inventory of the plants they house. Overall, we can say some tens of thousands of species are grown in these parks and gardens and collectively they represent a vast but often overlooked and neglected treasure house of plant riches.

Fig.5. Biosphere, Genoa, Italy (Photo V. H. Heywood).

Fig. 6. Jardin Exotique, Monaco (Photo V. H. Heywood).

Urban biodiversity and tourism

The Mediterranean is the world's leading tourist destination, with the twenty countries bordering the Mediterranean Sea attracting over 30% of world tourism. The 46,000 km long coastal zone is visited by about 183 million tourists during the 3-month summer season. 25,000 km of this total are already urbanized and have already exceeded a critical limit. An additional 100 million domestic tourists bring the total up to about 280 million visitors a year. Over 12 million tourists visit the Mediterranean islands each year.

The increase of tourism has led to massive urban and tourist development with accompanying infrastructural effects. This is especially accentuated in coastal areas such as in parts of the Mediterranean and on islands, leading to the phenomenon known as 'coastalization'[vii] . This has inevitably led to an impoverishment of biodiversity, loss or fragmentation of habitats but on the other hand has been instrumental in increasing the amount of cultivated plant biodiversity.

Urban trees

Trees, and notably street trees, are an important component of urban diversity and trees often give them a special character such as the pines of Rome (*Pinus pinea*), the plane trees (*Platanus* of the Ramblas in Barcelona, the bitter orange trees (*Citrus* × *aurantium*) in many Mediterranean towns and cities such as Athens, Rome, Sevilla, Marrakesh, Tel Aviv, Valencia. When in flower they often produce spectacular shows at certain times of the year such as the Jacaranda (*Jacaranda mimosifolia*) in Athens (Photo 1), the Judas tree (*Cercis siliquastrum*) in Rome.

Azahar – orange blossom in Spain

In Spain, the term Azahar (or Flor de Azahar) refers to various white flowers and by anastomasia to those of the orange, lemon and citron. It is popularly associated with the intensely perfumed orange blossom that is found in the streets, squares and patios of many towns and cities, especially in Andalucía and the Levant. Valencia is often known as the Ciudad del Azahar (City of orange blossom) and the name Costa del Azahar (coast of orange blossom) is refers to a 120 km stretch of the coast in the province of Castellón. The name comes from the hispanic Arabic azzahár, which in turn derives from the classic Arabic az-zahr (which means flowers). In April, the city of Córdoba celebrates the coming into flower of the orange blossom, as 'Córdoba en Azahar', with a series of events.

A wide range of tree species is grown in Mediterranean towns and cities, including many tropical and subtropical trees that are able to flourish in the benign climate of the Mediterranean, such as the Brazilian pepper tree (*Schinus terebinthifolius*), Pagoda tree (*Styphnolobium japonicum*), Indian bead tree (*Melia azedarach*), Jacaranda (*Jacaranda mimosifolia*), Rosewood (*Tipuana tipu*), and various palm species such as the Canary date palm (*Phoenix canariensis*), Hemp palm (*Trachycarpus fortunei*), Mexican Washingtonia (*Washingtonia robusta*), Date palm (*Phoenix dactylifera),* Californian Washingtonia (*Washingtonia filifera*). However, only a small number of trees dominate the urban street plantings, such as elms (*Ulmus* spp.), planes (*Platanus* spp.), Holm oak (*Quercus ilex*), black locust *(Robinia pseudacacia*), hackberry (*Celtis australis*, *C. occidentalis*), Japanese pagoda tree (*Sophora japonica*), *Albizzia julibrissin*, mulberry

(*Morus* sp.), poplar (*Populus* spp.), curtain (*Ficus microcarpa*), cypress (*Cupressus sempervirens*), Lime (*Tilia platyphyllos*).

Mediterranean cities vary both in the actual numbers of trees planted and the number of different species they represent. More than 55% of streets in Madrid are populated with trees, totalling altogether 300,000 specimens belonging to 220 species, while there are 153,000 trees in the streets of Barcelona, including over 150 different species. In 1998 Rome had 120,00 street trees belonging to 58 species. Madrid is, in fact the European capital with most street trees and second only to Tokyo globally.

Many Mediterranean cities such as Barcelona, Madrid, Valencia, have published guides to their urban street trees but there is no overall compilation. The city of Lucca, Italy, prepared an inventory of the 1 452 trees within its 15th-century city walls to optimize investments in adaptive management and the conservation of the city's historical urban forest.

The Barcelona Charter, the 'Declaration of the Rights of Trees in the City' was drawn up and signed in Barcelona on the occasion of the first congress of the Spanish Association of Arboriculture. This Charter establishes the rights of trees in the urban environment (Box aa).

Box aa :Commitments contained in the Declaration of the Rights of Trees in the City

– To situate trees in their basic role as one of the city's principal heritage resources.
– Comprehensive and continuous preparation and promotion of information, inventories, management techniques, practices, procedures, products, services and standards that facilitate the introduction of trees in the city in fitting and decent conditions
– To disseminate information: to inform and educate the general public, the various professional groups, the industrial and service sectors, schools, colleges and universities, about the basic importance of trees for life in the city.
– To establish policies, rules, regulations and practices in city government and administration that ensure optimal conditions for the life of trees.
– To reconsider all the elements that currently make up urban space and think ahead from the standpoint of the requirements and potential of the urban tree network as regards the conception, planning, creation, management, use and reuse of this public space.

Parameters such as the number of street trees per inhabitant indicate the street tree density per population. According to an EU COST working group, a survey between 1999 and 2001 to study tree establishment practice in European towns and cities (Pauleit & al. 2002), while most central European cities had a ratio of 50–80 street trees per 1000 inhabitants, although there was a wide variation between urban areas within a single country, and the tree density was as low as 20 street trees per 1000 inhabitants for Nice. A more recent study (Forman 2014) showed the number of trees varies from 2–22 per 100 people, and that in the Mediterranean cities sampled, Athens has the most trees per capita while Nice and Marseilles have the fewest.

Street trees play an important role in the ways cities function and provide a series of environmental and social benefits such as improved air quality, reduction of noise pollution, moderating the urban microclimate, improving the quality of life and by providing shade not only make circulating through the city more pleasant but also reduce air conditioning costs (Hàbitat Urbà 2011).

Survival rates for street trees vary considerably, from a few years to several decades or longer. The average survival rate in Barcelona is 50 years. The species of tree planted vary over time, responding to social, arboricultural and even political factors. In recent years, there has been a tendency for large trees to be replaced by smaller ones.

The street tree environment is both artificial and heavily managed and the rate of natural regeneration is negligible, so the main source of new trees is planting. As Roman (2014) puts it this 'makes tree-lined streets more akin to an orchard: a cultivated landscape, stewarded by humans, and grown for human benefit.' Marseille has published a Guide to Greening the Streets (Guide de végétalisation des rues)[viii]

Fig. 7. Jacaranda in flower in an Athens street (Photo V. H. Heywood).

Urban agriculture and horticulture

Urban agriculture[ix] has become a more common feature of European and Mediterranean cities in recent years. It can be defined briefly as the growing of plants and the raising of animals within and around cities but the critical difference from rural agriculture, is not location but the fact that it is integrated into the urban economic and ecological system (Mougeot 2001). It is extremely diverse and different typologies have been proposed. Although it is not the aim of urban agriculture, nor would it be desirable, to make cities sustainable in terms of food supply, it can provide a substantial proportion of food products from different types of crops (grains, root crops, vegetables, mushrooms, fruits) (Box 2), as well as non-food products (e.g. aromatic and medicinal herbs, ornamental plants, tree products). Urban and periurban agriculture also includes trees that are managed for producing fruit and fuelwood, as agroforestry) and small-scale aquaculture.

Urban agriculture has long been practised in east Mediterranean and North African Mediterranean cities although often not formally structured or officially recognized (Tawk & al. 2011). In the last decade or so, various innovative initiatives in North African cities have been developed such as the approach called 'Connecting Urban-Rural Spheres in Casablanca' (Giseke & al. 2015) in which urban open space and agriculture can be linked to a productive green infrastructure, forming new urban-rural linkages. There have also been any innovative developments in European Mediterranean cities in recent years, as in Greece (Morán & Fernández de Casadevante, 2014), France (Simón Rojo 2014; Scheromm 2015) , Italy (Antonelli & Lamberti 2012; Corrado 2013), Spain (de Felipe & Briz 2015; Romero. & Melo 2015).

Box 2. Urban farming

Vegetables have a short production cycle; some can be harvested within 60 days of planting, so are well suited for urban farming.

Garden plots can be up to 15 times more productive than rural holdings. An area of just one square metre can provide 20 kg of food a year.

Urban vegetable growers spend less on transport, packaging and storage, and can sell directly through street food stands and market stalls. More income goes to them instead of middlemen.

Urban agriculture provides employment and incomes for poor women and other disadvantaged groups.

Horticulture can generate one job every 100 sq m garden in production, input supply, marketing and value-addition from producer to consumer.

Source: http://www.fao.org/urban-agriculture/en/

Urban allotments and community gardens

Allotment gardens are a key feature of the urban landscape, providing numerous benefits beyond those of food production. These include ecosystem services such as local climate modification, pollination, and providing a pleasant location for socialising. The biodiversity of flora underpins many of these ecosystem services (Borysiak & al. 2016). As well as their various economic, social and cultural roles, allotments maintain a considerable diversity of plants and contribute increasingly to preserving traditional species, old cultivars and their genetic sources.

The term 'allotment' originates in the British usage of 'allotting' a parcel of land to an individual or family for non-commercial use as land to grow plants – mainly vegetables and ornamentals[x]. It is not widely used or translated into other languages in continental Europe although similar types of terrain are used there for growing plants for the same purposes, subject to their own particular form of regulation, such as the *jardins familiaux* in France, the *orti urbani* in Italy, and the *horts familiars*.

The tradition of providing allotments began in western and central Europe in the 19th century (Weirch, 2016) while in Mediterranean countries, allotments and community gardens other forms of urban gardening are a more recent development (Keshavarz & Bell 2016) and mainly found in large industrial cities such as Barcelona, Genoa and Marseille (Consales 2003) although there is now a growing interest in the concept. In fact, since 2008, there was a substantial growth in urban gardening, allotments and community gardens in countries all around the Mediterranean Sea, such as Cyprus, Greece Spain and Portugal, 'in response to the austerity policies in many countries, because of the recent economic crisis, together with high unemployment rates, food poverty or difficulties in maintaining public spaces' (Fox-Kämper 2016). More recently, the motivation has also come from the urban greening and sustainable living movements.

In Greece, there has been a remarkable development in recent years of community and urban agriculture in many cities, including allotment gardens 2014), merging food production, urban ecology, food sovereignty, social links and novel ways of thinking and inhabiting the cities (Morán & Fernández de Casadevante 2014). The first public policies to promote allotment gardens in Greece date from 2012, by developing social gardens for self-consumption for vulnerable groups. Although they began in medium-sized cities, these programmes spread quickly across the whole country – in Thermi, Kalamata, Tripoli, Larissa, Veria, Edesa, Lesbos and Crete as well as in metropolitan districts of Athens.

> In the face of 'the great socio-economic uncertainty the cities of the 21st century, the emergence of urban green commons (collectively managed green spaces) within the urban fabric responds to a contemporary need of urban resilience. As a form of "commons", the urban community gardens can be seen, except for productive landscapes and "foodscapes", as grounds of a new kind of urbanity, giving space to spontaneity, social coexistence, activism, bottom-up decision making and self-awareness around the role of the metropolis citizen'.
>
> Gavriilidou & Ritou (2016)

In France, according to Rubino (2007), in the aftermath of WWII, the term *jardins ouvriers* (so called because they were aimed at the disadvantaged working class) was replaced by *jardins familiaux*, shifting the attention from the users to their social characteristics, hence the term 'family gardens' that is also widely used.

So far, the plant diversity of allotments has been little studied or appreciated, especially in the Mediterranean. A study of the vascular flora of 11 allotment gardens in Poznań, Poland, in 3105 individual plots created between 1924 and 1982, totalling 150ha in area showed that the total vascular flora was 358 species with individual estates having a range of 182–248. Of these, 257 were native species and 101 were anthropophytes (Borysiak & al. 2016). Comparable data are not available for any Mediterranean allotments.

Community gardens

Community gardens (Jardins communautaires, orti/ giardini comunitari) are a new type of urban garden that has arisen more recently in Mediterranean towns and cities, often as a response to economic crises that lead to food poverty. In Greece, for example, community gardens have appeared within a context of social protest movements (Morán &

Fernández de Casadevante 2014). They are organized collectively by a group of people using individual or shared plots on private or public land, sometimes illegally, and may in some cases receive support from local government agencies or NGOs.

Micro-gardening

In addition to urban domestic vegetable gardens and allotments, a wide range of small-scale often highly innovative and *ad hoc* ways of growing both vegetables, herbs and ornamental plants can be found in and around many Mediterranean towns and cities. This is sometimes known as 'micro-gardening' (Box 3). With support from an FAO project, Cairo residents have grown an estimated 6 000 sq m of micro-gardens on the city's rooftops (FAO 2010)

Box 3. Micro-gardening

'Micro-gardening' is the intensive cultivation of a wide range of vegetables, roots and tubers, and herbs in small spaces, such as balconies, patios and rooftops. While urban residents have long grown vegetables in backyard plots, modern micro-gardening makes use of containers such as plastic lined wooden crates, custom-built tables and even old car tyres. It integrates horticulture production techniques with environmentally friendly technologies suited to cities, such as rainwater harvesting and household waste management. Micro-gardens allow low-income families to meet their needs for vitamins, minerals and plant protein by providing direct access to fresh, nutritious vegetables every day. They also offer a source of extra income from the sale of small surpluses.

Source: http://www.fao.org/ag/agp/greenercities/en/microgardens/index.html

Fig. 8. Street scape, Ortigia, Siracuse, Italy (Photo V. H. Heywood).

Informal urban green spaces

Informal green spaces, such as wastelands or brown field sites and abandoned industrial sites, tend to be overlooked as a source of valuable biodiversity. Although they tend to be colonized by weeds, ruderal plants and invasive species, they may also house considerable numbers of native plants. Some Mediterranean cities, such as Montpellier, France, have developed wasteland valorisation plans whereby such sites are inventoried and efforts made raise awareness of their importance and potential to change the perception of these areas from abandoned to added-value zones, leading to the integration of the wastelands into the urban green network. Another unusual example is transformation of an urban salt works into a public park in the urban area of Cagliari, Sardinia, Italy, following the suspension of production because of pollution from urban sewage (Lai 2013).

Flilibeck & al. (2016) caution that Mediterranean urban wastelands that are 'saved' with the aim of creating public green spaces are particularly at risk of being managed inappropriately from an ecological perspective and cites the example of a disused demolition waste landfill in Rome (Italy) where natural revegetation led to a very high vascular plant species density (269 species in 0.2 km^2). However, when local activists successfully campaigned to save the site from development, resulting in its designation as an Urban Nature Reserve, it was basically managed as a conventional neighbourhood park and as consequence, the number of vascular plants decreased by 50%.

Green roofs and living walls

A recent development has been the widespread adoption of green roofs and living walls as part of the urban greening system. Although green roofs may also be used for growing herbs and vegetables, they are primarily aimed at providing environmental benefits such as cooling.

Fig. 9. Jardin Vertical Caixaforum, Madrid, Spain (Photo V. H. Heywood).

Alien Invasive plants

One of the common consequences of urbanization is an increase in the number and extent of non-native invasive species by creating areas of disturbed habitat for non-native species to become established. While this is partly a result of increased invasion events, it can also be a consequence of the use of known alien invasive species in urban horticulture, including green roofs and living walls. Great care should be taken in the choice of species for urban greening to avoid such invasive elements. The guidelines given in codes of conduct on IAS for horticulture and botanic gardens should be followed (Heywood & Brunel 2009; Heywood 2013).

Conclusions

The rapid growth of urbanization in the Mediterranean region has thrown into focus the need for improving the quality of life of urban dwellers by providing green spaces so that contact with nature is not lost. As a response, many Mediterranean cities are engaged in urban green infrastructure projects, preserving remnants of natural vegetation, creating new reserves, urban forests and parks, encouraging informal local food projects such as allotments and community gardens, and reclaiming wastelands. The diversity of plant life in and around Mediterranean urban areas is remarkably complex and varied and is of enormous economic, social and cultural value, although there is a general lack of data on the biodiversity growing in the parks, gardens, forests, and streets of Mediterranean towns and cities. Conservation biologists have tended to ignore the extraordinary richness of this resource and strenuous efforts are needed to inventory, evaluate, conserve and exploit it for the benefit of those who live in these urban and peri-urban areas.

Fig. 10. *Ipomoea indica*, invasive in Sóller, Mallorca, Spain (Photo V. H. Heywood).

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Address of the author:
Vernon H. Heywood,
School of Biological Sciences, University of Reading, Whiteknights, Reading RG6 6AS, UK. Email: v.h.heywood@reading.ac.uk

Notes:
[i] http://www.parks.it/parco.nazionale.cinque.terre/Econtatti.php
[ii] http://www.parcs-naturels-regionaux.fr/article/missions
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[iv] http://www.parcomolentargius.it/

[v] http://www.parcomolentargius.it/
[vi] Présentation des parcs et jardins http://environnement.marseille.fr/presentation
[vii] http://www.interreg4c.eu/projects/project-details/index-project=60-periurban-parks-improving-environmental-conditions-in-suburban-areas&.html
[viii] Described as 'Linear and nuclear concentrations along the coast […] phenomena that are directly linked with intensive housing development, indiscriminate land occupation, and the possession of large reserves of land which it is possible to build on' in the conclusions of the International Congress, 'Sustainable Tourism in the Mediterranean: The Participation of Civil Society', 1998. MED Project ULIXES 21. For Sustainable Tourism in the Mediterranean.
[ix] http://environnement.marseille.fr/sites/default/files/contenu/environnement/PDF/guide-vegetalisation-des-rues.pdf
[x] Also often referred to as Urban and Periurban Agriculture (UPA) although peri-urban is normally understood to be included in Urban agriculture.
[xi] The socioeconomic role of the allotment has been described by the *Office International des Coins de Terre et des Jardins Familiaux*, the most important, European non-profit making union of national allotment and leisure garden federations with more than 2,000,000 affiliated leisure gardeners and leisure garden families, as:
- for the "community" a better quality of urban life through the reduction of noise, the binding of dust, the establishment of open green spaces in densely populated areas;
- for the "environment" the conservation of biotopes and the creation of linked biotopes;
- for "families" a meaningful leisure activity and the personal experience of sowing, growing, cultivating and harvesting healthy vegetables amidst high-rise buildings and the concrete jungle;
- for "children and adolescents" a place to play, communicate and to discover nature and its wonders;
- for "working people" relaxation from the stress of work;
- for the "unemployed" the feeling of being useful and not excluded as well as a supply of fresh vegetables at minimum cost;
- for "immigrant families" a possibility of communication and better integration in their host country;
- for "disabled persons" a place enabling them to participate in social life, to establish contacts and overcome loneliness;
- for "senior citizens" a place of communication with persons having the same interests as well as an opportunity of self-fulfillment during the period of retirement.

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Anna Maria Mannino & Paolo Balistreri

An updated overview of invasive *Caulerpa* taxa in Sicily and circum-Sicilian Islands, strategic zones within the NW Mediterranean Sea

Abstract

Mannino, A. M. & Balistreri, P.: An updated overview of invasive *Caulerpa* taxa in Sicily and circum-Sicilian Islands, strategic zones within the NW Mediterranean Sea. — Fl. Medit. 27: 221-240. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

The spread dynamics of invasive *Caulerpa* taxa (i.e. *Caulerpa cylindracea*, *C. taxifolia* var. *taxifolia* and *C. taxifolia* var. *distichophylla*) in Sicily and circum-Sicilian Islands, based on relevant publications, grey literature, unpublished data and *in situ* observations during the last 23 years, is presented here and discussed. Their known distribution is mapped. New records are also reported. Transport-stowaway is considered the most plausible vector of introduction of invasive *Caulerpa* in the area. The three invasive taxa showed different spread dynamics. *Caulerpa cylindracea* and *C. taxifolia* var. *distichophylla*, behaved as highly successful and fast-spreading taxa, i.e. as true invasive taxa. On the contrary, *C. taxifolia* var. *taxifolia* did not behave like the others, remaining limited to two small areas distant from each other. Due to their geographical position, Sicily and circum-Sicilian Islands are particularly vulnerable to biological invasions and therefore they could play an important role as receiver, transit and donor zone for alien species within the Mediterranean Sea. The creation of permanent observatories and alarm systems in this area might be an effective tool in the management of present and future introductions of alien species in the Mediterranean Sea.

Key words: *Caulerpa cylindracea, C. taxifolia,* invasive species, Mediterranean basin.

Introduction

The Mediterranean Sea is an important hotspot for alien species (Rilov & Galil 2009; Coll & al. 2010; Zenetos & al. 2012; Galil & al. 2015) which have almost reached a number of 1,000 (about 6% of the total flora and fauna) (Zenetos & al. 2012).

According to the definition adopted by the European Environmental Agency (2012), “an alien species is an organism introduced outside its natural past or present distribution range by human agency, either directly or indirectly.” Whereas species which have expanded their range as a result of changing environmental conditions are not considered alien species.

Por (1978) coined the term “Lessepsian migration” to indicate the phenomenon of migration of Red Sea species into the Mediterranean Sea through the Suez Canal (opened in 1869).

But later, Galil (2000) replaced the term "Lessepsian migration" with the original term "Erythrean invasion" because she considered this inflow of tropical species an invasion more than a migration ("cyclical and predictable movement between two geographic areas that is related to the spatio-temporal distribution of resources or the reproductive cycle").

In recent decades a conspicuous increase of introductions, essentially due to escape from confinement, transport-stowaway and corridor (i.e. Suez Canal) entries (categories according to CBD 2014), was registered. The Suez Canal is considered to be one of the main vectors for the introduction of alien species into the Mediterranean Sea. However, some authors (e.g. Por 2009) considered the current high settlement of tropical species coming from the Suez Canal, mainly due to the ongoing sea-warming, as a re-colonization by Tethyans descendants more than an invasion of alien species. As far as marine macrophytes are concerned, a total of 133 species (23 belong to Chlorophyta, 79 to Rhodophyta, 30 to Ochrophyta, and 1 to Tracheophyta) have been recently listed as possible aliens in the Mediterranean Sea (Verlaque & al. 2015). This number is likely to increase as proved by the recent record of *Halimeda incrassata* (J. Ellis) J.V. Lamouroux in the waters off Mallorca Island (Alós & al. 2016).

Invasive Alien Species (IAS) are considered to be among the most serious threats, after habitat losses, to biodiversity and natural ecosystem functioning (Bax & al. 2003; Wallentinus & Nyberg 2007). Among the IAS recorded in the Mediterranean Sea, the following three *Caulerpa* taxa have raised serious concern due to their potential or ascertained impact on the native communities (Boudouresque & al. 1995; Klein & Verlaque 2008; Katsanevakis & al. 2014).

Caulerpa cylindracea Sonder: even though it was reported along the coast of Tunisia by Hamel (1926), the occurrence off the coasts of Libya in 1990 (Nizamuddin 1991) is generally accepted as the first record for the Mediterranean Sea. It was initially considered a "Lessepsian migrant" (Alongi & al. 1993; Giaccone & Di Martino 1995a), but, recently, Belton & al. (2014) concluded that this species has been introduced from Australia and New Caledonia. Until Belton & al. (2014) it was reported in the literature as *Caulerpa racemosa* var. *cylindracea* (Sonder) Verlaque, Huisman and Boudouresque, a new combination proposed by Verlaque & al. (2003).

Caulerpa taxifolia (M. Vahl) C. Agardh (invasive aquarium strain): this strain, first recorded in the Mediterranean in 1984 (Meinesz & Hesse 1991), is genetically identical to the strain cultivated in aquaria of western Europe (Jousson & al. 1998). According to Meusnier & al. (2001), the first strain introduced in the Mediterranean is native to South-Eastern Australia.

Caulerpa taxifolia (Vahl) C. Agardh var. *distichophylla* (Sonder) Verlaque, Huisman and Procaccini: this alga, native to South Western Australia, was first reported in the Mediterranean Sea as *C. taxifolia* from the coasts of South Turkey (2006, by Cevik & al. 2007).

Within the Mediterranean Sea, Sicily and circum-Sicilian Islands, as a consequence of their strategic position both from a geographical and a transport-stowaway point of view, including fisheries and recreational fleets, are particularly vulnerable and suitable to biological marine invasions (Occhipinti-Ambrogi & al. 2011a, b; Coll & al. 2012; Katsanevakis & al. 2014; Mannino & al. 2014, 2015, 2017; Celesti-Grapow & al. 2016). Since reliable and accessible information (literature, online inventories and databases) on the spread dynamics, the introduction pathways and the invasiveness of marine alien species is crucial for planning effective management and conservation strategies, the aim of the present paper is to offer an updated overview of the distribution of invasive *Caulerpa* specific and infraspecific taxa in Sicily and in circum-Sicilian Islands.

Materials and methods

All the relevant publications and reports dealing with invasive *Caulerpa* taxa in Sicily and in circum-Sicilian Islands, from their first record in the area and updated till 2016, were searched and analysed, using standard databases and available libraries at the University of Palermo and at the Institut Méditerranéen d'Océanologie (MIO) of Marseille. *In situ* observations provided by the authors of the present paper were included, as well as personal communications provided by skilled citizen scientists.

The successful establishment of each taxon was determined on the basis of published and unpublished data. We considered species as established when the species was either established in the wild with free-living, self-maintaining and self-perpetuating populations, or recorded at least twice and spread over time and space. The most plausible pathway of introduction was attributed according to the hierarchical classification pathway adopted by the CBD (2014).

Results

Caulerpa cylindracea

Distribution (Table 1 and Fig. 1): since 1993 (first Italian record at Baia di San Panagia and at the Island of Lampedusa), the number of Sicilian sites affected by *Caulerpa cylindracea* has regularly increased and the alga has been steadily spreading, as indicated by the numerous new sightings recently recorded, mainly on the eastern coast. In particular, the number of new colonized sites has increased significantly from 2000 to 2007. Currently, 90% of areas colonized by *C. cylindracea* are located along the eastern and north-western coasts of Sicily.

Colonisation level: the level of colonisation ranged from sparse individuals to patches (ranging from 1 to 25 mq) and meadows (ranging from 150 mq to 1 ha) whereas the substratum cover (%) ranged from 5 to 100%.

Habitat (Fig. 2A, 3A, 3B): *Caulerpa cylindracea* is thriving under wide environmental conditions: in marine and hyperaline habitats, from the surface down to 50 m depth (even though the areas which were highly colonized ranged mainly from 0 to 20 m depth), on sand, rock and mud (mainly on sand), on exposed and sheltered sites, under low and high light conditions, in areas characterized by secondary volcanism phenomena (i.e. fumaroles and hot springs, e.g. Aeolian Islands), in altered areas as well as in pristine and protected areas (e.g. Marine Protected Areas and Natural Reserves).

Caulerpa cylindracea was found as an epibiont on different habitat-building species like *Mytilus galloprovincialis* (Lamarck, 1819), the two reef-building species, the vermetid *Dendropoma cristatum* (Biondi, 1859) and the polychaete *Sabellaria alveolata* (Linnaeus, 1767), but also on calcareous algae, sponges and corals. It was associated to both indige-

Table 1. Known sites of occurrence of *Caulerpa cylindracea* in Sicily and in circum-Sicilian Islands. MPA: Marine Protected Area; ONR: Oriented Natural Reserve.

Locality (site codes)	**References**
WESTERN COAST	
TRAPANI	
Capo Feto (1)	Piazzi & al. (2005), Riggio & al. (2007)
Mazara del Vallo (2)	Gagliano & al. (2002), P. Gandolfo (present work)
Marsala (3)	Piazzi & al. (2005), A.M. Mannino (present work)
ONR Saline di Trapani e Paceco (4)	Mannino & al. (2008)
Trapani, Torre Ligny, Rombo, Ronciglio (5)	Piazzi & al. (2005), A.M. Mannino (present work)
ONR Zingaro (6)	Riggio & al. (2007)
Golfo di Castellammare (7)	Piazzi & al. (2005), Riggio & al. (2007)
EGADI ISLANDS MPA	
Favignana Island (8)	Piazzi & al. (2005), Riggio & al. (2007), Mannino & al. (2016), A.M. Mannino (present work)
Levanzo Island (9)	Riggio & al. (2007), Mannino & al. (2016), A.M. Mannino (present work)
Marettimo Island (10)	Mannino & al. (2014), A.M. Mannino (present work)
NORTHERN COAST	
PALERMO	
Balestrate (11)	Riggio & al. (2007)
Cinisi (12)	A.M. Mannino (present work)
Punta Raisi (13)	S. Calascibetta (present work)
Capo Gallo-Isola delle Femmine MPA (14)	Mannino & al. (2008)
Casteldaccia (15)	A.M. Mannino (present work)
Termini Imerese (16)	Piazzi & al. (2005), Mannino & Di Giovanni (2011)
Ustica Island (17)	Di Trapani & al. (2016)
EASTERN COAST	
MESSINA	
Patti (18)	V. Di Martino (present work)
Oliveri (19), Milazzo (20)	A. Ruggeri (present work)
Torre Faro (21)	Riggio & al. (2007)
Strait of Messina (22)	Profeta & al. (2004)
Taormina (23)	V. Di Martino (present work)

Table 1. continued.

Eolian Archipelago (24)	V. Di Martino (present work)
CATANIA	
Santa Maria La Scala (25)	Di Martino (2001)
Capo Mulini (26)	Famà & al. (2000)
Isole Ciclopi (27)	Cormaci & Furnari (2005)
Acitrezza (28)	Verlaque & al. (2000)
Catania (29)	Piazzi & al. (2005)
SIRACUSA	
Brucoli (30)	Serio & Pizzuto (1998)
Baia di San Panagia (31)	Alongi & al. (1993), Giaccone & Di Martino (1995b), Pandolfo & Chemello (1995), Cantone (1999), Gianguzza & al. (2001, 2002)
Siracusa (32)	Di Martino (2001), Piazzi & al. (2005)
Peninsola Maddalena (33)	Marino & al. (1999), Di Martino & al. (2006)
Plemmirio MPA (34)	Di Martino (2001), Vinceti (2006)
Avola (35)	E. Tiralongo (present work)
Calamosche (36)	R. Barone (present work)
Capo Passero (37)	Di Martino (2001), Piazzi & al. (2005)
Isola di Capo Passero (38)	Di Martino & Stancanelli (1998)
SOUTHERN COAST	
RAGUSA	
Pozzallo (39)	Di Martino (2001), Piazzi & al. (2005)
Punta Braccetto (40)	Jongma & al. (2013), Musco & al. (2014)
Scoglitti (41)	M. Toccaceli & M. Gristina (present work)
AGRIGENTO	
Licata (42)	Riggio & al. (2007)
Agrigento (43)	A.M. Mannino (present work)
PELAGIAN ARCHIPELAGO	
Lampedusa Island (44)	Alongi & al. (1993), Piazzi & al. (2005), Alomar & al. (2016)
Linosa Island (45)	Piazzi & al. (2005), Azzurro & al. (2004, 2007), Lodola & al. (2012), Lodola (2013)
Pantelleria Island (46)	Di Martino (2001), Piazzi & al. (2005)

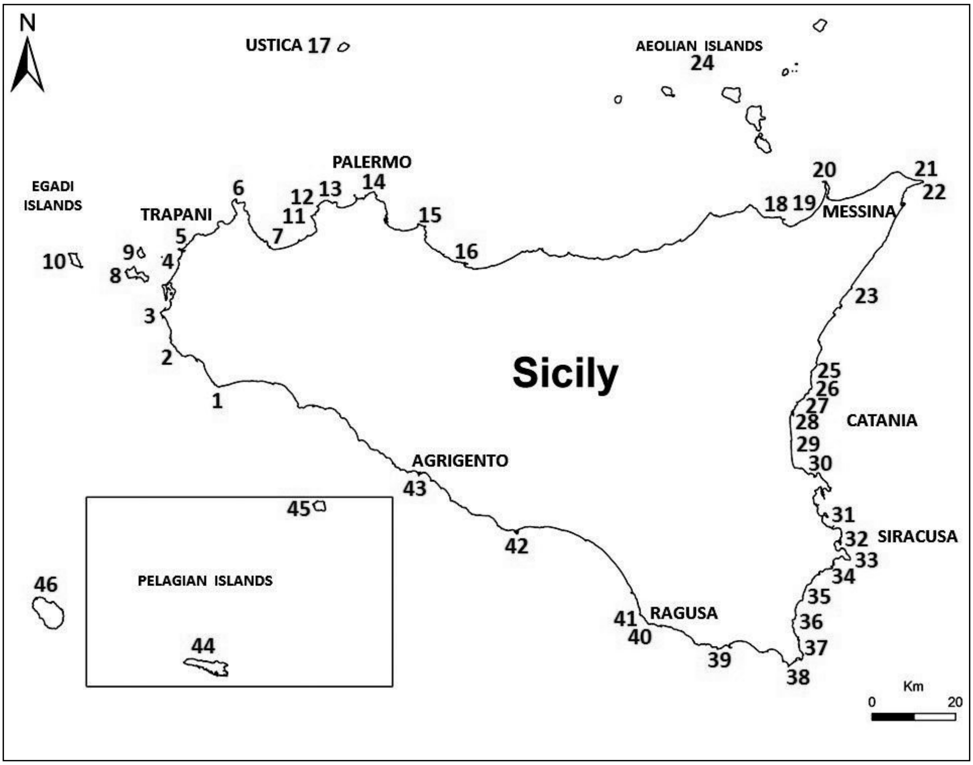

Fig. 1. Known sites of occurrence of *Caulerpa cylindracea* in Sicily and circum-Sicilian Islands (see Table 1 for the site codes).

nous and introduced macrophytes, such as *Posidonia oceanica* (L.) Delile (on *matte* as well as along the borders), *Cymodocea nodosa* (Ucria) Ascherson, *Ruppia cirrhosa* (Petagna) Grande, *Halophila stipulacea* (Forsskål) Ascherson, *Cystoseira* species, *Asparagopsis taxiformis* (Delile) Trevisan, *Ulva rigida* C. Agardh, *Dictyota spiralis* Montagne, *Caulerpa prolifera* (Forsskål) J.V. Lamouroux, *C. taxifolia* and *C. taxifolia* var. *distichophylla*.

Caulerpa taxifolia (invasive aquarium strain)

Distribution (Table 2 and Fig. 4): *Caulerpa taxifolia* was first observed in Sicily (off the coast of the Strait of Messina in 1993) ten years after its first Mediterranean record. In 2004 it was recorded along the coasts of Favignana Island. After that we have not had any further records till now.

Colonisation level: the level of colonisation ranged from patches to meadows (ranging from 0.5 mq to 1 ha).

Habitat (Fig. 2B, 3C): this alga was mainly found from 0 to 30 m depth, on rocky and sandy substrates, on dead matte of *P. oceanica,* intermingled with macroalgae or associated to *A. taxiformis, C. nodosa* and *C. cylindracea*.

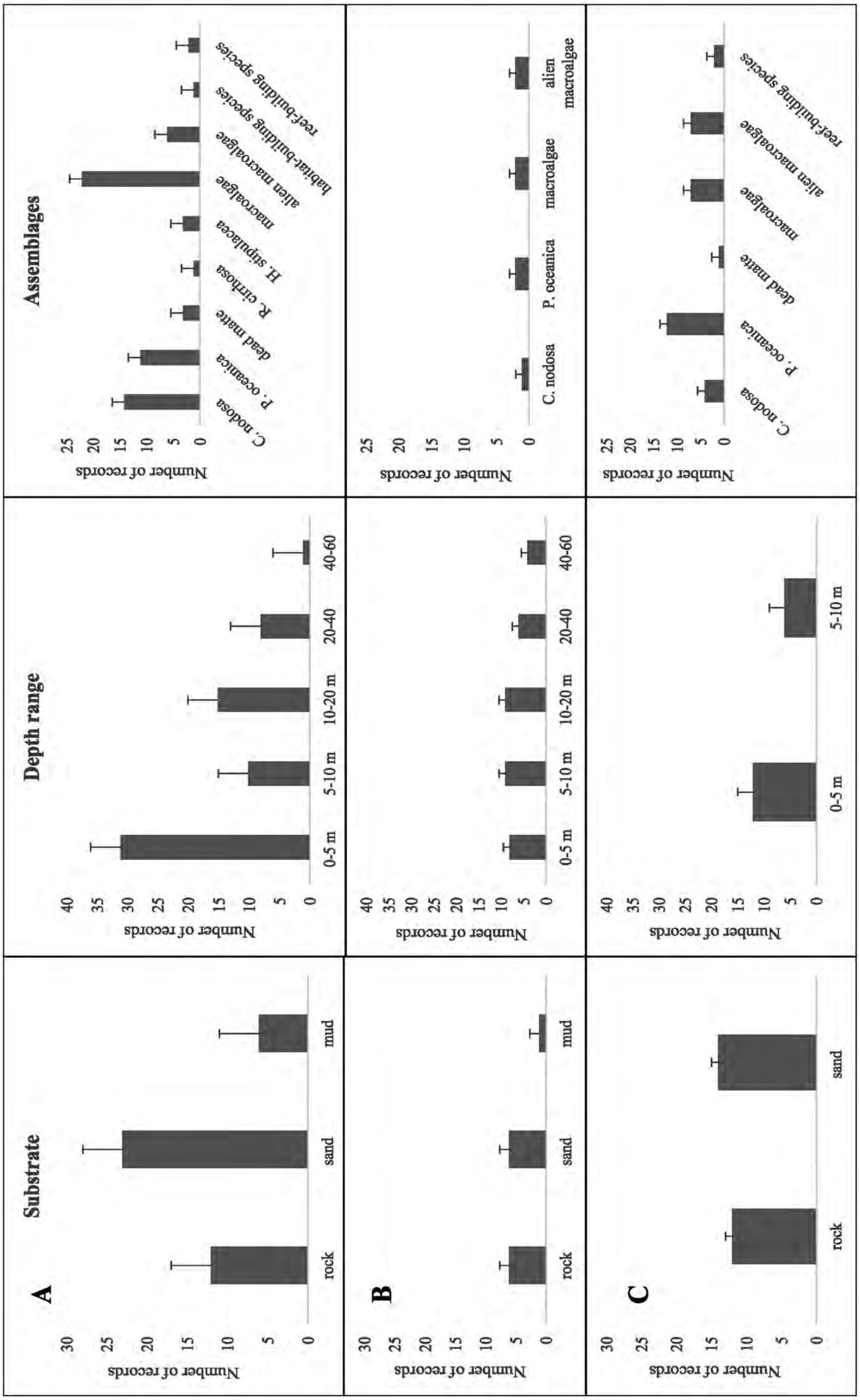

Fig. 2. Occurrences of *Caulerpa* taxa with respect to substrate typology, depth and native communities. A) *Caulerpa cylindracea*; B) *C. taxifolia*; C) *C. taxifolia* var. *distichophylla*.

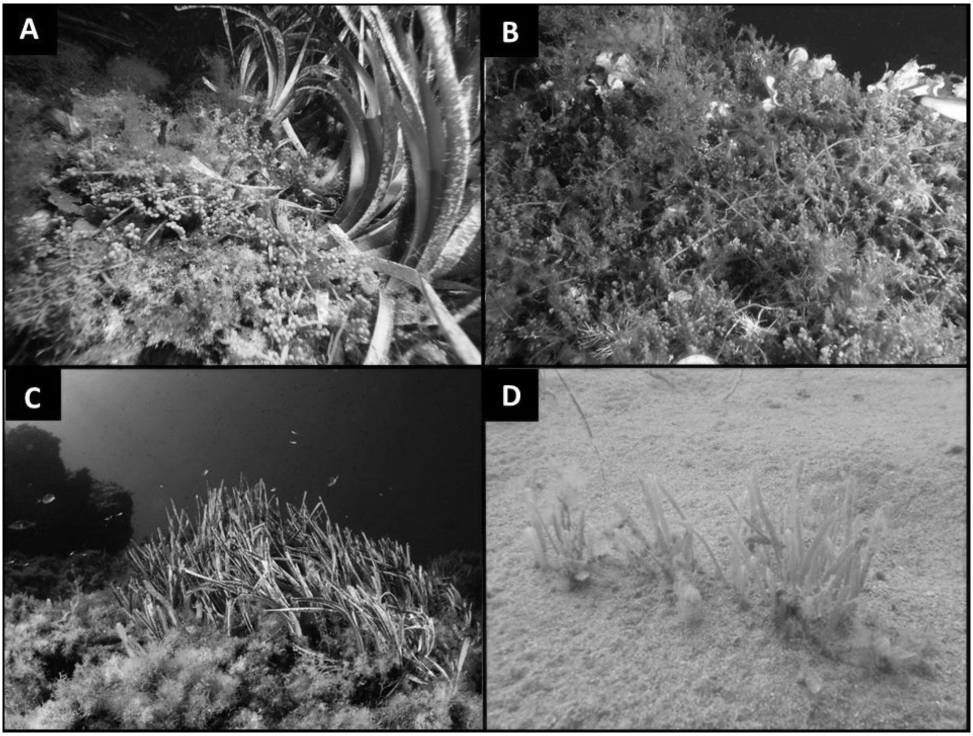

Fig. 3. *Caulerpa* species in different benthic assemblages along the coasts of Sicily and of circum-Sicilian Islands. A) *Caulerpa cylindracea* with *Posidonia oceanica* (Secca del Cammello - Marettimo, 28 m depth; photo Gianluca Neri); B) *Caulerpa cylindracea* with macroalgae and sponges (Secca del Toro – Favignana, 15 m depth; photo Sergio Zanoni); C) *Caulerpa taxifolia* in a *Posidonia oceanica* meadow (Strait of Messina, 12 m depth; photo Alessandro Pagano); D) *Caulerpa taxifolia* var. *distichophylla* in a *Cymodocea nodosa* meadow (Termini Imerese coast, 9-10 m depth; photo Marco Toccaceli).

Caulerpa taxifolia var. distichophylla

Distribution (Table 2 and Fig. 5): *Caulerpa taxifolia* var. *distichophylla* was first recorded on south-eastern coasts of Sicily in 2007 (as *C. distichophylla*, first Italian record). From then it spread rapidly along the southern coast and recently it was recorded along the northern and eastern coast. A new record (Termini Imerese) is here reported. From 2007 to 2009, 85 km of the south-eastern coast of Sicily (Isola delle Correnti, Capo Passero and Punta Braccetto) were already affected by *C. taxifolia* var. *distichophylla*.

Colonisation level: the level of colonisation ranged from sparse individuals to patches (about 100 cmq) whereas the substratum cover (%) mainly ranged from 8% to over 50%. In the southern coast its density showed an increasing gradient going from the west to the east.

Habitat (Fig. 2C, 3D): this alga occurs in shallow waters on sandy and rocky bottoms, mixed to *C. cylindracea*, on dead *matte* as well as along the borders of *P. oceanica* mead-

Table 2. Known sites of occurrence of *Caulerpa taxifolia* and *Caulerpa taxifolia* var. *distichophylla* from Sicily and circum-Sicilian Islands. MPA: Marine Protected Area.

Locality (site codes)	**References**
Caulerpa taxifolia	
WESTERN COAST	
EGADI ISLANDS MPA	
Favignana Island (8)	Gianguzza & al. (2006a, b), Riggio & al. (2007)
EASTERN COAST	
MESSINA	
Strait of Messina (22)	Di Martino (2001), Orestano & al. (2001), Profeta & al. (2004)
Torre Faro (21) – Ganzirri (47)	Fradà Orestano & al. (1994), Cantone (1999), Di Martino (2001), Orestano & al. (2001), Riggio & al. (2007)
Caulerpa taxifolia* var. *distichophylla	
NORTHERN COAST	
PALERMO	
Termini Imerese (16)	M. Toccaceli (present work)
Sant'Ambrogio (48)	Musco & al. (2014)
EASTERN COAST	
MESSINA	
Strait of Messina (22)	Picciotto & al. (2016)
SIRACUSA	
Isola delle Correnti (49)	Meinesz & al. (2010), Antoci & al. (2015)
Capo Passero (37)	Meinesz & al. (2010)
SOUTHERN COAST	
RAGUSA	
Punta Braccetto (40)	Meinesz & al. (2010), Jongma & al. (2013), Musco & al. (2014), Antoci & al. (2015)
Torre di Mezzo, Punta Secca, Marina di Ragusa, Donnalucata (50)	Musco & al. (2014)
Foce Fiume Irminio, Marina di Acate (51)	Antoci & al. (2015)
AGRIGENTO	
Malerba (52), Realmonte (53)	Antoci & al. (2015)
Torre Salsa (54)	Musco & al. (2014)

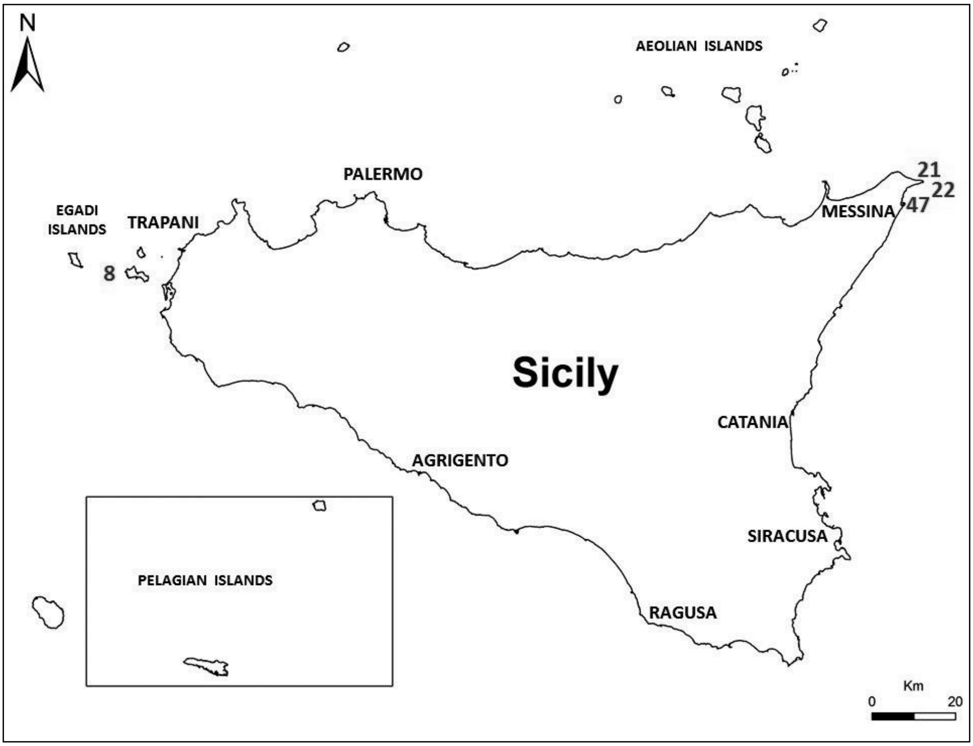

Fig. 4. Known sites of occurrence of *Caulerpa taxifolia* in Sicily and circum-Sicilian Islands (see Table 2 for the site codes).

ows, on the polychaete *Sabellaria* spp., and intermingled with macroalgae and *C. nodosa*. In the Strait of Messina, it occurs in habitats different to those occupied by *C. taxifolia*.

Discussion

Caulerpa cylindracea

Over the years, the level of colonization in the area has either decreased (A.M. Mannino, present work) or increased (Azzurro & al. 2004; Lodola & al. 2012).

Although Sicily and circum-Sicilian Islands have not been thoroughly investigated, the current data lead us to hypothesize that the entire coastline is affected by *C. cylindracea*.

Certainly, it is difficult to know the precise extent of the colonization in terms of area and coastline concerned, because mapping data are lacking and estimations of the reported colonized surfaces are not homogeneous and very often not accurate or completely lacking.

Although many colonized localities are touristic and/or fishing areas or are located in the vicinity of ports, non-urbanized areas (e.g. Marine Protected Areas and Natural Reserves) are also concerned.

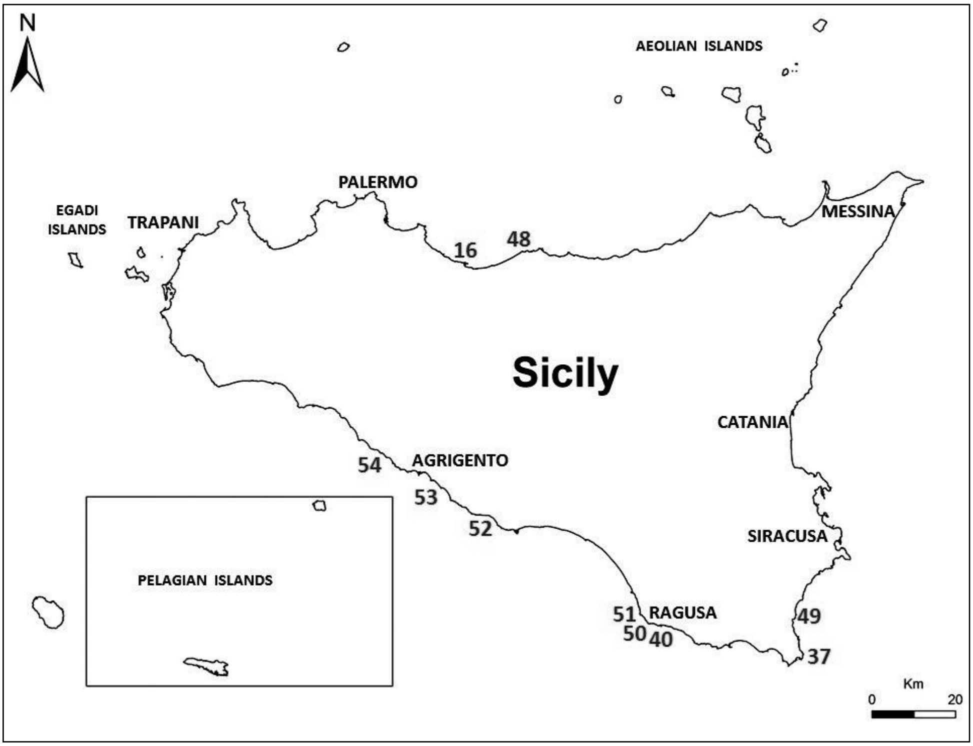

Fig. 5. Known sites of occurrence of *Caulerpa taxifolia* var. *distichophylla* in Sicily and circum-Sicilian Islands (see Table 2 for the site codes).

Similar rapid spreads were observed in other Mediterranean areas, e.g. along the French Mediterranean coasts and the south-eastern coast of Spain (Ruitton & al. 2005; Ruiz & al. 2011). However, even if *C. cylindracea* spread much faster and further than *C. taxifolia* it didn't generate the same public concern (Piazzi & al. 2005; Klein & Verlaque 2008; Boudouresque & al. 2009).

The spread of *C. cylindracea,* considered established in Sicily and in circum-Sicilian Islands, would probably result from the co-occurrence of extrinsic (i.e. current regime, temperate climate and presence of vectors of secondary dispersal) and intrinsic (i.e. the efficiency of its vegetative multiplication by cutting and propagules, the production of secondary metabolites) factors (Occhipinti-Ambrogi & al. 2011a, b; Gorbi & al. 2014). It has been suggested that the invasion of the Mediterranean region by *C. cylindracea* might have originated in the southern coast of Sicily (Papini & al. 2013). Transport-stowaway is considered the plausible pathway of introduction for local specimens but also the main vector of its spread.

The active mechanism of stolonisation allowed *C. cylindracea* to spread rapidly, forming compact multilayered mats which trap sediment creating a relevant decrease of redox potential underneath and negatively affecting the native assemblages (Piazzi & al. 2005;

Klein & Verlaque 2008; Holmer & al. 2009; Mannino & Di Giovanni 2011; Matijević & al. 2013). Therefore, it can be regarded as a "habitat modifier" (*sensu* Wallentinus & Nyberg 2007), ''ecosystem engineer'' (*sensu* Jones & al. 1994) and ''foundation species'' (*sensu* Bruno & al. 2003). Recently, it has been hypothesized that the bacterial community associated with *C. cylindracea* could have a potential role in its spread (Rizzo & al. 2016).

Fragmented or less structured habitats such as dead *mattes* of *P. oceanica*, sparse *P. oceanica* and *C. nodosa* meadows, algal turfs and annual photophilic macroalgal assemblages seem to be more vulnerable to invasion by *C. cylindracea* (Ceccherelli & al. 2000; Montefalcone & al. 2007; Katsanevakis & al. 2010). Recently, Bulleri & al. (2016) observed that the effects of *C. cylindracea* are more negative in well preserved sites.

Usually, *C. cylindracea* showed a marked seasonal cycle, with an alternation of a long growth period, from spring to autumn, and a withdrawal (resting period) in winter.

Gametogenesis has never been observed in Sicily and in circum-Sicilian Islands (Giaccone & Di Martino 1995; Di Martino & al. 2006; Mannino & Di Giovanni 2011).

Since gametogenesis has been locally observed (e.g. in the South Aegean Sea; Panayotidis & Žuljević 2001), it is likely that sexual reproduction may have contributed to its rapid spread in other parts of the Mediterranean Sea.

Caulerpa taxifolia (invasive aquarium strain)

Since it was officially reported exclusively for the coasts of the Strait of Messina and of Favignana Island so far (Fradà Orestano & al. 1994; Orestano & al. 2001; Profeta & al. 2004; Gianguzza & al. 2006a, b), its spread was very limited if compared to that of *C. cylindracea*. Its presence along the coast of Favignana Island is likely to be a consequence of a secondary anthropogenic introduction (Gianguzza & al. 2006a, 2006b).

According to Di Martino & Giaccone (1996) in the Strait of Messina the complex *C. taxifolia* - *Caulerpa mexicana* Sonder *ex* Kützing would be present. Chisholm & al. (1995) stated that the Mediterranean *C. taxifolia* and the Eastern Mediterranean *C. mexicana* would be conspecific, suggesting its occurrence in the Mediterranean as a result of a biogeographic dispersion instead of an accidental introduction. But later, Jousson & al. (1998) demonstrated that the aquarium-Mediterranean strain of *C. taxifolia* was not related to any specimens of *C. mexicana*, thus invalidating the hypothesis of Chisholm & al. (1995).

A combination of unfavourable intrinsic (e.g. lack of specialized propagules, low propagation speed and/or weakness of the population) and/or extrinsic factors (e.g. hydrodynamics conditions and lack of shipping-trade with the other parts of Sicily) could have stopped its northward and southward expansion and could be also responsible for the regression observed in the Strait of Messina between 2008 and 2009 (Meinesz & al. 2010). The regression and/or disappearance of *C. taxifolia* populations observed in other Mediterranean areas (Iveša & al. 2006; Montefalcone & al. 2015) has also been related to genetic degeneration of the Mediterranean clone and to the presence of parasites (Longepierre & al. 2005; Meinesz & al. 2010). As in other Mediterranean areas, sexual reproduction remains unknown. Transport-stowaway is considered the plausible pathway of introduction for local specimens.

Caulerpa taxifolia, which was also considered established in Sicily, did not behave as a highly successful and fast-spreading species as it did in other Mediterranean areas (Boudouresque & al. 1992; Meinesz & al. 2001; Balata & al. 2004) and as we would have expected from the "alga killer".

Caulerpa taxifolia var. *distichophylla*

As in other Mediterranean regions, it mainly occurs in shallow waters where it can be more easily ripped off and spread (Schembri & al. 2015). Even if it has been recently introduced, it is already established in the area and it is considered a potential threat for the indigenous communities but also for fishing activities, to such an extent that it is considered a real pest (Musco & al. 2014). It has been observed that winter water temperatures might limit its spread to the northern and western parts of the Mediterranean Sea (Jongma & al. 2013).

The occurrence of this alga in association with phanerogams and green algae of tropical-subtropical origin (e.g. *H. stipulacea* and *Penicillus capitatus* Lamarck) would suggest a reorganisation of Mediterranean benthic communities as a consequence of global change (Picciotto & al. 2016). Fertile thalli have not been observed in Sicily so far. Also for *C. taxifolia* var. *distichophylla* the Sicilian coast would be the start of an invasion in the Mediterranean Sea (Musco & al. 2014). Transport-stowaway is considered the plausible pathway of introduction for local specimens.

Sicily, representing the western and northern limit of this taxon (Jongma & al. 2013; Musco & al. 2014), would have been the source of the Maltese populations of *C. taxifolia* var. *distichophylla*. Since the traffic of recreational and/or commercial vessels is very intense between the two islands, shipping is the most likely vector (Schembri & al. 2015). As hydrodynamics conditions do not facilitate the westward and northward spread, secondary shipping could be the vector of its spread along the northern coast of Sicily.

Conclusions

In the Mediterranean Sea, maritime traffic plays an important role in the introduction and spread of alien species, and the Pacific Ocean is the main donor of alien species due to climatic affinities. Since the Suez Canal is considered to be one of the main pathways for the introduction of marine alien species, the creation of a second canal, increasing the number of introductions, will certainly have a strong impact on the Mediterranean ecosystems (Galil & al. 2015). Sicily and circum-Sicilian Islands, at the crossroads between the western and eastern Mediterranean and interested by intense maritime traffic, are particularly vulnerable to biological marine invasions. The fact that many colonized areas were located in the vicinity of harbours, and exposed to human activities (e.g. shipping, tourism, fishing), would support this hypothesis.

Indeed, maritime traffic can produce a constant spillover of new invaders into surrounding areas, making this area an important transit zone and a source for secondary dispersal, highlighting the key role it can play in the circulation of alien species within the Mediterranean Sea. In particular, as highlighted in this study, the southern and south-eastern coasts, bordering the Strait of Sicily, would deserve particular attention.

The three invasive taxa showed different spread dynamics. *Caulerpa cylindracea* and *C. taxifolia* var. *distichophylla* behaved as fast-spreading algae whereas *C. taxifolia* did not behave in the same manner. Divergent spread dynamics between *C. cylindracea* and *C. taxifolia* were already highlighted by Montefalcone & al. (2015) in the Ligurian Sea. As the authors stated, it is not possible to generalize the future behaviour of invasive species in the Mediterranean Sea. Moreover, the evaluation of the spread dynamics of invasive species requires long periods of study (Boudouresque & Verlaque 2012).

For a better understanding of the invasive potential and spread dynamics of alien species such as *Caulerpa* ones, a quick sighthing of any newly colonized area is fundamental (Klein & Verlaque 2008). Moreover, the establishment of regular monitoring programs, as also prescribed by the Marine Strategy Framework Directive (MSFD), including public awareness campaigns (e.g. the Project "*Caulerpa cylindracea* – Egadi Islands" sponsored by the Department of Biological Chemical and Pharmaceutical Sciences and Technologies, University of Palermo and the Egadi Islands Marine Protected Area), citizen science initiatives (e.g. "Seawatchers" available at http://www.observadoresdelmar.es/?idioma=en), online databases or networks such as ELNAIS (Ellenic Network on Aquatic Invasive Species) by the Hellenic Centre for Marine Research (HCMR), available at http://elnais.hcmr.gr, regular surveys and mapping by scientists, are welcome and necessary in order to assess the spread dynamics of those invasive species that raise serious concern. All these activities are fundamental to manage continuous spillover effects, especially in the areas which are more vulnerable to marine biological invasions and along the protected coasts. All information, regularly updated, would allow the creation of permanent observatories and warning systems of detection and if possible of control, but also the planning of suitable management activities.

Lastly, the Mediterranean region, which is described as one of the main climate change "hot-spots" (Giorgi 2006), should become warmer and drier during the 21st century, mirroring the global ocean tendency with an increase of about 3.1 °C predicted in the coming century (Ben Rais Lasram & al. 2010). Undoubtedly, the distribution of marine species, alien and native, in the Mediterranean Sea is currently changing as a consequence of seawarming. Tropical species are expanding in the southern Mediterranean areas whereas the northern Mediterranean areas are being more and more occupied by thermophilic indigenous species (Bianchi 2007). The possibility of a gradual westward expansion of tropical species has been already predicted by Por (1990). The abundance, distribution and geographic expansion of thermophilic species, alien or indigenous (the so-called phenomenon of "tropicalization", Bianchi & Morri 2003) are expected to increase, as a consequence of sea warming, Atlantic flux, lessepsian migration and human activities. Climate changes, making the Mediterranean Sea a favourable biogeographic area, will certainly facilitate the expansion of alien *Caulerpa* species within this Sea, and directly affect the indigenous macrophyte-dominated ecosystems (e.g. Harley & al. 2012), further confirming that monitoring programs are of great importance to gauge the spread dynamics of these marine alien species.

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Addresses of the authors:
Anna Maria Mannino[1] & Paolo Balistreri[2],
[1]Department of Biological, Chemical and Pharmaceutical Sciences and Technologies, Section of Botany and Plant Ecology, University of Palermo, Italy. E-mail: annamaria.mannino@unipa.it
[2]Vicolo Giotto 6, 91023 Favignana, Italy.

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D. A. Samaras, E. Eleftheriadou, K. Theodoropoulos & G. Karetsos

Contribution to the flora of Mt Goulinas (Sterea Ellas, Greece)

Abstract

Samaras, D. A., Eleftheriadou, E., Theodoropoulos K. & Karetsos, G.: Contribution to the flora of Mt Goulinas (Sterea Ellas, Greece). — Fl. Medit. 27: 241-266. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

Mt Goulinas is located in the NW part of Sterea Ellas in south-central Greece. A first floristic inventory of the mountain is presented based on field work and literature records. The known vascular flora of the study area consists of 487 taxa out of which 305 taxa are reported for the first time. Among these *Euphorbia phymatosperma* subsp. *cernua* and *Elymus caninus* are new to Sterea Ellas.

Key words: vascular plants, floristic inventory, south-central Greece.

Introduction

Over the last decades an intensive floristic research carried out in the mountains of Sterea Ellas in south-central Greece (Dimopoulos & al. 2013). Despite that big effort, the botanical exploration has been focused almost entirely on the high mountains, leaving outside extensive coastal, lowland and lower mountain areas. Mt Goulinas is one of these low mountains, with an elevation of less than 1500 m a.s.l., that has been "floristically ignored". Although Mt Goulinas presents a phytogeographical interest due to its geographical position and habitat richness, the only published floristic study of the area is that of Willing & Willing (2006, 2008). Two more studies of the vegetation and phytogeography of the mountains of Sterea Ellas, including Mt Goulinas, have been published by Barbéro & Quézel (1976) and Phitos (1960). A few records of Orchids have been published by Künkele (1983), Hölzinger & al. (1985) and Tsiftsis & Antonopoulos (2017).

This study tries to fill the gap in knowledge of the incompletely explored flora of Mt Goulinas by presenting a floristic catalogue of all vascular plant records of the first author together with literature records.

Materials and methods

Study area – Mt Goulinas is located in south-central Greece (Sterea Ellas), in the west part of Fthiotida prefecture. The mountain lies between 38º 49′ 20′′ and 38º 56′ 32′′ N of latitude and 21º 57′ 26′′ and 22º 12′ 05′′ E of longitude, and covers an area of 16,210 ha that ranges from 100 to 1459 m in elevation (Fig. 1). The study area is restricted among the rivers Sperchios, Inachos and Roustianitis. The dominant geological formation is flysch (consisted mainly of sandstone), while limestones and scree slope deposits occur, to a small extent, in the central part of the mountain, close to the highest summit (Kallergis & al. 1970). The climate is Mediterranean with wet, mild winters and dry, hot summers. According to Köppen climatic classification, the lower elevations belong to the Csa type, while the higher to the Csb (Samaras & al. 2008).

The most abundant vegetation type in the study area is the deciduous oak forest and scrub, dominated by *Quercus pubescens* in the lower elevations and *Q. frainetto* in the middle and higher elevations. Other deciduous trees like *Q. petraea* subsp. *polycarpa*, *Castanea sativa* and *Ostrya carpinifolia* can be found locally on north facing slopes in clumps or in mixture with *Q. frainetto*. In the higher elevations, above the oak forests, on north and north-east facing slopes can be found the Greek fir (*Abies cephalonica*) forest. In the highest elevations, above the timberline, forest fires, overgrazing and illegal logging

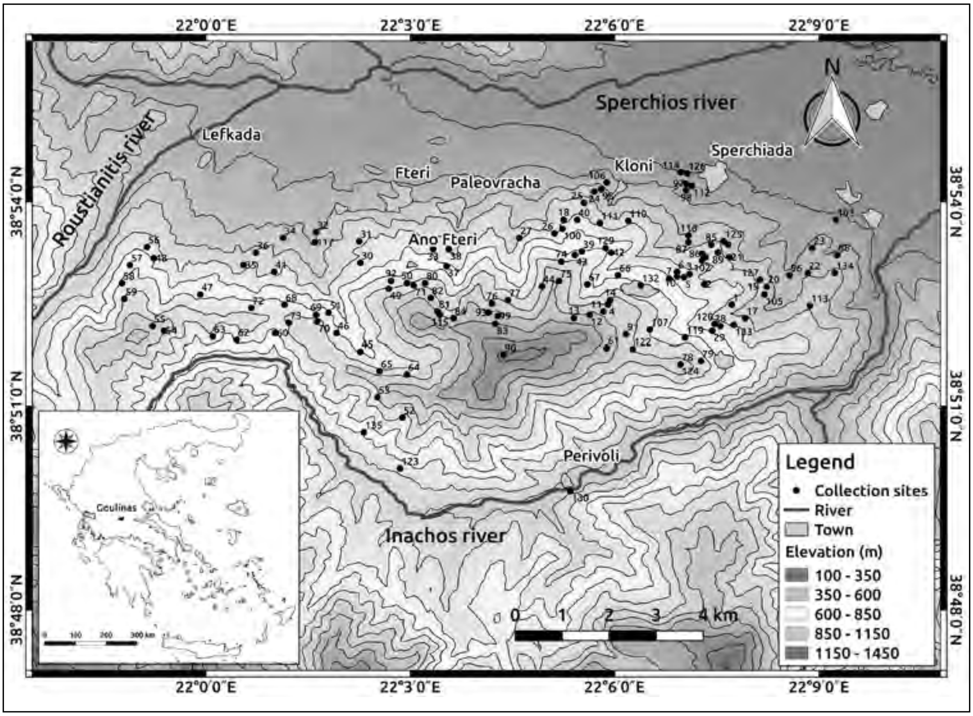

Fig. 1. Map of the study area and collection localities.

have lead to degradation and the replacement of forests by prickly juniper shrublands and anthropogenic, montane, dry grasslands. Extensive evergreen scrub vegetation (pseudomacchie) dominated by *Q. coccifera* occur in the lowlands and foothills of Mt Goulinas mainly in the eastern part of the study area. Along streams and rivers the riparian vegetation consists mainly of the tree species *Platanus orientalis*, *Salix alba*, *Populus alba* and *Alnus glutinosa* and the shrubs *Nerium oleander* and *Vitex agnus-castus*.

Data collection and analysis – The floristic catalogue is based on collections and field observations carried out by the first author during spring, summer and autumn of 2002-2003 and 2005-2007. Published records are also included in the catalogue. Plant specimens that were collected in the field are stored in the herbarium of the Laboratory of Forest Botany-Geobotany, in the Aristotle University of Thessaloniki, Greece (TAUF). Plant identification was based on the main national and European Floras (Tutin & al. 1968-1980, 1993; Strid 1986; Strid & Tan 1991, 1997, 2002) and selected taxonomic literature (Zohary & Heller 1984; Krendl 1986-1987; Boyce 1988, 1994; Zielinski 1990; Christensen 1992; Baumann & al. 2006). The nomenclature mainly follows Dimopoulos & al. (2013). Accepted names are set in boldface italics in the floristic catalogue. Families, genera, species and subspecies are arranged alphabetically within the four main taxonomic groups: *Pteridophyta*, *Gymnospermae*, *Dicotyledoneae* and *Monocotyledoneae*. Life-form categories of taxa are coded according to Raunkiaer's classification system as was modified by Dimopoulos & al. (2013). Chorological types of taxa are based on the system established for the checklist of vascular plants of Greece (Dimopoulos & al. 2013).

Collection localities – Collection sites (Fig. 1) are coded with numbers (locality codes). The locality codes of all specimens collected in the field are given in the floristic catalogue, in boldface, before the collection number. Information about the date of collection, the exact coordinates, the altitude and the habitat of the site is given below:

1: 38º 52' 29'' / 22º 07' 43'' – 570 m a.s.l. – 5/1/2002 – Forest of *Quercus pubescens*
2: 38º 52' 47'' / 22º 07' 19'' – 610 m a.s.l. – 5/4/2002 – Forest of *Q. frainetto*
3: 38º 52' 56'' / 22º 07' 06'' – 640 m a.s.l. – 5/7-27/2002, 7/10/2002 – Mixed forest of *Q. frainetto-Q. pubescens*
4: 38º 52' 29'' / 22º 05' 54'' – 990 m a.s.l. – 7/9/2002 – Forest of *Abies cephalonica*
5: 38º 52' 53'' / 22º 07' 01'' – 650 m a.s.l. – 7/11/2002 – Forest of *Q. frainetto*
6: 38º 52' 58'' / 22º 06' 55'' – 630 m a.s.l. – 7/12/2002 – Forest of *Q. frainetto*
7: 38º 52' 52'' / 22º 06' 48'' – 660-680 m a.s.l. – 7/13-16/2002, 6/22/2003 – Forest of *Q. frainetto*
10: 38º 52' 54'' / 22º 06' 55'' – 660-670 m a.s.l. – 7/18-19/2002 – Mixed forest of *Q. frainetto-Q. pubescens*
11: 38º 52' 23'' / 22º 05' 50'' – 1010 m a.s.l. – 7/22-26/2002 – Forest of *Abies cephalonica*
12: 38º 52' 20'' / 22º 05' 38'' – 1010 m a.s.l. – 6/19/2003 – Forest of *A. cephalonica*
13: 38º 52' 17'' / 22º 05' 24'' – 1020 m a.s.l. – 6/21/2003 – Forest of *A. cephalonica*
14: 38º 52' 33'' / 22º 05' 56'' – 960-990 m a.s.l. – 6/23-24/2003 – Forest of *A. cephalonica*
15: 38º 53' 22'' / 22º 07' 40'' – 460 m a.s.l. – 4/29/2005 – Forest of *Q. pubescens*
16: 38º 53' 11'' / 22º 07' 20'' – 560 m a.s.l. – 4/30/2005, 04/19/2006 – Meadow next to mixed forest of *Q. pubescens-Q. frainetto* / Mixed forest of *Q. pubescens-Q. frainetto*
17: 38º 52' 17'' / 22º 07' 55'' – 520 m a.s.l. – 5/2/2005 – Forest of *Q. frainetto*

18: 38º 53’ 44’’ / 22º 05’ 15’’ – 570 m a.s.l. – 5/3/2005 – Forest of *Q. frainetto*/Roadside in *Q. frainetto* forest
19: 38º 52’ 51’’ / 22º 08’ 08’’ – 460 m a.s.l. – 5/4/2005 – Forest of *Q. frainetto*
20: 38º 52’ 45’’ / 22º 08’ 14’’ – 450 m a.s.l. – 5/4/2005 – Mixed forest of *Q. pubescens-Q. frainetto*
21: 38º 53’ 11’’ / 22º 07’ 41’’ – 460-470 m a.s.l. – 5/5/2005 – Forest of *Q. pubescens*
22: 38º 52’ 57’’ / 22º 08’ 50’’ – 380 m a.s.l. – 6/7/2005 – Forest of *Q. pubescens*
23: 38º 53’ 19’’ / 22º 08’ 54’’ – 320 m a.s.l. – 6/7/2005 – Forest of *Q. pubescens* / Clearing in *Q. pubescens* forest
24: 38º 54’ 09’’ / 22º 05’ 42’’ – 470 m a.s.l. – 6/8/2005 – Forest of *Q. frainetto*
25: 38º 53’ 59’’ / 22º 05’ 33’’ – 530 m a.s.l. – 6/8/2005 – Forest of *Q. frainetto*
26: 38º 53’ 32’’ / 22º 05’ 07’’ – 630 m a.s.l. – 6/9/2005 – Forest of *Q. frainetto*
27: 38º 53’ 28’’ / 22º 04’ 36’’ – 580 m a.s.l. – 6/9/2005 – Forest of *Q. frainetto*
28: 38º 52’ 10’’ / 22º 07’ 33’’ – 650 m a.s.l. – 6/10/2005, 4/28/2006 – Forest of *Q. frainetto*
29: 38º 52’ 06’’ / 22º 07’ 26’’ – 690 m a.s.l. – 6/10/2005 – Forest of *Q. frainetto*
30: 38º 53’ 06’’ / 22º 02’ 16’’ – 640 m a.s.l. – 6/11/2005 – Forest of *Q. frainetto*
31: 38º 53’ 25’’ / 22º 02’ 15’’ – 560 m a.s.l. – 6/11/2005 – Forest of *Q. frainetto*
32: 38º 53’ 33’’ / 22º 01’ 37’’ – 400 m a.s.l. – 6/14/2005 – Forest of *Q. frainetto*
33: 38º 53’ 18’’ / 22º 03’ 20’’ – 680 m a.s.l. – 6/15/2005 – Forest of *Q. frainetto*
34: 38º 53’ 28’’ / 22º 01’ 08’’ – 440 m a.s.l. – 6/15/2005 – Forest of *Q. frainetto*
35: 38º 53’ 04’’ / 22º 00’ 33’’ – 560 m a.s.l. – 6/16/2005 – Forest of *Q. petraea*/Roadside in *Quercus petraea* forest
36: 38º 53’ 15’’ / 22º 00’ 44’’ – 530 m a.s.l. – 6/16/2005 – Forest of *Q. frainetto*
37: 38º 53’ 03’’ / 22º 03’ 32’’ – 710 m a.s.l. – 6/17/2005 – Mixed forest of *Q. frainetto-Castanea sativa-Q. petraea*
38: 38º 53’ 18’’ / 22º 03’ 34’’ – 590 m a.s.l. – 6/17/2005 – Forest of *Q. frainetto*
39: 38º 53’ 16’’ / 22º 05’ 31’’ – 710 m a.s.l. – 6/18/2005 – Mixed forest of *Q. frainetto-Q. petraea*
40: 38º 53’ 44’’ / 22º 05’ 27’’ – 630 m a.s.l. – 6/18/2005 – Forest of *Q. frainetto*
41: 38º 52’ 58’’ / 22º 01’ 00’’ – 570 m a.s.l. – 6/20/2005 – Forest of *Q. frainetto*
42: 38º 53’ 15’’ / 22º 05’ 57’’ – 780 m a.s.l. – 6/21/2005 – Forest of *Q. frainetto*
43: 38º 53’ 13’’ / 22º 05’ 25’’ – 840 m a.s.l. – 6/21/2005 – Forest of *Q. petraea*
44: 38º 52’ 45’’ / 22º 04’ 56’’ – 870 m a.s.l. – 6/22/2005 – Forest of *A. cephalonica*
45: 38º 51’ 48’’ / 22º 02’ 16’’ – 800 m a.s.l. – 6/23/2005 – Forest of *Q. frainetto*
46: 38º 52’ 04’’ / 22º 01’ 55’’ – 840 m a.s.l. – 6/23/2005 – Forest of *Castanea sativa*
47: 38º 52’ 38’’ / 21º 59’ 55’’ – 770 m a.s.l. – 6/24/2005 – Forest of *Q. frainetto*
48: 38º 53’ 10’’ / 21º 59’ 14’’ – 710 m a.s.l. – 6/24/2005 – Forest of *Q. frainetto*
49: 38º 52’ 43’’ / 22º 02’ 41’’ – 850-920 m a.s.l. – 6/25/2005 – Mixed forest of *Q. petraea-Q. frainetto-Castanea sativa*
50: 38º 52’ 48’’ / 22º 02’ 57’’ – 900 m a.s.l. – 6/25/2005 – Mixed forest of *Castanea sativa-Q. frainetto-Q. petraea*
51: 38º 52’ 22’’ / 22º 01’ 48’’ – 790 m a.s.l. – 6/26/2005 – Mixed forest of *Ostrya carpinifolia-Q. frainetto*
52: 38º 50’ 50’’ / 22º 02’ 53’’ – 900 m a.s.l. – 6/28/2005 – Forest of *Q. frainetto*
53: 38º 51’ 08’’ / 22º 02’ 31’’ – 1000 m a.s.l. – 6/28/2005 – Forest of *Q. frainetto*
54: 38º 52’ 06’’ / 21º 59’ 23’’ – 1030 m a.s.l. – 6/29/2005 – Forest of *Q. frainetto*
55: 38º 52’ 10’’ / 21º 59’ 13’’ – 1070 m a.s.l. – 6/29/2005 – Mixed forest of *Q. petraea-Abies cephalonica-Castanea sativa*
56: 38º 53’ 20’’ / 21º 59’ 08’’ – 660 m a.s.l. – 7/3/2005 – Forest of *Q. frainetto*
57: 38º 53’ 04’’ / 21º 58’ 53’’ – 750 m a.s.l. – 7/4/2005 – Forest of *Q. frainetto*
58: 38º 52’ 48’’ / 21º 58’ 46’’ – 840 m a.s.l. – 7/4/2005 – Forest of *Q. frainetto*

59: 38º 52' 34'' / 21º 58' 48'' – 910 m a.s.l. – 7/4/2005 – Mixed forest of *Q. petraea-Castanea sativa-Q. frainetto*
60: 38º 52' 04'' / 22º 01' 01'' – 800 m a.s.l. – 7/5/2005 – Forest of *Q. frainetto*
61: 38º 51' 51'' / 22º 05' 53'' – 750 m a.s.l. – 7/5/2005 – Forest of *Q. frainetto*
62: 38º 51' 58'' / 22º 00' 27'' – 830 m a.s.l. – 7/6/2005 – Forest of *Q. frainetto*
63: 38º 52' 01'' / 22º 00' 06'' – 860 m a.s.l. – 7/6/2005 – Forest of *Q. frainetto*
64: 38º 51' 28'' / 22º 02' 57'' – 970 m a.s.l. – 7/7/2005 – Mixed stand of *Platanus* orientalis-*Q. frainetto* / Roadside in *Q. frainetto* forest
65: 38º 51' 31'' / 22º 02' 33'' – 920 m a.s.l. – 7/7/2005 – Mixed forest of *Q. petraea-Q. frainetto*
66: 38º 52' 55'' / 22º 06' 03'' – 810 m a.s.l. – 7/8/2005 – Forest of *Abies cephalonica*
67: 38º 52' 47'' / 22º 05' 36'' – 840 m a.s.l. – 7/8/2005 – Forest of *A. cephalonica*
68: 38º 52' 29'' / 22º 01' 09'' – 810 m a.s.l. – 7/10/2005 – Forest of *Q. frainetto*
69: 38º 52' 20'' / 22º 01' 37'' – 860 m a.s.l. – 7/10/2005 – Mixed forest of *C. sativa-Q. petraea*
70: 38º 52' 14'' / 22º 01' 38'' – 910 m a.s.l. – 7/11/2005 – Mixed forest of *C. sativa-Q. frainetto*
71: 38º 52' 46'' / 22º 03' 03'' – 920 m a.s.l. – 7/11/2005 – Mixed forest of *C. sativa-Q. petraea*
72: 38º 52' 26'' / 22º 00' 40'' – 870 m a.s.l. – 7/12/2005 – Forest of *Q. frainetto*
73: 38º 52' 13'' / 22º 01'' 13'' – 900 m a.s.l. – 7/12/2005 – Forest of *Q. frainetto*
74: 38º 53' 07'' / 22º 05' 13'' – 910 m a.s.l. – 7/13/2005 – Mixed forest of *A. cephalonica-Q. petraea*
75: 38º 52' 50'' / 22º 05' 11'' – 1070 m a.s.l. – 7/13/2005 – Mixed forest of *A. cephalonica-Q. petraea*
76: 38º 52' 30'' / 22º 04' 12'' – 1030-1040 m a.s.l. – 7/18/2005 – Roadside / Clearing in *A. cephalonica-Q. petraea* forest / Mixed forest of *A. cephalonica-Q. petraea*
77: 38º 52' 33'' / 22º 04'' 26'' – 980 m a.s.l. – 7/18/2005 – Forest of *A. cephalonica*
78: 38º 51' 37'' / 22º 06' 58'' – 1060 m a.s.l. – 7/19/2005, 4/19/2006 – Forest of *Q. frainetto* / Clearing in *Q. frainetto* forest
79: 38º 51' 40'' / 22º 07' 16'' – 950 m a.s.l. – 7/19/2005, 4/19/2006 – Forest of *Q. frainetto*
80: 38º 52' 48'' / 22º 03' 13'' – 980 m a.s.l. – 7/20/2005 – Forest of *Q. petraea*/Mixed forest of *Q. petraea-Castanea sativa-Q. frainetto*
81: 38º 52' 23'' / 22º 03' 24'' – 1100 m a.s.l. – 7/20-23/2005 – Forest of *Q. petraea* / Mixed forest of *Q. petraea-Castanea sativa*
82: 38º 52' 35'' / 22º 03' 18'' – 1030 m a.s.l. – 7/21/2005 – Forest of *Q. petraea*
83: 38º 52' 12'' / 22º 04' 15'' – 1200 m a.s.l. – 7/22/2005 – Forest of *A. cephalonica*
84: 38º 52' 17'' / 22º 03' 38'' – 1110 m a.s.l. – 7/22/2005 – Mixed forest of *Q. petraea-A. cephalonica*
85: 38º 53' 22'' / 22º 07' 25'' – 520 m a.s.l. – 4/26/2006 – Forest of *Q. pubescens*
86: 38º 53' 14'' / 22º 07' 17'' – 540 m a.s.l. – 4/26/2006 – Forest of *Q. pubescens*
87: 38º 53' 24'' / 22º 07' 05'' – 470 m a.s.l. – 4/27/2006 – Forest of *Q. pubescens*
88: 38º 53' 13'' / 22º 09' 16'' – 350 m a.s.l. – 4/27/2006 – Forest of *Q. pubescens*
89: 38º 53' 15'' / 22º 07' 31'' – 530 m a.s.l. – 4/29/2006 – Forest of *Q. pubescens*
90: 38º 51' 45'' / 22º 04' 22'' – 1460 m a.s.l. – 6/12/2007 – Rocky slope
91: 38º 52' 03'' / 22º 06' 10'' – 1060 m a.s.l. – 6/12/2007 – Rocky meadow
92: 38º 52' 50'' / 22º 02' 43'' – 850 m a.s.l. – 6/25/2005 – Mixed forest of *Q. frainetto-Q. petraea-Castanea sativa*
93: 38º 52' 22'' / 22º 04' 09'' – 1100 m a.s.l. – 7/22/2005 – Roadside in *A. cephalonica* forest / Mixed forest of *A. cephalonica-Q. petraea*
95: 38º 54' 11'' / 22º 05' 48'' – 430 m a.s.l. – 5/7/2005 – Roadside
96: 38º 52' 55'' / 22º 08' 34'' – 310 m a.s.l. – 5/4/2005 – Roadside in meadow
97: 38º 54' 16'' / 22º 07' 03'' – 280 m a.s.l. – 4/24/2006 – Roadside
98: 38º 54' 10'' / 22º 07' 03'' – 250 m a.s.l. – 7/5/2005 – Roadside in meadow
99: 38º 52' 19'' / 22º 04' 17'' – 1140 m a.s.l. – 7/22/2005 – Forest of *A. cephalonica*
100: 38º 53' 36'' / 22º 05' 14'' – 610-620 m a.s.l. – 5/7/2005 – Roadside in *Q. frainetto* forest

102: 38º 53’ 08” / 22º 07’ 17” – 560 m a.s.l. – 4/30/2005 – Ravine
103: 38º 53’ 44” / 22º 09’ 15” – 260 m a.s.l. – 4/18/2006 – Abandoned field / Open shrubland with *Q. pubescens-Q. coccifera-Pyrus spinosa-Juniperus oxycedrus*
104: 490-580 m a.s.l. – 4/25/2003 – Margins of oak forest / Clearing in oak forest / Roadside
105: 38º 52’ 38” / 22º 08’ 12” – 470 m a.s.l. – 5/4/2005 – Meadow / Margins of oak forest
106: 38º 54’ 17” / 22º 05’ 53” – 360 m a.s.l. – 5/7/2005 – Roadside
107: 38º 52’ 07” / 22º 06’ 31” – 910 m a.s.l. – 4/19/2006 – Roadside
110: 38º 53’ 43” / 22º 06’ 12” – 580 m a.s.l. – 5/7/2005 – Roadside
111: 38º 53’ 41” / 22º 05’ 47” – 600 m a.s.l. – 5/7/2005 – Roadside in *Q. frainetto* forest / Margins of *Q. frainetto* forest
112: 38º 54’ 14” / 22º 07’ 08” – 230 m a.s.l. – 4/24/2006 – Meadow next to river
113: 38º 52’ 28” / 22º 08’ 52” – 4/27/2006 – Roadside
114: 38º 54’ 26” / 22º 06’ 58” – 200 m a.s.l. – 4/24/2006 – Reforestation of *Pinus*-along path
115: 38º 52’ 20” / 22º 03’ 26” – 1110 m a.s.l. – 7/23/2005 – Forest of *Q. petraea*
116: 38º 53’ 30” / 22º 07’ 05” – 430 m a.s.l. – 4/25/2006 – Roadside / Abandoned forest road
117: 38º 53’ 24” / 22º 01’ 36” – 380 m a.s.l. – 6/14/2005 – Roadside in a riverside
119: 38º 52’ 00” / 22º 07’ 02” – 850 m a.s.l. – 5/2/2005 – Roadside in a ravine
120: 38º 52’ 12” / 22º 07’ 28” – 640 m a.s.l. – 5/2/2005 – Meadow / *Q. frainetto* forest / Margins of *Q. frainetto* forest – damp place, next to water tank
122: 38º 51’ 50” / 22º 06’ 16” – 990 m a.s.l. – 4/19/2006 – Roadside next to stream
123: 38º 50’ 05” / 22º 02’ 51” – 640 m a.s.l. – 5/6/2005 – Roadside
124: 38º 51’ 37” / 22º 06’ 58” – 1100 m a.s.l. – 4/19/2006 – Forest of *Q. frainetto*
125: 38º 53’ 25” / 22º 07’ 36” – 480 m a.s.l. – 4/25/2006 – Meadow / Margins of *Q. pubescens* forest / Clearing in *Q. pubescens* forest
126: 38º 54’ 25” / 22º 07’ 04” – 210 m a.s.l. – 4/24/2006 – Reforestation of *Pinus*-along path
127: 38º 52’ 51” / 22º 08’ 08” – 450 m a.s.l. – 5/4/2005 – Clearing in *Q. pubescens* forest
129: 38º 53’ 19” / 22º 05’ 52” – 780 m a.s.l. – 6/21/2005 – Mixed forest of *Q. frainetto-Q. petraea*
130: 38º 49’ 45” / 22º 05’ 21” – 460 m a.s.l. – 5/6/2005 – Riverside
132: 38º 52’ 46” / 22º 06’ 23” – 800 m a.s.l. – 7/19/2005 – Roadside
133: 38º 52’ 11” / 22º 07’ 45” – 580 m a.s.l. – 5/2/2005 – Abandoned forest road
134: 38º 52’ 57” / 22º 09’ 14” – 410 m a.s.l. – 4/27/2006 – Stream
135: 38º 50’ 37” / 22º 02’ 19” – 650 m a.s.l. – 6/6/2005 – Roadside-Stream

Results

Floristic catalogue – The following abbreviations and symbols are used in the floristic catalogue:
+ : new record
* : literature report not confirmed
● : greek endemic
obs. : observed in the field (no collection available)
s.lat. : sensu lato
s.n. : without number
{=..} : synonym
{“..”} : misapplied name or misidentification
Sam. : leg. D. Samaras (TAUF), followed by collection number
B&Q : Barbéro & Quézel

W&W : Willing & Willing
H : Hölzinger & al.
K : Künkele
T&A : Tsiftsis & Antonopoulos

PTERIDOPHYTA

ASPLENIACEAE
\+ ***Asplenium adiantum-nigrum*** L. - H, Pt. - **5** (Sam.1), **24** (Sam.610), **87** (Sam.1189)
Asplenium onopteris L. - H, ME - B&Q (1976:15), **87** (Sam.1188), **92** (Sam.847)
\+ ***Asplenium trichomanes*** subsp. ***quadrivalens*** D. E. Mey. - H, EA - **92** (Sam.848)

DENNSTAEDTIACEAE
\+ ***Pteridium aquilinum*** (L.) Kuhn subsp. ***aquilinum*** - G, Co - **4** (Sam.2)

DRYOPTERIDACEAE
\+ ***Polystichum setiferum*** (Forssk.) Woynar - G, EA - **65** (Sam.942)

OPHIOGLOSSACEAE
\+ ***Ophioglossum vulgatum*** L. - G, Ct - **64** (Sam.940)

SPERMATOPHYTA – GYMNOSPERMAE

CUPRESSACEAE
Juniperus oxycedrus subsp. ***deltoides*** (R. P. Adams) N. G. Passal. - P, EM - B&Q (1976:15), **1** (Sam.24)

PINACEAE
\+ ● ***Abies cephalonica*** Loudon - P, Endem. - **4** (Sam.46), **11** (Sam.47), **93** (Sam.1072), **76** (Sam.1088)

TAXACEAE
\+ ***Taxus baccata*** L. - P, EA - **99** (Sam.1067)

SPERMATOPHYTA – ANGIOSPERMAE
DICOTYLEDONEAE

ACANTHACEAE
\+ ***Acanthus spinosus*** L. - H, Me - obs.

ACERACEAE
\+ ***Acer campestre*** L. - P, EA - **3** (Sam.70), **4** (Sam.71), **27** (Sam.648), **87** (Sam.1192)
\+ ***Acer monspessulanum*** L. subsp. ***monspessulanum*** - P, ME - **1** (Sam.72), **3** (Sam.73), **10** (Sam.74), **88** (Sam.1203)

AMARANTHACEAE
* ***Amaranthus albus*** L. - T, X - W&W (2006:37)
* ***Amaranthus blitoides*** S. Watson - T, X - W&W (2006:37)
* ***Amaranthus caudatus*** L. - T, X - W&W (2006:38)

* ***Amaranthus hybridus*** L. - T, X - W&W (2006:39)
* ***Amaranthus retroflexus*** L. - T, X - W&W (2006:40)

ANACARDIACEAE

Cotinus coggygria Scop. - P, EA - B&Q (1976:15), **95** (Sam.566)
Pistacia terebinthus L. subsp. ***terebinthus*** - P, Me - B&Q (1976:15), **15** (Sam.411), **88** (Sam.1200), **95** (Sam.567)

APIACEAE (*UMBELLIFERAE*)

\+ ***Anthriscus sylvestris*** subsp. ***nemorosus*** (M. Bieb.) Koso-Pol. - H, Pt - **12** (Sam.155), **65** (Sam.943)
\+ ***Bunium ferulaceum*** Sm. - G, EM. - **2** (Sam.167)
\+ ***Bupleurum glumaceum*** Sm. - T, Bk - **91** (Sam.1364)
\+ ***Chaerophyllum nodosum*** (L.) Crantz {= *Myrrhoides nodosa* (L.) Cannon} - T, MS - **3** (Sam.170), **67** (Sam.957b)
* ***Daucus carota*** L. s.lat. - T H, Pt - W&W (2006:62)
\+ ***Dichoropetalum vittijugum*** (Boiss.) Pimenov & Kljuykov {= *Peucedanum vittijugum* Boiss.} - H, Bk - **7** (Sam.156), **10** (Sam.157), **28** (Sam.662), **88** (Sam.1199)
\+ ***Eryngium campestre*** L. - H, EA - **13** (Sam.175), **15** (Sam.419)
\+ ***Ferulago sylvatica*** (Besser) Rchb. subsp. ***sylvatica*** - H, BI - **53** (Sam.869)
* ***Foeniculum vulgare*** Mill. - H, Me - W&W (2006:70)
Geocaryum capillifolium (Guss.) Coss. - G, BI - B&Q (1976:29), **2** (Sam.171), **3** (Sam.172), **4** (Sam.173), **12** (Sam.174), **16** (Sam.451), **17** (Sam.470), **24** (Sam.618)
\+ ***Oenanthe pimpinelloides*** L. s.lat. - H, EA - **3** (Sam.168, Sam.169), **17** (Sam.469), **19** (Sam.506), **22** (Sam.585), **86** (Sam.1181)
\+ ***Opopanax chironium*** (L.) W.D.J. Koch - H, ME - **88** (Sam.1205)
\+ ***Orlaya daucoides*** (L.) Greuter - T, MS - **15** (Sam.409), **42** (Sam.774), **45** (Sam.814), **87** (Sam.1185), **89** (Sam.1219), **96** (Sam.550), **97** (Sam.1124)
* ***Physospermum cornubiense*** (L.) DC. - H, EA - B&Q (1976:29)
* ***Pimpinella saxifraga*** L. - H, ES - W&W (2008:125)
\+ ***Scandix pecten-veneris*** L. - T, EA - **96** (Sam.549)
\+ ***Selinum silaifolium*** (Jacq.) Beck {= *Cnidium silaifolium* (Jacq.) Simonkai} - H, ME - **4** (Sam.176), **13** (Sam.177), **18** (Sam.488), **24** (Sam.619), **27** (Sam.653)
\+ ***Smyrnium perfoliatum*** subsp. ***rotundifolium*** (Mill.) Hartvig - H, Me - **3** (Sam.164, Sam.165), **10** (Sam.166)
\+ ***Tordylium apulum*** L. - T, Me - **97** (Sam.1128), **98** (Sam.581)
* ***Tordylium maximum*** L. - T, EA - W&W (2008:153)
Torilis africana Spreng. {= *T. arvensis* subsp. *purpurea* (Ten.) Hayek} - T, ME - W&W (2008:154), **1** (Sam.158), **2** (Sam.159), **3** (Sam.160, Sam.161), **6** (Sam.162), **12** (Sam.163), **16** (Sam.450), **56** (Sam.894), **85** (Sam.1154), **87** (Sam.1191)
\+ ***Torilis leptophylla*** (L.) Rchb. f. - T, EA - **90** (Sam.1393)

APOCYNACEAE

\+ ***Nerium oleander*** L. - P, Me - obs.
\+ ***Vinca major*** L. subsp. ***major*** - C, ME - obs.

AQUIFOLIACEAE

\+ ***Ilex aquifolium*** L. - P, ME - **83** (Sam.1056)

ARALIACEAE

\+ ***Hedera helix*** L. subsp. ***helix*** - P, ME - **3** (Sam.75), **5** (Sam.76), **11** (Sam.77)

ARISTOLOCHIACEAE

\+ ***Aristolochia elongata*** (Duch.) E. Nardi - G, Bk - **3** (Sam.3), **13** (Sam.4), **15** (Sam.435)
\+ ***Aristolochia rotunda*** subsp. ***insularis*** (Nardi & Arrigoni) Gamisans - G, ME - **3** (Sam.5)

ASTERACEAE **(*COMPOSITAE*)**

\+ ***Achillea grandifolia*** Friv. - H, BA - **84** (Sam.1081)
\+ ***Achillea nobilis*** subsp. ***neilreichii*** (A. Kern.) Velen. - H, EA - **90** (Sam.1394)
\+ ***Aetheorhiza bulbosa*** (L.) Cass. s.lat. - G, Me - **15** (Sam.418)
\+ ***Anthemis tinctoria*** subsp. ***parnassica*** (Boiss. & Heldr.) Nyman - H, Bk - **24** (Sam.617)
* ***Anthemis arvensis*** L. subsp. ***arvensis*** - T, EA - W&W (2006:43)
* ***Anthemis cotula*** L. - T, EA - W&W (2006:43)
* ***Anthemis ruthenica*** M. Bieb. - T, EA - W&W (2008:52)
\+ ***Bellis annua*** L. subsp. ***annua*** - T, Me - **1** (Sam.260)
* ***Bellis perennis*** L. - H, EA - W&W (2006:47)
* ***Carduus pycnocephalus*** L. - H, ME - W&W (2008:64)
\+ ***Carlina corymbosa*** subsp. ***graeca*** (Heldr. & Sartori) Nyman - H, BA - **5** (Sam.267), **10** (Sam.268), **14** (Sam.269), **15** (Sam.425), **22** (Sam.595), **85** (Sam.1278), **88** (Sam.1196), **89** (Sam.1230), **54** (Sam.876)
\+ ***Centaurea pichleri*** Boiss. - H, BA - **78** (Sam.1027)
* ***Centaurea salonitana*** Vis. - H, EA - W&W (2008:67)
* ***Centaurea solstitialis*** L. subsp. ***solstitialis*** - H, Me - W&W (2008:67)
* ***Chondrilla juncea*** L. - H, ME - W&W (2006:55)
Cichorium intybus L. - H, EA - W&W (2008:72), **85** (Sam.1274)
* ***Cirsium ligulare*** subsp. ***albanum*** Wettst. - H, Bk - W&W (2006:57)
\+ ***Crepis fraasii*** Sch. Bip. subsp. ***fraasii*** - H, EM - **2** (Sam.272), **3** (Sam.273), **4** (Sam.274), **12** (Sam.275), **13** (Sam.276), **22** (Sam.601)
* ***Crepis neglecta*** L. s.lat. {"Crepis capillaris (L.) Walk."} - T, BI - W&W (2008:77)
* ***Crepis setosa*** Haller f. - T, EA - W&W (2008:77)
\+ ***Crupina crupinastrum*** (Moris) Vis. - T, EA - **90** (Sam.1402)
* ***Dittrichia graveolens*** (L.) Greuter - T, Me - W&W (2006:64)
Doronicum orientale Hoffm. - G, EA - B&Q (1976:29), **3** (Sam.277), **11** (Sam.278, Sam.279), **16** (Sam.456)
* ***Erigeron bonariensis*** L. {= *Conyza bonariensis* (L.) Cronquist} - H, X - W&W (2006:58)
* ***Erigeron canadensis*** L. {= *Conyza canadensis* (L.) Cronquist} - H T, X - W&W (2006:59)
* ***Filago germanica*** (L.) Huds. {= *Filago vulgaris* Lam.} - T, Pt - W&W (2008:86)
* ***Glebionis segetum*** (L.) Fourr. {= *Chrysanthemum segetum* L. } - T, Me - W&W (2008:72)
* ***Helminthotheca echioides*** (L .) Holub {= *Picris echioides* L.} - T, Me - W&W (2008:124)
\+ ● ***Hieracium bracteolatum*** subsp. ***reinholdii*** (Boiss.) Zahn - H, Endem. - **24** (Sam.616), **35** (Sam.734), **41** (Sam.764), **48** (Sam.1280), **57** (Sam.899)
* ***Hypochaeris achyrophorus*** L. - T, Me - W&W (2008:98)
* ***Hypochaeris radicata*** L. - H, EA - W&W (2008:98)
\+ ***Lactuca hispida*** DC. {= *Cephalorrhynchus tuberosus* (Steven) Schcian} - G, EA - **51** (Sam.850)
\+ ***Lactuca muralis*** (L.) Gaertn. {= *Mycelis muralis* (L.) Dumort.} - H, Pt - **11** (Sam.290)
Lapsana communis subsp. ***adenophora*** (Boiss.) Rech. f. - H, BA - B&Q (1976:29), **52** (Sam.856), **64** (Sam.937), **70** (Sam.969), **72** (Sam.979), **84** (Sam.1077)

Leontodon tuberosus L. - H, Me - W&W (2006:76), **1** (Sam.289), **15** (Sam.423), **19** (Sam.509), **31** (Sam.689), **88** (Sam.1202), **89** (Sam.1228)

Matricaria chamomilla L.{= *Chamomilla recutita* (L.) Rauschert} - T, Co - W&W (2008:71), obs.

\+ ***Pilosella bauhini*** subsp. ***magyarica*** (Peter) S. Bräut. in Greuter & Raus {= *Hieracium bauhini* Schult.} - H, EA - **3** (Sam.280), **12** (Sam.282), **76** (Sam.1003), **89** (Sam.1233)

\+ ***Pilosella cymosa*** subsp. ***sabina*** (Sebast.) H.P. Fuchs - H, EA - **13** (Sam.285), **81** (Sam.1042)

\+ ***Ptilostemon strictus*** (Ten.) Greuter in Greuter & Rech. f. - H, BI - **11** (Sam.270), **35** (Sam.733), **42** (Sam.780), **48** (Sam.829, 1281)

\+ ***Rhagadiolus stellatus*** (L.) Gaertn. - T, Me - **1** (Sam.291), **7** (Sam.292), **15** (Sam.422), **16** (Sam.454)

Scolymus hispanicus L. subsp. ***hispanicus*** - H, Me - W&W (2006:91), obs.

\+ ***Scorzoneroides cichoriacea*** (Ten.) Greuter in Greuter, Gutermann & Talavera {= *Leontodon cichoriaceus* (Ten.) Sanguin.} - G, Me - **2** (Sam.286), **3** (Sam.287, Sam.288), **16** (Sam.455), **18** (Sam.490), **19** (Sam.510), **22** (Sam.600), **28** (Sam.1264), **85** (Sam.1172)

* ***Senecio vulgaris*** L. - T, Pt - W&W (2006:91)

Sonchus asper (L.) Hill subsp. ***asper*** - T, Pt - W&W (2008:148), **100** (Sam 568)

* ***Symphyotrichum squamatum*** (Spreng.) G.L. Nesom {= *Aster squamatus* (Spreng.) Hieron.} - C H, X - W&W (2006:44)

* ***Tanacetum parthenium*** (L.) Sch. Bip. - H, EA - W&W (2006:98)

* ***Xanthium spinosum*** L. - T, X - W&W (2006:104)

* ***Xanthium strumarium*** L. subsp. ***strumarium*** - T, Pt - W&W (2006:104)

BETULACEAE

\+ ***Carpinus orientalis*** Mill. subsp. ***orientalis*** - P, EA - **3** (Sam.6), **68** (Sam.960), **74** (Sam.985), **76** (Sam.1001)

\+ ***Ostrya carpinifolia*** Scop. - P, MS - **41** (Sam.763), **64** (Sam.932), **81** (Sam.1083), **100** (Sam.571)

\+ ***Alnus glutinosa*** (L.) Gaertn. subsp. ***glutinosa*** - P, ES - **130** (Sam.564)

\+ ***Corylus avellana*** L. - P, EA - **64** (Sam.941)

BORAGINACEAE

\+ ● ***Alkanna calliensis*** Boiss.- H, Endem. - **91** (Sam.1378), **123** (Sam. 559)

\+ ***Anchusa undulata*** subsp. ***hybrida*** (Ten.) Bég. - H, Me - **90** (Sam.1391)

\+ ***Buglossoides purpurocaerulea*** (L.) I. M. Johnst. - H, EA - **3** (Sam.258, Sam.259), **15** (Sam.427), **102** (Sam.529)

Echium italicum subsp. ***biebersteinii*** (Lacaita) Greuter & Burdet - H, MS - W&W (2008:82), obs.

* ***Heliotropium europaeum*** L. - T, ME - W&W (2006:71)

* ***Heliotropium hirsutissimum*** Grauer - T, EM - W&W (2006:72)

\+ ***Myosotis ramosissima*** Rochel subsp. ***ramosissima*** - T, EA - **1** (Sam.252), **2** (Sam.253), **3** (Sam.254), **15** (Sam.428), **30** (Sam.677), **31** (Sam.691), **32** (Sam.692), **42** (Sam.771), **78** (Sam.1024)

Myosotis sylvatica subsp. ***cyanea*** (Hayek) Vestergren - H T, Me - B&Q (1976:29), **4** (Sam.255), **11** (Sam.256), **12** (Sam.257), **42** (Sam.778), **43** (Sam.788), **44** (Sam.795), **45** (Sam.816), **51** (Sam.851), **53** (Sam.870), **65** (Sam.944), **69** (Sam.964), **74** (Sam.988), **75** (Sam.991), **76** (Sam.999), **80** (Sam.1037), **81** (Sam.1044), **82** (Sam.1048), **83** (Sam.1064)

\+ ***Neatostema apulum*** (L.) I. M. Johnst. - T, Me - obs.

Symphytum bulbosum K. F. Schimp. - G, Me - B&Q (1976:29), **1** (Sam.250), **13** (Sam.251)

***BRASSICACEAE* (*CRUCIFERAE*)**

\+ ***Aethionema saxatile*** subsp. ***graecum*** (Boiss. & Spruner) Hayek - C, BA - **90** (Sam.1415)

+ ***Alliaria petiolata*** (M. Bieb.) Cavara & Grande - H, Pt - **70** (Sam.972)
+ ***Alyssum montanum*** subsp. ***repens*** (Baumg.) Schmalh. - C, ME - **90** (Sam.1416)
+ ***Alyssum simplex*** Rudolphi {= *Alyssum minus* (L.) Rothm.} - T, ES - **97** (Sam.1125), **125** (Sam.1137)
+ ***Arabis collina*** Ten. - H, Me - **73** (Sam.984)
+ ***Arabis glabra*** (L.) Bernh. - H, Eu - **91** (Sam.1365)
+ ***Arabis turrita*** L. - H, EA - **51** (Sam.849)
+ ***Arabis verna*** (L.) R. Br. in W. T. Aiton - T, Me - **79** (Sam.1250)

Capsella bursa-pastoris (L.) Medik. - T H, Co - W&W (2008:63), obs.

+ ***Cardamine bulbifera*** (L.) Crantz - G, Eu - **64** (Sam.939)
+ ***Cardamine graeca*** L. - T, Me - **2** (Sam.7), **14** (Sam.8)
+ ***Cardamine hirsuta*** L. - T, Co - **2** (Sam.9), **11** (Sam.10), **16** (Sam.463)
+ ***Draba muralis*** L. - T, ME - **85** (Sam.1163), **78** (Sam.1023)
+ ● ***Erysimum asperulum*** Boiss. & Heldr. in Boiss. - H, Endem. - **91** (Sam.1366)
+ ***Erysimum microstylum*** Hausskn. - H, Bk - **90** (Sam.1417)
+ ***Lepidium draba*** L. subsp. ***draba*** - G H, Co - **111** (Sam.575)
+ ***Nasturtium officinale*** R. Br. - H, Co - **120** (Sam.533)

* ***Raphanus raphanistrum*** L. subsp. ***raphanistrum*** - T, EA - W&W (2008:135)
Rapistrum rugosum (L.) All. - T, EA - W&W (2008:135), **103** (Sam.s.n.), **105** (Sam.538)
Sisymbrium officinale (L.) Scop. - T, ES/[Co] - W&W (2008:147), **105** (Sam.539)

CAESALPINIACEAE

Cercis siliquastrum L. - P, MS - B&Q (1976:15), obs.

CAMPANULACEAE

* ***Campanula ramosissima*** Sm. - T, Me - W&W (2008:63)
* ***Campanula sparsa*** subsp. ***sphaerothrix*** (Griseb.) Hayek - T, Bk - B&Q (1976:29)

+ ***Campanula spatulata*** subsp. ***spruneriana*** (Hampe) Hayek - G, Bk - **1** (Sam.263), **2** (Sam.264), **3** (Sam.265), **12** (Sam.266), **44** (Sam.794), **84** (Sam.1080), **29** (Sam.1270)

Campanula trachelium subsp. ***athoa*** (Boiss. & Heldr.) Hayek - H, Bk - B&Q (1976:29), **41** (Sam.765), **84** (Sam.1076)

+ ***Legousia speculum-veneris*** (L.) Chaix - T, ME - **90** (Sam.1405)

CAPRIFOLIACEAE

+ ***Lonicera etrusca*** Santi - P, Me - **21** (Sam.525), **3** (Sam.262)

* ***Lonicera implexa*** Aiton - P, Me - B&Q (1976:15)

CARYOPHYLLACEAE

+ ***Arenaria serpyllifolia*** L. - T, EA - **14** (Sam.11)
+ ***Cerastium brachypetalum*** subsp. ***roeseri*** (Boiss. & Heldr.) Nyman - T, Me - **31** (Sam.686), **32** (Sam.697), **54** (Sam.875), **77** (Sam.1012), **78** (Sam.1020)
+ ***Cerastium brachypetalum*** subsp. ***tenoreanum*** (Ser.) Soó - T, Eu - **16** (Sam.461), **28** (Sam.659), **85** (Sam.1174)
+ ***Cerastium glomeratum*** Thuill. - T, Co - **104** (Sam.376)
+ ***Dianthus viscidus*** Bory & Chaub - H, BA - **7** (Sam.398)
+ ***Petrorhagia illyrica*** (L.) P. W. Ball & Heywood subsp. ***illyrica*** - H, Bk - **91** (Sam.1375)
+ ***Minuartia recurva*** subsp. ***condensata*** (C. Presl) Greuter & Burdet - H C, ME - **90** (Sam.1418)
+ ***Minuartia hybrida*** (Vill.) Schischk in Kom. - T, EA - **90** (Sam.1420)
+ ***Moehringia pentandra*** J. Gay - T, Me - **67** (Sam.958)

\+ ***Moenchia mantica*** (L.) Bartl. - T, ME - **31** (Sam.685), **54** (Sam.874), **105** (Sam.546)
\+ ***Petrorhagia dubia*** (Raf.) G. López & Romo - T, Me - **90** (Sam.1419), **105** (Sam.544)
\+ ***Petrorhagia obcordata*** (Margot & Reut.) Greuter & Burdet - T, BA - **91** (Sam.1371)
\+ ***Lychnis coronaria*** (L.) Desr. {= *Silene coronaria* (L.) Clairv.} - H, MS - **35** (Sam.729)
\+ ***Silene conica*** L. - T, EA - **90** (Sam.1422)
\+ ***Silene cretica*** L. - T, Me - **105** (Sam.545)
Silene italica (L.) Pers. subsp. ***italica*** - H, EA - B&Q (1976:29), **2** (Sam.12), **4** (Sam.14), **12** (Sam.13), **28** (Sam.1259)
\+ ***Silene multicaulis*** Guss. subsp. ***multicaulis*** - H, BI - **84** (Sam.1073)
\+ ***Silene viridiflora*** L. - H, ES - **56** (Sam.892)
\+ ***Silene vulgaris*** subsp. ***bosniaca*** (Beck) Greuter, Burdet & Long - H, Me - **12** (Sam.15)
\+ ***Stellaria cupaniana*** Jord. & Fourr. - T, Me - **1** (Sam.20), 2 (Sam.21), **15** (Sam.433), **16** (Sam.460), **17** (Sam.478), **18** (Sam.496), **28** (Sam.1257), **87** (Sam.1183), **89** (Sam.1221)
\+ ***Stellaria media*** (L.) Vill. - T H, Co - **3** (Sam.17), **4** (Sam.18), **11** (Sam.19), **18** (Sam.495), **43** (Sam.785a), **45** (Sam.817), **53** (Sam.867), **78** (Sam.1245), **79** (Sam. 1249), **85** (Sam.1168), **87** (Sam.1187), **16** (Sam. 1241)
\+ ***Velezia rigida*** L. - T, MS - **91** (Sam.1380)

CHENOPODIACEAE
* ***Atriplex patula*** L. - T, ES - W&W (2006:45)
* ***Chenopodium album*** L. - T, Co - W&W (2008:71)
* ***Chenopodium opulifolium*** Sehrad. - T, EA - W&W (2006:53)
* ***Chenopodium vulvaria*** L. - T, EA - W&W (2006:54)
* ***Dysphania ambrosioides*** (L.) Mosyakin & Clemants {= *Chenopodium ambrosioides* L.} - T H, X - W&W (2006:52)
* ***Dysphania botrys*** (L.) Mosyakin & Clemants {= *Chenopodium botrys* L.} - T, EA - W&W (2006:53)

CISTACEAE
Cistus creticus L. subsp. ***creticus*** - C, Me - B&Q (1976:15), **5** (Sam.78), **19** (Sam.507)
\+ ***Cistus salviifolius*** L. - C, Me - **106** (Sam.565)
\+ ***Helianthemum nummularium*** (L.) Mill. subsp. ***nummularium*** - C, Me - **107** (Sam.1099)
\+ ***Tuberaria guttata*** (L.) Fourr. - T, MA - **113** (Sam.1208)

CONVOLVULACEAE
Calystegia silvatica (Kit.) Griseb. - H, MS - W&W (2008:62), obs.
\+ ***Convolvulus arvensis*** L. - H G, Co - **90** (Sam.1388)
\+ ***Cuscuta brevistyla*** A. Rich. - T, ST - **42** (Sam.773)

CORNACEAE
\+ ***Cornus mas*** L. - P, EA - **3** (Sam.79)

CRASSULACEAE
\+ ***Sedum amplexicaule*** subsp. ***tenuifolium*** (Sm.) Greuter - C H, Me - **14** (Sam.22), **25** (Sam.630), **52** (Sam.863), **90** (Sam.1382)
\+ ***Sedum cepaea*** L. - T, Me - **30** (Sam.682), **35** (Sam.739), **44** (Sam.800), **57** (Sam.898)
\+ ***Sedum hispanicum*** L. - H C, EA - **90** (Sam.1384)
\+ ***Umbilicus luteus*** (Huds.) Webb & Berthel. - G, Me - **82** (Sam.1051)

CUCURBITACEAE

* ***Ecballium elaterium*** (L.) A. Rich. - G, MS - W&W (2006:65)

DIPSACACEAE

* ***Knautia integrifolia*** (L.) Bertol. subsp. ***integrifolia*** - T, Me - W&W (2008:99)
\+ ***Pterocephalus plumosus*** (L.) Coult. - T, MS - **91** (Sam.1367)
* ***Scabiosa columbaria*** L. subsp. ***columbaria*** - H, EA - W&W (2008:141)
* ***Scabiosa atropurpurea*** L. {= *Sixalix atropurpurea* (L .) Greuter & Burdet} - H, Me - W&W (2006:93)

ERICACEAE

\+ ***Hypopitys monotropa*** Crantz subsp. ***monotropa*** {= *Monotropa hypopitys* L.} - G, Bo - **41** (Sam.769)

EUPHORBIACEAE

\+ ***Euphorbia apios*** L. - G, Me - **3** (Sam.80, Sam.81), **24** (Sam.622)
\+ ***Euphorbia peplus*** L. - T, Co - **15** (Sam.410), **88** (Sam.1197)
\+ ***Euphorbia phymatosperma*** subsp. ***cernua*** (Coss. & Durieu) Vindt - T, Me - **17** (Sam.468), **32** (Sam.698), **36** (Sam.742), **56** (Sam.893)
* ***Euphorbia prostrata*** Aiton - T, X - W&W (2006:69)

FABACEAE

\+ ***Astragalus glycyphyllos*** subsp. ***glycyphylloides*** (DC.) Maire & Petitm. - C, BA - **44** (Sam.849)
\+ ***Astragalus pelecinus*** (L.) Barneby - T, Me - **125** (Sam.1149)
\+ ***Bituminaria bituminosa*** (L.) C.H. Stirt. - H, ME - **97** (Sam.1129)
Chamaecytisus hirsutus (L.) Link subsp. ***hirsutus*** {= *C. triflorus* (Lam.) Skalická} - C, Eu - B&Q (1976:29), **7** (Sam.97), **35** (Sam.725)
\+ ***Colutea arborescens*** L. subsp. ***arborescens*** - P, EA - **100** (Sam.572)
\+ ***Dorycnium herbaceum*** Vill. - H, ME - **49** (Sam.840)
Dorycnium hirsutum (L.) Ser. - H C, Me - B&Q (1976:15), **22** (Sam.599), **23** (Sam.609)
\+ ***Genista tinctoria*** L. subsp. ***tinctoria*** - C, ES - **24** (Sam.615), **30** (Sam.674), **62** (Sam.922), **111** (Sam.574)
\+ ***Hippocrepis emerus*** subsp. ***emeroides*** (Boiss. & Spruner) Greuter & Burdet ex Lassen {= *Coronilla emerus* subsp. *emeroides* (Boiss. & Spruner) Lassen} - P, EM - **27** (Sam.650, **59** (Sam.906, **100** (Sam.569
\+ ***Hymenocarpos circinnatus*** (L.) Savi - T, Me - **97** (Sam.1126)
\+ ***Lathyrus aphaca*** L. - T, MS - **1** (Sam.98), **3** (Sam.99), **18** (Sam.551)
\+ ***Lathyrus cicera*** L. - T, MS - **103** (Sam.s.n.), **116** (Sam.1130)
\+ ***Lathyrus digitatus*** (M. Bieb.) Fiori in Fiori & Paol. - H, Me - **3** (Sam.100), **16** (Sam.449), **61** (Sam.918), **62** (Sam.920), **73** (Sam.982)
\+ ***Lathyrus grandiflorus*** Sm. - H, BI - **76** (Sam.1006)
Lathyrus laxiflorus (Desf.) Kuntze - H, EM - B&Q (1976:29), **2** (Sam.101), **3** (Sam.102), **4** (Sam.103)
\+ ***Lathyrus niger*** (L.) Bernh. - H, ME - **11** (Sam.148), **25** (Sam.635), **35** (Sam.728), **44** (Sam.789), **44** (Sam.789)
\+ ***Lathyrus nissolia*** L. - T, ME - **21** (Sam.523)
\+ ***Lathyrus sphaericus*** Retz. - T, EA - **2** (Sam.104), **3** (Sam.105), **10** (Sam.106), **15** (Sam.891), **56** (Sam.408)
\+ ***Lathyrus venetus*** (Mill.) Wohlf. - H, Eu - **35** (Sam.726)

+ ***Lens ervoides*** (Brign.) Grande - T, Me - **107** (Sam.1100)
+ ***Lotus conimbricensis*** Brot. - T, Me - **125** (Sam.1148)
+ ***Lotus corniculatus*** L. - H, EA - **117** (Sam.707)
+ ***Medicago arabica*** (L.) Huds. - T, EA - **1** (Sam.107)
+ ***Medicago coronata*** (L.) Bartal. - T, MS - **112** (Sam.1109)
+ ***Medicago disciformis*** DC. - T, Me - **97** (Sam.1119)
+ ***Medicago minima*** (L.) Bartal. - T, Pt - **97** (Sam.1116, 1118), **107** (Sam.1102)
+ ***Medicago orbicularis*** (L.) Bartal. - T, MS - **97** (Sam.1115)
+ ***Medicago polymorpha*** L. - T, Pt - **97** (Sam.1114)
* ***Medicago sativa*** L. subsp. ***sativa*** - H, EA - W&W (2006:78)
+ ***Onobrychis caput-galli*** (L.) Lam. - T, Me - **97** (Sam.1117), **98** (Sam.580)
Ornithopus compressus L. - T, Me - W&W (2008:120), **21** (Sam.522, Sam.555)
+ ***Robinia pseudoacacia*** L. - P, X - obs.
+ ***Scorpiurus muricatus*** L. - T, Me - **97** (Sam.1127)
+ ***Securigera varia*** (L.) Lassen {= *Coronilla varia* L.} - H, EA - **81** (Sam.1084)
+ ***Spartium junceum*** L. - P, Me - obs.
+ ***Trifolium angustifolium*** L. - T, EA - **10** (Sam.108), **21** (Sam.521), **29** (Sam.670)
Trifolium arvense L. - T, Pt - W&W (2008:156), **31** (Sam.683), **24** (Sam.612), **110** (Sam.577)
+ ***Trifolium campestre*** Schreb. - T, EA - **3** (Sam.109), **22** (Sam.594), **29** (Sam.667), **32** (Sam.701), **57** (Sam.897), **125** (Sam.1136)
+ ***Trifolium grandiflorum*** Schreb. - T, MS - **1** (Sam.127), **2** (Sam.128), **12** (Sam.129), **24** (Sam.611), **25** (Sam.631), **28** (Sam.657, Sam.1261), **29** (Sam.668), **85** (Sam.1158), **111** (Sam.573)
+ ***Trifolium heldreichianum*** Hausskn. - G, BA - **7** (Sam.110, Sam.399), **25** (Sam.632), **32** (Sam.695), **33** (Sam.712)
+ ***Trifolium hirtum*** All. - T, Me - **90** (Sam. 1381)
+ ***Trifolium medium*** subsp. ***balcanicum*** Velen. - G, Bk - **14** (Sam.131), **44** (Sam.793), **47** (Sam.823), **49** (Sam.833), **50** (Sam.839), **55** (Sam.885a), **71** (Sam.974), **74** (Sam.987), **80** (Sam.1036), **81** (Sam.1043), **84** (Sam.1078)
* ***Trifolium nigrescens*** Viv. - T, Me - W&W (2006:100)
Trifolium ochroleucon subsp. ***roseum*** (C. Presl) Lassen in Greuter & Raus - H, Me - B&Q (1976:29), 2 (Sam.112), **3** (Sam.113), **12** (Sam.114), **16** (Sam.448), **19** (Sam.502), **23** (Sam.604), **25** (Sam.633), **29** (Sam.671), **30** (Sam.673), **47** (Sam.824), **48** (Sam.827), **55** (Sam.885b), **83** (Sam.1061)
+ ***Trifolium pannonicum*** Jacq. - G, ME - **67** (Sam.956), **78** (Sam.1026)
+ ***Trifolium patulum*** Tausch - G, BI - **24** (Sam.614), **35** (Sam.724), **36** (Sam.743)
Trifolium physodes M. Bieb. - H, Me - B&Q (1976:29), **1** (Sam.122), **2** (Sam.123), **3** (Sam.124), **12** (Sam.125), **14** (Sam.126), **26** (Sam.642)
Trifolium pignantii Fauché & Chaub. - G, Bk - B&Q (1976:29), **2** (Sam.115), **4** (Sam.116), **6** (Sam.117), **7** (Sam.118), **11** (Sam.119), **12** (Sam.120), **14** (Sam.121), **27** (Sam.649), **32** (Sam.694), **33** (Sam.713), **85** (Sam.1164), **111** (Sam.576)
* ***Trifolium pratense*** L. - H, EA - W&W (2006:100)
* ***Trifolium repens*** L. - H, Pt - W&W (2006:101)
+ ***Trifolium scabrum*** L. - T, EA - **91** (Sam.1374), **97** (Sam.1113)
+ ***Trifolium stellatum*** L. - T, Me - **19** (Sam.505), **89** (Sam.1215), **112** (Sam.1108), **21** (Sam.556)
+ ***Trifolium subterraneum*** L. - T, ME - **1** (Sam.130), **19** (Sam.504), **21** (Sam.520), **114** (Sam.1104)
+ ***Trifolium tenuifolium*** Ten. - T, EM - **24** (Sam.613), **29** (Sam.669), **42** (Sam.775), **54** (Sam.873)
+ ***Trifolium tomentosum*** L. - T, Me - **125** (Sam.1147)
* ***Trigonella corniculata*** (L.) L. subsp. ***corniculata*** - T, Me - W&W (2006:101)

+ ***Tripodion tetraphyllum*** (L.) Fourr. {= *Anthyllis tetraphylla* L.} - T, Me - **98** (Sam.582)
* ***Vicia angustifolia*** L. {= *Vicia sativa* (L.) Ehrh. subsp. *nigra*} - T, Pt - W&W (2006:103)
+ ***Vicia bithynica*** (L.) L. - T, Me - **113** (Sam.1211)
+ ***Vicia cassubica*** L. - H, EA - **4** (Sam.147), **18** (Sam.487), **33** (Sam.714), **35** (Sam.727), **38** (Sam.748)
* ***Vicia cracca*** L. - H, Ct - W&W (2006:103)
Vicia grandiflora Scop. - T, ME - W&W (2008:168), **2** (Sam.132), **3** (Sam.133, Sam.134), **7** (Sam.136, Sam.137), **10** (Sam.138), **26** (Sam.643), **28** (Sam.1258), **30** (Sam.675), **31** (Sam.684), **32** (Sam.696, Sam.700), **41** (Sam.766), **42** (Sam.772, Sam.779), **45** (Sam.813), **67** (Sam.957a), **117** (Sam.708)
+ ***Vicia hirsuta*** (L.) Gray - T, Pt - **2** (Sam.139), **3** (Sam.140, Sam.141), **10** (Sam.142), **15** (Sam.404), **16** (Sam.447), **18** (Sam.486), **19** (Sam.499), **21** (Sam.518)
+ ***Vicia incisa*** M. Bieb. {= *V. sativa* L. subsp. *incisa* (M.Bieb.) Arcang.} - T, EM - **2** (Sam.145), **3** (Sam.146), **32** (Sam.693)
+ ***Vicia lathyroides*** L. - T, ME - **1** (Sam.143), **3** (Sam.144), **13** (Sam.149), **15** (Sam.407), **21** (Sam.519b), **38** (Sam.747), **44** (Sam.790), **54** (Sam.871), **57** (Sam.896), **76** (Sam.1005), **77** (Sam.1010), **78** (Sam.1097), **79** (Sam.1251), **103** (Sam.s.n.), **114** (Sam.1105)
+ ***Vicia pannonica*** subsp. ***striata*** (M. Bieb) Nyman - T, ME - **103** (Sam.s.n.)
+ ***Vicia pubescens*** (DC.) Link - T, Me - **15** (Sam.405), **89** (Sam.1216)
+ ***Vicia tenuifolia*** subsp. ***dalmatica*** (A. Kern.) Greuter in Greuter & Raus - H, ME - **19** (Sam.500)
+ ***Vicia tetrasperma*** (L.) Shreb. - T, Pt - **17** (Sam.406), **19** (Sam.501), **29** (Sam.666), **34** (Sam.720)
Vicia villosa subsp. ***varia*** (Host) Corb. - T, ME - B&Q (1976:29), **105** (Sam.541)

FAGACEAE

Castanea sativa Mill. - P, Eu - B&Q (1976:29), **81** (Sam.1040), **82** (Sam.1052)
+ ***Quercus coccifera*** L. - P, Me - **4** (Sam.25)
Quercus frainetto Ten. - P, BA - B&Q (1976:29), **1** (Sam.26), **3** (Sam.34), **4** (Sam.37), **5** (Sam.35, Sam.36b), **7** (Sam.28), **11** (Sam.27, Sam.39), **14** (Sam.44), **24** (Sam.621), **25** (Sam.628), **26** (Sam.638), **27** (Sam.647), **89** (Sam.1212)
+ ***Quercus petraea*** subsp. ***polycarpa*** (Schur) Soó **-** P, Eu - **4** (Sam.29), **11** (Sam.30), **12** (Sam.31), **13** (Sam.32), **26** (Sam.639), **80** (Sam.1034, Sam.1089), **93** (Sam.1071), **115** (Sam.1086)
Quercus pubescens Willd. - P, ME - B&Q (1976:15), **1** (Sam.33), **5** (Sam.36a), **4** (Sam.38), **11** (Sam.40), **14** (Sam.41, Sam.43, Sam.45)

FUMARIACEAE

+ ***Corydalis cava*** (L.) Schweigger & Körte - G, EA - **78** (Sam.1094)
+ ***Fumaria officinalis*** L. subsp. ***officinalis*** - T, Pt - **105** (Sam.543)

GENTIANACEAE

+ ***Blackstonia perfoliata*** (L.) Huds. subsp. ***perfoliata*** - T, ME - obs.
+ ***Centaurium erythraea*** Rafn s.lat. - T H, EA - **24** (Sam.623, Sam.624)

GERANIACEAE

+ ***Erodium cicutarium*** (L.) L' Hér. in Aiton - T, Ct - **90** (Sam.1397), **116** (Sam.1131)
+ ***Geranium asphodeloides*** Burm. f. subsp. ***asphodeloides*** - H, MS - **3** (Sam.82, Sam.83, Sam.84), **49** (Sam.841), **52** (Sam.855)
+ ***Geranium columbinum*** L. - T, EA - **1** (Sam.85), **117** (Sam.710)
+ ***Geranium dissectum*** L. - T, EA - **21** (Sam.553)
Geranium lucidum L. - T, EA - W&W (2008:91), **1** (Sam.86), **12** (Sam.87), **44** (Sam.799)

\+ ***Geranium peloponesiacum*** Boiss. - H, Bk - 119 (Sam.530), **18** (Sam.489), **28** (Sam.1256), **39** (Sam.755), **44** (Sam.798), **52** (Sam.854), **79** (Sam.1030)
\+ ***Geranium pusillum*** Burm. f. - T, EA - **15** (Sam.413)
\+ ***Geranium molle*** L. - T, Pt - **1** (Sam.88)
\+ ***Geranium purpureum*** Vill. - T, Me - **1** (Sam.89), **3** (Sam.90), **13** (Sam.91), **14** (Sam.92), **15** (Sam.414), **16** (Sam.453), **34** (Sam.721), **85** (Sam.1161), **89** (Sam.1231)
\+ ***Geranium rotundifolium*** L. - T, Pt - **1** (Sam.93)

***HYPERICACEAE* (*GUTTIFERAE*)**

\+ ***Hypericum perfoliatum*** L. - H, Me - **23** (Sam.606)
Hypericum perforatum L. subsp. ***veronense*** (Schrank) A. Fröhl. - H, Pt - W&W (2006:73), **7** (Sam.397)
\+ ***Hypericum spruneri*** Boiss. - H, BI - **2** (Sam.95), **3** (Sam.96), **4** (Sam.94), **15** (Sam.412), **23** (Sam.605), **24** (Sam.620), **26** (Sam.641), **30** (Sam.676), **52** (Sam.862), **62** (Sam.923), **66** (Sam.950), **77** (Sam.1013)

JUGLANDACEAE

\+ ***Juglans regia*** L. - P, ME - obs.

***LAMIACEAE* (*LABIATAE*)**

\+ ***Ajuga reptans*** L. - G, EA - **64** (Sam.936), **120** (Sam.532)
* ***Ballota nigra*** L. - H, EA - W&W (2006:46)
\+ ***Clinopodium alpinum*** subsp. ***meridionale*** *(Nyman) Govaerts* {= *Acinos alpinus* subsp. *meridionalis* (Nyman) P.W. Ball; *Satureja alpina* subsp. *meridionalis* (Nyman) Greuter & Burdet} - H, Me - **90** (Sam.1395)
\+ ***Clinopodium grandiflorum*** (L.) Kuntze {= *Calamintha grandiflora* (L.) Moench; *Satureja grandiflora* (L.) Scheele} - H, ME - **53** (Sam.865)
* ***Clinopodium nepeta*** subsp. ***glandulosum*** (Req.) Govaerts {= *Calamintha nepeta* subsp. *glandulosa* (Req.) P.W. Ball }- H, ME - W&W (2008:62)
Clinopodium vulgare subsp. ***orientale*** Bothmer {= *Satureja vulgaris* subsp. *orientalis* (Bothmer) Greuter & Burdet, "C. vulgare subsp. arundanum (Boiss.) Nyman"} - H, Me - B&Q (1976:29), **91** (Sam.1379), **3** (Sam.239), **4** (Sam.238), **15** (Sam.429), **17** (Sam.474), **19** (Sam.512), **22** (Sam.593), **83** (Sam.1060)
\+ ***Lamium bifidum*** subsp. ***balcanicum*** Velen. - T, Bk - **1** (Sam.246), **3** (Sam.247), **79** (Sam.1254), **87** (Sam.1186)
\+ ***Lamium bifidum*** Cirillo subsp. ***bifidum*** - T, Me - **104** (Sam.390)
\+ ***Lamium garganicum*** L. subsp. ***garganicum*** - H, Me - 14 (Sam.248, Sam.249), **55** (Sam.886), **65** (Sam.946), **82** (Sam.1049), **84** (Sam.1079), **122** (Sam.1098)
\+ ***Lamium purpureum*** L. - T, EA - **104** (Sam.395)
* ***Marrubium peregrinum*** L. - H, Eu - W&W (2006:77)
\+ ***Melissa officinalis*** L. subsp. ***officinalis*** - H, Me - **132** (Sam.1032)
* ***Melittis melissophyllum*** subsp. ***albida*** (Guss.) P.W. Ball - H, Eu - B&Q (1976:29)
* ***Mentha spicata*** subsp. ***condensata*** (Briq.) Greuter & Burdet {= *Mentha microphylla* K. Koch} - H, Me - W&W (2006:78)
* ***Mentha pulegium*** L. - H, Me - W&W (2006:79)
* ***Micromeria graeca*** (L.) Rchb. subsp. ***graeca*** - C, Me - B&Q (1976:15)
\+ ***Origanum vulgare*** subsp. ***hirtum*** (Link) A. Terracc. - H G, BA - **1** (Sam.245), **16** (Sam.458), **21** (Sam.526), **22** (Sam.592), **52** (Sam.859)
\+ ***Phlomis fruticosa*** L. - P, Me - **1** (Sam.244)

\+ ***Prunella vulgaris*** L. - H, EA - **54** (Sam.877)
\+ ***Salvia argentea*** L. - H, Me - **91** (Sam.1363)
\+ ***Scutellaria columnae*** All. subsp. ***columnae*** - H, Me - **26** (Sam.645), **18** (Sam.491), **53** (Sam.866)
\+ ***Stachys germanica*** subsp. ***heldreichii*** (Boiss.) Hayek - H, EM - **90** (Sam.1390)
\+ ● ***Stachys graeca*** Boiss. & Heldr. in Boiss. {"Stachys acutifolia Bory & Chaub."} - H, Endem. - **15** (Sam.437), **20** (Sam.516), **117** (Sam.711)
* ***Teucrium capitatum*** L. subsp. ***capitatum*** - C, Me - B&Q (1976:15)
\+ ***Teucrium chamaedrys*** L. subsp. ***chamaedrys*** - C, Me - **16** (Sam.464), **22** (Sam.588), **85** (Sam.1173), **91** (Sam.1377)
* ***Teucrium divaricatum*** Heldr. s.lat. - C, EM - B&Q (1976:15)
Thymus longicaulis subsp. ***chaubardii*** (Rchb. f.) Jalas {= *Thymus ocheus* Boiss.} - C, BA - B&Q (1976:29), **1** (Sam.240), **3** (Sam.241, Sam.242), **5** (Sam.243), **25** (Sam.636), **26** (Sam.644), **42** (Sam.776), **52** (Sam.858), **59** (Sam.908), **80** (Sam.1038), **90** (Sam.1385)

LORANTHACEAE
\+ ***Loranthus europaeus*** Jacq. - P, EA - obs.

MALVACEAE
* ***Abutilon theophrastii*** Medik. - T, EA - W&W (2006:36)
* ***Malva sylvestris*** L. - T H, EA - W&W (2006:77)

MORINACEAE
\+ ***Morina persica*** L. - H, MS - obs.

OLEACEAE
\+ ***Fraxinus angustifolia*** subsp. ***oxycarpa*** (Willd.) Franco & Rocha Afonso - P, EA - **4** (Sam.231), **11** (Sam.232), **14** (Sam.233, Sam.234, Sam.235)
\+ ***Fraxinus ornus*** L. - P, ME - **3** (Sam.236), **14** (Sam.237), **44** (Sam.792)
Phillyrea latifolia L. - P, Me - B&Q (1976:15), **3** (Sam.230)

ONAGRACEAE
* ***Epilobium hirsutum*** L. - H, EA - W&W (2006:67)
\+ ***Epilobium lanceolatum*** Sebast. & Mauri - H, EA - **65** (Sam.947), **45** (Sam.812), **69** (Sam.965), **77** (Sam.1011)

PAPAVERACEAE
Papaver rhoeas L. - T, Pt - W&W (2008:121), obs.

PLANTAGINACEAE
* ***Plantago major*** L. subsp. ***major*** - H, EA - W&W (2008:127)

PLATANACEAE
\+ ***Platanus orientalis*** L. - P, EM - obs.

PLUMBAGINACEAE
* ***Plumbago europaea*** L. - C P, Me - W&W (2006:84)

POLYGONACEAE
* ***Persicaria maculosa*** Gray - T, EA - W&W (2008:122)

* ***Polygonum arenarium*** Waldst. & Kit. - T, EA - W&W (2006:84)
* ***Polygonum arenastrum*** Boreau - T, EA - W&W (2006:85)
* ***Polygonum aviculare*** L. subsp. ***aviculare*** - T, Ct - W&W (2006:85)
* ***Rumex pulcher*** L. subsp. ***pulcher*** - H, MS - W&W (2008:138)
\+ ***Rumex tuberosus*** L. subsp. ***tuberosus*** - G, MS - **13** (Sam.48), **39** (Sam.752), **76** (Sam.1000)
\+ ***Rumex acetosella*** subsp. ***acetoselloides*** (Balansa) Nijs - H, EA - **90** (Sam.1383)

PRIMULACEAE
* ***Cyclamen graecum*** Link subsp. ***graecum*** - G, EM - W&W (2006:61)
\+ ***Cyclamen hederifolium*** Aiton subsp. ***hederifolium*** - G, Me - **1** (Sam.228), **3** (Sam.229), **44** (Sam.802), **85** (Sam.1275**)**, **125** (Sam.1273)
\+ ***Lysimachia atropurpurea*** L. - G, BA - **123** (Sam.562)
\+ ***Lysimachia punctata*** L. - H, Eu - **35** (Sam.740), **64** (Sam.935)

PUNICACEAE
* ***Punica granatum*** L. - P, X - W&W (2008:132)

RANUNCULACEAE
\+ ***Anemone apennina*** subsp. ***blanda*** (Schott & Kotschy) Nyman - G, EM - **3** (Sam.49, Sam.50), **45** (Sam.811), **52** (Sam.857), **64** (Sam.933)
\+ ***Anemone pavonina*** Lam. - G, Me - **1** (Sam.51), **3** (Sam.52, Sam.53)
\+ ***Clematis flammula*** L. - P, MS - **3** (Sam.54), **10** (Sam.55), **21** (Sam.527)
* ***Clematis vitalba*** L. - P, EA - W&W (2006:57)
\+ ***Consolida ajacis*** (L.) Schur {''Consolida ambigua"} - T, Me - **91** (Sam.1370)
* ***Delphinium peregrinum*** L. - T, MS - W&W (2006:63)
\+ ***Ficaria*** subsp. ***ficariiformis*** (F. W. Schultz) B. Walln. {= *Ranunculus ficaria* subsp. *ficariiformis* (F. W. Schultz) Rouy & Fouc.} - G, Me - **1** (Sam.62), **2** (Sam.63)
Helleborus odorus subsp. ***cyclophyllus*** (A. Braun) Maire & Petitm. - G, Bk - B&Q (1976:29), **3** (Sam.56, Sam.57), **4** (Sam.58), **11** (Sam.59), **35** (Sam.732)
Nigella damascena L. - T, Me - W&W (2008:116), **90** (Sam.1400), **91** (Sam.1369)
\+ ***Ranunculus gracilis*** E. D. Clarke - H, BA - **18** (Sam.494), **120** (Sam.535), **16** (Sam.1093)
\+ ***Ranunculus neapolitanus*** Ten. {= *R. bulbosus* subsp. *neapolitanus* (Ten.) H. Lindb., "R. bulbosus subsp. aleae (Willk.) Rouy & Fouc."} - H, Me - **1** (Sam.64), **3** (Sam.65, Sam.66), **6** (Sam.67), **15** (Sam.432), **120** (Sam.534a)
\+ ***Ranunculus paludosus*** Poir. - H, ME - **3** (Sam.60, Sam.61), **15** (Sam.431), **19** (Sam.513), **85** (Sam.1153), **89** (Sam.1223)
\+ ***Ranunculus psilostachys*** Griseb. - H, Bk - **7** (Sam.68), **17** (Sam.476), **18** (Sam.493), **85** (Sam.1160a), **16** (Sam.1239**)**
\+ ***Ranunculus velutinus*** Ten. - H, Me - **17** (Sam.477), **43** (Sam.786), **78** (Sam.1025), **120** (Sam.534b)

RHAMNACEAE
Paliurus spina-christi Mill. - P, EA - B&Q (1976:15), **85** (Sam.1160b)

ROSACEAE
\+ ***Agrimonia eupatoria*** L. subsp. ***eupatoria*** - H, EA - **3** (Sam.215), **1** (Sam.214), **15** (Sam.416), **22** (Sam.591)
Aremonia agrimonoides (L.) DC. subsp. ***agrimonoides*** - H, BC - B&Q (1976:29), **1** (Sam.209), **3** (Sam.210, Sam.211, Sam.213), **4** (Sam.212)

\+ ***Crataegus monogyna*** Jacq. - P, Pt - **1** (Sam.204), **10** (Sam.205), **11** (Sam.206), **13** (Sam.207), **14** (Sam.208), **17** (Sam.472)
\+ ***Geum urbanum*** L. - H, EA - **69** (Sam.967), **124** (Sam.1096)
\+ ***Malus sylvestris*** (L.) Mill. subsp. ***sylvestris*** - P, Eu - **81** (Sam.1085)
\+ ***Potentilla inclinata*** Vill. - H, EA - **35** (Sam.741), **90** (Sam.1398)
Potentilla micrantha DC. in Lam. & DC. - H, EA - B&Q (1976:29), **3** (Sam.199, Sam.200), **4** (Sam.201), **11** (Sam.202), **27** (Sam.651), **33** (Sam.715), **39** (Sam.754), **40** (Sam.760), **51** (Sam.853), **52** (Sam.861), **83** (Sam.1068)
\+ ***Prunus avium*** (L.) L. - P, EA - **49** (Sam.842), **69** (Sam.962), **70** (Sam.968), **84** (Sam.1074)
Prunus cocomilia Ten. - P, EM - B&Q (1976:15), obs.
\+ ***Prunus domestica*** subsp. ***insititia*** (L.) Bonnier & Layens - P, EA - **3** (Sam.190), **7** (Sam.191), **11** (Sam.192, Sam.193), **13** (Sam.194), **14** (Sam.195), **17** (Sam.471), **26** (Sam.640), **34** (Sam.723), **35** (Sam.731), **52** (Sam.860), **64** (Sam.931), **65** (Sam.945), **66** (Sam.948), **76** (Sam.1002), **84** (Sam.1075)
\+ ***Prunus mahaleb*** L. subsp. ***mahaleb*** - P, EA - 4 (Sam.196), **11** (Sam.197, Sam.198), **44** (Sam.791), **49** (Sam.843), **55** (Sam.884)
* ***Pyrus communis*** L. - P, EA - B&Q (1976:29)
\+ ***Pyrus spinosa*** Forssk. {= *P. amygdaliformis* Vill.} - P, Me - **15** (Sam.417), **74** (Sam.986)
\+ ***Rosa arvensis*** Huds. - P, Me - **3** (Sam.182, 183, 401, 402, 403), **4** (Sam.184), **7** (Sam.400), **21** (Sam.524), **45** (Sam.807a), **64** (Sam.929b), **66** (Sam.949), **82** (Sam.1054), **85** (Sam.1166), **88** (Sam.1194), **89** (Sam.1224)
\+ ***Rosa canina*** L. - P, Pt - **10** (Sam.186), **45** (Sam.807b), **56** (Sam.889), **59** (Sam.905), **64** (Sam.930)
\+ ***Rosa pulverulenta*** M. Bieb. {= *R. glutinosa* Sm.} - P, ME - **4** (Sam.187), **11** (Sam.189)
\+ ***Rosa tomentosa*** Sm. in Sm. & Sowerby - C, ME - **64** (Sam.929a), **70** (Sam.970), **82** (Sam.1055), **86** (Sam.1179)
\+ ***Rubus canescens*** DC. - P, EA - **1** (Sam.178), **2** (Sam.179), **3** (Sam.180), **4** (Sam.181), **41** (Sam.762), **64** (Sam.926), **70** (Sam.971), **80** (Sam.1035), **83** (Sam.1069)
\+ ***Rubus hirtus*** Waldst. & Kit. - P, EA - **64** (Sam.927), **81** (Sam.1041), **83** (Sam.1058, Sam.1070)
Rubus sanctus Schreb. {= *R. ulmifolius* Schott} - P, MS - W&W (2006:88), **64** (Sam.928)
\+ ***Sanguisorba minor*** subsp. ***balearica*** (Nyman) Muños Garm. & C. Navaro {= *S. minor* subsp. *muricata* (Bonnier & Layens) Briq.} - H, EA - **15** (Sam.415), **22** (Sam.597), **100** (Sam.570), **123** (Sam.560)
Sorbus torminalis (L.) Crantz - P, EA - B&Q (1976:29), **25** (Sam.629), **58** (Sam.904)
\+ ***Sorbus umbellata*** (Desf.) Fritsch in A. Kern. - P, BA - **83** (Sam.1059)

RUBIACEAE
\+ ***Crucianella angustifolia*** L. - T, ME - **7** (Sam.296), **91** (Sam.1376)
\+ ***Cruciata pedemontana*** (Bellardi) Ehrend. - T, EA - **7** (Sam.295)
\+ ***Galium aparine*** L. - T, EA - **1** (Sam.297), **2** (Sam.298), **3** (Sam.299), **11** (Sam.300), **41** (Sam.768), **45** (Sam.810)
\+ ***Galium heldreichii*** Halácsy - H, BA - **16** (Sam.457), **17** (Sam.473), **19** (Sam.511), **22** (Sam.589), **25** (Sam.634), **27** (Sam.655), **30** (Sam.680), **31** (Sam.687), **45** (Sam.808), **48** (Sam.828), **49** (Sam.845), **50** (Sam.838), **60** (Sam.912), **72** (Sam.978b), **85** (Sam.1171), **88** (Sam.1193), **89** (Sam.1226)
\+ ***Galium hellenicum*** Krendl - H, Bk - **22** (Sam.590), **27** (Sam.654), **31** (Sam.688), **37** (Sam.744), **39** (Sam.753), **43** (Sam.787), **44** (Sam.805), **44** (Sam.796), **45** (Sam.809), **47** (Sam.825), **49** (Sam.844), **49** (Sam.834), **50** (Sam.837), **54** (Sam.878), **60** (Sam.911), **62** (Sam.919), **63** (Sam.924), **69** (Sam.966), **72** (Sam.978a), **73** (Sam.981), **76** (Sam.1004), **87** (Sam.1190)
\+ ***Galium laconicum*** Boiss. & Heldr. in Boiss. - H, BA - **72** (Sam.977)
\+ ***Galium rotundifolium*** L. - H, EA - **17** obs.

* ***Rubia peregrina*** L. - P, MA - B&Q (1976:15)
\+ ***Sherardia arvensis*** L. - T, EA - **15** (Sam.426), **125** (Sam.1146, Sam.1135), **126** (Sam.1103)

SALICACEAE
\+ ***Populus alba*** L. - P, EA - obs.
\+ ***Salix alba*** L. - P, EA - **130** (Sam.563)
\+ ***Salix amplexicaulis*** Bory & Chaub. in Bory - P, Me - **133** (Sam.536)

SANTALACEAE
\+ ***Thesium divaricatum*** Mert. & W. D. J. Koch - H, ME - **24** (Sam.625), **30** (Sam.679)
\+ ***Viscum album*** subsp. ***abietis*** (Wiesb.) Abrom. in Wünsche - P, EA - obs.

SAXIFRAGACEAE
\+ ***Saxifraga carpetana*** subsp. ***graeca*** (Boiss. & Heldr.) D. A. Webb - H, Me - **2** (Sam.69), **28** (Sam.658, Sam.1263), **45** (Sam.815)
\+ ***Saxifraga rotundifolia*** subsp. ***chrysosplenifolia*** (Boiss.) D. A. Webb - H, Bk - **119** (Sam.531)

SCROPHULARIACEAE
* ***Verbascum blattaria*** L. - H, EA - W&W (2006:102)
\+ ***Verbascum undulatum*** Lam. - H, Bk - **91** (Sam.1373)

SOLANACEAE
* ***Lycium chinense*** Mill. - P, X - W&W (2006:77)
* ***Solanum nigrum*** L. - P, Co - W&W (2006:94)

URTICACEAE
* ***Parietaria judaica*** L. {= *Parietaria diffusa* Mert. & W. D. J. Koch} - H, EA - W&W (2008:122)

VERBENACEAE
* ***Verbena officinalis*** L. - H, Ct - W&W (2006:103)
Vitex agnus-castus L. - P, MS - B&Q (1976:15), W&W (2006:104), obs.

VERONICACEAE
Digitalis ferruginea L. subsp. ***ferruginea*** - H, ME - B&Q (1976:29), **13** (Sam.227), **72** (Sam.975), **76** (Sam.998, Sam.1087)
\+ ***Digitalis grandiflora*** Mill. - H, Eu - 55 (Sam.882)
\+ ***Digitalis laevigata*** subsp. ***graeca*** (Ivanina) Werner - H, Bk - **35** (Sam.730), **55** (Sam.883), **72** (Sam.976)
* ***Kickxia commutata*** subsp. ***graeca*** (Bory & Chaub.) R. Fem. - H, EM - W&W (2006:75)
* ***Linaria pelisseriana*** (L.) Mill. - T, MS - W&W (2008:104)
\+ ***Veronica anagallis-aquatica*** L. subsp. ***anagallis-aquatica*** - H T, Co - **134** (Sam.1212)
\+ ***Veronica arvensis*** L. - T, EA - **1** (Sam.218), **32** (Sam.702), **34** (Sam.719), **38** (Sam.749), **56** (Sam.890), **89** (Sam.1222)
● ***Veronica chamaedrys*** subsp. ***chamaedryoides*** (Bory & Chaub.) M.A. Fisch. in Strid & Tan - H, Endem. - B&Q (1976:29), **1** (Sam.219), **3** (Sam.220), Sam.221), **4** (Sam.222), **83** (Sam.1063)
\+ ***Veronica cymbalaria*** Bodard - T, Me - **1** (Sam.223), **2** (Sam.224), **3** (Sam.225), **15** (Sam.430), **16** (Sam.459), **17** (Sam.475), **18** (Sam.492), **43** (Sam.785b), **79** (Sam.1255), **85** (Sam.1170)
\+ ***Veronica hederifolia*** L. - T, EA - **3** (Sam.226), **78** (Sam.1243)

VALERIANACEAE

\+ ***Valerianella carinata*** Loisel. - T, EA - **15** (Sam.434), **79** (Sam.1253)

\+ ***Valerianella coronata*** (L.) DC. - T, EA - **90** (Sam.1421), **97** (Sam.1112)

\+ ***Valerianella locusta*** (L.) Laterr. - T, EA - **2** (Sam.301), **16** (Sam.462), **29** (Sam.1266), **85** (Sam.1176)

VIOLACEAE

\+ ***Viola aetolica*** Boiss. & Heldr. - H, Bk - **83** (Sam.1065)

\+ ***Viola alba*** subsp. ***dehnhardtii*** (Ten.) W. Becker - H, Me - **3** (Sam.150, Sam.151), **4** (Sam.152), **10** (Sam.153), **11** (Sam.154), **46** (Sam.822)

\+ ***Viola kitaibeliana*** Schult. in Roem. & Schult. - T, ME - **90** (Sam.1399)

ZYGOPHYLACEAE

* ***Tribulus terrestris*** L. - T, Co - W&W (2006:99)

SPERMATOPHYTA – ANGIOSPERMAE
MONOCOTYLEDONEAE

ALLIACEAE

\+ ***Allium guttatum*** subsp. ***tenorei*** (Parl.) Soldano {= *A. guttatum* subsp. *sardoum* (Moris) Stearn} - G, Me - **3** (Sam.358), **10** (Sam.359)

* ***Allium sphaerocephalon*** L. subsp. ***sphaerocephalon*** - G, ME - W&W (2008:47)

AMARYLLIDACEAE

* ***Sternbergia lutea*** (L.) Spreng. subsp. ***lutea*** - G, MS - W&W (2006:97)

ARACEAE

\+ ***Arum cylindraceum*** Gasp. {= *A. alpinum* Schott & Kotschy} - G, ME - **7** (Sam.302), **13** (Sam.303), **17** (Sam.480)

ASPARAGACEAE

Asparagus acutifolius L. - C, Me - B&Q (1976:15), **5** (Sam.360), **85** (Sam.1155)

ASPHODELACEAE

\+ ***Asphodelus ramosus*** L. subsp. ***ramosus*** {“A. aestivus Brot.”} - G, Me - **127** (Sam.552)

CYPERACEAE

\+ ***Carex distachya*** Desf. - H, ME - **15** (Sam.441), **32** (Sam.699), **66** (Sam.952), **67** (Sam.959), **85** (Sam.1159)

\+ ***Carex divulsa*** Stokes - H, EA - **86** (Sam.1177)

\+ ***Carex flacca*** subsp. ***serrulata*** (Spreng.) Greuter in Greuter & Rech. f. - G, MS - **3** (Sam.305, Sam.304), **17** (Sam.485), **85** (Sam.1152), **86** (Sam.1178), **89** (Sam.1225)

\+ ***Carex pendula*** Huds. - H, EA - **135** (Sam.558)

DIOSCOREACEAE

\+ ***Dioscorea communis*** (L.) Caddick & Wilkin {= *Tamus communis* L.} - G, ME - **17** (Sam.479), **35** (Sam.735), **82** (Sam.1050)

HYACINTHACEAE

\+ ***Muscari comosum*** (L.) Mill. - G, ME - **1** (Sam.361), **17** (Sam.481)
Prospero autumnale (L.) Speta - G, Me - W&W (2006:91), **125** (Sam.1271)

IRIDACEAE

\+ ***Iris tuberosa*** L. {= *Hermodactylus tuberosus* (L.) Mill.} - G, Me - **15** (Sam.439)

JUNCACEAE

Luzula forsteri (Sm.) DC. - H, Me - B&Q (1976:29), **2** (Sam.357)

ORCHIDACEAE

\+ ***Anacamptis morio*** subsp. ***caucasica*** (K. Koch) H. Kretzschmar, Eccarius & H. Dietr. - G, MS - obs.
\+ ***Cephalanthera longifolia*** (L.) Fritsch - G, EA - **35** (Sam.736), **59** (Sam.910)
\+ ***Cephalanthera rubra*** (L.) Rich. - G, EA - **14** (Sam.363), **76** (Sam.1007)
\+ ***Dactylorhiza romana*** subsp. ***romana*** {= *D. sambucina* (L.) Soó subsp. *pseudosambucina* (Ten.) Sunderm.} - G, Me - **26** (Sam.646), **28** (Sam.664, Sam.1260), **29** (Sam.672, Sam.1267), **39** (Sam.756), **49** (Sam.835)
\+ ***Epipactis helleborine*** (L.) Grantz subsp. ***helleborine*** - G, Pt - **45** (Sam.818), **48** (Sam.830), **75** (Sam.992), **76** (Sam.1008), **83** (Sam.1066)
\+ ***Epipactis microphylla*** (Ehrh.) Sw. - G, EA - **4** (Sam.365)
\+ ***Limodorum abortivum*** (L.) Sw. - G, Me - **44** (Sam.803)
\+ ***Neotinea maculata*** (Desf.) Stearn - G, Me - **33** (Sam.716), **54** (Sam.881), **57** (Sam.901), **66** (Sam.951), **16** (Sam.1092)
\+ ***Neottia nidus-avis*** (L.) Rich. - G, EA - **41** (Sam.770), **44** (Sam.804), **75** (Sam.994)
* ***Ophrys apifera*** Huds. - G, ME - H (1985)
* ***Ophrys helenae*** Renz - G, Bk - T&A (2017)
* ***Ophrys holoserica*** (Burm. f.) Greuter subsp. ***holoserica*** - G, Me - H (1985)
Ophrys sphegodes subsp. ***mammosa*** (Desf.) Soo ex E. Nelson - G, ME - obs., K (1983), H (1985), T&A (2017)
Ophrys sphegodes subsp. ***spruneri*** (Nyman) E. Nelson - G, EM - obs., H (1985), T&A (2017)
* ***Ophrys tenthredinifera*** Willd. - G, Me - T&A (2017)
\+ ***Ophrys umbilicata*** Desf. subsp. ***umbilicata*** - G, Me - obs.
* ***Orchis anthropophora*** (L.) All. - G, MA - T&A (2017)
Orchis italica Poir. in Lam. & al. - G, Me - **103** (Sam.1236), T&A (2017)
\+ ***Orchis provincialis*** Lam. & DC. - G, ME - **28** (Sam.665), **29** (Sam.1268), **39** (Sam.758), **43** (Sam.784), **44** (Sam.801), **48** (Sam.831), **54** (Sam.880), **55** (Sam.887), **57** (Sam.900), **58** (Sam.903), **59** (Sam.909), **74** (Sam.989), **81** (Sam.1047)
\+ ***Platanthera chlorantha*** (Custer) Rchb. in Mössler - G, ES. - **28** (Sam.663), **35** (Sam.737)
Spiranthes spiralis (L.) Chevall. - G, EA - **85** (Sam.1977), T&A (2017)

POACEAE

Achnatherum bromoides (L.) P. Beauv. {= *Stipa bromoides* (L.) Dörfl.} - H, Me - B&Q (1976:15), **3** (Sam.354, Sam.355), **15** (Sam.442), **16** (Sam.466), **19** (Sam.515), **22** (Sam.602), **66** (Sam.953), **89** (Sam.1229)
\+ ***Aegilops biuncialis*** Vis. subsp. ***biuncialis*** {= *A. lorentii* Hochst.} - T, MS - **90** (Sam.1408)
\+ ***Aegilops geniculata*** Roth - T, Me - **125** (Sam. 1145)
\+ ***Aira elegantissima*** Schur - T, MS - **30** (Sam.678), **31** (Sam.690)
\+ ***Anthoxanthum odoratum*** L. - H, Co - **5** (Sam.306), **15** (Sam.446)

Arrhenatherum elatius (L.) J. Presl & C. Presl - H, Pt - B&Q (1976:29), **2** (Sam.307), **3** (Sam.308, Sam.309,), **4** (Sam.310), **12** (Sam.314)
Brachypodium pinnatum (L.) P. Beauv. - H, ES - B&Q (1976:29), **3** (Sam.318), **40** (Sam.761)
Brachypodium sylvaticum (Huds.) P. Beauv. subsp. ***sylvaticum*** - H, Pt - B&Q (1976:29), W&W (2008:59), **4** (Sam.326), **15** (Sam.443), **17** (Sam.483)
\+ ***Briza maxima*** L. - T, ST - **25** (Sam.637)
* ***Bromus sterilis*** L. - T, MS - W&W (2008:61)
\+ ***Bromus tectorum*** L. - T, Pt - **90** (Sam.1414)
* ***Catapodium rigidum*** (L.) C. E. Hubb. - T, Me - W&W (2008:67)
Cynosurus echinatus L. - T, Me - W&W (2008:79), **3** (Sam.330), **5** (Sam.331)
Cynosurus effusus Link. {= *C. elegans* Desf.} - T, Me - B&Q (1976:29), **4** (Sam.329), **12** (Sam.332), **15** (Sam.445), **16** (Sam.1238), **21** (Sam.528), **28** (Sam.1262), **88** (Sam.1195)
Dactylis glomerata subsp. ***hispanica*** (Roth) Nyman - H, Me - B&Q (1976:29), **1** (Sam.334), **3** (Sam.335, Sam.336), **4** (Sam.337)
\+ ***Dasypyrum villosum*** (L.) P. Candargy - T, MS - **90** (Sam.1410)
* ***Digitaria sanguinalis*** (L.) Scop. subsp. ***sanguinalis*** - T, Co - W&W (2006:63)
\+ ***Elymus caninus*** (L.) L. {= *Agropyron caninum* L.} - H, ES - **22** (Sam.602), **23** (Sam.607)
\+ ***Elymus panormitanus*** (Parl.) Tzvelev {= *Roegneria panormitana* (Parl.) Nevski} - H, Me - **3** (Sam.338), **46** (Sam.821)
* ***Eragrostis cilianensis*** (All.) Janch. subsp. ***cilianensis*** - T, Co - W&W (2006:68)
* ***Eragrostis minor*** Host subsp. ***minor*** - T, Co - W&W (2006:68)
* ***Eragrostis pilosa*** (L.) P. Beauv. - T, Co - W&W (2006:68)
\+ ***Festuca heterophylla*** Lam. - H, Eu - **6** (Sam.340), **35** (Sam.738), **37** (Sam.745), **39** (Sam.759), **44** (Sam.806), **47** (Sam.826), **49** (Sam.836, Sam.846), **55** (Sam.888), **57** (Sam.902), **60** (Sam.915), **63** (Sam.925), **68** (Sam.961), **71** (Sam.973), **72** (Sam.980), **129** (Sam.781)
\+ ***Festuca valesiaca*** subsp. ***valesiaca*** - H, EA - **14** (Sam.342), **75** (Sam.995), **78** (Sam.1028)
* ***Holcus lanatus*** L. - H, ES - W&W (2008:95)
* ***Hordeum murinum*** L. subsp. ***murinum*** - T, MS - W&W (2008:96)
\+ ***Koeleria lobata*** (M. Bieb.) Roem. & Schult. {= *K. splendes* C. Presl} - H, Me - **90** (Sam.1412)
* ***Lolium rigidum*** Gaudin subsp. ***rigidum*** - T, ST - W&W (2008:106)
Melica uniflora Retz. - H, Pt - B&Q (1976:29), **11** (Sam.344), **14** (Sam.346)
\+ ***Phleum phleoides*** (L.) H. Karst. {= *P. montanum* K. Koch} - H, Eurosib. - **42** (Sam.777), **54** (Sam.879), **90** (Sam.1409)
* ***Phleum subulatum*** (Savi) Asch. & Graebn. - T, Me - W&W (2008:124)
* ***Poa annua*** L. - T, Co - W&W (2008:127)
\+ ***Poa bulbosa*** L. subsp. ***bulbosa*** - H, Pt - **2** (Sam.347, **12** (Sam.348), **15** (Sam.440), **16** (Sam.465), **19** (Sam.514), **28** (Sam.1265), **38** (Sam.750), **85** (Sam.1175), **89**(Sam.1227)
* ***Poa nemoralis*** L. subsp. ***nemoralis*** - H, ES - B&Q (1976:29)
\+ ***Poa trivialis*** subsp. ***sylvicola*** (Guss.) H. Lindb. - H, EA - **1** (Sam.349), **2** (Sam.350), **3** (Sam.351, Sam.352), **17** (Sam.482), **18** (Sam.498), **22** (Sam.603), **24** (Sam.626), **38** (Sam.751), **46** (Sam.820), **81** (Sam.1046), **85** (Sam.1167), **89** (Sam.1218)
\+ ***Secale strictum*** (C. Presl) C. Presl subsp. ***strictum*** {= *S. montanum* Guss.} - H, MS - **90** (Sam.1413)
* ***Setaria viridis*** (L.) P. Beauv. subsp. ***viridis*** - T, Co - W&W (2006:92)
* ***Sorghum halepense*** (L.) Pers. - G, X - W&W (2006:96)
\+ ***Taeniatherum caput-medusae*** subsp. ***crinitum*** (Schreb.) Melderis - T, Me - **90** (Sam.1406)
* ***Tragus racemosus*** (L.) All. - T, Co - W&W (2006:99)

RUSCACEAE
Ruscus aculeatus L. - G C, ME - B&Q (1976:15), **2** (Sam.362)

Table 1. Numbers of plant families, genera, species, subspecies and taxa in the three main taxonomic groups of the vascular flora of Mt. Goulinas.

	Families	Genera	Species	Subspecies	Specific and subspecific taxa
Pteridophytes	4	4	6	2	6
Gymnosperms	3	3	3	1	3
Angiosperms	74	278	475	139	478
Total	81	285	484	142	487

Spectra and notes on the floristic catalogue – The so far known vascular flora of Mt Goulinas consists of 487 taxa, belonging to 81 families and 285 genera (Table 1). From these, 381 taxa were either collected or observed by the first author, while 106 literature references could not be confirmed. From the total number of taxa, 305 are reported for the first time. Among the new references we can mention *Euphorbia phymatosperma* subsp. c*ernua* and *Elymus caninus*, two taxa that are reported for the first time from Sterea Ellas. *Campanula sparsa* subsp. *sphaerothrix,* although not confirmed for Mt Goulinas, was collected by the first author from the neighbour Mt Oxia (unpublished material) and therefore the report from Barbéro & Quézel (1976) may be correct. Six (6) Greek endemics are reported from Mt Goulinas, five (5) of them for the first time: *Abies cephalonica*, *Hieracium bracteolatum* subsp. *reinholdii*, *Alkanna calliensis*, *Erysimum asperulum* and

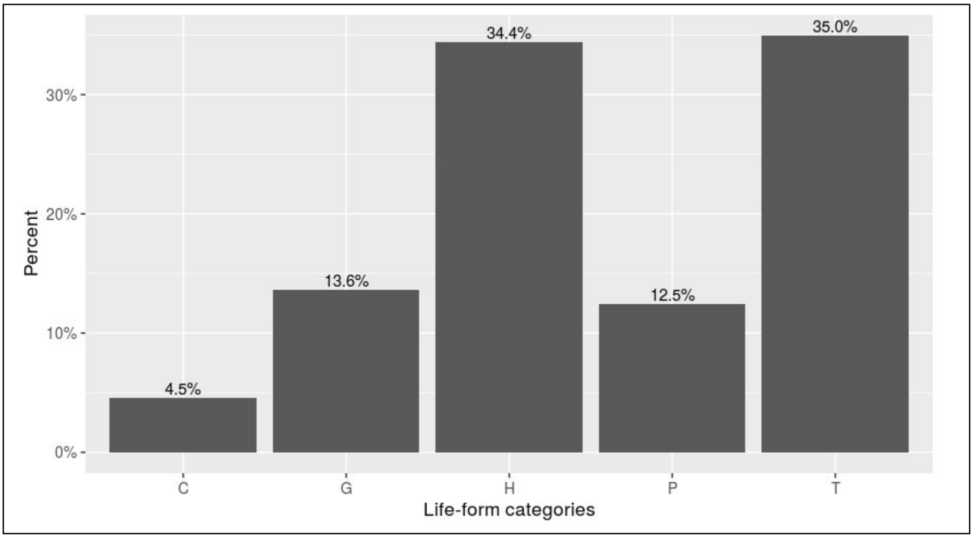

Fig. 2. Life-form spectrum of the vascular flora of Mt Goulinas. P: Phanerophytes, C: Chamaephytes, H: Hemicryptophytes, G: Geophytes, T: Therophytes.

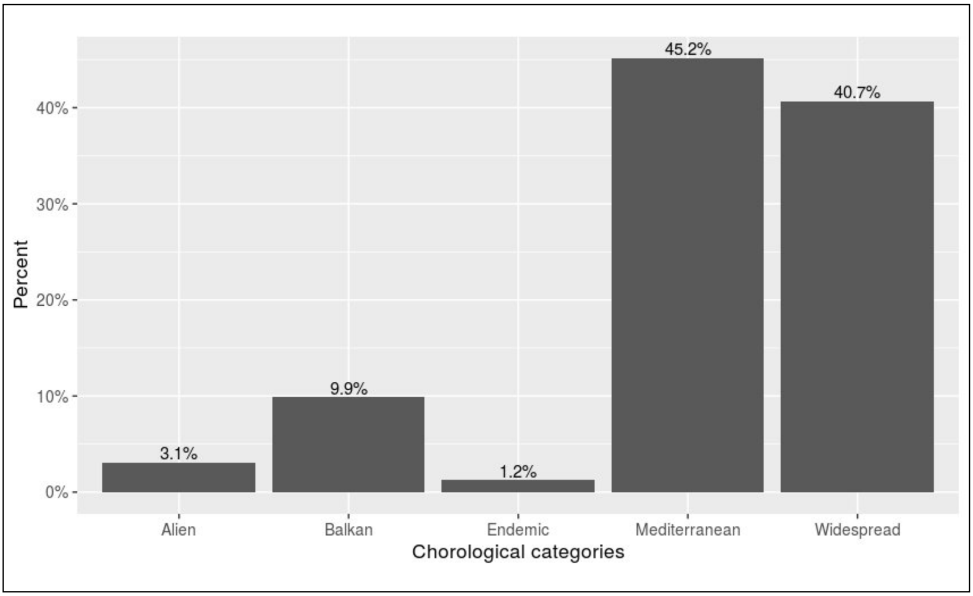

Fig. 3. Chorological spectrum of the vascular flora of Mt Goulinas.

Stachys graeca. Forty eight (48) Balkan and sub-Balkan endemics are also reported, 36 of which are new records for the study area.

Hemicryptophytes and therophytes are the most abundant plant life forms in the flora of Mt Goulinas with a proportion of 34.4 % and 35 % respectively (Fig. 2). Geophytes and phanerophytes follow with 13.6 % and 12.5 % respectively, while chamaephytes are by far the less abundant (4.5 %). The most abundant chorological group of plants are the Mediterranean taxa (220 taxa – 45.2 %), followed by the Widespread taxa (198 taxa – 40.7 %) (Fig. 3). The proportion of Balkan taxa, Greek endemics and Aliens is much lower (9.9 %, 1.2 % and 3.1 % respectively).

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Addresses of the authors:
Dimitrios A. Samaras[1,2], Eleni Eleftheriadou[1], Konstantinos Theodoropoulos[1] & Georgios Karetsos[2],
[1]Aristotle University of Thessaloniki, School of Forestry and Natural Environment, Laboratory of Forest Botany - Geobotany, P.O. Box 270, University Campus, GR-54124, Thessaloniki, Greece
[2]Hellenic Agricultural Organization «DEMETER», Institute of Mediterranean Forest Ecosystems, P.O. Box 14180, Terma Alkmanos, Ilisia, GR-11528, Athens, Greece
Corresponding author: Dimitrios A. Samaras, E-mail: mail@dimitrios-samaras.net

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Francesco M. Raimondo & Vivienne Spadaro

First finding in Sicily of *Bidens subalternans* (*Asteraceae*)

Abstract

Raimondo, F. M. & Spadaro, V.: First finding in Sicily of *Bidens subalternans* (*Asteraceae*). — Fl. Medit. 27: 267-273. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

It is reported the presence in Sicily of a new alien species destined to a progressive further spread in the Island. It is *Bidens subalternans* DC., an annual asteracea of American origin, already known in other Italian regions (Friuli Venezia Giulia, Lombardia, Marche, Lazio and Campania) and in other European countries (Belgium, Corse, Croatia, Cyprus, France, Germany, Great Britain, Montenegro, Republic of Serbia, Slovenia, Spain, Switzerland). The new locality, in Sicily, occurs along the roadside Monreale – Pioppo, south of the city of Palermo. In this station, *B. subalternans* is found together with *B. pilosa* subsp. *minor* and other indigenous and exotic nitrophilous taxa. The population observed near Monreale (Palermo), is quite large and, according to the methods of dispersion, shows in Sicily an invasive tendency in favourable environment. The affinities of *B. subalternans* with *B. bipinnata* L. – with which the species was sometimes confused – is also discussed.

Key words: Alien flora, vascular plants, Italy, Mediterranean area.

Introduction

Bidens L. is a genus of the *Asteraceae* known since a long time in Europe; in fact, some of its species are to be considered native (Tutin & al. 1974.). The Italian flora includes 11 species (Conti & al. 2005, 2007): three of them are considered native (Bartolucci & al. in press). In Sicily, a species of this genus was already reported by Ucria (1789) and even earlier - in prelinnean times - by Cupani in his *Panphyton Siculum* of 1713 (Pastena & al. 2003). *Bidens* L. has been up to now represented by 6 specific and infraspecific taxa and among them is *B. bipinnata* L. (Giardina & al. 2007), taxon reported in various locality of the island, and that shows some similarities with other taxa with which in the past it could even be confused.

During distributive studies in W Sicily on *B. pilosa* L., we had the opportunity to find a dense population of another species of the genus, initially confused with *B. pinnata* L. The comparison of the new collected materials with other herbarium specimens housed in PAL allowed to attribute this population to *B. subalternans* DC., a taxon that has been recorded in the Italian peninsula since several decades. This finding is the object of ours contribution.

Taxonomy

On the basis of two characters (achenes and bristled awns), the collected samples of *Bidens* are attributed to *B. subalternans* DC. (Cabrera 1974; Tutin 1976; Bogosavljević & Zlatković 2015).

Bidens subalternans DC., Prodr. 5:600. 1836. [*B. quadrangularis* DC. *loc. cit*., *B. platensis* Manganaro, Ann. Nus. Nac. Buenos Aires, 24: 230. 1913] (Fig. 1)

Annual herb, with erect stem, branched, tetragonous, glabrous or sparsely bristly, 40-100 cm high. Leaves opposite, petiolate, ovate lanceolate, deeply pinnatisect or bipinnatisect, 6-20 cm long, with linear spine and lanceolate segments, briefly bristly. A few, long pedunculate capitula, arranged in corymbose heads at the ends of the branches. Hemispherical receptacle of 6 × 6-8 mm: linear phyllaries, more or less rough. Generally dimorphic flowers: white or yellowish, ligulate the ray ones (sometimes with a rudimentary or absent ligule); hermaphroditic and tubular those of the disc. Cypsela linear, tetragonous, the external 6-8 mm long, 8-14 mm the internal ones. Pappus formed by four aristae 1-2.5 mm long, covered by retracted hairs.

Geographic origin and ecology

According to Cabrera (1974), *Bidens subalternans* is native to South of Brazil, Bolivia, Uruguay and north and central Argentina. In the native area, the species is frequent as summer and autumn weed.

The studied population

The new population of *B. subalternans*, as far as noted, occupies road edges and slopes - mainly in the upstream - for a total length of about 3 km. It is settled on nitrophilous substrates of limestone matrix, from about 350 to 500 m a.s.l., between the eastern suburbs of the town of Monreale, up to the surroundings little village of Pioppo, along the Strada Statale 186 (Fig. 2). On the whole there are several thousand mature individuals, sometimes forming more or less monospecific coenosis, sometimes in communities where *B. subalternans* is still prevalent. It is associated with *B. pilosa pilosa* (var. *pilosa* and var. *minor* (Blume) Sherff), *Mercurialis perennis* L., *Malva sylvestris* L. subsp. *sylvestris*, *Ricinus communis* L., *Solanum nigrum* L., *Lobularia maritima* (L.) Desv. subsp. *maritima*, *Antirrhinum siculum* Mill., *Calendula* sp., *Pennisetum setaceum* (Forssk.) Chiov., *Sonchus tenerrimus* L., *Chenopodium murale* L., *Amaranthus retroflexus* L., *Parietaria judaica* L., *Erodium malacoides* (L.) L'Hér., *Bituminaria bituminosa* (L.) C. H. Stirt., *Helminthotheca echioides* (L.) Holub, *Scabiosa atropurpurea* L., *Oxalis pes-caprae* L., *Boerhaavia repens* subsp. *viscosa* (Choisy) Maire, *Brassica rapa* subsp. *campestris* (L.) A. R. Clapham, *Dittrichia viscosa* (L.) Greuter subsp. *viscosa* and *Rubus* sp.

Taxonomic and chorological remarks

Bidens subalternans DC., native to South America, and now widespread in various countries of Europe (Belgium, Corse, Croatia, Cyprus, France, Germany, Great

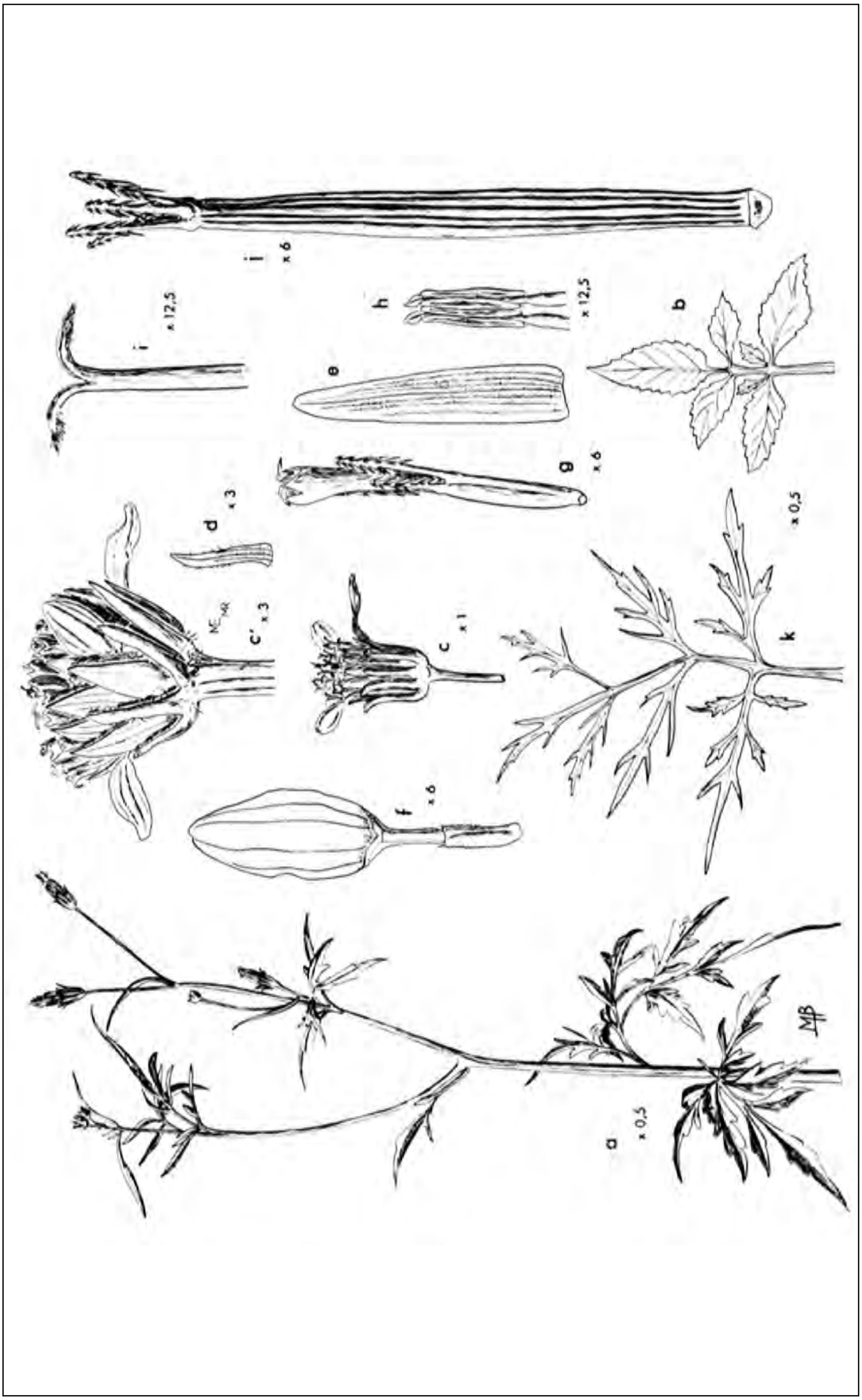

Fig. 1. *Bidens subalternans* DC. var. *subalternans*: **a**)Habit; **b)** leaf; **c)** capitula; **d)** phyllary; **e)** palea; **f)** ligulate flower; **g)** disc flower; **h)** anthers; **i)** apex of the style; **J)** cypsela;. **K)** leaf of *B. subalternans* var. *simulans* Sherff (from Cabrera 1974).

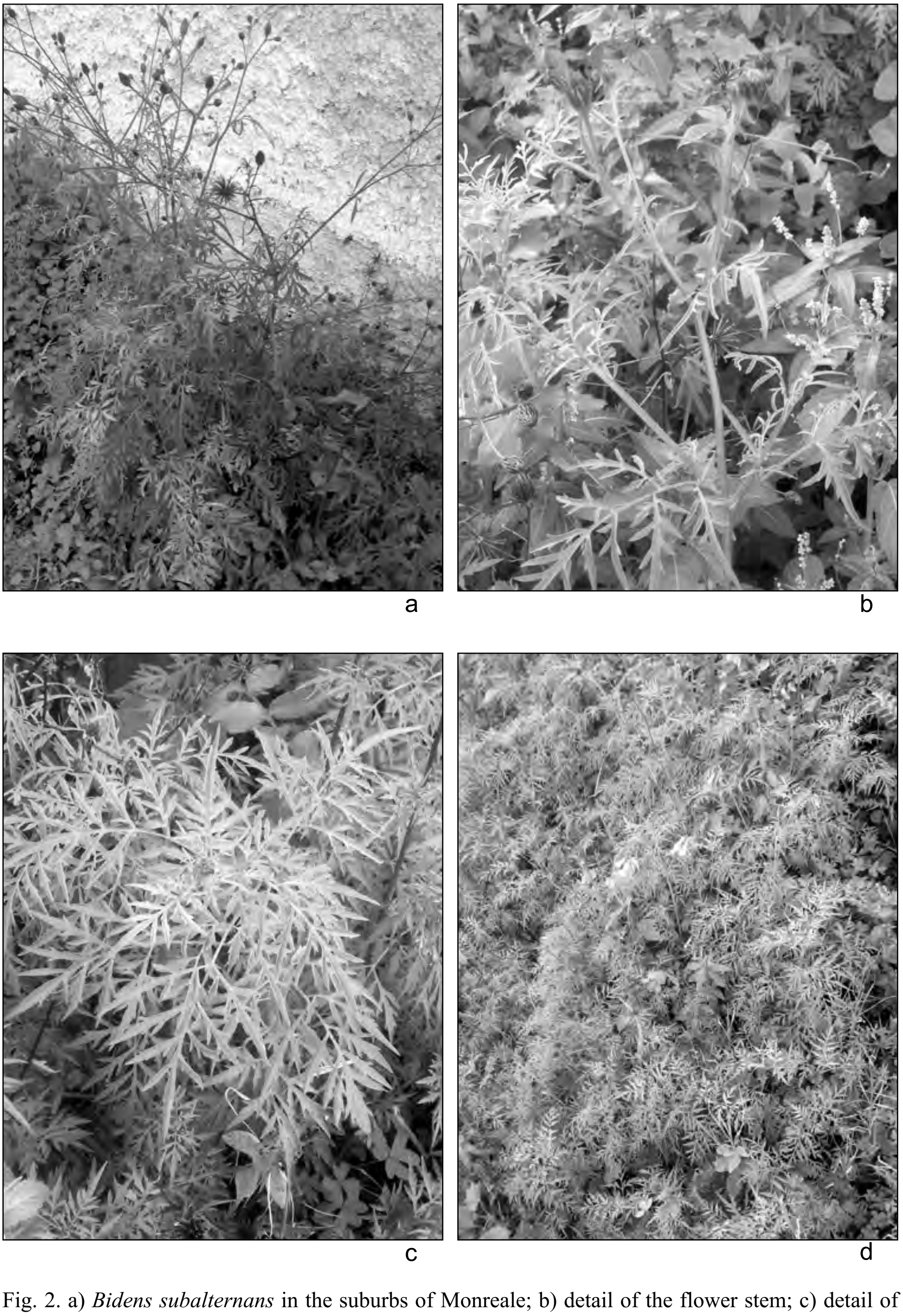

Fig. 2. a) *Bidens subalternans* in the suburbs of Monreale; b) detail of the flower stem; c) detail of the cauline leaves; d) dense population in the new Sicilian locality.

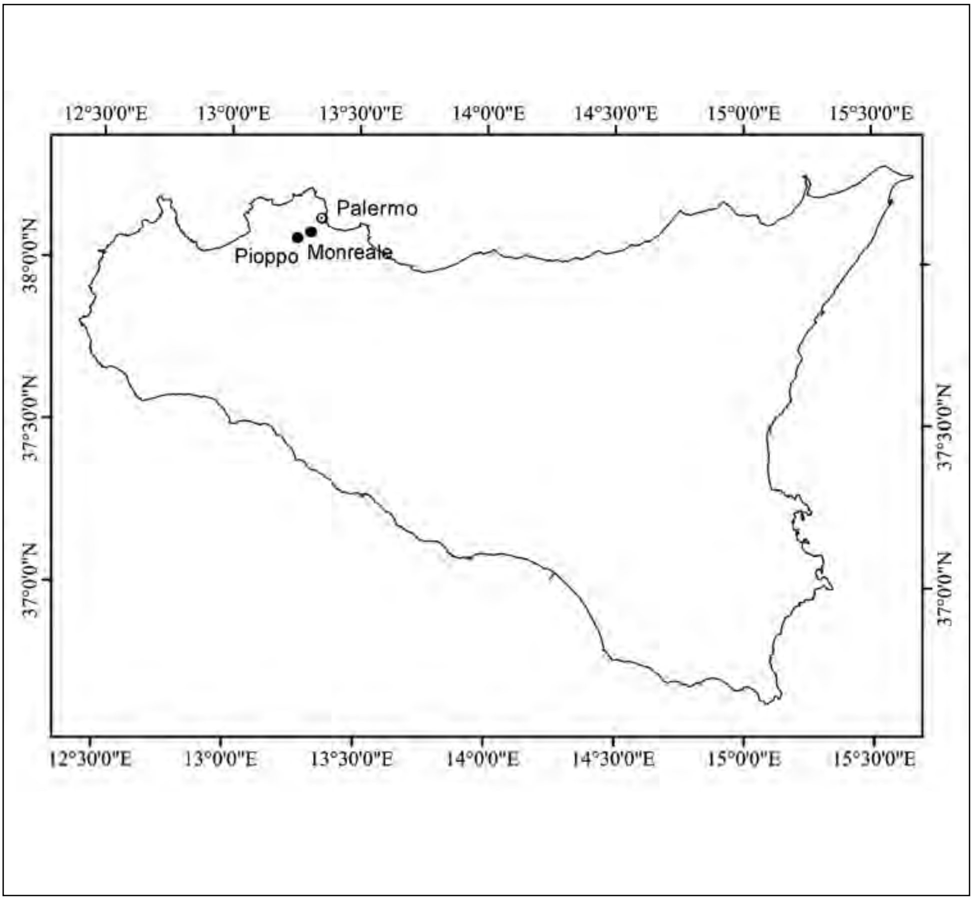

Fig. 3. Localities of the first finding in Sicily of *Bidens subalternans*.

Britain, Montenegro, Republic of Serbia, Slovenia, Spain, Switzerland) (Greuter 2006 -), Asia and Africa, has some variability and has often been confused with *B. bipinnata* (Latini & al. 2016).

In addition to the nominal species, there is a var. *simulans* Sherff. It differs from the typical variety for very dissected leaves, with linear or linear-lanceolate segments. It is found, usually, together with the species.

Based on this possible confusion – as was recently verified in Lazio (C Italy) by Latini & al. (2016) – the known geographic distribution of the two taxa should be checked. *B. subalternans* differs from *B. bipinnata* by the thinner, ramified only in the upper part stems, reflexed leaves, generally lanceolate and toothed leaf segments, as well as by the achenes, 0.6-1.4 cm long, and with aristae 1-2.5 mm long; whereas in *B. bipinnata* the leaf segments are deltoids and almost whole, and the achenes are 1-1.8 cm long, with aristae of 2-4 mm (Cabrera 1974).

Specimina

Sicily: Monreale, ai margini della strada provinciale per Pioppo [on the borders of a provicial route to Pioppo], 38° 03′ 53″ N 13° 6′ 3″ E, 420 m a.s.l., 20.6.2016, *Raimondo* (PAL, PAL-Gr, FI); Circonvallazione di Monreale, S.S. 186, habitat ruderale [bypass road of Monreale, S.S. 186, ruderal habitat], 38° 04′ 17″ N 13° 16′ 28″ E, 345 m (a.s.l.), 28.09.2017, *Spadaro* (PAL, PAL-Gr, FI).

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Address of the authors:
Fancesco M. Raimondo & Vivienne Spadaro,
Department STEBICEF/ Section of Botany and Plant Ecology, University of Palermo,
Via Archirafi 38, I 9023 – Palermo, Italy. E-mail: francesco.raimondo@unipa.it

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Mediterranean plant karyological data – 27

edited by G. Kamari, C. Blanché & S. Siljak-Yakovlev

Abstract

Kamari, G., Blanché, C. & Siljak-Yakovlev, S. (eds): Mediterranean plant karyological data – 27. — Fl. Medit. 27: 275-301. 2017. — ISSN: 1120-4052 printed, 2240-4538 online.

This is the twenty-seventh of a series of karyological data from Mediterranean area, peri-Alpine communities and the Atlantic Islands, in English or French language. It comprises contributions on 32 taxa: *Crocus* from Cyprus, F.Y.R.O.M., Israel, Italy, Jordan, Kosovo, Lebanon, Libya, Montenegro, Romania, Sicily, Syria and Turkey by C. A. Heywood, P. Bareka, Th. Karamplianis & G. Kamari (Nos 1903-1918); *Centaurea* from Croatia by I. Carev, F. Pustahija, M. Ruščić & S. Siljak-Yakovlev (Nos 1919-1925); *Anacamptis*, *Asphodelus*, *Dactylorhiza*, *Digitalis*, *Narcissus*, *Platanthera*, *Polygonatum* from Bosnia-Herzegovina, Croatia and Lebanon by F. Pustahija, E. M. Šolić & S. Siljak-Yakovlev (1926-1934).

During the OPTIMA Meeting held in Montpellier (6-11 June 2016), the Commission of Karyosystematics agreed to change the previous name of the column “Mediterranean Chromosome Number Reports” in Flora Mediterranea for a most comprehensive title recognizing the true scope of the contributions usually published (which include, karyotype analysis, evolutionary consequences, bibliographic critical review, as well as biogeographical considerations, taxonomic remarks etc., derived from chromosome studies). The current title for the series is thus: “Mediterranea plant karyological data” (MPKD). The Commission also decided the addition of the titles of single contributions to valorize the work of the contributors.

Addresses of the editors:

Prof. Emer. Georgia Kamari, Botanical Institute, Department of Biology, University of Patras, GR-265 00 Patras, Greece. E-mail: kamari@upatras.gr

Prof. Cesar Blanché, IRBio-GReB, Laboratori de Botànica, Facultat de Farmàcia, Universitat de Barcelona, Av. Joan XXIII s/n, E-08028 Barcelona, Catalonia, Spain. E-mail: cesarblanche@ub.edu

Dr. Sonja Siljak-Yakovlev, Ecologie, Systématique et Evolution, Département "Evolution des angiospermes", Univ. Paris-Sud, CNRS, AgroParisTech, Université Paris-Saclay, Bât 360, 91405 Orsay cedex, France. E-mail: sonia.yakovlev@u-psud.fr

C. A. Heywood, P. Bareka, Th. Karamplianis & G. Kamari

Karyological study of miscellaneous *Crocus* (*Iridaceae*) species

Abstract

Heywood, C. A., Bareka, P., Karamplianis, Th. & Kamari, G. 2017: Karyological study of miscellaneous *Crocus* (*Iridaceae*) species [In Kamari, G., Blanché, C. & Siljak-Yakovlev, S. (eds), Mediterranean plant karyological data - 27]. – Fl. Medit. 27: 276-288. doi: 10.7320/FlMedit27.276

Chromosome numbers and karyotypes are given for the following species of *Crocus*: *C. aleppicus*, *C. banaticus*, *C. boulosii*, *C. etruscus*, *C. gargaricus*, *C. herbertii*, *C. hermoneus*, *C. kosaninii*, *C. leichtlinii*, *C. longiflorus*, *C. moabiticus*, *C. scardicus, C. sieheanus*, *C. tommasinianus*, *C. veneris*. Chromosome counts are also given for *C. banaticus* and *C. longiflorus.* Intraspecific variation was found in *C. allepicus* and *C. hermoneus*. Karyotype microphotographs or karyogram drawings are provided and karyotype morphology is discussed.

The genus *Crocus* is characterized by an enormous chromosomal variability. Some groups and species have proved particularly difficult taxonomically and have been found to contain chromosomal intraspecific variation. Although the chromosome number for several species mentioned in this study has been given in the past (Brighton & al. 1973), the karyotype morphology for most of them was unknown until now.

1903. ***Crocus aleppicus*** Baker **—** 2*n* = 16 (Figs 1a, 1b & 4a).

Sy: Homs - Damascus, 34° 06’ N, 36° 77’ E, *Birkinshaw s.n.*, *ref. no 73.2833* (K).
— Homs - Damascus, 33° 84’ N, 36° 59’ E, *Birkinshaw s.n.*, *ref. no 70.1445* (K).
— W Dier Atiyah, Antilebanon, 34° 09’ N, 36° 76’ E, *Barkoudah 162*, *ref. no 73.2967* (K). – Fig. 1b.
Le: 3 km S of Baalbek, 33° 97’ N, 36° 19’ E, *Marr 1677*, *ref. no 72.65* (K).

Feinbrun & Shmida (1977) reported 2*n* = 16 for *C. aleppicus* collected from Golan, Israel. We also found 2*n* = 16 in this species and the four counts made extend the range as three were collected in Syria and one in Lebanon. Although all the plants examined had 2*n* = 16, one collection from Syria (73.2967) had a different karyotype morphology. Mathew (1982) states that plant material from its northern distribution (mainly Syria and partly Lebanon) holds blackish anthers. It is unknown if this karyotype from Syria (73.2967) is of atypical morphology; if so, then it suggests that this material might be of new infraspecific entity.

C. aleppicus is widespread in W Syria, through Lebanon to NE Israel and Jordan. It is an extremely variable species and further study might well discover further cytological variation. The most closely related species to *C. aleppicus* is *C. veneris* from Cyprus which has the same chromosome number and a similar seed surface (Mathew 1982).

$2n$ = 16A Cytotype. This comprised eight pairs of acrocentric chromosomes ($2n$ = 12st + 4st-SAT = 16), quite small in size, ranging between 2.34 to 5.00 µm. Small satellites were observed on the two smallest chromosome pairs (Figs 1a & 4a).

$2n$ = 16B Cytotype. The collection from Antilebanon (coll. Barkoudah 162) had slightly larger chromosomes and a karyotype consisting of one pair of metacentric chromosomes and seven arocentric pairs, ranging in size from 2.97 to 7.34 µm. The smallest chromosome pair has very small short arms subtending small satellites. Satellites were also observed on two other acrocentrics, also on the short arms (Fig. 1b). The karyotype formula is given as $2n$ = 2m + 8st + 6st-SAT = 16 chromosomes.

1904. *Crocus banaticus* J. Gay — $2n$ = 26.

Rm: Sinaia, 45° 33' N, 25° 55' E, *Barret s.n.*, *ref. no 70.139* (K).
— Hunedoara, 45° 75' N, 22° 90' E, *Prasil KP42/72*, *ref. no 70.1391* (K).
— Hateg, 45° 61' N, 22° 95' E, *Prasil KP22/72*, *ref. no 73.68* (K).
— South of Oradea, 46° 93' N, 21° 91' E, *Prasil KP01/73*, *ref. no 76.252* (K).

Mathew (1982) formerly placed *C. banaticus* in the subgenus *Crociris* B. Mathew, in contrast, Petersen & al. (2008) in their phylogenetic study reported that Crocuses are of monophyletic origin; therefore the genus lacks any subgeneric division. It differs from other species in three ways; the style is branched into many slender lilac branches, the anthers open introrsely and the inner perianth segments are very much smaller than the outer ones. Because of this it is also been known as *C. iridiflorus* Heuff. ex Rchb. under which name it was chromosome counted by Heitz (1926), who reported $2n$ = 24–26 chromosomes, while Mather (1932) recorded $2n$ = 26. Karasawa (1943, 1950) reported $2n$ = 9 for *C. banaticus*, but this must have been wrongly identified material.

In this study four collections from Romania were examined and all had $2n$ = 26. The chromosomes were small with indistinct centromeres and a detailed analysis was not possible. However, it could be seen that one pair of acrocentric chromosomes has large satellites.

1905. *Crocus baytopiorum* B. Mathew — $2n$ = 28 (Fig. 1c).

Tu: Honaz Dağ, 37° 68' N, 29° 30' E, *Baytop ISTE23.781*, *ref. no 73.2971* (K).
— Honaz Dağ, 37° 71' N, 29° 236' E, *Baytop ISTE23.781*, *ref. no 73.2811* (K).
— Honaz Dağ, 37° 73' N, 29° 34' E, *Mathew 8262*, *ref. no 76.234* (K).

This species from Turkey has no close relatives, although in some characters it resembles the *C. vernus* group (Mathew 1982). Mathew (2002) states that the taxon should be treated as a member of its own new series which he named series *Baytopi* B. Mathew (Mathew & al. 2009). Additionally, phylogenetic studies of Petersen & al. (2008) and Harpke & al. (2013) supported excluding the taxon from series *Verni* B. Mathew.

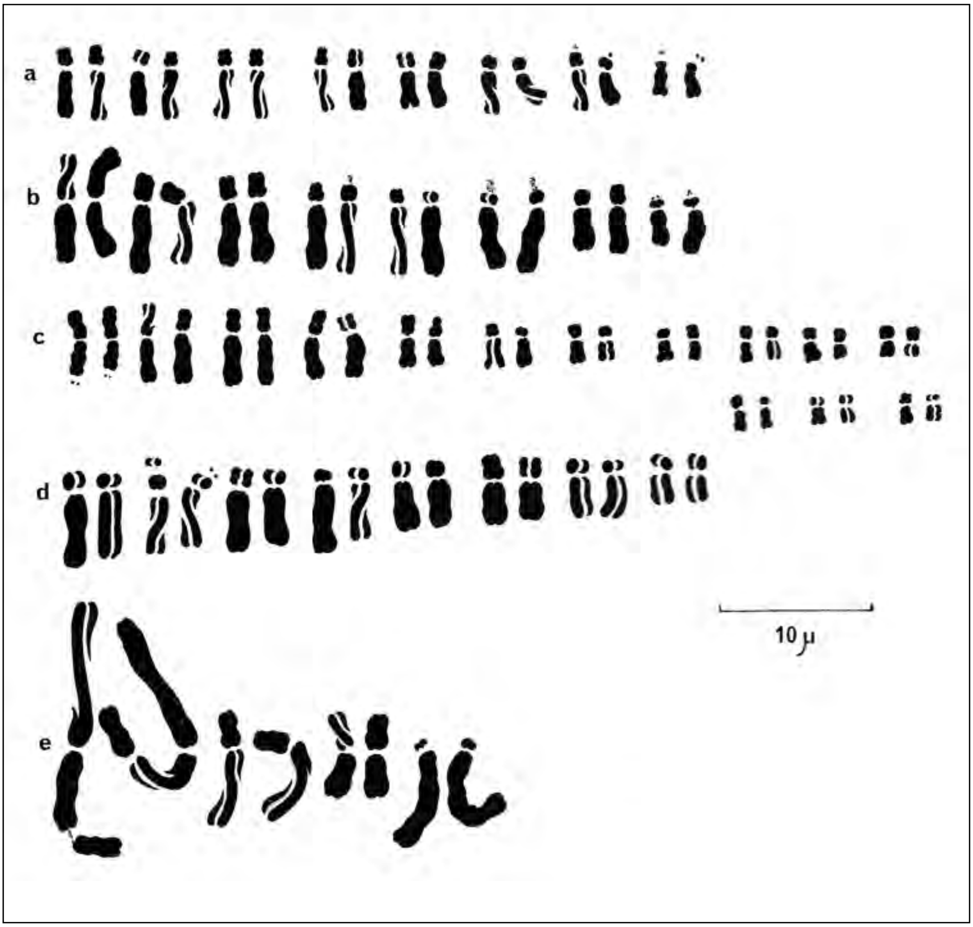

Fig. 1. Karyograms of *Crocus* species: **a,** *C. aleppicus* (ref. no 71.2333), $2n = 16A$; **b,** *C. aleppicus* (ref. no 73.2967), $2n = 16A$; **c,** *C. baytopiorum* (ref. no 76.234), $2n = 28$; **d,** *C. boulosii* (ref. no 80.38), $2n = 16$; **e,** *C. etruscus* (ref. no 77.182), $2n = 8$ chromosomes.

Three collections were examined cytologically and they all came from Honaz Dağ in Turkey. They had $2n = 28$ and a karyotype consisting of small chromosomes, varying in size between 1.72 and 4.22 µm; one pair of metacentrics with small satellites, four pairs of sub-medians and nine pairs of acrocentric grading down in size (Fig. 1c). There was no obvious link with the *C. vernus* aggregate.

1906. ***Crocus boulosii*** Greuter — $2n = 16$ (Fig. 1d).

Li: Marawah, E of Benghazi, 32° 48’ N, 21° 40’ E, *Koenen & Sarnetzki s.n.*, *ref. no 80.38* (K).

A rare *Crocus* from Libya is *C. boulosii*, whose closest affinities lie with *C. aleppicus* from the E Mediterranean mainland and with *C. veneris* Tapp. ex Poech from Cyprus. Although all three have the same chromosome number 2*n* = 16, there is no obvious link karyologically. The sixteen chromosomes of *C. boulosii* are all acrocentric grading only slightly down in size (3.12–6.25 µm). Quite small satellites were present on the short arms of the second pair (Fig. 1d).

1907. *Crocus etruscus* Parl. — 2*n* = 8 (Figs 1e & 4b).

It: Montieri near Massa Maritima, alt. 2400m, 43° 13’ N, 11° 02’ E, *Marr 1870*, *ref. no 69.1188* (K).
— North Massa Maritima, road to Niccioleta, 43° 06’ N, 10° 90’ E, *Marr 1860*, *ref. no 77.182* (K).

Karasawa (1937, 1943) and Brandizzi & al. (1996) reported 2*n* = 8 for this species, while Mather (1932) reported 2*n* = 11. The latter is thought to be a cultivar. Moreover, Baldini (1990) gave also the somatic number and the karyotype of this species. Indeed, *C. etruscus*, is an Italian species, with 2*n* = 8 large chromosomes and a very distinctive karyotype. This comprises one pair of large metacentrics with a secondary constriction interstitially situated along one of the arms; one pair of sub-medians, a small pair of metacentrics and one pair of acrocentrics with very small short arms (Fig. 1e). The karyotype formula is slightly different from the one given by Baldini (l.c.) and is given as 2*n* = 4m + 2sm + 2st = 8 since there were no M chromosomes or microsatellites observed in the populations studied here. The chromosomes are ranging in size from 7.66 to 18.75 µm. The large metacentrics and acrocentrics make excellent marker chromosomes and because of this, it has been possible to consider that *C. vernus* (L.) Hill subsp. *vernus* 2*n* = 16 (as *C. napolitanus* Mord. Laun.; Brighton 1976), which refers to the newly described *C. neglectus* Peruzzi & Carta, is an allo-tetraploid (Frello & Heslop-Harrison 2000) formed from an hybrid between *C. etruscus* and *C. vernus* subsp. *vernus* with 2*n* = 8. This is further supported by phenotypic characters and geographical distribution. Harpke & al. (2015) reports that the maternal origin of the *C. neglectus* is *C. ilvensis,* both taxa shared *nhd*F haplotype, and is parapatric only with *C. etruscus*.

It is thought that allo-polyploidy occurs elsewhere in the genus but it is not easy to discover it without clear marker chromosomes in the progenitors and only with classical karyological research.

1908. *Crocus gargaricus* Herb. — 2*n* = 30 (Figs 2b & 4c).

Tu: Muğla - Göktepe, 37° 31’ N, 28° 50’ E, *Baytop s.n.*, *ref. no 81.62* (K).

The preparations of *C. gargaricus* were made using 2% aceto-orcein stain in addition to the Feulgen and this may be why the chromosomes in this collection are slightly larger (1.34–5.94 µm). Once again it had 2*n* = 30 but the small satellites on the long arms of the

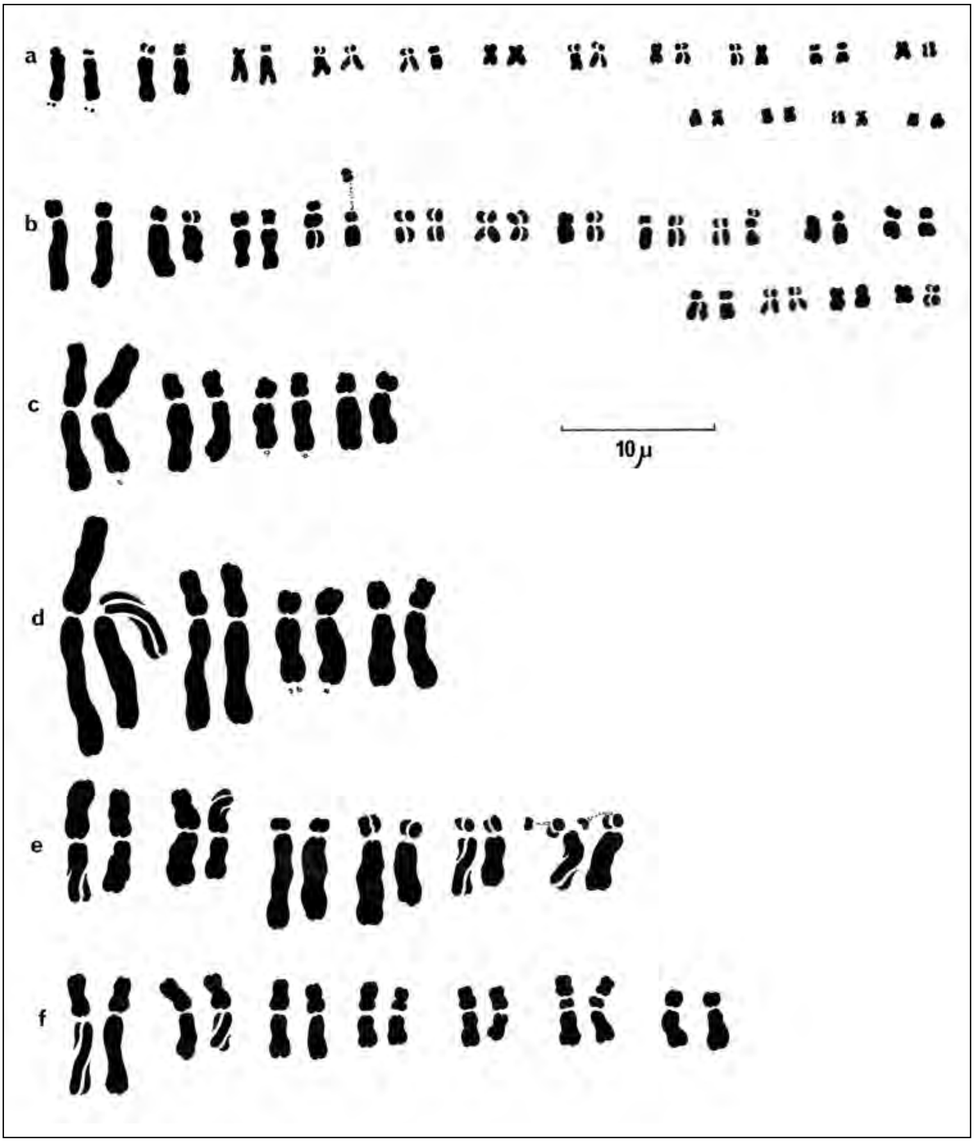

Fig. 2. Karyograms of *Crocus* species: **a,** *C. herbertii* (ref. no 76.381), 2*n* = 30; **b,** *C. gargaricus* (ref. no 81.62), 2*n* = 30; **c,** *C. hermoneus* (ref. no 80.230), 2*n* = 8; **d,** *C. hermoneus* (ref. no 80.228), 2*n* = 8; **e,** *C. hermoneus* (ref. no 70.203), 2*n* = 12; **f,** *C. kosaninii* (ref. no 78.47), 2*n* = 14 chromosomes.

large acrocentrics were not visible, and large satellites could be clearly seen on one pair of small submedians plus one other small submedian (Figs 2b & 4c). These satellites were large enough to be regarded as secondary constrictions occurring interstitially.

1909. ***Crocus herbertii*** (B. Mathew) B. Mathew — 2*n* = 30 (Fig. 2a).

Tu: Ulu Dağ, 40° 07' N, 29° 22' E, *Marr 2216*, *ref. no 70.1516* (K).
— Ulu Dağ, alt. 1600 m, 40° 07' N, 29° 22' E, *Pasche 75/27B*, *ref. no 76.381* (K).

Mathew (1984) divided *C. gargaricus* into two subspecies; subsp. *gargaricus* and subsp. *herbertii*. His taxonomic treatment was based on the presence of stoloniferous roots and fine-reticulate corm tunics in subsp. *herbertii*. Mathew & al. (2009), in the light of phylogenetic evidence by Petersen & al. (2008), indicate that the taxon merits recognition at specific rank. In this present study, we opt in favour of *C. herbertii* over *C. thirkeanus* [a taxonomic entity "resurrected" by Rukšāns (2017) and followed by Govaerts & Barker (2017)] even though the latter antedate's subsp. *herbertii*, as type material has not been traced (Mathew 1984). This species comes from Ulu Dağ in northwestern Turkey.

C. herbertii has very small chromosomes, ranging from 1.03 to 3.59 µm, and karyotype details were difficult, however it was possible to distinguish two pairs of larger acrocentrics with satellites on the long arms (Fig. 2a).

1910. ***Crocus hermoneus*** Kotschy ex Maw — 2*n* = 8, 12 (including subsp. ***hermoneus*** and subsp. ***palaestinus*** Feinbrun) (Figs 2c, 2d, 2e & 5a).

Ir: NNE Majdal - Shams, 33° 26' N, 35° 77' E, *Avi Shmida s.n.*, *ref. no 80.230* (K). — 2*n* = 12. – Figs 2c & 5a.
— Jerusalem, 31° 78' N, 35° 20' E, *Awishai s.n.*, *ref. no 70.203* (K). — 2*n* = 12. – Fig. 2e.
Jo: Salt Arda road to Ghor, 32° 07' N, 35° 70' E, *Al-Eisawi s.n.*, *ref. no 80.228* (K). — 2*n* = 8. – Fig. 2d.
— Amman, Umm Uthainah, 31° 97' N, 35° 87' E, *Al-Eisawi s.n.*, *ref. no 80.229* (K). — 2*n* = 8.

Feinbrun (1958) reported 2*n* = 12 for *C. hermoneus* and in 1977 (Feinbrun & Shmida 1977) she subdivided the species into subsp. *hermoneus* and subsp. *palaestinus*. She found 2*n* = 8 in the former and 2*n* = 12 in the latter. Material from Dr. Al-Eisawi from Salt and Amman in Jordan was assigned by Mathew (1982) to subsp. *palaestinus* but cytologically it corresponded with the subsp. *hermoneus* material of Avi Shmida from Israel, having 2*n* = 8 and a similar karyotype morphology.

C. hermoneus 2*n* = 8 Cytotype: had a karyotype consisting of one pair of large metacentrics, one pair of large sub-medians and two pairs of smaller arocentrics one pair of which had small satellites on the long arms (2*n* = 2m + 2sm + 2st + 2st-SAT = 8), ranging in size from 5.00 to 9.68 µm (Figs 2c, 2d & 5a). A small satellite was occasionally visible on one of the large metacentrics.

C. hermoneus 2*n* = 12 Cytotype: had a karyotype consisting of two pairs of metacentrics and four pairs of acrocentrics with small short arms (2*n* = 4m + 6st + 2st-SAT = 8), which are smaller in size than those of 2*n* = 8 Cytotype (4.69–8.13 µm). One pair of acrocentrics had large satellites on the short arms (Fig. 2e). This corresponds with the findings of Feinbrun & Shmida (1977).

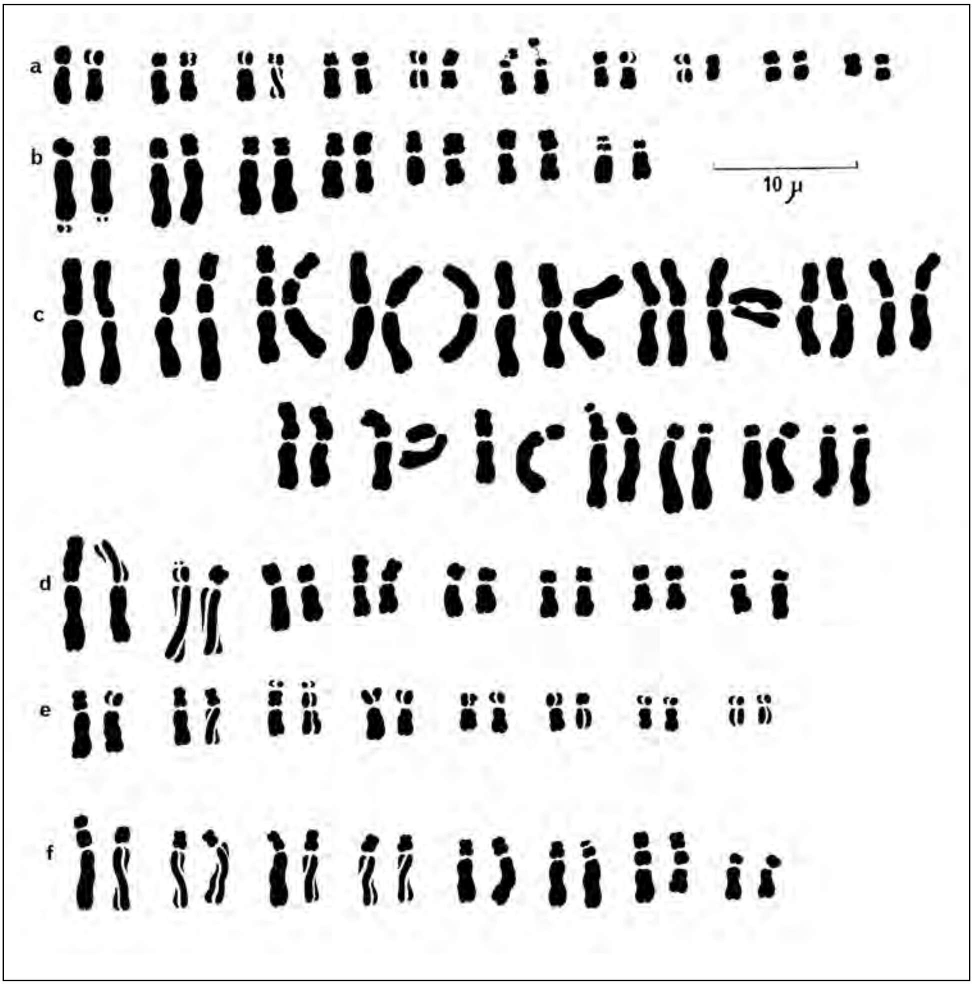

Fig. 3. Karyograms of *Crocus* species: **a,** *C. leichtlinii* (ref. no 77.28), 2*n* = 20; **b,** *C. moabiticus* (ref. no 80.233), 2*n* = 14; **c,** *C. scardicus* (ref. no 80.243), 2*n* = 34; **d,** *C. sieheanus* (ref. no 70.172), 2*n* = 16; **e,** *C. tommasinianus* (ref. no 73.2897), 2*n* = 16; **f,** *C. veneris* (ref. no 73.2969), 2*n* = 16 chromosomes.

1911. *Crocus kosaninii* Pulevič **—** 2*n* = 14 (Figs 2f & 5b).

Sr: Kosovo near Kacanik, 42° 23' N, 21° 25' E, *Pulevič s.n.*, *ref. no 78.47* (K).
— 13 km N of Kacanik, 42° 33' N, 21° 20' E, *Crook 3007*, *ref. no 78.46* (K).

C. kosaninii is a relatively recently described species belonging to the *C. vernus* group (Mathew 1982; Harpke & al. 2015). Both the number, 2*n* = 14, and the karyotype are new to this group although the submedians with interstitial secondary constrictions are a feature of many members. *C. kosaninii* had a karyotype consisting of one large pair of submedians, five pairs of median-submedian chromosomes, one pair of which had secondary constrictions and one pair of acrocentrics. The chromosome size varies from 3.90 to 7.81 μm (Figs 2f & 5b).

1912. *Crocus leichtlinii* (Dewar) Bowles — 2*n* = 20 (Figs 3a & 5c).

Tu: Karacadağ Urfa, alt. 1750 m, 37° 73' N, 39° 64' E, *Watson 1084*, *ref. no 72.61* (K).
— Karacadağ, alt. 1800 m, 37° 67' N, 39° 82' E, *Baytop ISTE31.324*, *ref. no 77.28* (K).

Mather (1932) reported 2*n* = 20 for this species and our results confirm this. *C. leichtlinii* comes from Karacadağ in south-eastern Turkey. Both collections had 2*n* = 20 small chromosomes (1.83–4.33 μm) and a karyotype consisting of four pairs of acrocentrics, one pair of medians, two pairs of acrocentrics with large satellites on the short arms and three pairs of small median chromosomes (2*n* = 8m + 8st + 4st-SAT = 20) (Figs 3a & 5c).

1913. *Crocus longiflorus* Raf. — 2*n* = 28.

It: Italy, *Marr 2592, ref. no 77.792* (K).
Si: Sicily, E side of Mt. Etna, 37° 75' N, 15° 06' E, *Marr 2702*, *ref. no 76.290* (K).
— Sicily, Mt. Etna road, 37° 69' N, 15° 03' E, *Marr 2568A*, *ref. no 79.714* (K).
— Sicily, E side of Mt. Etna, 37° 75' N, 15° 06' E, *Marr 2702*, *ref. no 76.290* (K).
— Malta, Verdala heights, 35° 86' N, 14° 40' E, *Saliba s.n.*, *ref. no 72.185* (K).
— Malta, Verdala heights, 35° 87' N, 14° 39' E, *Saliba s.n.*, *ref. no 74.1335* (K).

Mather (1932), Karasawa (1943) and Goldblatt & Takei (1997) reported 2*n* = 28 for this species and our results confirm this. Six collections from Sicily, Malta and Italy all had 2*n* = 28 small chromosomes; the karyotypes, however, were not clear enough to allow a more detailed analysis.

1914. *Crocus moabiticus* Bornm. & Dinsm. ex Bornm. — 2*n* = 14 (Fig. 3b).

Jo: Moab, 33 km SW Madaba, 31° 90' N, 35° 76' E, *Al-Eisawi s.n., ref. no 80.233* (K).

Mathew (1982) allies *C. moabiticus* to the Greek *C. cartwrightianus* 2*n* = 16, but cytologically and geographically it is closer to *C. pallasii* subsp. *dispathaceus* with 2*n* = 14 (Brighton 1977) and *C. naqabensis* with 2*n* = 14 chromosomes (Al-Eisawi 2001). The collection examined came from Jordan and had a karyotype consisting of three pairs of acrocentrics with large satellites on the long arms of the first pair, three pairs of submedians and one pair of acrocentrics with small short arms subtending small satellites (Fig. 3b). The size of the chromosomes ranges from 2.83 to 6.17 μm.

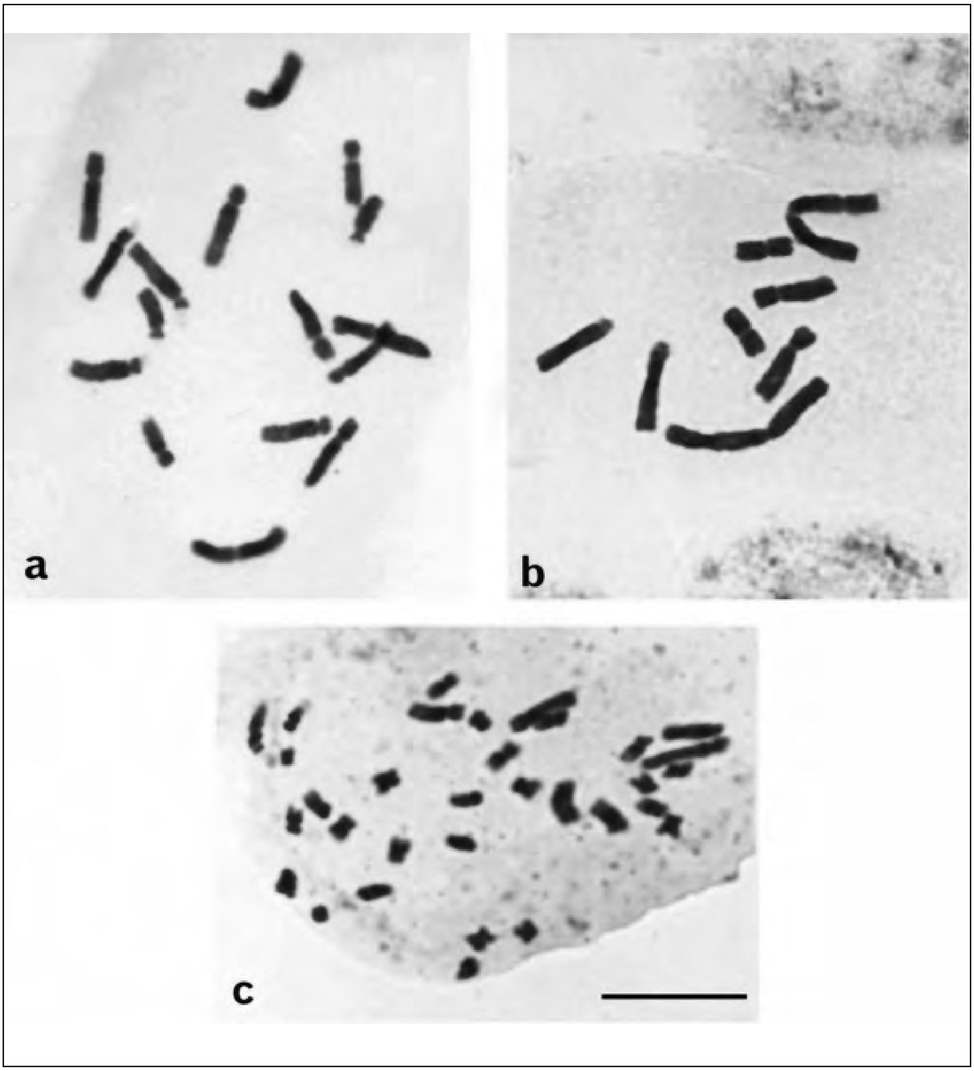

Fig. 4. Microphotographs of mitotic metaphase plates of *Crocus* species: **a,** *C. aleppicus* (ref. no 73.2967), 2*n* = 16; **b,** *C. etruscus* (ref. no 69.1188), 2*n* = 8; **c,** & **d,** *C. gargaricus* (ref. no 81.62), 2*n* = 30. – Scale bar = 10 µm.

1915. *Crocus scardicus* Kosanin — 2*n* = 34 (Figs 3c & 5d).

Mk: F.Y.R.O.M., Sar Planina, 42° 05' N, 20° 83' E, *Mathew 5254*, *ref. no 70.191* (K). — 2*n* = 34.

— F.Y.R.O.M., Tetovo, Popova Sapka, 42° 01' N, 20° 87' E, *Archibald s.n.*, *ref. no 80.243* (K). — 2*n* = 34.

Both of the collections of *C. scardicus* examined here had 2*n* = 34. The karyotype consisted of twelve pairs of metacentric chromosomes, one heteromorphic pair with a median and acrocentric chromosome, one pair of acrocentrics with a satellite on one chromosome, on the short arm and three pairs of acrocentrics with small short arms. Interstitial secondary constrictions could be seen in at least three of the metacentrics. The chromosome size ranges from 5.08 to 9.02 µm. The chromosomes did not readily fall into sets of four although they did fall in to sets of three (3x = 33 + 1) (Figs 3c & 5d), and while being very similar to those of *C. pelistericus* 2*n* = 34 there were some differences in karyotype morphology. Šopova (1972) reported counts of 2*n* = 32, 34, 35 & 36. She considered it to be a tetraploid with a tendency towards reduction. Obviously meiotic studies are needed in this case, and it would be interesting to do geimsa or other techniques on these two species.

C. scardicus and *C. pelistericus* are the only *Crocus* species which do not have a pale stripe on the upper surface of the leaf. Both species are distinct and very localized in their distribution.

1916. *Crocus sieheanus* B. L. Burtt — 2*n* = 16 (Figs 3d & 5e).

Tu: Niğde, 37° 99’ N, 34° 68’ E, *Mathew 4085*, *ref. no 69.1140* (K).
— Pozanti, 37° 43’ N, 34° 88’ E, *Mathew 4486B*, *ref. no 70.172* (K).

C. sieheanus is a distinct species from southern-central Turkey. Karasawa (1943) reported 2*n* = 16 for this species and both our collections have the same number. The karyotype consisted of one pair of large metacentric, one pair of large acrocentric with satellites on the short arms, five pairs of acrocentric and one smaller pair of metacentric varying in size from 3.17 to 8.33 µm (Figs 3d & 5e).

1917. *Crocus tommasinianus* Herb. — 2*n* = 16 (Fig. 3e).

Cg: Crmnica, 42° 41’ N, 19° 05’ E, *Lovka s.n.*, *ref. no 73.3008* (K).
— Mt. Lovcen, 42° 40’ N, 18° 82’ E, *Mathew 7528*, *ref. no 73.2897* (K).
— Mt. Orjen, 42° 60’ N, 18° 54’ E, *Mathew 5298*, *ref. no 70.212* (K).
— Mt. Orjen, 42° 60’ N, 18° 55’ E, *Mathew 5280*, *ref. no 70.165* (K).
— Mt. Orjen, 42° 60’ N, 18° 54’ E, *Mathew 5288*, *ref. no 69.1141* (K).

Mather (1932), Brittingham (1934), Pathaak (1940), Karasawa (1943) and Sušnik & Lovka (1973) all reported 2*n* = 16 for this species, and our results confirm this. Five collections all had the same karyotype of small chromosomes (2.17–4.83 µm), submedian to acrocentric with large satellites on one pair of submedians (Fig. 3e).

1918. *Crocus veneris* Tapp. ex Poech. — 2*n* = 16 (Fig. 3f).

Cy: Kalogrea, 35° 34’ N, 33° 62’ E, *Osorio-Tafall & Seraphim 7856*, *ref. no 73.33* (K).
— Kalogrea, 35° 33’ N, 33° 64’ E, *Osorio-Tafall & Seraphim 8217*, *ref. no 73.2969* (K).

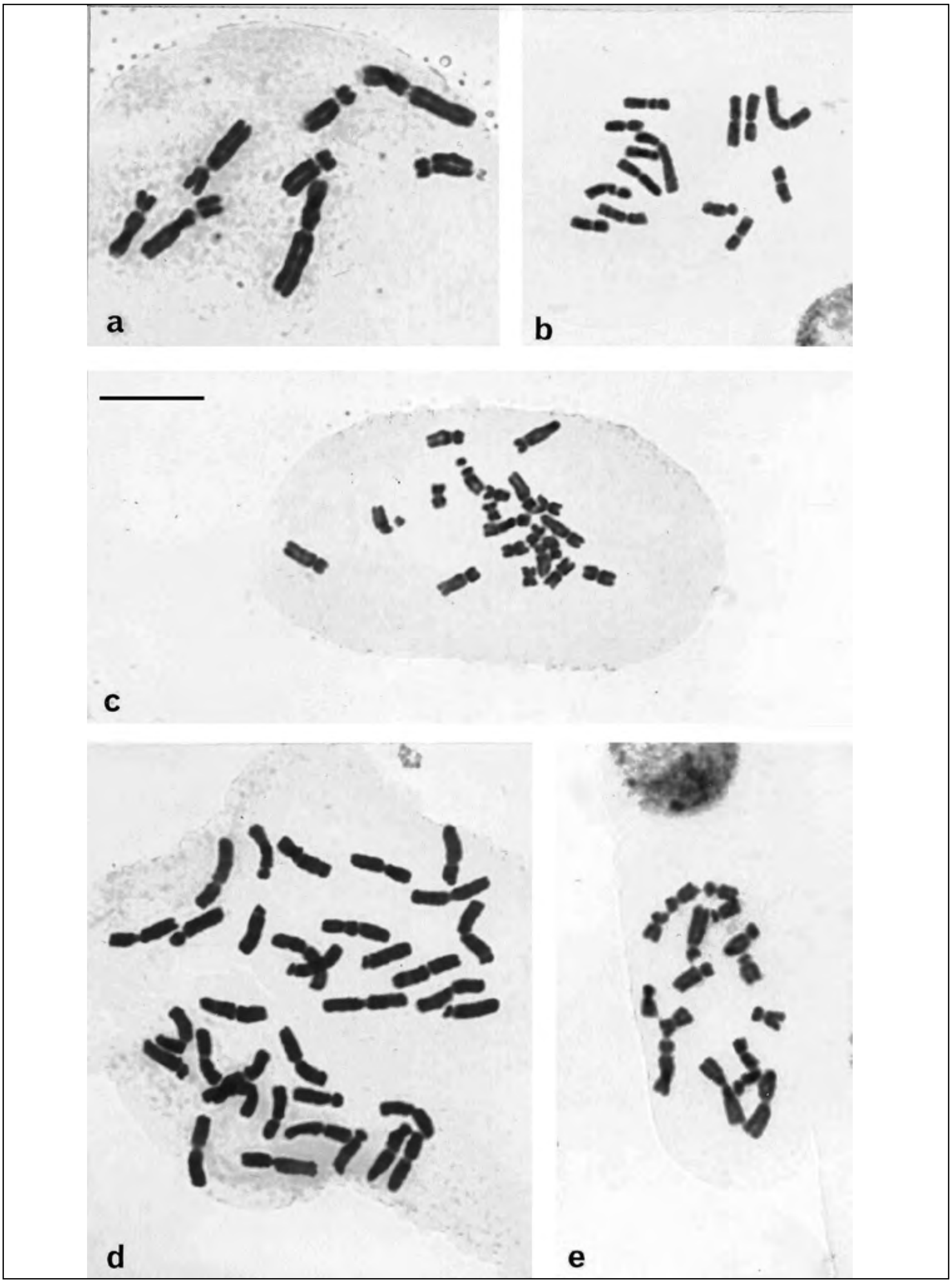

Fig. 5. Microphotographs of mitotic metaphase plates of *Crocus* species: **a,** *C. hermoneus* (ref. no 80.230), $2n = 8$; **b,** *C. kosaninii* (ref. no 78.47), $2n = 14$; **c,** *C. leichtlinii* (ref. no 77.28), $2n = 20$; **d,** *C. scardicus* (ref. no 80.243), $2n = 34$; **e,** *C. sieheanus* (ref. no 69.1140), $2n = 16$. – Scale bar = 10 µm.

— S of Agios Ambrosios, 35° 32' N, 33° 58' E, *Osorio-Tafall & Seraphim 8014*, *ref. no 73.2957* (K).

C. veneris is closely related to *C. aleppicus*, and like it has $2n = 16$ chromosomes but with a different karyotype, consisting of eight pairs of acrocentric chromosomes with one pair of satellites and a pair of proximal secondary constrictions in the long arms of another pair of chromosomes. The karyotype formula is given as $2n$ = 14st + 2st-SAT = 16 with chromosomes ranging in size from 3.33 to 6.00 µm (Fig. 3f).

The chromosomes of *Crocus* continue to exhibit a bewildering array of variability, even within species and between subspecies. It is clearly a genus which merits a considerable amount of further research.

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Addresses of the authors:
Heywood, Christine A.[1], Bareka, Pepy[2], Karamplianis, Theophanis[3] & Kamari, Georgia[4],
[1]Wokingham, RG40 1TP, UK. E-mail: caheywood@btinternet.com
[2]Laboratory of Systematic Botany, Faculty of Crop Science, Agricultural University of Athens, Iera Odos 75, GR-11855 Athens, Greece. E-mail: bareka@aua.gr
[3]Department of Ecology & Systematics, Faculty of Biology, National & Kapodistrian University of Athens, Panepistimiopolis, GR-157 03 Athens, Greece. E-mail: theo_karamp@biol.uoa.gr
[4]Botanical Institute, Department of Biology, University of Patras, GR-26500 Patras, Greece. E-mail: kamari@upatras.gr

I. Carev, F. Pustahija, M. Ruščić & S. Siljak-Yakovlev

Chromosome number and ploidy level in seven *Centaurea* species from Croatia

Abstract

Carev, I., Pustahija, F., Ruščić, M. & Siljak-Yakovlev, S. 2017: Chromosome number and ploidy level in seven *Centaurea* species from Croatia [In Kamari, G., Blanché, C. & Siljak-Yakovlev, S. (eds), Mediterranean chromosome data - 27]. – Fl. Medit. 27: 289-294. doi:10.7320/FlMedit27.289

Seven *Centaurea* species from Croatia (*C. alba*, *C. calcitrapa*, *C. cristata*, *C. rhenana*, *C. rupestris*, *C. salonitana* and *C. solstitialis*) belonging to five sections were studied. Chromosome numbers and metaphase plates are presented. All species studied here were found to be either diploid or tetraploid with the exception of *C. salonitana* which presented both ploidy levels: one diploid and one tetraploid population were detected.

1919. ***Centaurea alba*** L. — 2*n* = 2x = 18 (Fig. 1A).

Ct: Klis, Split, limestones, 43° 33' 34,97" N, 16° 31' 34,69" E, 315 m a.s.l., 12 Jul 2016, FNST_DB_2016_CA_10 (FNST – Fac. Natural Sciences Split, DB - Dept. of Biol.).

Centaurea alba L. [Syn.: *C. calva* Reut. ex Nyman, *C. deusta* subsp. *concolor* (DC.) Hayek, *C. globosa* Hort. ex DC., *C. haynaldiiformis* Prodan, *C. nitida* Lam., *C. strobilacea* Scop. (The Plant List 2013; Nikolić 2017)], which belongs to section *Phalolepis* (Cass.) DC., is a biennial or perennial European-Mediterranean floral element. It is spread over dry rocky meadows of the Mediterranean, sub-Mediterranean and mountainous regions of southern Europe (Dostál 1976; Nikolić 2017).

The chromosome number 2*n* = 18 reported here confirms the number given by several authors (IPCN 1979; Siljak-Yakovlev 2005; Siljak-Yakovlev & al. 2010), but tetraploid chromosome number (2*n* = 4x = 36) is also reported by Kuzmanov & al. (1986) and Bancheva & Greilhuber (2006). Measured genome sizes of this species are 2C = 1.67 pg (Siljak-Yakovlev & al. 2010) and 2C = 3.58 pg (Bancheva & Greilhuber 2006) which also pointed out the existence of two ploidy levels.

1920. ***Centaurea calcitrapa*** L. — 2*n* = 2x = 20 (Fig. 1B).

Ct: Rupotine, Klis, Split, limestones, 43° 33' 29,43" N, 16° 30' 48,66" E, 240 m a.s.l., 12 Jul 2016, FNST_DB_2016_CC_9.

Centaurea calcitrapa L. [Syn.: *Calcitrapa calcitrapa* (L.) Hill, *C. hybrida* Sweet, *C. hypophaestum* Gaertn., *C. lanceolata* Lam., *C. myacantha* Cass., *C. phoenicea* Sweet, *C. stellaris* Hill, *C. stellata* Lam., *C. vulgaris* Bernh., *Centaurea adulterina* Moretti ex DC., *C. calcitrapoides* L., *C. carduifolia* Salisb., *C. devauxii* Nyman, *C. horrida* Ten., *C. hybrida* Chaix, *C. macroacantha* Guss., *C. myacantha* DC., *C. penicillata* Delile, *C. trichacantha* Willd. ex Spreng. (The Plant List 2013)], belongs to *Dumulosae* (Hayek) Dostál section. It is biennial plant that belongs to the European-Mediterranean floral element. This species is found in ruderal anthropogenic habitats and it is native to south-eastern Europe and Asia Minor, but also naturalized in Western and Central Europe, Africa, West Asia up to NW India (Dostál 1976; Nikolić 2017).

According to relevant literature (Fedorov 1969; IPCN 1979), this species has a stable chromosome number 2*n* = 20 that we also found.

1921. *Centaurea cristata* Bartl. — 2*n* = 4x = 36 (Fig. 1C).

Ct: Kaštela, Kozjak, Split, limestones, 43° 33' 26,48'' N, 16° 18' 13,86'' E, 154 m a.s.l., 12 Jul 2016, FNST_DB_2016_CC_19.

Centaurea cristata Bartl. [Syn.: *Acosta cristata* (Bartl.) Holub, *C. acutiloba* DC., *C. cristata* subsp. *rabenhorstiana* (Sch. Bip.) Nyman, *C. karschiana* Auersw. ex Nyman, *C. rabenhorstiana* Sch. Bip. ex Nyman, *C. scopolii* Vest, *C. spinosociliata* subsp. *cristata* (Bartl.) Dostál (The Plant List 2013)], which belongs to *Arenariae* (Hayek) Dostál section, is biennial Illyrian-Adriatic endemic knapweed. This species is making the sub-Mediterranean and epi-Mediterranean eastern Adriatic dry lawns along the coastal slopes of the Croatian Littoral from the island Krk to the Neretva river in the Mediterranean vegetation zone (Dostál 1976; NKS 2014; Nikolić 2017).

The chromosome count for this taxon 2*n* = 36 confirms the data reported by Lovrić (1982).

1922. ***Centaurea rhenana*** Boreau — 2*n* = 4x = 36 (Fig. 1D).

Ct: Pasjača, Konavoske Stijene, Konavli, limestones, 42° 34' 52,81'' N, 18° 14' 59,97'' E, 163 m a.s.l., 25 Jun 2016, FNST_DB_2016_CR_17.

Centaurea rhenana Boreau [Syn.: *Acosta rhenana* (Boreau) Soják, *Acrolophus rhenanus* (Boreau) A. Löve & D. Löve, *Centaurea maculosa* Lam. subsp. *rhenana* (Boreau) Gugler, *C. paniculata* var. *rhenana* (Boreau) Rouy, *C. stoebe* L., *C. stoebe* L. subsp. *stoebe*, *C. stoebe* subsp. *maculosa* (Lam.) Hayek, *C. stoebe* subsp. *rhenana* (Boreau) Schinz & Thell.], belongs to *Maculosae* Dostál section and is a biennial or perennial plant. Its distribution range is quite wide, across the lawns and rocks of Central and South-Eastern Europe to the central Russia (Dostál 1976; Nikolić 2017).

The tetraploid chromosome number 2*n* = 4x = 36, found in this study, confirms previous reports (Fedorov 1969; IPCN 1979; Bancheva & Greilhuber 2006), but diploid individuals are also recorded 2*n* = 18, 18+0-2Bs in available literature (IPCN 1979; Bancheva &

Greilhuber 2006). Different 2C values, corresponding to two ploidy levels, were measured for this species: 1.70, 1.76, 1.84, 3.10, 3.16, 3.20 and 3.30 pg (Bennett & Leitch 2012; GSAD 2013). In our study only tetraploid individuals were recorded.

1923. ***Centaurea rupestris*** L. — 2*n* = 2x = 20 (Fig. 1E).

Ct: Pustinja Blaca, Klis, Split, limestones, 43° 34’ 15,17” N, 16° 28’ 38,51” E, 435 m a.s.l., 12 Jul 2016, FNST_DB_2016_CR_16.

Centaurea rupestris L. [Syn.: *Acrocentron tenuifolium* Cass., *Calcitrapa rupestris* (L.) Sweet, *Centaurea adonidifolia* Rchb., *C. rupestris* subsp. *aculeata* Arcang., *C. saxatilis* Bertol. ex Nyman, *C. variabilis* Bartl. ex Steud., *Colymbada rupestris* (L.) Holub) (The Plant List 2013)], belongs to section *Acrocentron* (Cass.) DC. It is a biennial plant, present on the two shores of the Adriatic and South East Europe, above all in the Carpathian-Danubian region, in the Epi-Mediterranean vegetation zone (Dostál 1976; Zepigi 2008; Nikolić 2017).

The diploid chromosome number 2*n* = 20 has been reported by Siljak (1977), Siljak-Yakovlev (2005) and Van Loon & Kieft (1980), but additionally the somatic number 2*n* = 24 was reported (Fedorov 1969; Van Loon & Kieft 1980). Here we confirm 2*n* = 20 chromosomes. Siljak-Yakovlev & al. (2010) reported genome sizes for the species 2C = 2.33 and 3.50 pg.

1924. ***Centaurea salonitana*** Vis. — 2*n* = 2x = 20 (Fig. 1F) and 2*n* = 4x = 40.

Ct: Kijevo, Mt. Dinara, limestones, 43° 59’ 38,44” N, 16° 24’ 07,49” E, 447 m a.s.l., 17 Jun 2016, FNST_DB_2016_CS_7. — 2*n* = 2x = 20.

— Žnjan, Split, limestones, 43° 30’ 29,24” N, 16° 29’ 36,03” E, 72 m a.s.l., 16 Jun 2016, FNST_DB_2016_CS_12. — 2*n* = 4x = 40.

Centaurea salonitana Vis. [Syn.: *Acrocentron salonitanum* (Vis.) Á. Löve & D. Löve, *Centaurea centauroides* M. Bieb., *C. collina* var. *macracantha* DC., *C. latifolia* Pers., *C. latisquama* DC., *C. latisquama* subsp. *salonitana* (Vis.) Nyman, *C. liliniea* Velen., *C. neglecta* Besser, *C. reflexa* subsp. *salonitana* (Vis.) Mikheev, *C. salonitana* var. *macracantha* (DC.) Boiss. & Heldr., *C. salonitana* var. *macracantha* DC., *C. salonitana* var. *subinermis* Boiss., *C. stribrnyi* Velen., *C. tatarica* Pall., *Colymbada salonitana* (Vis.) Holub, *Crepula centauroides* (L.) Hill) (The Plant List 2013)], belongs to section *Acrocentron* (Cass.) DC., is a perennial plant, widespread on the lawn sand rocky meadows of South East and Central Europe (Dostál 1976; Nikolić 2017).

We found one diploid (2*n* = 20) and one tetraploid (2*n* = 4x = 40) population. The diploid chromosome number confirms previous reports (Fedorov 1969; Siljak-Yakovlev & Gorenflot 1977; IPCN 1979), as well as the tetraploid number that confirms findings of Siljak-Yakovlev & Gorenflot (1977) and IPCN (1979).

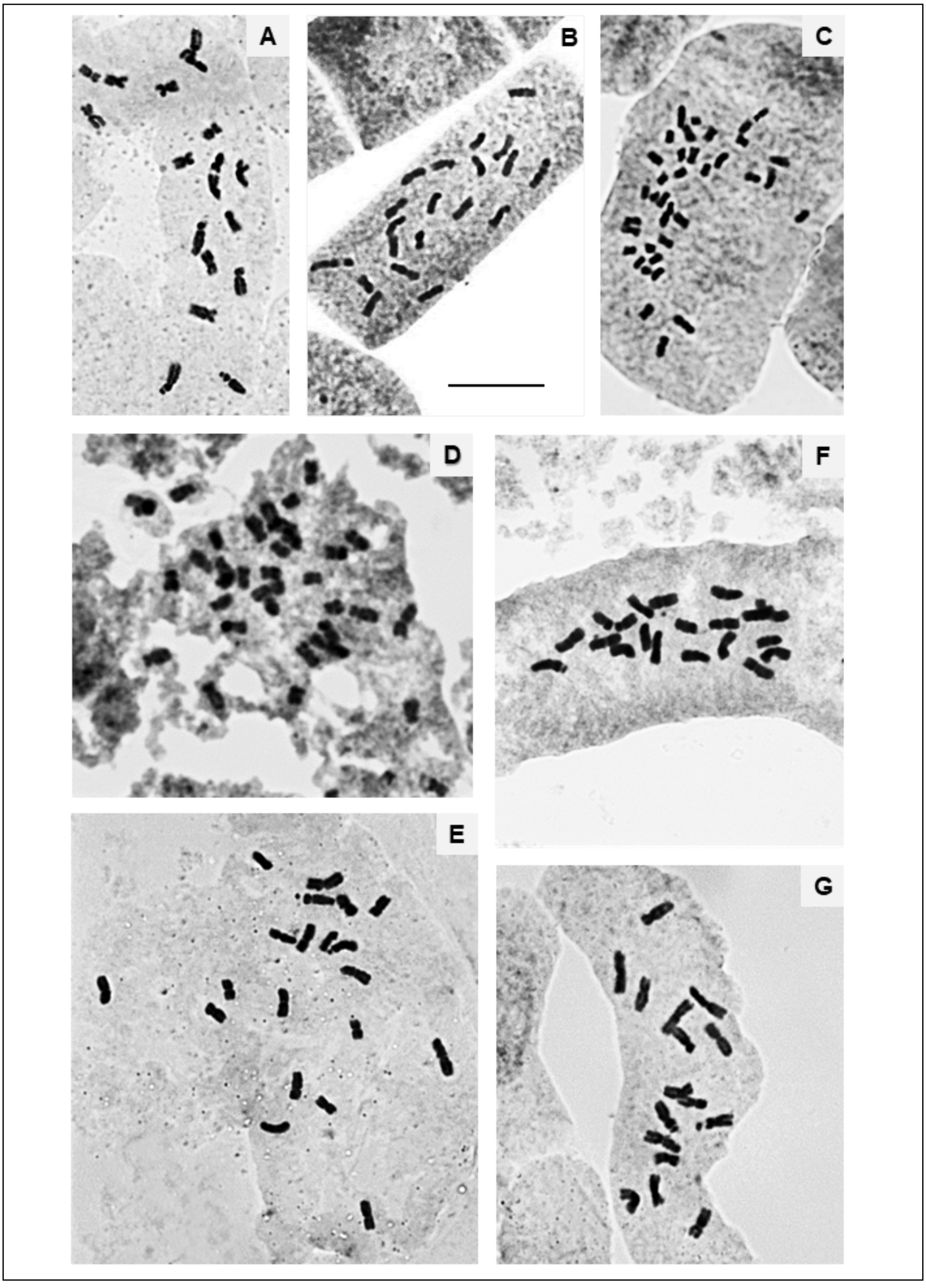

Fig. 1. Mitotic methaphase plates of *Centaurea*: **A**, *C. alba*, 2*n* = 14; **B**, *C. calcitrapa*, 2*n* = 20; **C,** *C. cristata*, 2*n* = 36; **D**, *C. rhenana*, 2*n* = 30; **E**, *C. rupestris*, 2*n* = 20; **F**, *C. salonitana*, 2*n* = 20; **G**, *C. solstitialis*, 2*n* = 16. – Scale bar = 10 µm.

1925. ***Centaurea solstitialis*** L. — $2n = 2x = 16$ (Fig. 1G).

Ct: Marjan, Split, limestones, 43° 30' 31,37" N, 16° 25' 59,18" E, 64 m a.s.l., 12 Jul 2013, FNST_DB_2013_CS_17.

Centaurea solstitialis L. [Syn.: *Calcitrapa lutea* Delarbre, *C. solstitialis* (L.) Lam., *Centaurea cyanifolia* Poir., *C. parvispina* Láng ex Gugler, *C. pseudosolstitialis* Debeaux, *Cyanus solstitialis* J. Presl & C. Presl, *Leucantha solstitialis* (L.) Á. Löve & D. Löve) (The Plant List 2013)], belongs to *Dumulosae* (Hayek) Dostál section, is annual to biennial, spread on dry open habitats of southern Europe, but expanded and naturalized in parts of Central Europe. It belongs to the South-European floral element (Dostál 1976; Nikolić 2017).

Different authors (Fedorov 1969; IPCN 1979; Bennett & Leitch 2012) counted the same chromosome number ($2n = 16$), but also $2n = 18$ can be found in the literature (IPCN 1979). Bancheva & Greilhuber (2006) estimated genome size for *C. solstitialis* 2C = 1.74 pg and Carev & al. (2017) reported higher value of 2C = 1.95 pg.

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Addresses of the authors:
Carev, Ivana[1], Pustahija, Fatima[2], Rušćić, Mirko[3] & Siljak-Yakovlev, Sonja[4],
[1]Department of Biochemistry, Faculty of Chemistry and Technology, University of Split, Ruđera Boškovića 35, 21 000 Split, Croatia. E-mail: ivana.carev@ktf-split.hr
[2]Fatima Pustahija, Faculty of Forestry, University of Sarajevo, Zagrebačka 20, Sarajevo, Bosnia and Herzegovina. E-mail: f.pustahija@sfsa.unsa.ba
[3]Department of Biology, Faculty of Natural Sciences, University of Split, Ruđera Boškovića 33, 21 000 Split, Croatia. E-mail: mrus@pmfst.hr
[4]Ecologie, Systématique et Evolution, Département "Evolution des angiospermes", Univ. Paris-Sud, CNRS, AgroParisTech, Université Paris-Saclay, Bât 360, 91405 Orsay cedex, France. E-mail: sonia.yakovlev@u-psud.fr

F. Pustahija, E. M. Šolić & S. Siljak-Yakovlev

Karyological study of some Mediterranean species from Bosnia and Herzegovina, Croatia and Lebanon

Abstract

Pustahija, F., Šolić, E. M. & Siljak-Yakovlev, S. 2017: Karyological study of some Mediterranean species from Bosnia and Herzegovina, Croatia and Lebanon [In Kamari, G., Blanché, C. & Siljak-Yakovlev, S. (eds), Mediterranean chromosome data - 27]. – Fl. Medit. 27: 295-301. doi: 10.7320/FlMedit27.295

Chromosome numbers and metaphase plates are given for seven species from Bosnia and Herzegovina (*Anacamptis morio*, *Asphodelus albus*, *Dactylorhiza maculata*, *Digitalis grandiflora*, *Narcissus poeticus*, *Platanthera bifolia*, *Polygonatum multiflorum*), and one species from Croatia (*Narcissus obsoletus*) and Lebanon (*Narcissus tazetta*). Chromosome counts and genome sizes are discussed.

1926. ***Anacamptis morio*** (L.) R. M. Bateman, Pridgeon & M. W. Chase — $2n = 36$ (Fig. 1a).

BH: Mliništa, Glamoč, limestones, 44° 14’ 04,65’’ N, 16° 50’ 00,72’’ E, 1220 m a.s.l., 10 May 2008, private herbarium of F.P.

Anacamptis morio (L.) R. M. Bateman, Pridgeon & M. W. Chase is a bulbous herbaceous perennial plant, native to western Eurasia, ranging from Europe to Iran.

The chromosome number $2n = 36$ counted here agrees with some previous reports, since this species has a variable number of chromosome counts $2n = 20$, 32, 36 and 38 (Fedorov 1969; IPCN 1979). Siljak-Yakovlev & al. (2010) published the genome size of 2C = 19.27 pg for this species as *Orchis morio* L. from other BH population.

1927. ***Asphodelus albus*** Mill. — $2n = 28$ (Fig. 1b).

BH: Galečić, Livno, limestones, 43° 47’ 18,55’’ N, 17° 10’ 14,86’’ E, 1071 m a.s.l., 19 May 2008, private herbarium of F.P.

Asphodelus albus Mill. is a herbaceous perennial plant, native to the Mediterranean area.

The diploid chromosome number $2n = 28$ confirms previous reports of Capineri & al. (1978), Díaz Lifante (1996) and Siljak-Yakovlev & al. (2010), but differs from $2n = 26$ (Fedorov 1969), $2n = 56$ (Fedorov 1969; Guillén & Laínz 1997) and $2n = 84$ (Guillén & Laínz 1997). The measured genome size for $2n = 28$ is 2C = 7.25 pg (Siljak-Yakovlev & al. 2010).

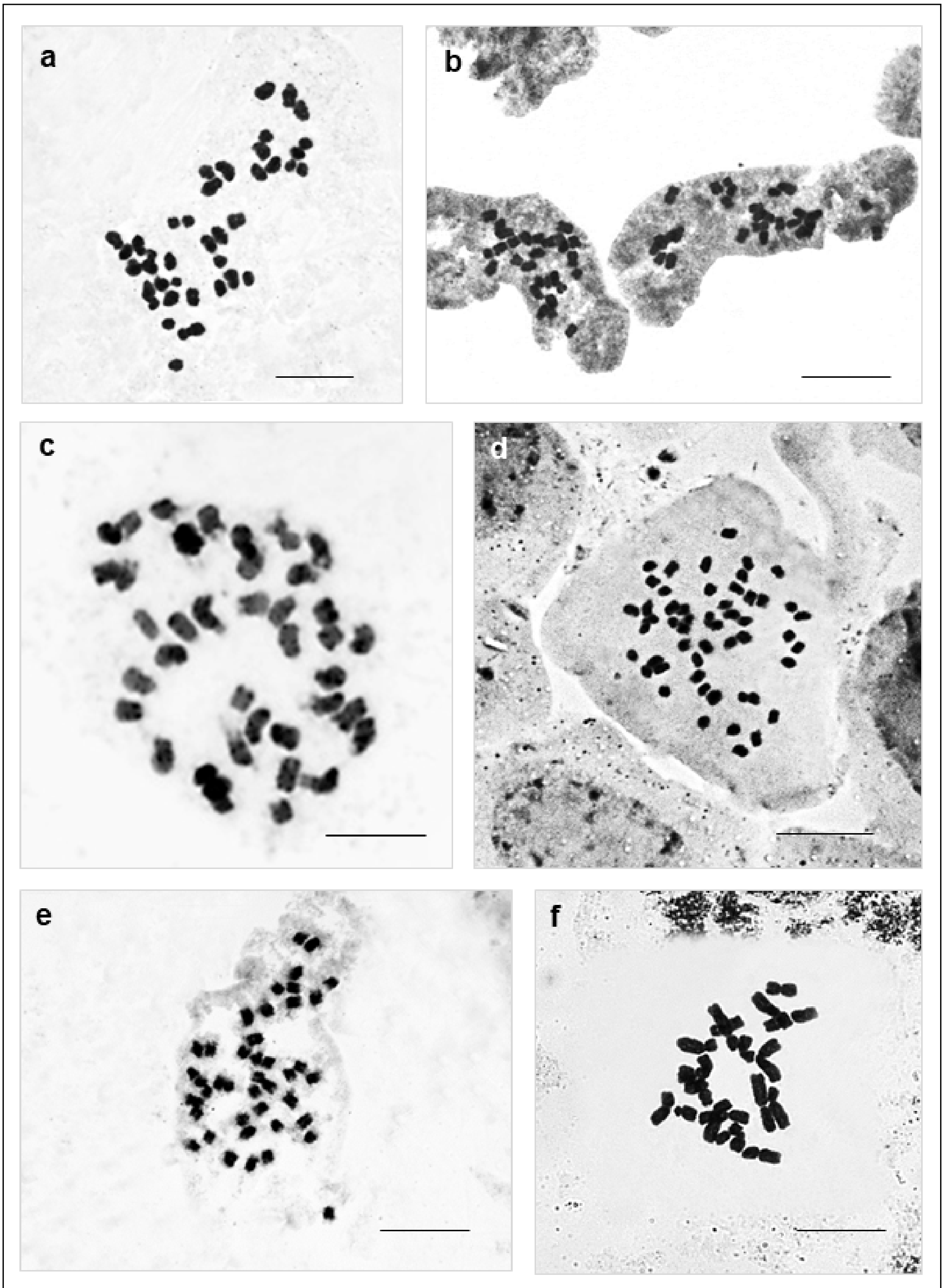

Fig. 1. Mitotic methaphase plates of: **a,** *Anacamptis morio*, $2n = 36$; **b,** *Asphodelus albus*, $2n = 28$; **c,** *Dactylorhiza maculata*, $2n = 40$; **d,** *Digitalis grandiflora*, $2n = 56$; **e,** *Platanthera bifolia*, $2n = 42$; **f,** *Polygonatum odoratum*, $2n = 20$. – Scale bars = 10 µm.

1928. ***Dactylorhiza maculata*** (L.) Soó — 2*n* = 40 (Fig. 1c).

BH: Katranica, Muške Vode, Kladanj, serpentine, 44° 14' 11,64" N, 18° 34' 17,87" E, 825 m a.s.l., 06 May 2008, private herbarium of F.P.

Dactylorhiza maculata (L.) Soó is a herbaceous perennial plant, native to Europe, but also found in Algeria, Morocco, western Siberia and Canada.

Different chromosome numbers (2*n* = 40, 40-41, 60, 78 and 80) are given in the literature for this species (IPCN 1979; Bertolini & al. 2000; Aagaard & al. 2005; Siljak-Yakovlev & al. 2010), and our count of 2*n* = 40 is in accordance with previous reports for diploids. Siljak-Yakovlev & al. (2010) estimated the genome size for diploids (2C = 6.80 pg) and Aagaard & al. (2005) for tetraploids (2C = 11.32 pg).

1929. ***Digitalis grandiflora*** Mill. — 2*n* = 56 (Fig. 1d).

BH Papratnica, Žepče, serpentine, 44° 26' 13,33" N, 17° 58' 39,33" E, 333 m a.s.l., 29 Jun 2008, private herbarium of F.P.

Digitalis grandiflora Mill. is a herbaceous biennial or perennial plant, native to southern Europe and Asia.

The diploid chromosome number 2*n* = 56 is stable for the species and coincides with data obtained by different authors (Fedorov 1969; IPCN 1979; Vidic & al. 2009; Temsch & al. 2010; Pustahija & al. 2013). Estimated genome sizes for the species are 2C = 2.30 pg (Temsch & al. 2010), 2.56 pg (Pustahija & al. 2013) and 2.60 pg (Vidic & al. 2009).

1930. ***Narcissus obsoletus*** (Haw.) Spach — 2*n* = 30 (Fig. 2a).

Ct: Lovište, Pelješac Peninsula, limestones, 43° 02' 47,32" N, 17° 00' 10,33" E, 12 m a.s.l., 19 Oct 2008, private herbarium of E.M.Š.

Narcissus obsoletus (Haw.) Spach is a bulbous herbaceous perennial plant, native to the Mediterranean littoral with geographical distribution from northern Africa and the Iberian Peninsula to Israel on east.

This is the first finding of this species for the Croatian flora identified also thanks to count of chromosome number 2*n* = 30 and analysis of chromosome complement, which is in agreement with data obtained by Díaz Lifante & al. (2009). Siljak-Yakovlev & al. (2010) published its genome size but as *N. serotinus* L. 2C = 43.85 pg.

1931. ***Narcissus poeticus*** L. — 2*n* = 14, 14+1-2Bs & 21+0-3Bs (Figs 2b, c & d).

BH: Katranica, Muške Vode, Kladanj, serpentine, 44° 14' 11,64" N, 18° 34' 17,87" E, 825 m a.s.l., 06 May 2008, private herbarium of F.P.

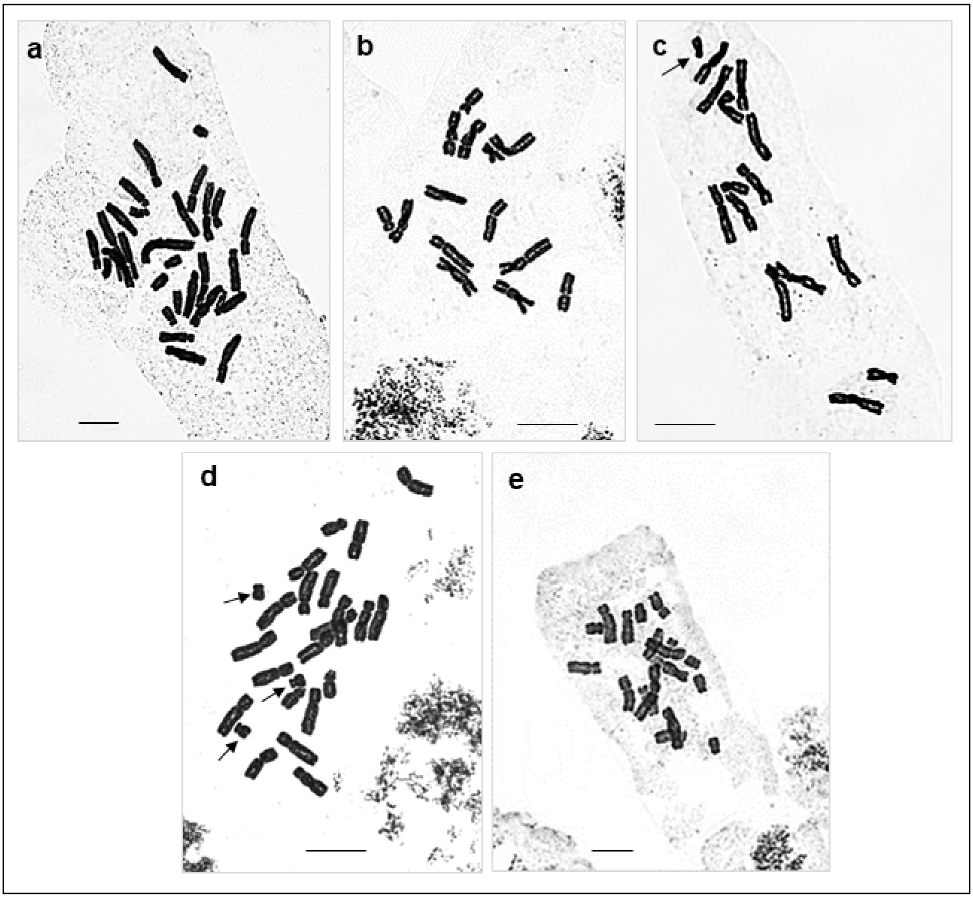

Fig. 2. Mitotic methaphase plates of *Narcissus:* **a,** *N. obsoletus*, $2n = 30$; **b,** *N. poeticus*, $2n = 14$ (population Katranica); **c,** *N. poeticus*, $2n = 14+1B$ (population Donje Peulje); **d,** *N. poeticus*, $2n = 21+3Bs$ (population Avtovac); **e,** *N. tazetta*, $2n = 18$. – Arrows indicate the B chromosomes. Scale bars = 10 µm.

— Donje Peulje, Bosansko Grahovo, limestone, 44° 08' 42,81" N, 16° 27' 48,12" E, 810 m a.s.l., 10 May 2008, private herbarium of F.P.

— Avtovac, Gatačko Polje, Gacko, limestones, 43° 07' 49,40" N, 18° 34' 01,46" E, 949 m a.s.l., 13 May 2008, private herbarium of F.P.

Narcissus poeticus L. is a bulbous herbaceous perennial plant, native to central and southern Europe and cultivated, as a horticultural species, throughout the world.

The diploid chromosome number $2n = 14+0\text{-}2Bs$ is reported by several authors (Fedorov 1969; IPCN 1979; Zonneveld 2008; Siljak-Yakovlev & al. 2010; Pustahija & al. 2013) as well as triploid chromosome number $2n = 21$ (Fedorov 1969; IPCN 1979;

Brandham & Kirton 1987; Siljak-Yakovlev & al. 2010). Here we confirm chromosome numbers of diploids 2*n* = 14 + 0-2Bs and triploids 2*n* = 21 + 0-3Bs. Genome sizes of diploids were 24.33 (Siljak-Yakovlev & al. 2010), 26.00 (Zonneveld 2008), 27.50 pg (Olszewska & Osiecka 1982), and for triploids 2C = 34.55 pg (Siljak-Yakovlev & al. 2010).

1932. *Narcissus tazetta* L. — 2*n* = 18 (Fig. 2e).

Le: El Aleli, limestones, 30 m a.s.l., 13 Apr 2012, leg. *M. Bou Dagher-Kharrat s.n*.

Narcissus tazetta L. is a bulbous herbaceous perennial and ornamental plant, native to the Mediterranean region from Portugal to Turkey, but widespread all over the world.

In the literature, very diverse reports are present for this species in relation to its chromosome number: 2*n* = 14, 20, 21, 22, 24, 28, 30 and 32 (Fedorov 1969; IPCN 1979; Brandham & Kirton 1987; Zonneveld 2008; Bennett & Leitch 2012; Boukhenane & al. 2015). Here we present, for the first time, the chromosome number 2*n* = 18 that we found in one Lebanon population. This finding merites to be deepened. Three different genome sizes are published for this species 2C = 25 pg (Bou Dagher-Kharrat & al. 2013), 2C = 30.30 (Zonneveld 2008), 39.54 pg (Vesely & al. 2011).

1933. *Platanthera bifolia* (L.) Rich. — 2*n* = 42 (Fig. 1e).

BH: Katranica, Muške Vode, Kladanj, serpentine, 44° 14’ 11,64’’ N, 18° 34’ 17,87’’ E, 825 m a.s.l., 06 May 2008, private herbarium of F.P.

Platanthera bifolia (L.) Rich. is a tuberculous herbaceous perennial plant, native to Europe, Asia-Temperate, Algeria and Tunisia.

The diploid chromosome number 2*n* = 42 is in accordance with the most aviable literature data (Fedorov 1969; IPCN 1979; Siljak-Yakovlev & al. 2010) but not with 2*n* = 16 and 40 (IPCN 1979). Estimated amounts of nuclear DNA were 2C = 13.74 and 19.89 pg by Siljak-Yakovlev & al. 2010 and Vesely & al. 2011, respectively.

1934. *Polygonatum odoratum* (Mill.) Druce — 2*n* = 20 (Fig. 1f).

BH: Katranica, Muške Vode, Kladanj, serpentine, 44° 14’ 11,64’’ N, 18° 34’ 17,87’’ E, 825 m a.s.l., 06 May 2008, private herbarium of F.P.

Polygonatum odoratum (Mill.) Druce is a rhizomatous herbaceous perennial plant, native to Europe, Caucasus, Siberia, Russian Far East, China, Mongolia, Korea and Japan.

A very diverse chromosome number for the species can be found in the literature 2*n* = 16, 18, 20, 20+0-2Bs, 22, 24, 30 and 40 (Fedorov 1969; IPCN 1979; Siljak-Yakovlev & al. 2010), where the 2*n* = 20 that we found is the most common. Measured genome sizes are

2C = 19.66 (Siljak-Yakovlev & al. 2010), 20.04 (Vesely & al. 2011) and 23.10 pg (Zonneveld & al. 2005).

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Addresses of the authors:
Pustahija, Fatima[1], Šolić, Edita Marija[2] & Siljak-Yakovlev, Sonja[3],
[1]Faculty of Forestry, University of Sarajevo, Zagrebačka 20, Sarajevo, Bosnia and Herzegovina. E-mail: f.pustahija@sfsa.unsa.ba
[2]Institute “Mountain and Sea”, Franjevački put 1, H-21300 Makarska, Croatia. E-mail: meditasolic@gmail.com
[3]Ecologie, Systématique et Evolution, Département “Evolution des angiospermes”, Univ. Paris-Sud, CNRS, AgroParisTech, Université Paris-Saclay, Bât 360, 91405 Orsay cedex, France. E-mail: sonia.yakovlev@u-psud.fr

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