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Contents

Communications

Posters

Salvatore Brullo

Criteria and techniques in the taxonomic investigation of the Mediterranean flora

Abstract

Brullo, S.: Criteria and techniques in the taxonomic investigation of the Mediterranean flora. — Bocconea 23: 7-18. 2009. — ISSN 1120-4052.

The author illustrates some criteria and techniques, adopted by the same in the taxonomic investigations of genera belonging to the Mediterranean flora. Examples regarding some critical groups of *Astragalus*, *Allium* and *Limonium* are provided. It is argued that ecological observations, a detailed caryological and morphological study, together with a precise and truthful iconography are essential needs for a correct taxonomic investigation.

Introduction

The Mediterranean flora is one of the most studied, but still presents many unsolved problems, due to the many critical genera or species complexes, which are still lacking of an exhaustive systematic handling. The occurrence of several critical taxa is linked to the remarkable environmental heterogeneity and to the natural fragmentation of the Mediterranean lands, consisting of islands and peninsulas with a complex orography. Moreover, the detectable high variability among currently isolated populations is often linked to palaeogeographic vicissitudes that may have joint and split these populations several times during the last 5 Mio. yrs.

The morphologic variability shown by several Mediterranean taxa has been often neglected or only superficially investigated by the many authors who did not have the possibility to observe the populations in the field and to examine many herbarium specimens sampled from the whole distribution range of a certain critical group.

Basing on my personal experience, there are different techniques and criteria that should be adopted for the taxonomic investigation of the Mediterranean critical taxa, depending on the intrinsic features of each groups. Some examples are provided in the following paragraph.

Astragalus

The first example regards the thorny dwarf-shrub *Astragalus creticus* Lam., growing on the Cretan mountains. Until a recent past, all the known populations were attributed to the sole species *A. creticus.* As a matter of fact, it is possible to recognize three distinctive types of such plant, which differ from both the morphologic and ecologic viewpoint (Brullo & Giusso 2001, 2003).

The pulvines of the typical *A. creticus* are characterized by a greyish colour given by the dense hairiness of such species, which colonizes steep stony slopes on lithosoils. Instead, the populations living on the floor of dolines are looking much greener, due to the scarce hairiness (Fig. 1). The ones living on the easternmost Cretan massif, Afendi Kavousi, are clearly more thermophilous than the other Cretan *Astragalus* populations, since they live at lower altitudes: even in this case, their leaves are less densely hairy than the those of the typical *A. creticus*.

The above mentioned ecological differences, together with at-first-glance impressions of the plant colour, raised a thorough morphological study of all the populations of the Cretan spiny *Astragalus*. It could be claimed that different ecological conditions are selecting different ecotypes within the same species, but the detailed morphometric and morphologic analysis revealed some more remarkable differences among the three "ecotypes". The populations colonizing the bottom of karstic dolines have been described as a distinct species, *A. dolinicolus* Brullo & Giusso, which is clearly different from *A. creticus* not only for its ecological requirements but also for several features regarding the leaves, bracts, flowers and legumes. The populations of Afendi Kavousi revealed closer relationships with the typical *A. creticus*, so they have been treated as a subspecies of the same: *A. creticus* ssp. *minoicus* Brullo & Giusso. While *A. dolinicolus* is sympatric to *A. creticus*, of which can be considered as an ecological vicariant adapted to longer snow-deck and deeper soils, the one of Afendi Kavousi, being allopatric to *A. creticus*, is clearly a geographic vicariant of the same. Therefore, it can be considered a schyzoendemism resulting from the splitting of a formerly continuous distribution range, with secundary adaptation to more thermophilous conditions. Since all the spiny *Astragalus* are autogamic, there is no possibility of hybridization among them, so they should be considered as distinct species, at least in the case of sympatric populations.

Like in most of the *Fabaceae*, the main diagnostic characters are found in the leaves, legumes and flowers. It must be noted that leaves and legumes can be studied on dried material, but the flowers must necessarily be examined while they are fresh. Instead, they can be preserved in isotonic solutions, since not even the rehydration of dried floral pieces lets them acquiring the pristine shape (Fig. 2). Quality and details of the iconography are not accessorial tools, but extremely important components in the taxonomical investigation.

Fig. 1. At the periphery of the karstic dolines in the Cretan massif of Psiloriti, specimens of *Astragalus creticus* (left) are often living together with *Astragalus dolinicolus* (right).

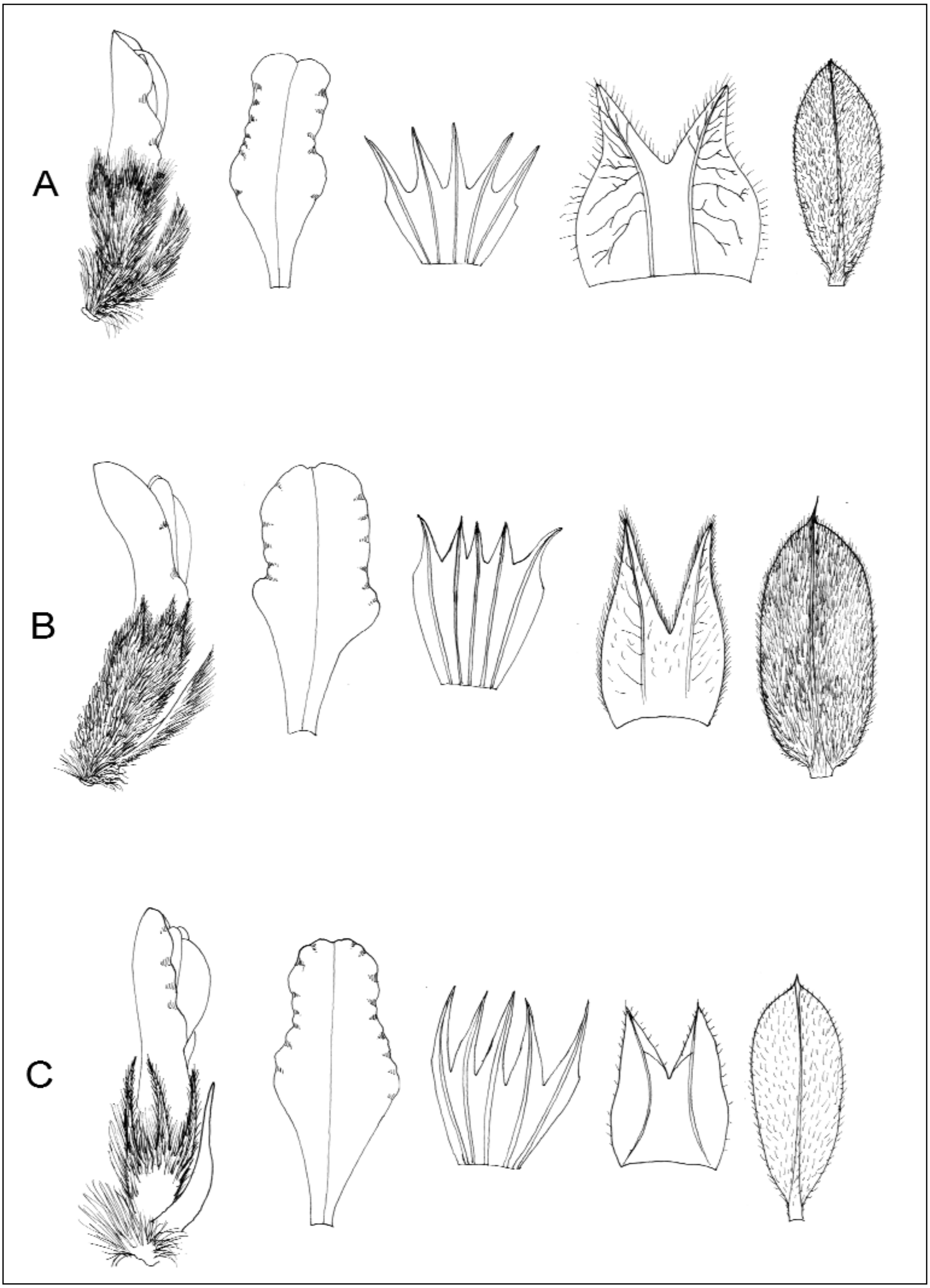

Fig. 2. Comparison of flowers with bracts, standards, open calyces, stipules and leaflets of *A. creticus* subsp. *creticus* (A), *A. creticus* subsp. *minoicus* (B) and *A. dolinicolus* (C). All drawings are based on fresh material (after Brullo & Giusso 2003, modified).

Allium

As already noticed by G. Don (1826), the very first monographer of the genus *Allium,* it is not possible to study garlics on dry specimens (" The genus *Allium* can only be studied satisfactorily from living specimens; for, in Herbaria, the species of this genus, like other liliaceous plants, are seldom found to retain their characters, so as to be recognised with certainty"). Unfortunately, his suggestion has not been followed by most of the subsequent monographers. Indeed, most of the diagnostic characters are in the very delicate flowers, which entirely loose their pristine morphology once dried.

What G. Don said can be exemplified with the case of *A. tenuiflorum* Ten. (Fig. 3): dried flowers are looking completely different from the fresh ones. The colour is nearly purplish instead of pink-whitish; tepals are looking linear instead of obovate-elliptical and the corolla looks cylindrical, not campanulate. The original iconography by Tenore (1811-1815) was clearly based on dried specimens and this is confirmed in the protologue, where it is mistakenly declared "corolla cylindrica" and "petalis linearibus acutis, apice revolutis". As it can be seen from the photo of the living inflorescence (Fig. 3) tepals are not linear, nor curved at the apex, and the corolla is not cylindrical, nor purplish (Brullo & al. 2002, 2003).

A superficial diagnosis, together with an imprecise iconography, is often causing wrong information on the species distribution and identification. Until recent times, *A. tenuiflorum* and allied taxa have been often confused with *A. pallens*, or *A. paniculatum*, and the diversity shown by some pop-

Fig. 3. Comparison of living (A), dried (B) and Tenore's iconography (C) of inflorescences of *Allium tenuiflorum* Ten. from the locus classicus.

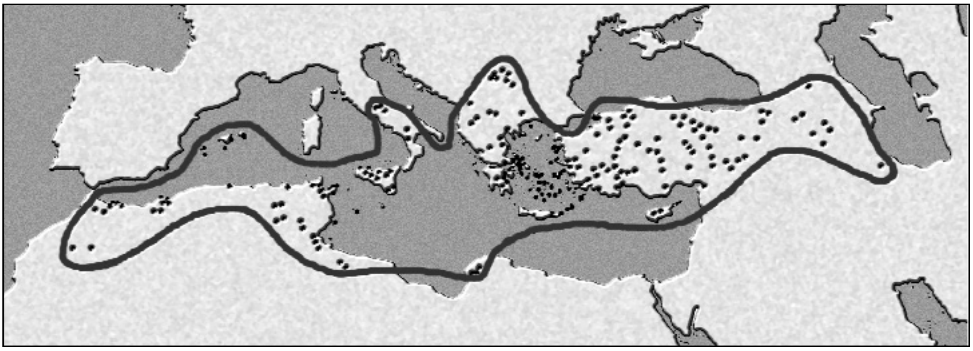

Fig. 4. Geographical distribution of the *Allium cupanii* group. Dots are showing the investigated populations.

ulations has been neglected. An accurate study on all the known populations of *A. tenuiflorum* (Brullo & al. 2002), led to the identification of two new species, *A. apulum* and *A. diomedeum*, together with a complete redefinition of the distribution range of *A. tenuiflorum*.

Another example is provided by *Allium cupanii* Rafin., a species complex that I have been studying in the last 25 years, by visiting and sampling most of the populations where this species was recorded, in many Mediterranean countries (Fig. 4). In Fig. 5, some typical features in common to all the species belonging to the complex "*Allium cupanii*" are shown, i.e. valves of the spathes partially or entirely connate, erect at blossom, and bulbs covered by a network of reticulated fibres.

Again, a detailed and truthful iconography represents an essential need for the precise taxonomical diagnosis: in Fig. 6, an old iconography of *A. cupanii* by Fiori (1923) is compared to a new unpublished one, drawn by myself, basing on living material. In the Fiori's drawing, clearly obtained from a dried specimen, the reticulated fibres of the bulbs are evident, but many other important diagnostic characters are missing: such as the floral pieces, or the hairiness of the leaf sheaths.

I consider the group of *Allium cupanii* a fascinating research theme, because of the many scattered populations and because of the great morphologic variability through them. The diagnostic characters are sometimes difficult to be seen, but they are highly constant in each population. They include: size and shape of the flower, shape of the tepals, length of the stamens, tunics attached or split at the base of the bulb, the occurrence of two or four bostryces in the floral umbel, that goes with the fusion of the spathes: partially connate valves are always found together with four bostryces, while entirely connate valves are normally associated with two bostryces, even if, more rarely, they may also occur with four bostryces (Fig. 7).

By the observation of these diagnostic characters, it is possible to identify five groups of species:

The cycle of *Allium callidyction* is including diploid species ($2n=2x=16$) with four bostryces and partially connate valves. They are likely to be the most primitive and most of them are found in Turkey, Iran, Iraq, with some extremely isolated populations in Calabria, Cyrenaica and Evvoia (Fig. 8A).

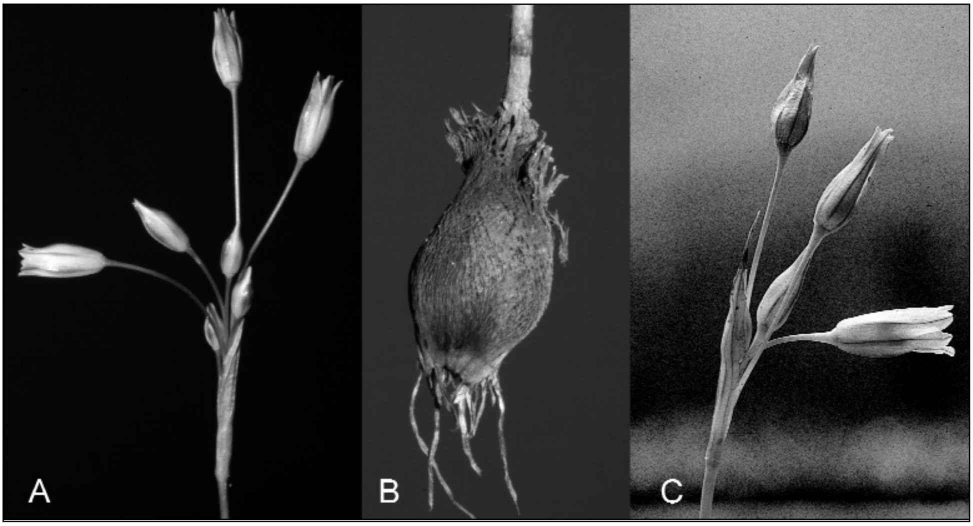

Fig. 5. Details of living specimens of *Allium cupanii* group: umbel (A) and bulb (B) of *A. cupanii* s. str. from Madonie (Sicily); umbel (C) of *A. pentadactyli* from Aspromonte (S Italy).

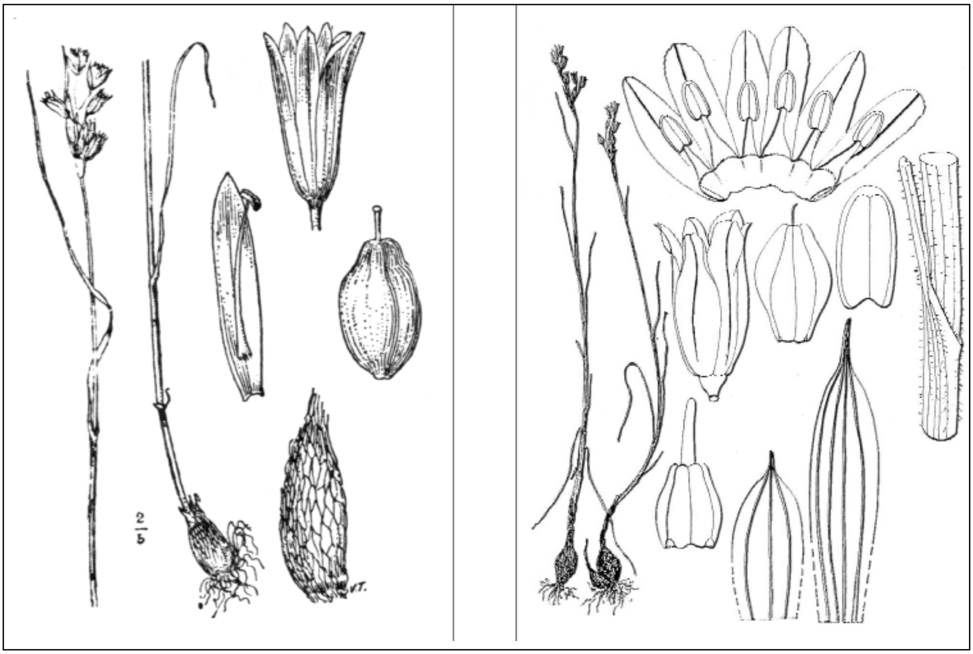

Fig. 6. Iconography of *Allium cupanii* s. str., on the left by Fiori (1923), on the right by Brullo (unpublished).

The cycle of *Allium balcanicum* is including diploid species (2*n*=2x=16) with two bostryces and connate valves. Most of these species are found in the Balcanic peninsula and in Western Turkey (Fig. 8B).

The cycle of *Allium cupanii* is including tetraploid species (2*n*=4x=32) with two bostryces and connate valves. Most of them are found, either, in southern Italy and North-West Africa (Fig. 8C).

From the above-mentioned species it is likely to be derived the cycle of *Allium antonii-bolosii* including tetraploid-aneuploid populations (2*n*=4x=30) restricted to the Balearic Islands (Fig. 8D), to which, in addition to *Allium antonii-bolosii*, also *Allium eivissianum* is belonging (Miceli & Garbari 1987).

Aneuploid populations (2*n*=2x=14) are also found within the diploids: this is the case of the cycle of *Allium hirtovaginatum*, characterized by two bostryces, a sole valve and split tunics at the base of the bulb. This group seems to be rather successful, because it stretches over most of the Mediterranean basin (Fig. 9), particularly in coastal stony slopes or rupestrian sites, characterized by a remarkable seasonal aridity. Their evolutionary success is probably related to the greater number of fibrous layers which protect the bulb against the dry climate conditions.

The species complex "*Allium cupanii*" provides a fascinating example of adaptive radiation, combined with an east-westwards gradient of ploidy, which was highlighted for the first time by Garbari & al. (1979). The supposed phylogenetic relationships within the group are the following (Fig. 10): the common ancestor is likely to be *Allium lacerum*, from which the cycle of *Allium callidyction* is likely to be derived at first, with the loss of the cilia in the tepals. The evolutionary chances of this group are seemingly exhausted. From *Allium lacerum*, through *Allium incisum*, all the other cycles are likely to be derived, with the aneuploid groups being the ultimate product of the

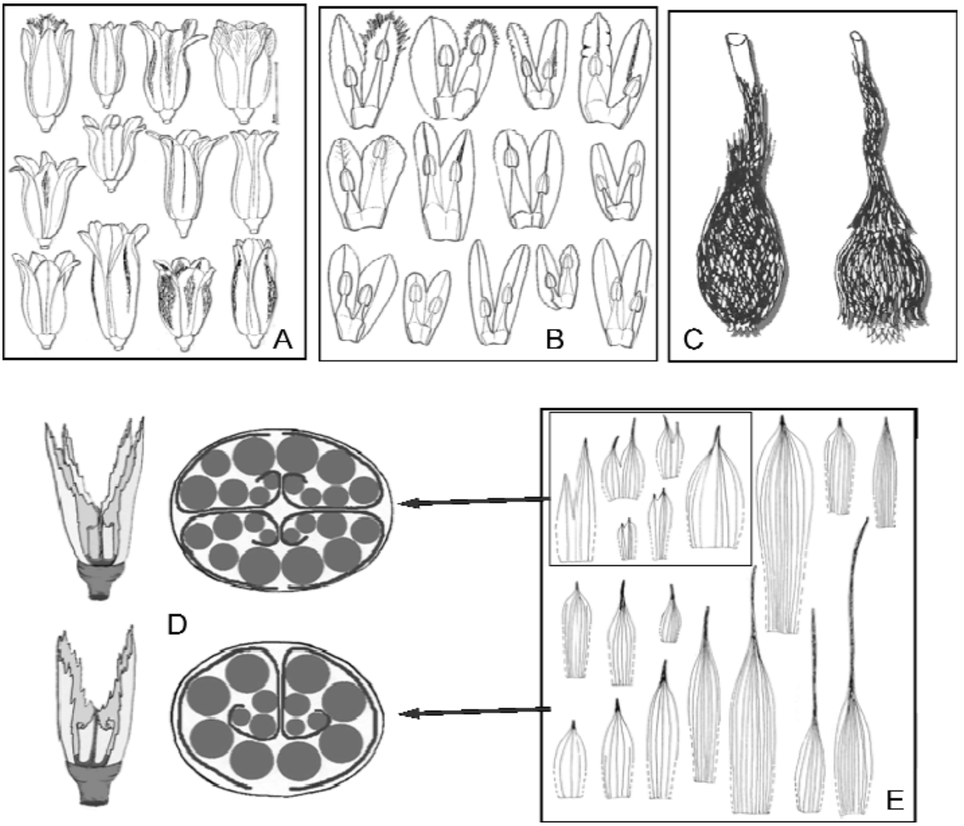

Fig. 7. Illustrative tables of the variability of some morphologic features in the *Allium cupanii* groups: Perigon (A), Detail of tepals and stamens (B), bulb tunics (C), bostryces (D) and spathe valves (E).

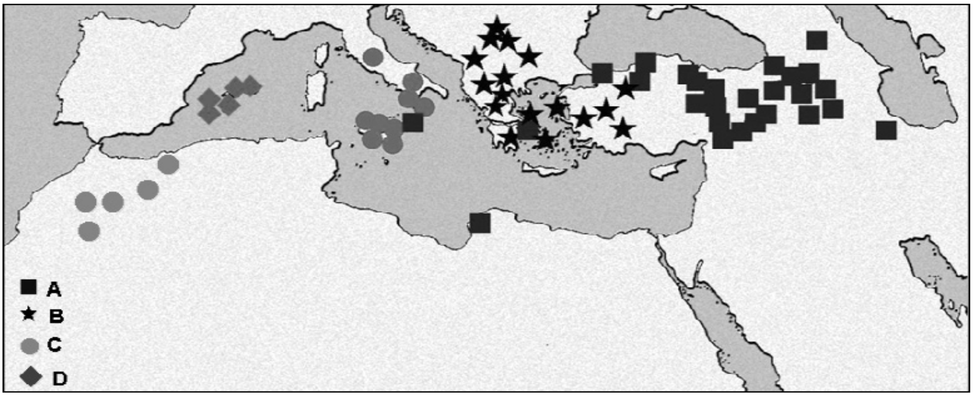

Fig. 8. Distribution range of *Allium callidictyon* cycle (A), *A. balcanicum* cycle (B), *A. cupanii* cycle (C), and *A. antonii-bolosii* cycle (D).

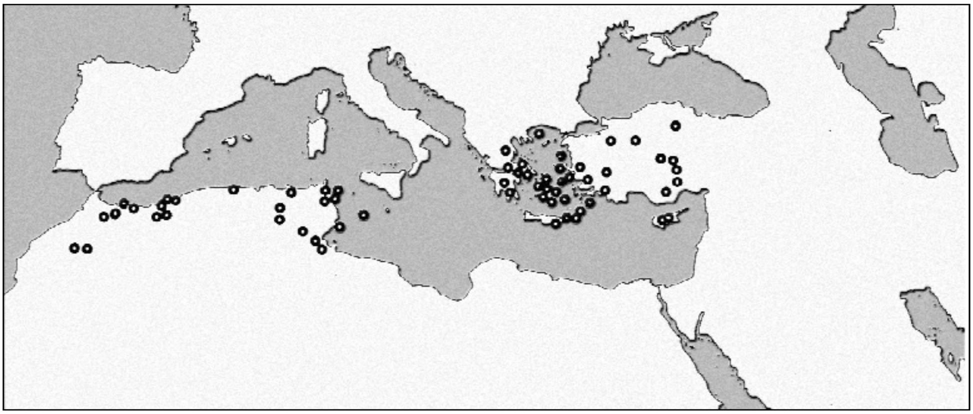

Fig. 9. Distribution range of *Allium hirtovaginatum* cycle.

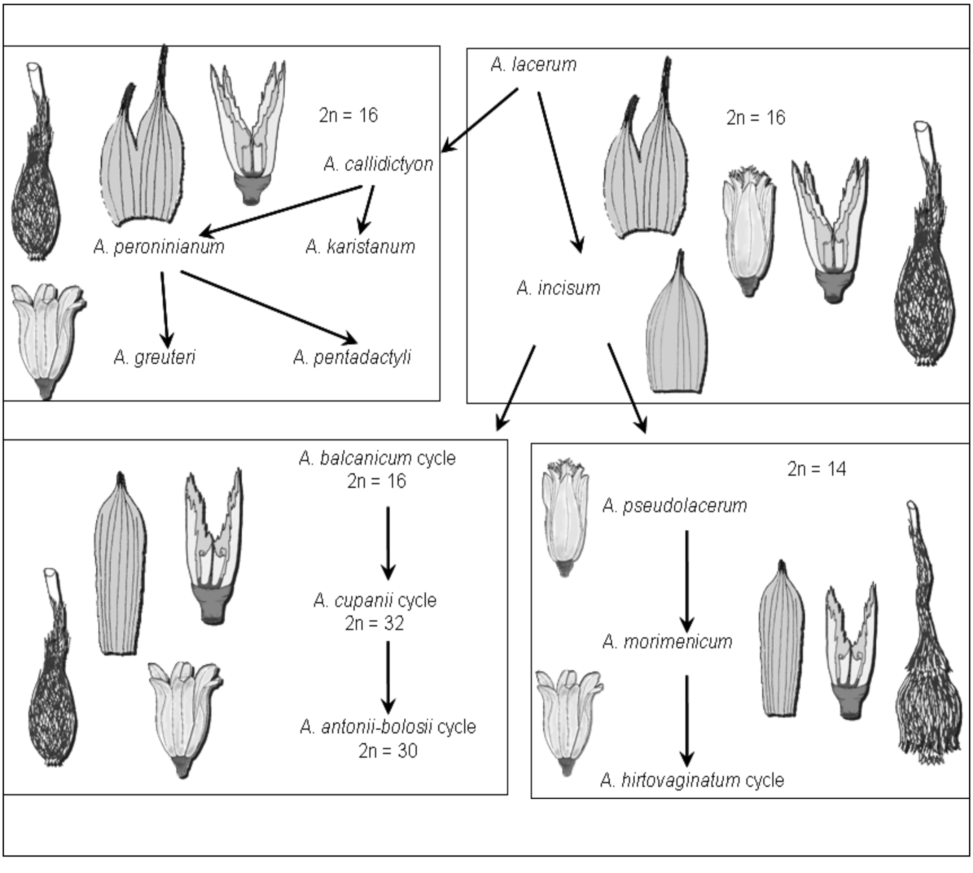

Fig. 10. Hypothetical phylogenetic relationships in the *Allium cupanii* group.

adaptive radiation. On one side, through *A. pseudolacerum* and *A. morimenicum*, where ciliate tepals are still present, the cycle of *A. hirtovaginatum* is derived. On the other side, the radiation passed through the diploid cycle of *A. balcanicum* to the one tetraploid-euploid of *A. cupanii* and, finally, to the tetraploid aneuploid of *A. antonii-bolosii*. Such evolutionary hypothesis is still waiting to be confirmed by molecular analyses, but I think that at the basis of any good molecular analysis there must be a detailed caryological and morphological study, that must be conducted throughout all the populations of any investigated cycle.

Limonium

Another genus where the speciation through poliploidy, hybridisation, aneuploidy, and apomixis is well known is the genus *Limonium*. In this case, the morphologic variability can be well studied on dry specimens, but the observations on leaves and stems must be integrated with a detailed morphometric analysis on the shape and size of the spikelet pieces, which, due to their small dimensions, have been neglected in the past by many authors.

Fig. 11. Iconography of *Limonium roridum* (sub *Statice rorida*) after Sibthorp & Smith (1821).

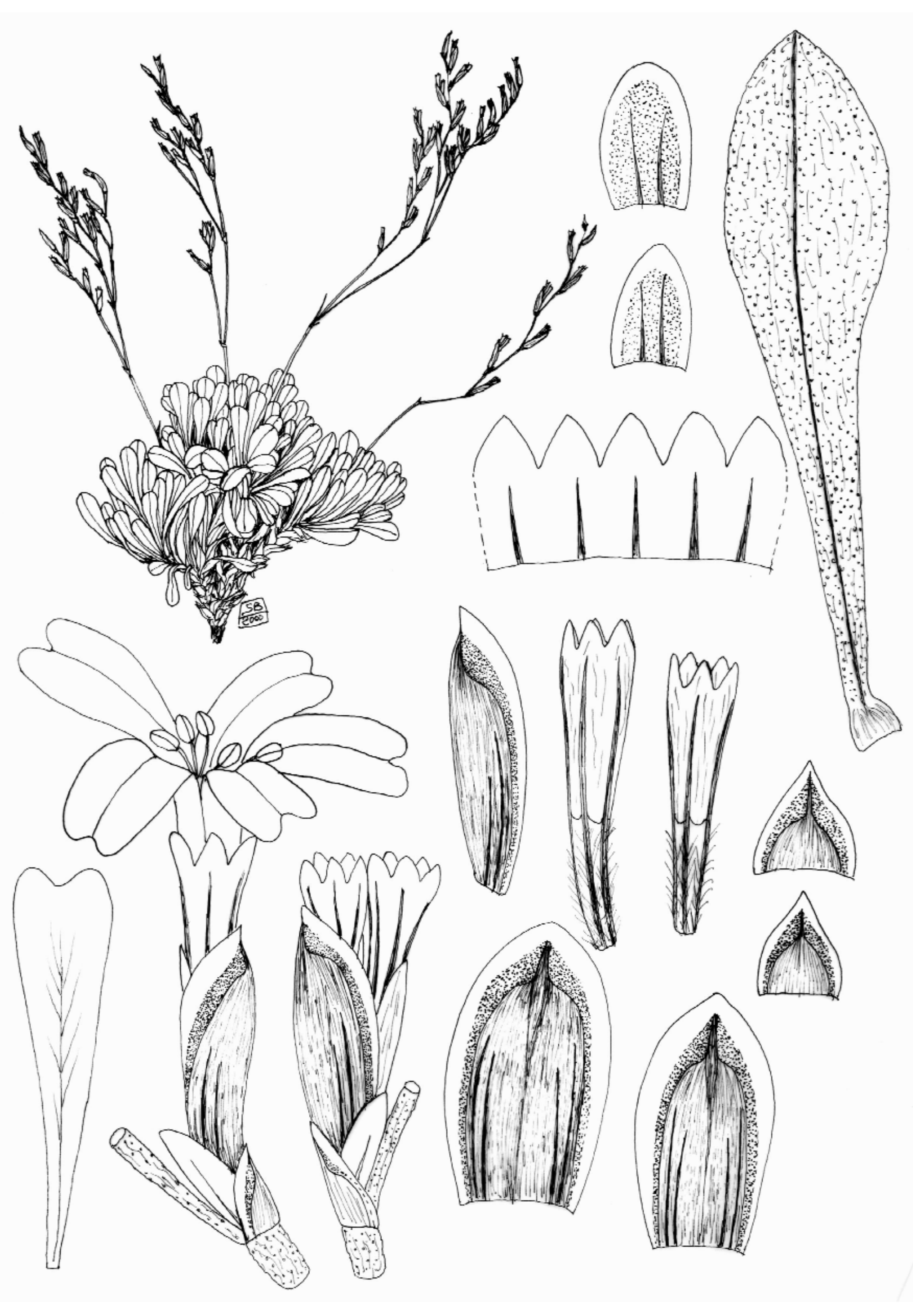

Fig. 12. Iconography of *Limonium graecum* from locus classicus (Brullo, unpublished).

Fig. 13. Re-hydrated material of *L. cancellatum* on sticky paper (left) and iconography (Brullo, unpublished).

The initiator of the modern trends in the taxonomic investigation of the genus *Limonium* have been Pignatti (1962, 1972). His analytical approach has been followed, among the other, by Brullo (1978, 1980), Erben (1978, 1993), Artelari (1984) and by Arrigoni & Diana (1993), so that at present the knowledge on the Mediterranean populations of the genus at issue are significantly improved during the last four decades and some old mistakes have been clarified.

For example, the case of *Limonium graecum* (Poir.) Rech. provides a further proof on how a good iconography is a fundamental need in plant taxonomy. At the origin of the misleading regarding such species was the lack of any iconography, together a scarce knowledge on the old specimens on which the original diagnosis was based (lectotypification was never done until now). So it happened that name *L. graecum* in most cases has been mistakenly used by many authors for *L. roridum* (Sibth. et Smith) Brullo & Guarino. The latter, illustrated and described by Sibthorp and Smith (1821) being quite common in the Aegean region, like the real *L. graecum*. In Figg. 11 and 12, the differences between the two species can be well compared.

In order to obtain an accurate and detailed iconography of *Limonium* specimens, I use to hydrate the spikelets and to fix leaves, spikelets and floral pieces on sticky paper, then, basing on such material, I prepare the drawings with the help of a microscope with camera lucida. An example of such technique is provided in Fig. 13, where an Istrian population of *L. cancellatum* (Bert.) O. Kuntze is examined.

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R. Guarino, S. Addamiano, M. La Rosa & S. Pignatti

Impact of information technology on future floras

Abstract

Guarino, R., Addamiano, S., La Rosa, M. & Pignatti, S.: Impact of information technology on future floras. — Bocconea 23: 19-23. 2009. — ISSN 1120-4060.

Some important facilities offered by the information technology to innovate the development of traditional floras are illustrated and discussed. These include: random access interactive tools for the identification of species, low cost, easy updating, virtually unlimited space for high resolution images and texts, on-line utilities, strong synergy between authors and users. It is argued that the combination of printed books with integrated digital utilities and data-sources is the most desirable structure for future floras.

Introduction

In plant taxonomy, classification aims at reconstructing an evolutionary history, which is usually represented by means of phylogenetic trees. One of the first examples of hierarchical classification of the living organisms is provided by the Tabulae Phytosophicae, created by Federico Cesi about 400 years ago. The goal of the dichotomies of Federico Cesi is actually the same of the bifurcations of a modern cladogram, i.e. the ordination of groups of living organism on the basis of their reciprocal similarities and relationships.

Until a recent past, the analysis of the objects to be classified was essentially based on their outer look, and groups were made on the basis of observable features, but the adoption of cytochemical and molecular analyses has made modern taxonomy less and less based on morphological criteria. As a consequence, the classical dichotomous keys are getting more and more unfriendly to the user, at least for the higher taxonomical ranks. See, for instance, the morphologic heterogeneity of the plant genera which are currently ascribed to the families *Plantaginacee* and *Caprifoliacee* in the APG classification (www.mobot.org/MOBOT/research/APweb/).

In the last two decades, many changes took place, not only in the systematic approaches to the classification of plants, but also in the number and kind of potential users of such classification. The increasing popularity of the "wilderness experience" and the raised public concern on themes like the conservation of biodiversity and ecosystems, of which vascular plants are the most visible part, created a new demand for qualified botanical information from a number of non-specialists, for educational, recreational and commercial purposes. Unfortunately, the enthusiasm of non-specialists seldom matches a sound botanical knowledge, mainly for the following two reasons: the use of a classical flora is too difficult for a beginner and in most cases popular floristic books do not offer complete and updated information enough on the flora of any given place.

Information technology offers a number of facilities to make easily accessible authoritative and updated floristic information to a wide readership. In the following paragraphs, some functions and possibilities offered by interactive digital tools to the authors and users of a flora will be commented.

Classification and identification

The approach followed by the classification of species is hierarchical; it is based on current phylogenetic hypotheses, and the tools traditionally used for the identification of objects are dichotomous keys, which are rather coherent with the bifurcations of phylogenetic trees.

The word "classification" has been often used as a synonym of "identification", but the meanings of the two words are different, since an identification procedure just aims at finding the name for a specimen, eventually in order to get information on it. Therefore, "identification" is a more comprehensive term: the process behind must not necessarily be hierarchic, nor based on phylogenetic hypotheses, and it is polytomous, meaning that all diagnostic characters do have the same rank and there are many ways to start the identification procedure.

In the case of vascular plants, there are many ways to identify a specimen. One possibility is to trace back to its origin by following the bifurcations of its phylogenetic tree, but this is not always the easiest and quickest one. For instance, plant species can be ordered on the basis of the chromatic differences of the flowers, or according to the shape and integrity of their petals. There are several possibilities, not necessarily based on morphologic characters, but also on "fuzzy" criteria, like the preferred habitat types, or the geographical distribution. Each single attribute leading to an ordination of the objects, even if not relevant from the phylogenetic viewpoint, or too "feeble" for dichotomous keys, can represent a useful criterion for the identification of plant species.

Random-access interactive tools

Bulk of the knowledge on a certain species can be broken down and organized into non-hierarchical categories by means of fields and variables implemented in a database. Through the simultaneous combination of different attributes the universe of species belonging to any flora can be easily split into smaller groups, which makes the identification procedure easier and faster. The combination of different queries facilitates the identification of a species through many possible ways, depending on the user's choices instead of the current phylogenetic hypotheses.

Starting from this basis, many interactive identification tools have been developed, during the last 30 years. The oldest one is the Australian system of softwares named "DELTA

Intkey", which started to be developed in 1971. It has been applied in many countries and for different groups of organisms (http://delta-intkey.com/). Another example from Australia is "LucID", developed at the University of Queensland, and particularly used for educational products like the interactive CD for the Identification of endangered Australian plants (http://www.lucidcentral.org/). In Europe, the Dutch package "IdentifiIT" has been used to implement the Interactive Flora of NW Europe (http://nlbif.eti.uva.nl). In the USA, "MeKA", created at the Berkeley University, is a useful tool for the identification of biological specimens, but not only: its very first application was an interactive identification tool for Ukuleles (http://ucjeps.berkeley.edu/meacham/meka/)!

In Italy, the software FRIDA has been created at the Biological Department of the University of Trieste, and it is currently applied in the project Dryades, counting many applications on vascular plants, but also on fungi, lichens and algae (http://www.dryades.eu/).

A quite complete and recently updated list on the "Programs for interactive identification and information retrieval" was published by Dallwitz (2007), the inventor of the Delta Intkey System.

Information technology and Floras

Floras are the most important tool for the identification of species and filing of information on the plant taxa living in a certain region. For about three centuries, they have been firmly clung to the encyclopaedic tradition of the eighteenth century, which conceived them as a catalogue of species, arranged in systematic categories (genus, family, order, class) and accompanied by dichotomous keys, descriptions and illustrations. Most of the oldest floras are still remembered for their accurate and rich iconography, but in the long run the tradition of botanical drawings has faded away, and the illustrations of modern floras tend to be more deficient than in the past. As a consequence, floras became, over time, more and more stuff for specialists. Paradoxically, while many efforts were done to make the knowledge accessible to everybody and to stimulate the public interest on scientific themes, floras progressively thinned out the iconography and decreased the length of the descriptions of species, becoming definitely unappealing to the beginners.

On the other hand, little efforts have been made to integrate the morphologic descriptions in the floras with information on species biology and ecology, so floras do not seem to be encyclopaedic works any longer, because they do not include all the available information on any given species; rather they look like unpractical handbooks where to find a name for herbarium specimens and, whenever possible, some general notes on the species distribution.

Some important facilities offered by the information technology to innovate the planning out of traditional floras are discussed below:

Classical dichotomous keys can be flanked by random access interactive tools, which can help non-expert users in identifying specimens, so to reach the available information on a given species.

In traditional floras, the Linnean name is the only way to designate unequivocally a certain species. The Linnean nomenclature is based on a phylogenetic classification that is subject to frequent changes in consequence of the recent advances in phylogenetic research (Nimis, 2001). In the interactive classifications tools, the Linnean name is just one of the variables that are used to define an object and it can be easily updated without changing the structure of the identification tool. With reference to the Italian flora, the numerical codes proposed by Pignatti in 1978 are an example of remarkable far-sightedness, but they have reached a real utility after the diffusion of personal computers and scientific databases.

All traditional floras are bound by the limited space of printed pages. A significant advance towards the satisfaction of the non-expert readership can be made by supplying the text with images and glossary. Information technology provides virtually unlimited space for high resolution images and texts. Moreover, concepts and terminology can be commented and/or illustrated by on-line utilities, like glossaries or illustrative tables. This will hold the encyclopaedic tradition of floras forever.

Due to high editorial and publishing costs, traditional floras are conceived to keep on the market for at least a decade, before being replaced by a new edition. A digital flora or digital complements of a printed flora can be frequently updated at reduced editorial costs and publishing is practically costless. The updates can be made regularly available on-line, e.g., to all registered users. This is an optimal condition for open-ended works, like floras are per definition.

A digital flora (or its digital complements) can be linked to many websites, including regional data banks on georeferenced floristic records and map services. The accessibility and connectivity of a digital flora is much higher than in a traditional flora, so that authors and users can interact on-line very easily, to create contents, share knowledge and improve the performances of the digital archives and data bases.

Discussion

Information technology offers many possibilities to innovate the planning out of a traditional flora in all its fundamental parts: keys, descriptions, illustrations and updates.

The future challenge for the authors of floras is to balance innovation and tradition in the best way. There is no doubt about the importance of books and the documentary value of printed paper. No doubt, as well, on the pleasure that to leaf through a book still gives to the reader. No doubt, a handy field flora on paper is still more practical and safe in the field than any electronic equipment using internet technology. No doubt there are still people not hanging on the internet all the time. But the most recent information on plant species (digital images, georeferenced records, polytomous keys...) cannot be regularly added into traditional flora volumes only.

The combination of printed books with integrated digital utilities and data-sources is the most desirable structure for future floras, “integrated” meaning that printed and digital contents should support each other without overlaps. The second edition of the Pignatti’s flora of Italy will try to comply with this strategic vision: a software, called FID, that means Flora Italiana Digitale (Italian Digital Flora), has been constructed and designed to integrate the second edition of the Pignatti's flora, which is expected to be published by the end of 2010. The FID will link together interactive polytomous keys, an on-line thesaurus, illustrations and one template per each single species, including a distribution map (referred to the Italian regions), ecograms, a text-box and up to 24 high-resolution colour images.

Up to now, the digital components of the second edition of the Pignatti's flora are the result of the cooperation of more than 140 people, who provided information and contents for the flora. One relevant point is the direct involvement of secondary schools for testing polytomous keys and usability of the contents. A second relevant point is the lack of sponsors and their material, so that all the contents will not only help in presenting and making more accessible information on the plant species, but they will also celebrate the praiseworthy synergy of people sharing the same passion for the beauty of the floristic research.

We do hope that similar initiatives and future developments of the FID will help in filling the gap between the instruments and techniques currently used for the promotion of commercial goods and those commonly used for the enhancement of biodiversity and natural ecosystems, that, even if not tradable, greatly contribute to improve the quality of our lives.

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C. Blasi, G. Capotorti, L. Michetti, L. Rosati & D. Smiraglia

Landscape heterogeneity and vegetation potential in Italy

Abstract

Blasi, C., Capotorti, G., Michetti, L., Rosati, L. & Smiraglia, D.: Landscape heterogeneity and vegetation potential in Italy. — Bocconea 23: 25-32. 2009. — ISSN 1120-4060.

We describe the relationship between landscape heterogeneity and vegetation potential in Italy within the international context of landscape characterization and assessment. Considering the Italian pattern of biodiversity on a landscape scale, we briefly describe the main national biogeographic features and illustrate the most recent hierarchical classification in homogeneous land units and main vegetation potential characteristics. Lastly, the results obtained by geographically integrating landscape diversity and vegetation series distribution are presented according to their relevance to conservation and ongoing national projects, such as those aimed at identifying and mapping important plant areas (IPAs), outlining, locating and characterising old growth forest in the national parks, rating plant invasion on a national scale, and assessing landscape conservation in the national parks and, more generally, in Italy.

Introduction

Landscapes are the result of a complex interaction of physical, biological and social-economic factors. Given the importance of land planning, land management and biodiversity conservation, landscapes need to be described, characterized and spatially located (Sims & al. 1996). Recently, landscape classification and mapping has once again become the focus of attention on account of its relevance to understanding ecological patterns and processes and addressing environmental tasks (Klijn & de Haes 1994; Zonneveld 1995; Bailey 1996; Metzger & al. 2005).

The European Landscape Convention (signed in Florence in 2000 by 34 states of the Council of Europe and ratified by 27 of these states) defines landscape as "an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors". Since then, the perceptive vision of landscape has been gradually replaced by a more ecological vision based on the recognition of local territorial identity as opposed to the aesthetic perception of the individual. Therefore, since landscape, according to the European Landscape Convention, is synonymous with territory, a scientific hierarchical classification can be used to define and map landscape units (Jongman & al. 2006). Moreover, thanks to this new approach, it is now possible to relate landscape ecology to geobotany by exploiting the hierarchical classification of territory and the GIS system.

We present the resulting definition and mapping of the Italian national landscapes and their relationships with the phytocoenotic potential.

Biodiversity, landscape heterogeneity and vegetation potential in Italy

In general terms, the geographic distribution of biodiversity is connected with the physical features and gradients of the environment (climate, lithology, morphology) as well as with the paleogeographic and paleoclimatic histories. Italy is one of the richest biodiversity hotspots in the world, boasting the presence of 6711 vascular plant taxa (Conti & al. 2005). Various components of this great biodiversity, which expresses itself in both potential and actual terms, was recently investigated by more than one hundred researchers (Blasi & al. eds. 2007a).

Within the European context (Rivas-Martinez & al. 2004), the Italian Peninsula is biogeographically linked to eastern Europe, with southern Italy being characterised by Mediterranean types, while the north is more closely linked to central European biogeographic types (Blasi & al. 2007b). On a national level, many phytogeographic subdivisions have been proposed (Giacomini 1958; Arrigoni 1980; Rivas-Martinez & al. 2004), and more recently revised, with regard to the boundary between the central European and Mediterranean regions; the latest proposal for this boundary is further south (near Monte Pollino) than the previous proposals (Blasi & al. in press).

Landscape heterogeneity investigations on a national level have also recently been conducted on the basis of specially compiled thematic maps (Blasi & al. 2007c). According to a map-making approach proposed in 2000 (Blasi & al. 2000), we identified homogeneous land units on a progressively finer spatial scale, integrating bioclimatic, lithological and morphological features as diagnostic attributes. Just as the macro-bioclimate was used to map the land regions (Mediterranean, Temperate and Transitional), the land regions together with the lithologic features (8 main types plus lagoons, glaciers and lakes, originally extracted from a rich geolithological multiscale map collection) provided the land systems, which in turn were combined with the morphological features (10 classes divided according to gradient, aspect, elevation and landform, originally elaborated from a digital elevation model) to provide the land sub-systems (Fig. 1).

Disregarding the land use patterns as a diagnostic character, this classification model provides a useful ecological framework for environmental potentiality investigations, such as vegetation potential characterization (Blasi & al. 2005). In this regard, a distinction must be made between i) Potential Natural Vegetation, defined as the vegetation in a given habitat that would develop at once to a mature stage without human influences (Tuxen 1956; Westhoff & van der Maarel 1973), and ii) Vegetation Series, which is the combination of all the plant communities that would develop to the same mature stage under uniform environmental conditions (Rivas-Martinez 1976; Géhu 1986; Rivas-Martinez 2005), thus even under the influence of human activities on plant communities that grow in current climatic and edaphic conditions. The latter definition was used to characterize vegetation potential in Italy in both typological and spatial terms (vegetation series types and their distribution). On the adopted scale of 1:250,000, 306 different vegetation series were recognised: 258 types with a dominantly forestal vocation cover 92.5% of the national territory, while 48 types with a shrubby, herbaceous, chamaephyitic, hydrophytic, aquatic and psammophilous vocation cover the remaining 7.5% (Blasi & al. 2004).

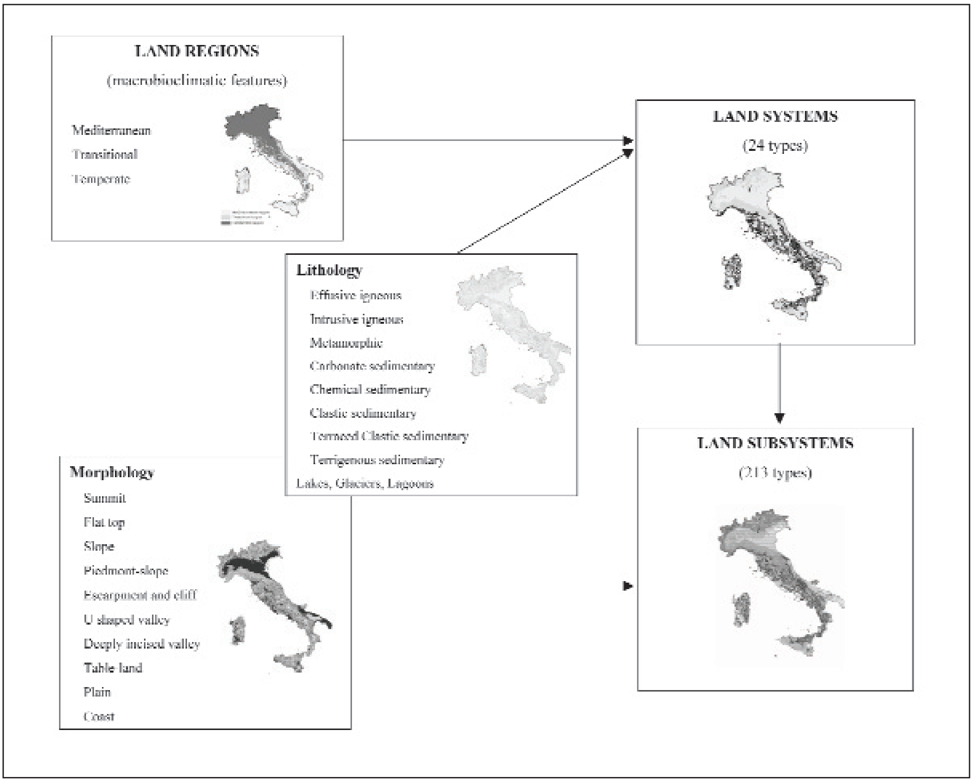

Fig. 1. Landscape classification of Italy.

Vegetation series in Italian landscape systems

The comprehensive biotic and abiotic data bank described above was used to correlate the Land System cartography with the Vegetation Series Map of Italy.

Thus, every land system in each of the three Italian land regions (with a Mediterranean, Transitional or Temperate macrobioclimatic feature) was described using syndynamic information on the total number of series present, the number of series that cover more than 5% of the system (threshold of significant coverage), the number of exclusive series (i.e. those not present in other land systems) and the types of dominant series (those which cover more than 10% within the system).

The complete results, shown in Tables 1-3, reveal the following noteworthy findings: i) the higher number of vegetation series in the Temperate region than in the other two land regions, owing above all to this region’s larger coverage (58% of the national territory compared with 25% in the Mediterranean region and 18% in the Transitional region); ii) the low average cover percentage of the vegetation series, which is due to both the high number of these series and the very marked land heterogeneity; iii) the extremely low number of exclusive vegetation series, which in the Transitional region are altogether absent.

Table 1. Vegetation series in the Land System of the Mediterranean Region.

Land System	Land system extension (ha x1000)	total nr of series	nr of series >5% in the system	nr of exclusive series	dominant series (>10% in the system)
effusive igneous	717	65	7	1	*Carpino orientalis-Querco cerridis* sigmetum *Violo dehnhardtii-Querco suberis* sigmetum *Mespilo germanicae-Querco frainetto* sigmetum *Oleo-Querco virgilianae* sigmetum
intrusive igneous	338	35	4	-	*Galio scabri-Querco suberis* sigmetum *Prasio majoris-Querco ilicis typicum et phillyreetosum angustifoliae* sigmetum
metamorphic	275	49	3	-	*Prasio majoris-Querco ilicis typicum et phillyreetosum angustifoliae* sigmetum *Galio scabri-Querco suberis* sigmetum *Erico arboreae-Querco virgilianae* sigmetum
carbonate sedimentary	1576	103	4	1	*Cyclamino hederifolii-Querco ilicis* sigmetum *Cyclamino hederifolii-Querco ilicis* sigmetum *myrtetosum communis* *Oleo-Querco virgilianae* sigmetum
chemical sedimentary	193	43	2	-	*Oleo-Querco virgilianae* sigmetum
clastic sedimentary	1431	98	6	-	*Oleo-Querco virgilianae* sigmetum Geosigmetum*: Salicion albae, Populion albae, Alno-Ulmion*
terraced clastic sedimentary	1219	88	7	-	*Irido collinae-Querco virgilianae* sigmetum
terrigenous sedimentary	1623	103	4	-	*Oleo-Querco virgilianae* sigmetum *Erico arboreae-Querco virgilianae* sigmetum

Table 2. Vegetation series in the Land System of the Transitional Region.

Land System	Land system extension (ha x1000)	total nr of series	nr of series >5% in the system	nr of exclusive series	dominant series (>10% in the system)
effusive igneous	437	59	6	-	*Coronillo emeri-Querco cerridis* sigmetum *Violo dehnhardtii-Querco suberis* sigmetum *Carpino orientalis-Querco cerridis* sigmetum
intrusive igneous	345	35	7	-	*Violo dehnhardtii-Querco suberis* sigmetum *Ornithogalo pyrenaici-Querco ichnusae* sigmetum *Aceri monspessulani-Querco ilicis* sigmetum
metamorphic	409	49	7	-	*Erico arboreae-Querco virgilianae* sigmetum *Prasio majoris-Querco ilicis typicum et phillyreetosum angustifoliae* sigmetum *Physospermo verticillati-Querco cerridis* sigmetum
carbonate sedimentary	1003	117	6	-	*Stipo bromoidis-Querco dalechampii* sigmetum
chemical sedimentary	47	30	8	-	*Oleo-Querco virgilianae* sigmetum *Erico arboreae-Querco virgilianae* sigmetum *Roso sempervirentis-Querco pubescentis* sigmetum
clastic sedimentary	536	89	3	-	Geosigmetum*: Salicion albae, Populion albae, Alno-Ulmion* *Roso sempervirentis-Querco pubescentis* sigmetum
terraced clastic sedimentary	549	73	4	-	*Roso sempervirentis-Querco pubescentis* sigmetum
terrigenous sedimentary	1938	114	4	-	*Roso sempervirentis-Querco pubescentis* sigmetum

Table 3. Vegetation series in the Land System of the Temperate Region.

Land System	Land system extension (ha x1000)	total nr of series	nr of series >5% in the system	nr of exclusive series	dominant series (>10% in the system)
effusive igneous	572	116	5	5	*Coronillo emeri-Querco cerridis* sigmetum
intrusive igneous	356	81	6	1	*Anemono apenninae-Fago sylvaticae* sigmetum Geosigmetum*: Caricion curvulae, Festucion variae, Androsacion vandelii, Androsacion alpinae, Caricion fuscae, Salicion herbaceae, Loiseleurio-Vaccinion*
metamorphic	2096	123	5	1	Geosigmeum*:Caricion curvulae, Festucion variae, Androsacion vandelii, Androsacion alpinae, Caricion fuscae, Salicion herbaceae, Loiseleurio-Vaccinion* *Luzulo niveae-Fago sylvaticae* sigmetum
carbonate sedimentary	3586	195	3	1	*Scutellario columnae-Ostryo carpinifoliae* sigmetum
chemical sedimentary	76	48	6	-	*Physospermo cornubiensis-Querco petraeae* sigmetum*; Cytiso sessilifolii-Quercenion pubescentis* *Lonicero xylostei-Querco cerridis* sigmetum *Erico arboreae-Querco cerridis* sigmetum
clastic sedimentary	3866	169	4	1	*Asparago tenuifolii-Querco roboris* sigmetum Geosigmeum*: Salicetum incano-purpureae, Salicetum triandrae, Populetum albae, Salicetum cinereae, Carici-Alnetum glutinosae*
terraced clastic sedimentary	2455	120	5	-	*Carpinion betuli* *Erythronio-Carpinion; Asparago tenuifolii-Querco roboris* sigmetum
terrigenous sedimentary	4143	198	5	3	-

Conclusions

Landscape classification is now consolidated in Italy, in accordance with international projects such as GEOSS-Global Earth Observation System of Systems (GEO Science & Technology Committee 2007) and ELCAI-European Landscape Character Assessment Initiative (Wascher 2005).

The Vegetation Series Map of Italy can be used to compare the potential landscape and vegetation with the existing landscape and vegetation, thereby providing an important tool for landscape ecology and landscape planning on a variety of levels. Indeed, this reference frame can be used for conservation purposes i.e. to assess landscape diversity on a national level, to check Rete Natura 2000 representativeness (Rosati & al. 2007), to define targets and indicators designed to reduce the loss of biodiversity on a landscape level (Corona & Marchetti 2007), and to monitor and assess land use changes in relation to the potential of the environment (Smiraglia & al. 2007).

Moreover, the definition of landscapes units relative to the flora, biogeography, ecology and syntaxonomy is also being used as a framework for other recent national projects, such as those aimed at identifying and mapping important plant areas (IPAs), outlining, locating and characterising old growth forest in the national parks, rating plant invasion on a national scale, and assessing landscape conservation in the national parks and, more generally, in Italy.

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Giovanni Spampinato

Phytocoenotic diversity in Southern Italy

Abstract

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The author presents an overview of phytocoenotic diversity in Southern Italy from the phytogeographic and phytosociological point of view. The ecological, chorological, floristic and structural characteristics of the natural plant communities occurring in this area are examined. The remarkable phytosociological diversity is correlated with the bioclimatic and geomorphologic features of the territory.

Introduction

Biodiversity can be considered as the variety of life on Earth and the different combinations that it forms. It is the result of millions of years of evolution, modeled by natural processes and, in the last few millennia, increasingly influenced by man.

Biodiversity manifests itself at different levels. Using biological species as a reference, a distinction is usually made between a specific level, a sub-specific level (genetic diversity) and a supra-specific level (ecological diversity).

Whittaker (1972) distinguishes among various levels of biodiversity on various scales that are now widely accepted by the scientific community. He evidences an α diversity, seen as the diversity of species in a given habitat, a β diversity, or diversity of habitats in a wide area, and a γ diversity, or the diversity of species at a regional level without considering types of habitat.

Loidi (2004) states that vegetation is a good indicator of biodiversity and that the α diversity, regarding vascular flora, can be evaluated by means of the list of species occurring in the phytosociological relevés. He also shows that the β diversity is linked to the phytocoenoses of an area, which is a direct consequence of the environmental heterogeneity, and that the γ diversity can be inferred from the complete set of phytocoenoses occurring in a given area. According to Loidi (l.c.) several authors (Pilieu 1991; Loidi 2004; Redžić 2007, Willmer & al. 2004), highlighted that the syntaxonomic diversity of vegetation is a good indicator of habitat diversity and heterogeneity. In particular, using the phytosociological method, vegetation can, quite easily, be analyzed, distinguished into plant communities or phytocoenoses and finally mapped. This finds many applications in territory management. Moreover the knowledges on phytocoenotic diversity have a remarkable phytogeographic meaning because they allow to characterize areas with analogous vegetation interested from the same paleogeographic vicissitudes.

This paper presents an overview of knowledge about the phytocoenotic diversity of vegetation in Southern Italy, as defined by the phytosociological method. At the present time we have several territorial and syntaxonomic studies, as well as the availability of an uncritical syntaxonomic survey of the Italian regions (the LISY project), with which it is possible to provide a concise and up-to date scheme of the phytocoenotic diversity that characterizes Southern Italy.

In Italy there is no up-to-date national checklist regarding phytocoenotic diversity, even though an attempt was made for some regions in 1995 during a meeting organized by the Accademia Nazionale dei Lincei (Camarda & Satta 1995; Mariotti 1995, Giglio & Tammaro 1995; Brullo & al. 1995; Poldini & Vidali 1995; Pignatti & Pignatti 1995). At present an updated checklist is available only for Sicily (Brullo & al. 2002).

In several other European countries, on the other hand, relatively complete checklists are available (Lawesson 2004; Rivas Martinez & al. 2001; Borhidi 1996; Schaminée & al. 1995-1999; Mucina & al. 1993; Pott 1995). An overview of phytosociological alliances for the whole of Europe was produced by Rodwell & al. (2002). These authors consider phytosociological knowledge concerning Italy as moderate on the basis of the number of relevés, the existence of a national database and the publication of a national overview.

Study area

Southern Italy is a large territory of almost 58,000 Km^2 including 4 regions: Campania, Apulia, Basilicata and Calabria. It is dominated by the Southern Apennine range, which constitutes a clearly defined geographic unit extending from the Sannio mountains in Campania to the Strait of Messina with peaks that only in the Pollino massif and in the Sirino-Papa mountain exceed 2,000 m a.s.l. (Serra Dolcedorme 2267 m) (Fig. 1).

Phytogeographic features

From the phytogeographic point of view, while in the past Southern Italy was referred exclusively to the Mediterranean region (Giacomini & Fenaroli, 1958; Meusel & al. 1965), nowadays various authors (Pedrotti 1996, Rivas Martinez & al. 2004a) are agree in referring Southern Italy to two separate regions, European and Mediterranean, within the Holarctic kingdom. In particular, Rivas Martinez & al. (l.c.) attribute this territory to the Eurosiberian and Mediterranean biogeographic regions; the former is represented by the Apennine province, while the latter is represented by the Italo-Tyrrhenian province (with the western Italian coastal sector that includes Campania, Basilicata and Calabria), and by the Adriatic province with the Apulian sector.

Geolithological features

The Apennine, like other Mediterranean ranges, originated from interaction between the African and European plates. Lentini & al. (1995) evidence the complex genesis and substrate diversity of the Southern Apennine. They point out that, from a structural viewpoint, in Southern Italy it is possible to recognize 4 geolithological units: the Calabrian-Peloritan arc, formed by crystalline bedrock with relative debris covers, the Apulian block belonging to the African plate and formed of limestone, and two series of sedimentary bedrocks that are part of the Apennine-Maghrebian chain and the external trust system (Fig. 2).

Bioclimatic features

Recent acquisitions in bioclimatic classification (Biondi & Baldoni 1994, Rivas Martinez 1995) allow to attribute the bioclimate of Southern Italy to two different typologies. The territory that goes from sea level to approximately 800-1000 m a.s.l. falls into the Mediterranean bioclimate that, according to Rivas Martinez & al. (2004b), can be classified as oceanic pluvioseasonal Mediterranean. The territories above approximately 800-1000 m a.s.l., on the other hand, are characterized by a Temperate oceanic bioclimate.

Blasi e Michetti (2007) carried out an in-depth analysis of the bioclimatic features of Italy, showing that in it is possible to recognize many different transitions zones within each macrobioclimate. In particularly, in Southern Italy they identify 6 bioclimatic typologies: Mediterranean oceanic, Mediterranean oceanic of transition, Temperate oceanic, Temperate oceanic of transition, Temperate oceanic-semicontinental, and Temperate oceanic-semicontinental of transition.

Materials and Methods

The survey of the phytocoenoses occurring in was carried out using data from the LISY project. This project, promoted and supported by the "Italian Society of Vegetation Science", allowed the realization of an uncritical list of the syntaxonomic units known for the vegetation of the various Italian regions. (Albano & Marchiori 2001; Di Pietro & Fascetti 2001; Ercole & Filesi 2001; Fascetti & al. 2007; Marchiori & Albano 2007; Rosati & Surbera 2007; Passalacqua & al. 2007; Spampinato 2001). Updated studies relating to

Fig. 1. Physiographic map of Southern Italy.

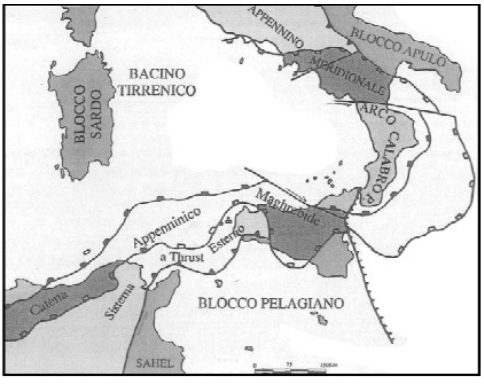

Fig. 2. Tectonic features of the central Mediterranean area (from Lentini & al., 1995, modified).

the vegetation of the territory and the syntaxomomic revisions available in literature are also examined (Bianco & al. 1988; Brullo & al. 1997, 2001a, 2001b, 2005, 2006; Blasi & al. 2004, 2006, Biondi & al. 1995, 2003, 2004, 2006; Di Pietro & al. 2004; Corbetta & al. 2004; Forte & al 2005; Fanelli & al. 2001; Rosati & al. 2005).

All the data were put into a database. With the purpose of drawing up a concise and updated scheme of the phytocoenotic diversity of Southern Italy, a syntaxonomic revision of all the data published for the regions of Southern Italy (Apulia, Campania, Basilicata and Calabria) was carried out. The nomenclature of the syntaxa follows the criteria defined by the international code of phytosociology (Weber & al. 2000) and takes account of the nomenclatural revision performed by Rivas Martinez & al. (2001).

The distribution of syntax, especially those endemic, was also examined to highlight the phytogeographic significance of the syntaxonomic knowledges

Results

Critical revision of the published data concerning vegetation in Southern Italy made it possible to realize an up-to-date syntaxonomic scheme and to make some considerations on the phytocoenotic diversity and richness of this territory. Table 1 lists the syntaxonomic scheme up to sub-alliance level, highlighting the occurrence of each sintaxon in the regions Southern Italy.

The revision allowed the identification of 515 associations grouped into 156 alliances, 84 orders, and 49 classes (Table 2). In comparison with the data known for Europe and cited by Rodwell & al. (2002), 61% of the classes, 36% of the orders and 18% of the alliances are present in Southern Italy.

The number of associations occurring in each vegetation class shows that the phytocoenotic diversity is concentrated in a very few classes (Fig. 3). In fact, most classes are present with one or only a few associations, and only some of them include a considerable number of plant communities.

This distribution appears quite similar to that noted in the taxonomic field, where most of the species are concentrated in a few supra-specific taxonomic units.

The most represented class is *Quercetea ilicis*, with 58 plant communities. This high phytocoenotic diversity depends essentially on the importance and diversification that the vegetation belonging to this class has in Southern Italy. It is followed by the *Querco-Fagetea* class, with 36 plant communities showing that vegetation typical of habitats with a temperate bioclimate also introduces an elevated degree of diversification.

Among the most represented classes there is that of *Stellarietea mediae*, indicating a considerable anthropic impact on the territory, mainly localized in the coastal and hilly belt. Other well represented classes are those of *Lygeo-Stipetea, Tuberarietea* and *Cisto-Micromerietea*, which include plant communities deriving from the degradation of *Quercetea ilicis* woods. Less represented is the *Festuco-Brometea* class which is dynamically linked to the *Querco-Fagetea* woods.

Considering the year of description of the associations, it is clear that they tend to increase in time (Fig. 4). This testifies that many progresses have recently been made in the analysis and definition of Southern Italian vegetation typologies. It can also be

Tab. 1. Syntaxonomic scheme of Southern Italy vegetation up to suballiances with indication of regional distribution (BS: Basilicata, CM: Campania, CL: Calabria, PG: Apulia).

QUERCETEA ILICIS Br.-Bl. ex A. Bolòs 1950 - CL PG BS CM
QUERCETALIA ILICIS Br.-Bl.1936 em.Riv. Mart.1975 - CL PG BS CM
Fraxino orni-Quercion ilicis Biondi, Casavecchia & Gigante 2003 - CL PG BS CM
QUERCETALIA CALLIPRINI Zoohary 1955- CL PG BS CM
Oleo-Ceratonion Br.-Bl.ex Guinochet & Drouin. 1944 em. Riv. Mart.1975 - CL PG BS CM
Ericion arboreae Riv. Mart (1975) 1987 - PG CL BS
Juniperion turbinatae Riv. Mart. (1975) 1987 - PG CL BS
QUERCO-FAGETEA Br.-Bl. & Vlieger in Vlieger 1937 - CL PG BS CM
FAGETALIA SYLVATICAE Pawl. in Pawl. & al. 1928 - CL PG BS CM
Doronico-Fagion Ubaldi & al. ex Ubaldi 1995 - CL BS CM
Campanulo trichocalycinae-Fagion Ubaldi ex Brullo,Scelsi & Spamp.2001 - CL CM BS
Aremonio-Fagion sylvaticae (Horvat 1938) Torok, Podani, Borhidi 1989 - CM
QUERCETALIA PUBESCENTI-PETRAEAE Klika 1933 - CL CM BS PG
Teucrio siculi-Quercion cerridis Ubaldi 1988 - CL CM BS PG
Ptilostemo stricti-Quercenion cerridis Bonin & Gamisans 1977 - CL CM BS
Tilio-Ostryion carpinifoliae Brullo, Scelsi & Spamp. 2001 - CL
Pino-Quercion congestae Brullo, Scelsi, Siracusa & Spamp. 1999 - CL PG
Quercenion virgilianae Blasi, Di Pietro & Filesi 2004 - CL PG
Carpinion orientalis Horvat 1958 - CL CM BS PG
Festuco exaltatae-Ostryenion carpinifoliae Blasi,Filibek & Rosati 2006 - CL CM BS PG
Lauro nobilis-Quercenion pubescentis Ubaldi 1995 - PG CM
Corylo-Polulion tremulae (Br.-Bl.ex O.Bolos 1973) Riv.-Mart. & Costa 1998 - CM CL
Aceri obtusati-Populeion tremulae Taffetani 2000 - CM CL
SALICI PURPUREAE-POPULETEA NIGRAE (Riv. Mart. & Cantó ex Riv. Mart., Básc.,Díaz, Fernán.-G. & Loidi 1991) Riv. Mart. & al. 2002 - CM PG BS CL
POPULETALIA ALBAE Br.-Bl. ex Tchou 1948 - CM PG BS CL
Populion albae Br.-Bl. ex Tchou 1948 - CM PG BS CL
Osmundo-Alnion glutinosae (Br.-Bl., P. Silva & Rozeira 1956) Dierschke & Riv. Mart. in Riv. Mart. 1975 - CL BS
Alno-Ulmion Br.-Bl. & R. Tx. ex Tchou 1948 - CL CM BS PG
Alno-Quercion roboris Horvat 1950 - CL BS PG CM
Platanion orientalis I & V. Karpati 1961 - CM CL
SALICETALIA PURPUREAE Moor 1958 - CL CM BS PG
Salicion albae Soó 1930 em. Moor 1958 - CL CM BS PG
ALNETEA GLUTINOSAE Br.-Bl. & R.Tx. ex Westhoff, Dijk & Passchier 1946 - BS CL
ALNETALIA GLUTINOSAE R.Tx. 1937 em. Müller & Görs 1958 - BS CL
Salicion cinereae Müller & Görs 1958 - BS CL
NERIO-TAMARICETEA Br.-Bl. & O. Bolòs 1957 - CL CM BS
TAMARICETALIA Br.-Bl.& O.Bolòs 1957 em.Izco,Fernand.& Molinia 1984 - CL CM BS
Rubo-Nerion oleandri O. Bolòs 1985 - CL CM BS
Tamaricion africanae Br.-Bl O. Bolòs 1958 - CL BS
PINO-JUNIPERETEA Riv. Mart. 1964 - CL BS
JUNIPERETALIA HEMISPHAERICAE Riv.Mart. & Molina in Riv.Mart. & al.1999 - CL BS
Berberidion aetnensis Brullo, Giusso & Guarino 2001 - CL
PINO-JUNIPERETALIA Rivas -Martinez 1964 - CL BS
Daphno oleoidis-Juniperion alpinae Stanisci 1997 - CL BS
RHAMNO-PRUNETEA Rivas Goday & Borja ex Tüxen 1962 - CL CM BS PG
PRUNETALIA SPINOSAE R. Tx. 1952 - CL CM BS PG
Cytision sessiliflorii Biondi in Biondi, Allegrezza & Guitan 1988 - CM
Berberidion vulgaris Br.-Bl. 1950 - CL PG
Fraxino orni-Berberidenion Poldini & Vidali 1995 - CL PG
Berberidenion vulgaris Géhu Foucault & Delis-Dusollier 1983 - PG
Pruno-Rubion ulmifolii O.Bolòs 1954 - CL CM BS
Pruno-Rubenion ulmifolii O.Bolòs 1954 - CL CM BS
CYTISETEA STRIATO-SCOPARII Riv. Mart. 1975- CL
CYTISETALIA STRIATO-SCOPARII Riv. Mart. 1975 - CL
Violion messanensis Brullo & Fumari in Barbagallo & al. 1982 - CL
CISTO-MICROMERIETEA Oberdorfer 1954 - CM PG BS CL
CISTO-ERICETALIA Horvatic 1958 - CM PG BS CL
Cisto-Ericion Horvatic 1958 - CM PG BS CL
Cisto eriocephali-Ericion multiflorae Biondi 2000 - CM
Cytiso spinescentis-Satureion montanae Pirone & Tamm. 1997 - PG CM BS
PEGANO-SALSOLETEA Br.-Bl. & O. Bolòs 1958 - CL BS PG
SALSOLO-PEGANETALIA Br.-Bl. & O. Bolòs 1954 - CL BS PG
Salsolo vermiculatae-Peganion harmalae Br.-Bl. & O. Bolòs 1954 - CL BS
Artemision arborescentis Géhu & Biondi 1986 - CL BS PG
SCROPHULARIO-HELICHRYSETEA Brullo, Scelsi & Spampinato 1998 - CL BS CM
SCROPHULARIO-HELICHRYSETALIA Brullo 1984 - CL BS CM
Euphorbion rigidae Brullo & Spamp. 1990 - CL BS
Linarion purpureae Brullo 1984 - CL BS CM
RUMICI-ASTRAGALETEA SICULI Pign.& Nimis in Pign. & al.1980 em.Mucina 1997 - CL
ANTHEMIDETALIA CALABRAE Brullo, Scelsi & Spamp. 2001 - CL
Armerion aspromontanae Brullo, Scelsi & Spamp. 2001 - CL
Koelerio-Astragalion calabricae Giacomini & Gentile ex Brullo 2005 - CL
FESTUCO-BROMETEA Br.-Bl. & Tx. 1943 - CM PG BS CL
BROMETALIA ERECTI Br.-Bl. 1936 - CM PG BS CL
Artemisio albae-Bromenalia erecti Biondi & al. 1995 - CM PG BS CL
Phleo ambigui-Bromion erecti Biondi & Blasi ex Biondi, Ballelli, Allegrezza & Zuccarello 1995 - CL BS
Sideridenion syriacae Biondi, Ballelli, Allegrezza & Zuccarello 1995 - BS Cl
Xerobromion erecti Br.-Bl. & Moor 1938 - BS
SCORZONERO-CHRYSOPOGONETALIA Horvatic & Horvat 1956 - CL BS PG
Cytiso-Bromion erecti Bonin 1969 - CL BS
Hippocrepido claucae-Stipion austroitalicae Forte & Terzi 2005 - PG
SESLERETALIA TENUIFOLIAE Horvat 1930 - CL BS CM
Seslerion apenninae Furnari in Bruno & Furnari 1966 - CL BS CM
Festucion violaceae Avena & Bruno 1975 - CL BS
THLASPIETEA ROTUNDIFOLII Br.-Bl. 1948 - CL BS
THLASPIETALIA STYLOSII Avena & Bruno 1975 - CL BS
Linario-Festucion dimorphae Avena & Bruno 1975 - CL
Stipion calamagrostidis Br.-Bl. 1930 - BS
ASPLENIETEA TRICHOMANIS (Br.-Bl.in Meier & Br.-Bl.1934) Oberd.1977 - CM PG BS CL
ASPLENIETALIA GLANDULOSI Br.-Bl. & Meier 1934 - CM PG BS CL
Dianthion rupicolae Brullo & Marcenò 1979 - CL CM BS
Centaureion pentadactylis Brullo, Scelsi & Spampinato 2001 - CL
CENTAUREO CAMPANULETALIA Trinajstic 1980 - PG
Asperulion garganicae Bianco, Brullo, Pignatti E. & S. 1988 - PG
POTENTILLETALIA CAULESCENTIS Br.-Bl. in Br.-Bl. & Jenny 1926 - CL BS
Saxifragion australis Biondi & Ballelli ex Brullo 1984 - CL BS
ONOSMETALIA FRUTESCENTIS Quezel 1964 - PG
Campanulion versicoloris Quezel 1964 - PG
ANOMODONTO-POLYPODIETALIA O. Bolòs & Vives in O. Bolòs 1957 - CL
Bartramio-Polypodion serrati O. Bolòs & Vives in O. Bolòs 1957 - CL
Pohlio-Asplenion septentrionalis Brullo & Siracusa in Brullo & al.2001 - CL
HYPNO-POLYPODIETALIA VULGARIS Jurko & Peciar ex Brullo Scelsi & Spamp.2001 - CL
Hypno-Polypodion vulgaris Mucina 1993 - CL
CHEILANTHETALIA MARANTHO-MADERENSIS Saenz & Riv. Mart. 1979 - CL
Phagnalo-Cheilanthion maderensis Loisel 1970 corr.Perez Carro & al.1989 - CL
ADIANTETEA Br.-Bl. & R. Tx. ex Br.-Bl. 1948 - CM PG BS CL
ADIANTETALIA Br.-Bl. ex Horvatic 1939 - CM PG BS CL
Adiantion Br.-Bl. ex Horvatic 1934 - CM PG BS CL
CRITHMO-LIMONIETEA Br.-Bl. 1952 - CL PG BS CM
CRITHMO-LIMONIETALIA Molinier 1934 - CL PG BS CM
Crithmo-Limonion Molinier 1934 - CL PG BS CM
Anthyllidion barba-jovis Brullo & De Marco 1989 - PG CM
Plantagini-Thymelaeion hirsutae Bartolo & Brullo 1992 - CM PG
AMMOPHILETEA Br.-Bl.& R.Tx.ex Westhoff Dijk & Passchier 1946 - CL PG BS CM
AMMOPHILETALIA Br.-Bl. 1933 - CL BS PG CM
Ammophilion australis Br.-Bl.1921 corr. Riv.Mart., Costa & Izco in Riv.Mart. & al.1990 - CL BS PG
CRUCIANELLETALIA MARITIMAE Sissingh 1974 - CL BS PG
Ononidion ramosissimae Pignatti 1952 - CL BS PG
Psammo-Koelerion macranthe Pignatti 1952 - BS
CAKILETEA MARITIMAE R. Tx. & Preising in R. Tx. 1950 - CL PG BS CM
EUPHORBIETALIA PEPLIS R. Tx. 1950 - CL BS PG CM
Euphorbion peplis R. Tx. 1950 - CL BS PG CM
SARCOCORNIETEA FRUTICOSAE Br.-Bl. & R.Tx.ex A.Bolòs 1950 em.O.Bolòs 1967 - CL PG BS
SARCOCORNIETALIA FRUTICOSAE Br.-Bl.1933 em. O.Bolòs 1967 - CL BS PG
Sarcocornion fruticosae Br.-Bl. 1933 em. Brullo & Furnari 1988 - CL
Suaedion verae (Riv. Mart., Lousã, T.E. Díaz, Fernández-González & J.C. Costa 1990) Riv. Mart., Fernández-González & Loidi 1999 - CL BS PG
Arthrocnemion glauci Riv. Mart. & Costa 1984 - BS PG
THERO-SUADETEA Riv. Mart. 1972 - CL BS PG
THERO-SALICORNIETALIA EUROPEA Tx in Tx & Oberd. ex Géhu & Géhu-Franck 1984 - CL BS PG
Salicornion patulae Géhu & Géhu-Franck 1984 - CL BS PG
THERO-SUAEDETALIA Br.-Bl. & O. Bolòs 1958 - BS PG
Thero-Suaedion Br.-Bl. in Br.-Bl., Roussine & Nègre 1952 - BS PG
JUNCETEA MARITIMI Br.Bl. in Br.-Bl., Roussine & Nègre 1952 - CL BS PG
JUNCETALIA MARITIMI Br.Bl. ex Horvatic 1934 - CL BS PG
Juncion maritimi Br.Bl. ex Horvatic 1934 - CL BS PG
Juncenion maritimae Géhu & Biondi 1995 - PG
Pucciniellienion festuciformis (Géhu & Scoppola 1984, in Géhu & al 1984) Géhu & Biondi 1995 -
Plantaginion crassifoliae Br.-Bl.(1931) 1952 - CL BS PG
Elytrigio-Artemision coerulescentis (Pign. 1953) Géhu & Scoppola in Géhu & al. 1984 - BS PG
LYGEO-STIPETEA Riv. Mart. 1978 - CL PG BS CM
LYGEO-STIPETALIA Br.-Bl. & Bolòs 1958 em. Riv. Mart. 1978 - CL PG BS CM
Moricandio-Lygeion sparti Brullo, De Marco & Signorello 1990 - CL BS
Polygonion tenoreani Brullo, De Marco & Signorello 1990 - CL BS
HYPARRHENIETALIA Riv. Mart. 1978 - CL PG BS CM
Avenulo-Ampelodesmion mauritanici Minissale 1995 - CL CM
Saturejo-Hyparrhenion hirtae O. Bolòs 1961 - CL PG CM
Saturejo-Hyparrhenenion hirtae O. Bolòs 1961 - CL PG CM
Aristido-Hyparrheneion hirtae Brullo, Scelsi & Spamp. 1997 - CL
Thero-Brachypodion ramosi Br.-Bl. 1925 - CL PG CM
Bromo-Oryzopsion miliaceae O.Bolòs 1970 – CL

TUBERARIETEA GUTTATAE (Br.-Bl.1940) Riv.Goday & Riv.Mart.1963 - CL PG BS CM
TRACHYNETALIA DISTACHYAE Riv. Mart. 1978 - CL PG BS CM
Onobrychido-Ptilostemion stellati Brullo Scelsi & Spamp. 2001 - CL
Plantagini-Catapodion marini Brullo 1985 - CL
Trachynion distachyae Riv. Mart. 1978 - CL
TUBERARIETALIA GUTTATAE Br.-Bl.1940 - CL BS PG CM
Tuberarion guttatae Br.-Bl.1940 - CL CM
Sclerantho-Myosotidion incrassatae Brullo, Scelsi & Spamp. 2001 - CL
MALCOLMIETALIA Rivas Goday 1957 - CL CM BS PG
Alkanno-Maresion nanae Rivas Goday ex Rivas Goday & Riv. Mart. 1963 corr. Díez-Garretas & al. 2001 - CL PG BS
Laguro ovati-Vulpion membranaceae Gehu & Biondi 1994 - CL BS PG CM
SEDO-SCLERANTHETEA Br.-Bl. 1946 em. Th Muller 1961 - CM
SEDO-SCLERANTHETALIA Br.-Bl. 1955 - CM
Alisso alyssoides-Sedion albae Oberd. & Th Muller 1961 - CM
SAGINETEA MARITIMAE Westh., Leeuw. & Adriani 1962 - CL PG BS
FRANKENIETALIA PULVERULENTAE Riv.Mart.ex Castrov.& Porta 1976 - CL PG BS
Frankenion pulverulentae Riv. Mart. ex Castroviejo & Porta 1976 - CL PG
Gaudinio-Podospermion cani Brullo & Siracusa 2000 - CL
Hordeion marini Ladero, Navarro, Valle, Marcos, Ruiz & Santos 1984 - CL
CRYPSIDETALIA ACULEATAE Vicherek 1973 - BS PG
Crypsidion aculeatae Pignatti 1954 - BS PG
LEMNETEA MINORIS R. Tx. ex O. Bolòs & Masclans 1955 - CL PG BS CM
LEMNETALIA MINORIS R. Tx. ex O. Bolòs & Masclans 1955 - CL PG BS CM
Lemnion minoris R. Tx. ex O. Bolòs & Masclans 1955 - CL PG BS CM
PLATYHYPNIDIO-FONTINALETEA ANTI-PYRETICAE Philippi 1956 - CL
BRACHYTHECIETALIA PLUMOSI Philippi 1956 - CL
Scapanion undulatae Philippi 1956 - CL
LEPTODICTYETALIA RIPARII Philippi 1956 - CL
Platyhypnidion rusciformis Philippi 1956 - CL
POTAMETEA PECTINATI R.Tx. & Preising 1942 - CL PG BS CM
POTAMETALIA W. Koch 1926 - CL PG BS CM
Nymphaeion albae Oberd. 1957 - CL BS
Potamion pectinati(Koch 1926) Libbert 1931 - PG BS
Ranunculion aquatilis Passarge 1964 - CL
UTRICULARIETALIA Den Hartog & Segal 1964 - BS PG CL
Utricularion Den Hartog & Segal 1964 - PG
Ceratophyllion demersi Den Hartog & Segal ex Passarge 1996 - BS CL
Zannichellion pedicellatae Schaminée, Lanjouw & Schip. 1990 em.Pott 1992 - BS
CHARETEA FRAGILIS Fukarek & Kraush 1964 - PG
CHARETALIA HISPIDAE Sauer & Kraush 1964 - PG
Charion canescentis Kraush 1964 - PG
RUPPIETEA J.Tx.1960 - CL PG
RUPPIETALIA J.Tx.1960 - CL PG
Ruppion maritimae Br.-Bl. *ex* Westhoff in Bennema, & al. 1943 - CL PG
POSIDONIETEA Den Hartog 1976 - CL PG BS
POSIDONIETALIA Den Hartog 1976 - CL PG BS
Posidonion oceanici Br.-Bl., Roussine & Nègre 1952 - CL PG BS
ISOËTO-NANOJUNCETEA Br.-Bl. & R. Tx. ex Westhoff & al. 1946 - CL PG
NANOCYPERETALIA Klika 1935 - CL PG
Nanocyperion flavescentis W. Koch ex Libbert 1932 - CL PG
Cicendion (Rivas Goday in Rivas Goday & Borja 1961) Br.-Bl. 1967 - CL
ZOSTERETEA MARINAE Pignatti 1954 - PG
ZOSTERETALIA MARINAE Beguinot 1941 em. R.Tx & Oberd. 1958 - PG
Zosterion marinae Christiansen 1934 - PG
HALODULO WRIGHTII-THALASSIETEA TESTUDIUM Den Hartog ex Riv. Mart., Fernández-González & Loidi 1999 - PG
THALASSIO- SYRINGODIETALIA FILIFORMIS Borhidi, Muñiz & Del Risco in Borhidi 1996 - PG
Syringodio-Thalassion testudinum Borhidi 1996 - PG
MONTIO-CARDAMINETEA Br.-Bl. & R. Tx. ex Br.-Bl. 1948 - CL
MONTIO-CARDAMINETALIA Pawlowski in Pawlowski & al. 1928 - CL
Caricion remotae Kästner 1941 - CL
Cardamino-Montion Br.-Bl. 1926 - CL
Cratoneurion commutati W. Koch 1928 - CL
MOLINIO-ARRHENATERETEA R. Tx. 1937 - CL PG BS CM
MOLINETALIA Koch 1937 - CL
Calthion Tx. 1937 em. Bàl.Tul. 1978 - CL
Filipenduleion ulmariae (Lohm. in Oberd. & al. 1967) Bal.Tul. 1978 - CL
ARRHENATHERETALIA Pawl.1928 - BS CL CM
Cynosurion Tx. 1947 - CL
Arrhenatherion W. Koch 1926 - CL BS
CIRSIETALIA VALLIS-DEMONIS Brullo & Grillo 1978 - CL
Plantaginion cupanii Brullo & Grillo 1978 - CL
HOLOSCHOENETALIA Br.-Bl. ex Tchou 1948 - CL BS
Molinio-Holoschoenion vulgaris Br.Bl. ex Tchou 1948 - PG
Dactylorhizo-Juncion striati Brullo & Grillo 1978 - CL BS
Senecion samniti Bonin 1978 - CL BS
PLANTAGINETALIA MAJORIS R. Tx. 1950 - CL CM BS
Trifolio fragiferi-Cynodontion Br.-Bl. & O. Bolòs 1958 - CL
Lolio-Plantaginion majoris Sissingh 1969 - CL CM
Paspalo-Polypogonion verticillati Br.-Bl.in Br.-Bl., Rouss.& Nègre 1952 - CL
Mento-Juncion inflexi De Focault 1984 - CL BS
NARDETEA STRICTAE Rivas Goday ex Riv. Goday & Riv. Mart. 1963 - CL BS
NARDETALIA STRICTAE Oberd. 1949 - CL BS
Ranunculo-Nardion strictae Bonin 1972 - CL BS
ISOËTO-LITTORELLETEA Br.-Bl. & Vlieger in Vlieger 1937 - CL
LITTORELLETALIA W. Koch 1926 - CL
Hyperico elodis-Sparganion Br.-Bl. & R. Tx. ex Oberd. 1957 - CL
SCHEUCHZERIO-CARICETEA FUSCAE R. Tx. 1937 - CL
CARICETALIA FUSCAE W. Koch 1926 em. Br.-Bl. 1949 - CL
Caricion fuscae W. Koch 1926 em. Klika 1934 - CL
PHRAGMITO-MAGNOCARICETEA Klika in Klika & Novak 1941 - CL PG BS CM
PHRAGMITETALIA W. Koch 1926 em. Pignatti 1954 - CL PG BS CM
Phragmition W. Koch 1926 - CL PG BS CM
NASTURTIO-GLYCERIETALIA Pignatti 1954 - CL PG BS
Nasturtion officinalis Géhu & Géhu-Franck 1987 - CL PG
Glycerio-Sparganion Br.-Bl. & Sissingh in Boer 1942 - CL BS
SCIRPETALIA COMPACTI Hejný in Holub, Hejný, Moravec & Neuhäusl 1967 corr. Riv. Mart., Costa, Castroviejo & E. Valdés 1980 - CL PG BS
Scirpion compacti Dahl & Hadač 1941 corr. Riv. Mart. & al.1980- CL PG BS
MAGNOCARICETALIA Pignatti 1954 - BS CL PG
Magnocaricion elatæ Kock 1926 - BS CL PG
ARTEMISIETEA VULGARIS Th. Mueller 1981 in Oberd. 1983 - CL
ARTEMISIETALIA VULGARIS Lohm. in Tx. 1947 - CL
Arction lappae Tx. (1937) em. 1950 - CL
GALIO-URTICETEA Passarge ex Kopecky 1969 - CL PG
CIRCAEO-STACHYETALIA SYLVATICAE Passarge 1967 - CL
Mycelido-Stachyion sylvaticae Passarge (1967) 1979 - CL
CONVOLVULETALIA SEPIUM R. Tx.1950 - CL PG
Balloto-Conion maculati Brullo in Brullo & Marcenò 1985 - CL
Senecionion fluviatilis R. Tx. 1950 - CL
Dorycnion recti Géhu & Biondi 1988 - PG
GLECHOMETALIA HEDERACEÆ R. Tx. in R. Tx. & Brun-Hool 1975 - CL
Antriscion nemorosae Brullo in Brullo & Marcenò 1985 - CL
Aegopodion podagrariae Tx. 1967 - CL
Galio-Alliarion petiolatae Oberd. & Lohm.1967 - CL
EPILOBIETEA ANGUSTIFOLII R. Tx. & Preising ex v. Rochow 1951 - CL
ATROPETALIA BELLADONNAE Vlieger 1937 - CL
Atropion belladonnae Br.-Bl. ex Aichinger 1933 - CL
Epilobion angustifolii (Rubel 1933) Soò 1933 - CL
PARIETARIETEA JUDAICAE Oberd. 1977 - CL PG BS CM
TORTULO-CYMBALARIETALIA Segal 1969 - CL PG BS CM
Parietarion judaicae Segal 1969 - CL PG BS CM
Cymbalario-Asplenion Segal 1969 - CL BS PG
ONOPORDETEA ACANTHI Br.-Bl. 1964 - CL
CARTHAMETALIA LANATI Brullo in Brullo & Marcenò 1985 - CL
Onopordion illyrici Oberd. 1954 - CL
POLYGONO-POETEA ANNUAE Riv. Mart. 1975 - CL PG
POLYGONO ARENASTRI-POETALIA ANNUAE R.Tx in Géhu, Richard & Tüxen 1972 corr. Riv. Mart., & al. 1991 - CL PG
Polycarpion tetraphylli Riv. Mart. 1975 - CL PG
Matricario-Polygonion arenastri Riv. Mart. 1975 corr. Riv. Mart., Báscones, T.E. Díaz, Fernández-González & Loidi 1991 - PG
PAPAVERETEA RHOEADIS Brullo, Scelsi & Spamp. 2001 - CL PG BS CM
PAPAVERETALIA RHOEADIS Hüppe & Hofmeister ex Theurillat & al.1995 - CL PG BS CM
Ridolfion segeti Nègre ex Riv. Mart. & al. 1999- CL PG BS CM
Roemerion hybridae Br.-Bl. ex Riv. Mart. & al. 1999 - CL
APERETALIA SPICAE-VENTI J. & R. Tx. in Malato Beliz & al. 1960 - CL
Scleranthion annui (Kruseman & Vlieger 1939) Sissingh in Westhoff & al.1946 - CL
STELLARIETEA MEDIAE R.Tx., Lohmeyer & Preising ex v.Rochow 1951 - CL PG BS CM
POLYGONO-CHENOPODIETALIA ALBI R.Tx. & Lohm in R.Tx.1950 em.J.Tx.1966 - CL PG BS CM
Fumarion wirtgenio-agrariae Brullo in Brullo & Marcenò 1985 - CL
SOLANO-POLYGONETALIA CONVOLVULI (Sissingh in Westhoff & al. 1946) O. Bolòs 1962 em. Brullo & Marcenò 1980 - CL PG
Panico-Setarion Sissingh in Westhoff & al. 1946 - CL PG
Diplotaxion erucoidis Br.-Bl. in Br.-Bl. & al.1936 em.Brullo & Marcenò 1980 - CL
Chenopodion botryos Brullo & Marcenò 1980 - CL BS
URTICO-SCROPHULARIETALIA PEREGRINAE Brullo in Brullo & Marcenò 1985 - CL
Allion triquetri O. Bolòs 1967 - CL
Veronico-Urticion urentis Brullo in Brullo & Marcenò 1985 - CL
CHENOPODIETALIA MURALIS Br.-Bl.in Br.-Bl. & al.1936 em.Riv.Mart. 1977 - CL BS
Chenopodion muralis Br.-Bl. in Br.-Bl. & al. 1936 em. Brullo 1985 - CL BS
Malvion parvifloræ (Riv. Mart. 1978) Brullo in Brullo & Marcenò 1985 - CL
Mesembryanthemion crystallini Riv. Mart. & al. 1993 - PG
THERO-BROMETALIA (Rivas Goday & Rivas-Martínez ex Esteve 1973) O. Bolòs 1975 - BS CL CM PG
Hordeion leporini Br.-Bl. in Br.-Bl. & al. 1936 - BS CL CM PG
Echio plantaginei-Galactition tomentosae O. Bolòs & Molinier 1969 - CL BS CM
GERANIO-CARDAMINETALIA HIRSUTAE Brullo in Brullo & Marcenò 1985 - CL
Valantio-Galion muralis Brullo in Brullo & Marcenò 1985 - CL

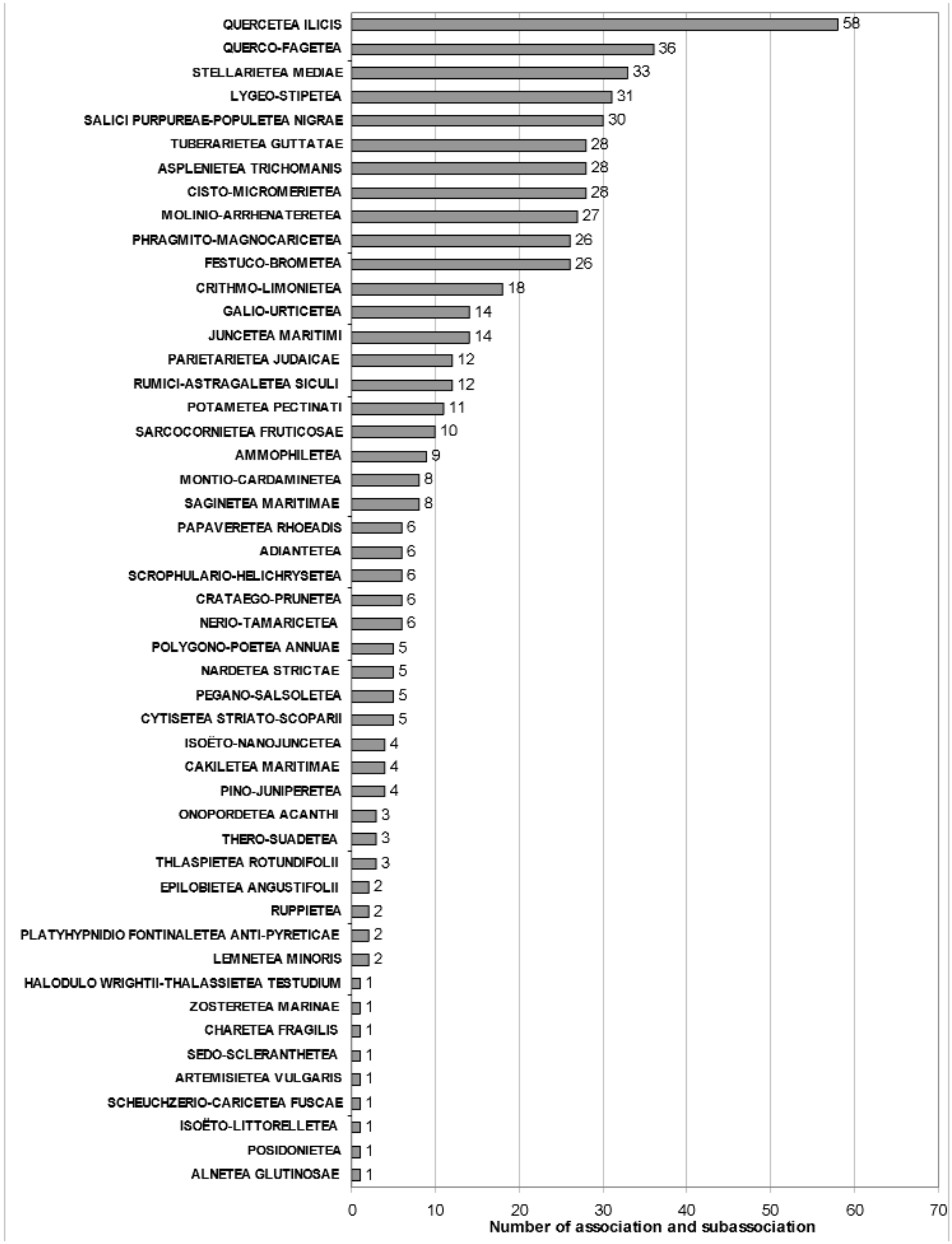

Fig. 3. Number of associations and subassociations occurring in each class of vegetation.

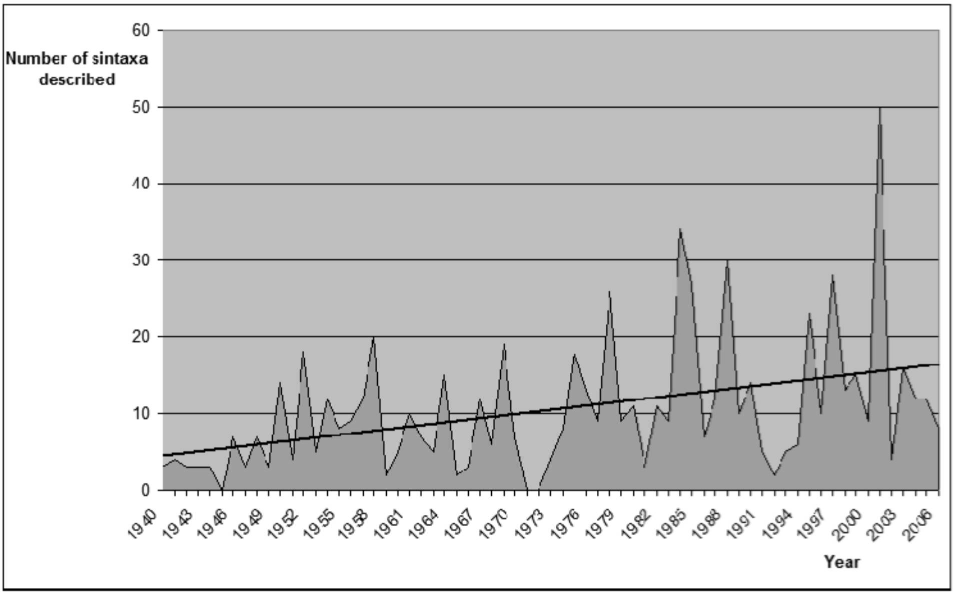

Fig. 4. Number of associations described in each year.

Tab. 2. Number of syntaxa occurring in Southern Italy and in each region.

	S Italy	**Basilicata**	**Calabria**	**Campania**	**Apulia**
Classes	**49**	33	33	33	33
Orders	**84**	50	75	32	50
Sub orders	**1**	1	1	1	1
Alliance	**156**	69	128	44	66
Suballiance	**13**	6	10	6	10
Associations	**515**	105	342	79	143
Subassociations	**50**	10	13	23	18
Total Sintaxa	**868**	274	614	209	321

assumed that further studies on the vegetation of Southern Italy will allow other phytocoenoses to be detected for this territory. The total number of phytocoenoses currently known is therefore probably underestimated.

Taking into consideration the number of syntaxa known for each region (Table 1), it is possible to observe that Calabria shows the higher number of syntaxa than the other regions. It is followed by Apulia and Basilicata while Campania has the lowest number. The greater syntaxonomic diversity in Calabria depends not only on the remarkable environmental heterogeneity of this region but also on the availability of a greater number of territorial studies.

The critical revision carried out has also highlighted the partial syntaxonomic autonomy of Southern Italy vegetation as shown by the occurrence of several syntaxa of rank superior to association, mainly alliances and suballiances, endemics of this territory. Table 3 lists the alliances and suballiances exclusive to Southern Italy. It also gives the alliances and suballiances occurring only in Southern Italy and Sicily, those that extend their geographic distribution to central Italy, and those occurring in the whole Italian Peninsula and Sicily.

Among the endemic alliances and sub-alliances of Southern Italy it worth to be mentioned those of forest interest, such as *Campanulo trichocalycinae-Fagion*, an endemic alliance of Calabria, Campania and Basilicata that groups the microtherm beech woods of

Table 3. Distribution of endemic alliances and suballiances.

	Region			
Alliances and suballiances endemic of Southern Italy	**Campania**	**Basilicata**	**Apulia**	**Calabria**
Campanulo trichocalycinae-Fagion Ubaldi ex Brullo, Scelsi & Spampinato 2001	*	*		*
Ptilostemo stricti-Quercenion cerridis Bonin & Gamisans 1977	*	*		*
Festuco exaltatae-Ostryenion carpinifoliae Blasi, Filibek & Rosati 2006	*	*		*
Tilio-Ostryion carpinifoliae Brullo, Scelsi & Spampinato 2001				*
Hippocrepido claucae-Stipion austroitalicae Forte & Terzi 2005			*	
Asperulion garganicae Bianco, Brullo, Pignatti E. & S. 1988			*	
Centaureion pentadactylis Brullo, Scelsi & Spampinato 2001				*
Ranunculo-Nardion strictae Bonin 1972		*		*
Armerion aspromontanae Brullo, Scelsi & Spampinato 2001				*
Koelerio brutiae-Astragalinon calabricae Giacomini & Gentile ex Brullo 2005				*
Cytiso-Bromion erecti Bonin 1969		*		*
Festucion violaceae Avena & Bruno 1975		*		*
Scleranthо-Myosotidion incrassatae Brullo, Scelsi & Spampinato 2001				*
Senecion samniti Bonin 1978		*		*
Alliances and suballiances endemic of Southern Italy an Sicily				
Pohlio-Asplenion septentrionalis Brullo & Siracusa in Brullo & al. 2000				*
Berberidion aetnensis Brullo, Giusso & Guarino 2001		*		*
Euphorbion rigidae Brullo, Scelsi & Spampinato 1998		*		*
Linarion purpureae Brullo 1984	*	*		*
Dianthion rupicolae Brullo & Marcenò 1979	*	*		*
Moricandio-Lygeion sparti Brullo, De Marco & Signorello 1990		*		*
Aristido-Hyparrheneion hirtae Brullo, Scelsi & Spampinato 1997				*
Avenulo-Ampelodesmion mauritanici Minissale 1995				*
Violion messanensis Brullo & Furnari in Barbagallo & al. 1982				*
Pino-Quercion congestae Brullo, Scelsi, Siracusa & Spampinato 1999				*
Plantaginion cupanii Brullo & Grillo 1978				*
Dactylorhizo-Juncion striati Brullo & Grillo 1978		*		*
Alliances and suballiances endemic of Southern and Central Italy				
Seslerion apenninae Furnari in Bruno & Furnari 1966	*	*		*
Daphno oleoidis-Juniperion alpinae Stanisci 1997		*		*
Alliances and suballiances endemic of Southern-Central Italy and Sicily				
Saxifragion australis Biondi & Ballelli ex Brullo 1984		*	*	*
Doronico-Fagion Ubaldi & al. ex Ubaldi 1995	*	*	*	*

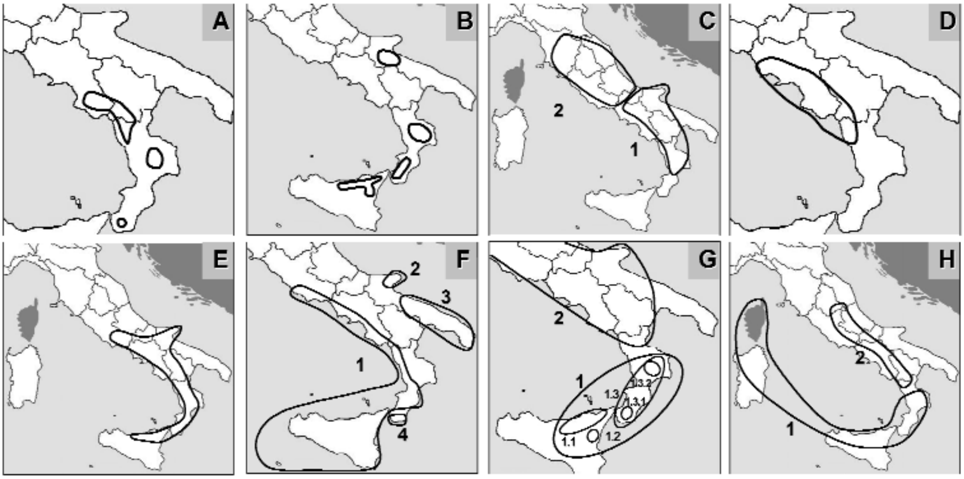

Fig. 5. Distribution of some endemic sintaxa of Southern Italy. A – *Campanulo trichocalycinae-Fagion*; B – *Pino-Quercion congestae;* C – *Teucrio-Quercion cerridis*: 1) *Ptilostemo-Quercenion cerridis,* 2) *Teucrio siculi-Quercenion cerridis*; D – *Festuco exaltatae-Ostryenion carpinifoliae*; E – *Doronico-Fagion*; F - Alliances of casmophilous vegetation: 1 - *Dianthion rupicolae,* 2 - *Asperulion garganicae*, 3 - *Campanulion versicolor*, 4 - *Centaureion pentadactyli;* G – Montane and oromediterranean grassland and scrub: 1) *Rumici-Astragaletea*: 1.1 - *Jurinetalia bocconei*; 1.2 - *Rumici-Astragaletalia*; 1.3 - *Antemidetalia calabrice*; 1.3.1 - *Armerion aspromontanae*; 1.3.2 - *Koelerio-Astragalion calabricae*; 2) *Festuco-Brometea*; H – *Pino-Junipertea*: 1 - *Berberidion aetnensis,* 2 - *Daphno oleoidis-Juniperion nanae*.

the upper mountain belt (Fig. 5A), or the *Pino-Quercion congestae* alliance comprises the *Quercus congesta*-dominated woods of Southern Calabria and northern Sicily (Fig. 5B). Recently this alliance has also been quoted for Apulia and Sardinia too (Biondi & al. 2004). Also *Tilio-Ostryon carpinifoliae*, alliance which includes mixed forests of ravines and abrupt rocky slopes, is endemic to Calabria (Brullo & al. 2001b).

Other endemic forest syntaxa are those including meso-xerophytic broad-leaved woods recently examined by Blasi & al. (2004) from the syntaxonomic viewpoint. These authors evidence some sub-alliances occurring only in Southern Italy or, sometimes, also in contiguous regions like *Ptilostemo stricti-Quercenion cerridis*, a sub-alliance of *Teucrio siculi-Quercion cerridis* exclusive to Southern Italy (Fig. 5C). Also in the mixed mesophytic deciduous woods of *Carpinion orientalis,* Blasi & al. (2006) distinguish the *Ostrya carpinifolia*-dominated mixed woods of Southern Italy, including them in the particular alliance of *Festuco exaltatae-Ostryenion carpinifoliae* (Fig. 5D).

Some alliances are well represented in Southern Italy and extend their geographical distribution to central Italy and Sicily, such as *Doronico-Fagion* which includes macrotherm beech woods characterized by the occurrence of evergreen species (Fig. 5E).

Among the syntaxa exclusive to only one region, the alliances including the chasmophilous vegetation, such as the *Centaureion pentadactyli*, endemic to Southern Calabria (Brullo & Spampinato 2003), or the *Asperulion garganicae,* endemic to the Gargano cliff

(Bianco & al. 1988) have to be the mentioned. Other chasmophilous alliance have a wider distribution, such as *Dianthion rupicolae,* found along the Tyrrhenian coastal cliffs from Southern Lazio down to Calabria and Sicily, or *Campanulion vericoloris,* alliance occurring in Apulia and Greece (Fig. 5F).

Other sintaxa exclusive to only one region are alliances including mountain and upper-mountain pastures with hemicrypto-chamaephytic structure of the mountain stands of Aspromonte and Sila massifs, respectively represented by *Armerion aspromontanae* and *Koelerio-Astragalion calabricae* (Brullo & al. 2005). These syntaxa have been included in the *Anthemidetalia calabrice,* an order endemic to Calabria, and in the *Rumici-Astragaletea* class that replaces *Festuco-Brometea* on the heights of Southern and Central Calabria and northern Sicily (Fig. 5G).

A somewhat similar distribution is shown by the alliances of *Pino-Juniperetea* in the central Mediterranean (Fig. 5H). This class groups the open orophilous woody vegetation of Mediterranean mountains dominated by gymnosperms. It has an extremely fragmented distribution and is represented in Italy by two alliances: *Berberidion aetnensis,* which includes the vegetation of central and Southern Calabria, Sicily, Sardinia and Corsica, and *Daphno oleoidis-Juniperion nanae* which instead groups the vegetation occurring from the central to the Southern Apennine up to the Pollino massif (Brullo & al. 2001b; Stanisci 1997).

As highlighted by various authors (Bonin 1978, Quezel & Medail 2003, etc.) although the vegetation of Southern Italy shows connections with that European and western Mediterranean, it has greater affinities with that of the Balkan Peninsula. This is testified by the occurrence of several Balkanic alliances in Southern Italy, such as *Platanion orientalis* which groups riparian woods with *Platanus orientalis* (Corbetta & al. 2004) and *Alno-Quercion roboris* including ash-alder floodplain woods (Brullo & Spampinato 1999) or *Carpinion orientalis* and *Campanulion versicoloris* as mentioned previously.

Outline of Southern italian vegetation

The list of the phytocoenoses occurring in Southern Italy shows that the vegetation of this territory is characterized by an elevated phytocoenotic diversity that is not easy to summarise in few words. A brief overview of the phytocoenotic diversity in Southern Italy in relation to the ecological and bioclimatic characteristics of this territory is given below. Only the mature stages, mainly of forest type, were considered.

Vegetation of the Mediterranean zone

The thermo-Mediterranean belt, characterized by warm, arid and long-lasting dry summers, is localized in the coastal and low hilly areas and it is widespread on the Ionian side, while it is absent, or only of limited extension, in the Tyrrhenian and Adriatic sides. This territory is characterized by the *Quercetalia calliprini* order, locally represented by the *Oleo-Ceratonion* and *Juniperion turbinatae* alliances. *Oleo-Ceratonion* is the alliance richest in phytocoenoses, mainly including primary formations that in the past were common in coastal areas with sporadic inland penetration chiefly in the Ionian side.

Anthropization of the coastal area has considerably reduced the extension of this vegetation, so that currently only small and very localized stands are to be found mostly within cultivated areas. In fact, although maquis is a formation that is relatively well adapted to fire, systematic fire disturbance have caused them to be replaced by garigues of *Cisto-Micromerietea* or, more frequently, by dry grasslands of *Lygeo-Stipetea* that dominate the landscape of the coastal territory of Southern Italy.

The meso-Mediterranean belt is occupied by sclerophillous broadleaved forest vegetation of *Quercetalia ilicis*, chiefly represented by evergreen holm oak woods referable to several associations or xerophilous deciduous oak woods of *Quercus virgiliana*. Biondi & al. (2003) recently highlighted the phytogeographic and syntaxonomic autonomy of the Italian evergreen forest vegetation, ascribing it to *Fraxino orni-Quercion ilicis*, alliance which replaces *Quercion ilicis* in central Mediterranean Europe. Dynamically connected to the forest communities of *Quercetalia ilicis* is the secondary maquis of *Quercetalia calliprini*, such as those belonging to the *Ericion arboreae*.

The supra-Mediterranean belt is poorly represented due to the direct transition from the meso-Mediterranean belt to the meso- or supra-Temperate ones. The supra-Mediterranean belt, when found, is usually characterized by mesophilous holm oak woods such as those of *Teucrio-Quercetum ilicis* in central and Southern Calabria.

Vegetation of the temperate zone

As highlighted by Blasi & al. (1999) the Mediterranean-Temperate boundary is not a clear limit but rather a mosaic of vegetation typologies belonging to these two bioclimatic zones.

The mountain territory of Southern Italy, which has a Temperate oceanic bioclimate, is mostly occupied by beech woods and deciduous oak forests of *Querco-Fagetea*. The mixed oak woods, characterized by the occurrence of various deciduous oaks and several other meso-thermophilous woody species of the *Quercetalia pubescenti-petrea*, are quite well represented in the hilly and sub-mountain areas with a meso- or supra-Temperate bioclimate, especially in those areas where the climate is less oceanic.

According to Blasi & al. (2004), the vegetation belonging to this order, is represented in Southern Italy by 5 different alliances:

- *Teucrio siculi-Quercion cerridis*, represented by the sub-alliance *Ptilostemo stricti-Quercenion cerridis,* including oak woods dominated by *Quercus cerris* or *Q. frainetto*.
- *Tilio-Ostryion carpinifoliae*, grouping gorge woods dominated by broadleaved mesophilous species.
- *Pino-Quercion congestae* grouping *Quercus congesta*-dominated woods.
- *Carpinion orientalis*, represented by the *Festuco exaltatae-Ostryenion carpinifolia,* sub-alliance including *Ostrya carpinifolia*-dominated woods, and *Lauro nobilis-Quercenion pubescentis*.
- *Corylo-Populion tremulae,* grouping pioneer forest vegetation with *Populus tremula.*

Beech forests, together with other mesophilous broadleaved forest communities, are included in the *Fagetalia sylvaticae* order and they are well represented in all the mountains ranging between 1,000 and 2,000 m of altitude. They are favoured by the temperate oceanic bioclimatic conditions with a humid or hyper-humid ombrotypes and occupy a greater altitudinal range on the Tyrrhenian side of the territory, where they benefit from the humid westerlies affecting the Southern Apennine. In particular, in the Calabrian Apennine the proximity of the mountain ranges to the sea emphasizes the oceanic character of the climate and allows a remarkable downshifting of beech woods, which often come into direct contact with the holm-oak forests and in some cases occupy heterotopic stands located at an altitude as low as 400-500 m. The beech forests of Southern Italy are classified in two alliances: *Doronico-Fagion* and *Campanulo trichocalycinae-Fagion,* which show phytogeographic affinities with analogous syntaxa in the Balkan Peninsula for the presence of different nemoral species with eastern geographic distribution as *Doronicum orientale* and *Campaluna trichocalycina.*

In the Southern Apennine there is no alpine belt as the peaks are not enough high. Beech forests potentially cover all the higher summits of Southern Italy with the exception of the Pollino massif, where pastures of *Seslerion appenninae* and orophilous pine forests of *Pinus leucodermis* of *Daphno oleoidis-Juniperion alpinae* occur.

In the territories characterized by carbonatic substrata, along the Apennine range up to the Pollino mountains in northern Calabria, the degradation of the *Querco-Fagetea* forests favours the colonization by thickets of *Crataego-Prunetea* and pastures of *Festuco-Brometea*, while on crystalline substrata of central and Southern Calabria the secondary vegetation is represented by thickets of *Cytisetea striato-scopari* and orophilous grasslands of *Anthemidetalia calabricae.*

Conclusion

The vegetational and in particular phytosociological studies available for Southern Italy make it possible to compile a relatively complete scheme of the phytocoenotic diversity of this territory. The analysis carried out has highlighted a remarkable phytocoenotic heterogeneity that is mainly due to the different bioclimatic and geopedological conditions.

In such a circumscribed territory phytocoenoses typical of the Southern Mediterranean, as the steppes of *Aristido-Hyparrhenenion hirtae*, and phytocoenoses of central European or Balkan type, as pastures of *Cynosurion cristatae* or forests of *Carpinion orientalis*, are present.

To assess the phytocoenotic diversity, anthropic action must also be considered.

Man has been present for millennia in these territories and his action has often deeply modified the vegetation. In most of the territory, particularly in coastal and low hilly areas, the man-induced transformations have partly destroyed the natural vegetation, favouring at the same time the settlement of semi-natural or synanthropic phytocoenoses that have progressively led to an increase in the phytocoenotic diversity. This is evident, for instance, from the wealth of phytocoenoses that have classes including semi-natural vegetation as *Lygeo-Stipetea,* or anthropogenic vegetation such as *Stellarietea mediae*.

A strong correlation has emerged between the bioclomatic and phytocoenotic characteristics of this territory, especially when phytocoenoses correspond to syntaxonomic

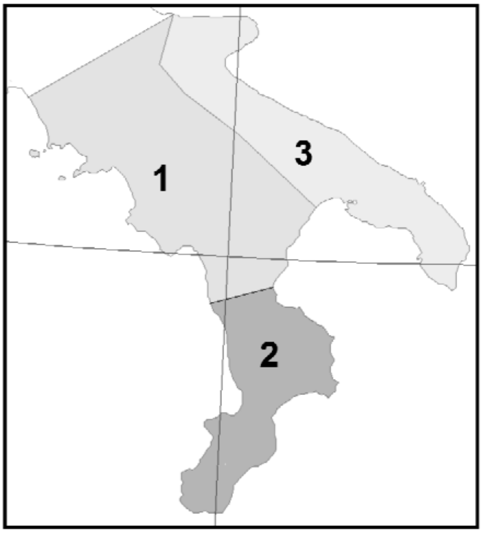

Fig. 6. Homogeneous areas individuated according to syntaxa unit distribution.

units phytosociologically well-defined. Nevertheless, the available data are still not sufficient to carry out a detailed distribution of each association since only generic indications are often available. In addition, several areas of Southern Italy are still lacking of in-depth territorial studies.

From the phytogeographic point of view, the phytocoenotic diversity shows that Southern Italy cannot be considered as an autonomous phytogeographic unit, since none classes or orders of vegetation is exclusively found in this territory.

The phytocoenotic difference between Southern Italy and the rest of Italy is however emphasized by the presence of several alliances and sub-alliances endemic to this territory. In particular, three homogeneous areas (Fig.6) can be easily recognized when analyzing the distribution of the syntaxa occurring in the territory at issue: 1) the carbonatic or flyschoid Southern Apennines ranging from Sannio mountains (Campania) to Pollino massif (Calabria), 2) the Southern and Central Calabria from Sila to Aspromonte, predominantly characterized by crystalline substrata, and 3) the Apulian territory which is purely calcareous. Syntaxa present only in the first area are: *Festuco exaltatae-Ostryenion carpinifoliae, Seslerion apenninae, Daphno oleoidis-Juniperion alpinae, Phleo ambigui-Bromion erecti, Senecion samniti, Cytiso-Bromion erecti, Alisso alyssoides-Sedion albae*. Syntaxa exclusive of the second area are: *Centaureion pentadactylis, Anthemidetalia calabricae, Cytisetalia striato-scoparii, Tilio-Ostryion carpinifoliae, Phagnalo-Cheilanthion maderensis, Onobrychido-Ptilostemion stellati.* Between the syntaxa present only in the third area they can be cited: *Hippocrepido claucae-Stipion austroitalicae, Asperulion garganicae, Campanulion versicoloris*. The noteworthy phytogeographic importance of these territories should deserve further studies focused also on the floristic and paleobotanic aspects.

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Traditional use of plants in the Béni-Abbès region (NW - Algerian Sahara)

Abstract

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Wild plants are still widely used for many purposes in the Algerian Sahara. Over the last decade, their exploitation has even increased due to the economic crisis. The small oasis of Béni-Abbès, located in the north-western part of the Algerian Sahara, supports a relatively rich flora (250 species) despite an annual rainfall of less than 80 mm. This is due to the presence in the immediate vicinity of several major habitats: hills or mountains (djebels), dry riverbeds (wadis) and dunes (erg). Large quantities of plants, whether for medicinal, fodder or fuel purposes are sold in the market of Béni-Abbès. These are gathered from the surrounding areas and modern means of transport has made it much easier to collect large quantities. An account of the use and their ecology will be given for the commonest plants: *Ammodaucus leucotrichus, Cotula cinerea, Matricaria pubescens* and *Zygophyllum gaetulum*. In rainy years, impressive quantities of these annuals are available leading to a significant fall in price, balanced by shortages in drought years. Annuals appear to be able to tolerate this collecting but there is evidence of pressure on the populations of least some woody shrubs. The most striking example is the depletion of the endemic *Fredolia aretioides*.

Introduction

The use of plants for therapeutic and practical purposes in North Africa dates back to immemorial times (Boulos 1983). Considering the great diversity of medicinal plants in Algeria and their multitude of uses by local communities, there is an urgent need to gather and synthesize as much information as possible on these plants and their applications before social, economic and cultural changes lead to the loss of much of this accumulated wealth of knowledge.

Most frequently, surveys on the local use of plants are undertaken throughout the country by students writing up their theses. These works are rarely published and this explains the low production of theses (Doreau 1961; Belguedj 1966; Merad-Chiali 1973; Brette 1986) and books on the traditional use of plants (Beloued 1998; Baba Aissa 1999). Over the last two decades, ethnobotanical investigators have shown increased interest in the Algerian Sahara and several valuable contributions have been published (Maiza & al. 1993; Benchelah 2000; Gast 2000; Hammiche & Maiza 2006).

The use of medicinal plants in the Algerian Sahara used to be an important activity in the everyday life of nomads where, much of the flora was valued for either medicinal, food or other practical uses. Going back fifty years, nomads had an intimate knowledge of the natural resources, and almost everyone knew the names of the plants and their uses. Today, the knowledge of medicinal plants is confined to the older generation. The strong tradition in the use of medicinal plants is characterized nowadays by a high demand across the population regardless of age or gender. As a result, there is a more or less noticeable impact on several key species in the Algerian Sahara.

Geographical, habitat and climatic context

The present survey was carried out in the Béni-Abbès area, an important oasis of the Algerian Sahara, situated 1200 km south-west of Algiers, at an altitude of 450 m. The Béni-Abbès region is located at the junction of several major desert landforms (Fig. 1): these are the dunes of the Great Western Erg, the saline Saoura wadi which runs parallel with the edge of the Great Western Erg, the Ougarta Mountains which afford bare rocky slopes with dry non-saline wadis and the dayas (small clay-sandy depressions) scattered within the Guir Hamada.

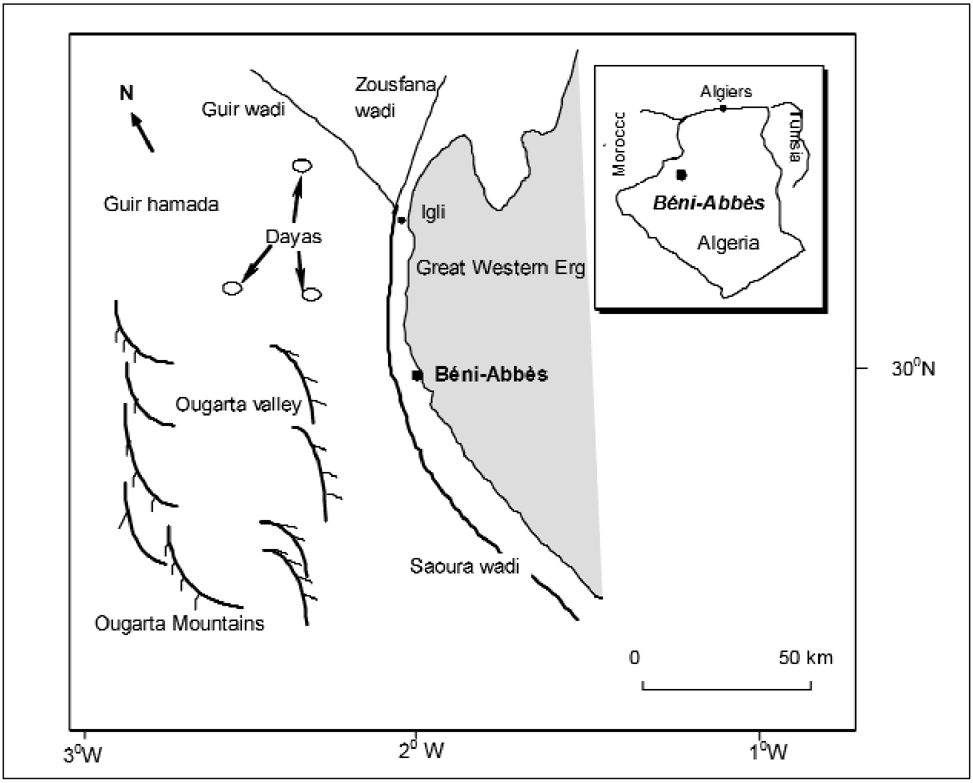

Fig. 1. The Béni-Abbès oasis in the Algerian Sahara and main grazing sites in the Béni-Abbès area.

The Béni-Abbès area has a desert climate with mean annual rainfall of 30 mm (range 3-110 mm, with great variation in year to year totals). The great majority of the rainfall occurs in the winter. The mean annual temperature is 23°C, with high diurnal and monthly temperature variation (Dubief 1959).

Flora and vegetation of the Béni-Abbès region

The flora of the Béni-Abbès region is relatively rich with 250 species (Guinet 1954). There are several notable north-western Saharan endemic species which characterize the flora of the region such as *Withania adpressa, Fredolia aretioides* and *Limoniastrum feei.* Nomenclature follows Ozenda (2004) and Boulos (1999-2005). Vegetation is considered typical of the north-west Sahara (Quézel 1965) and has been described by Guinet (1954, 1958) and Benhouhou (2001, 2003).

Vegetation is confined to those parts of the major landform systems - wadis (dry river beds), dayas, djebels (rocky slopes) and erg (vast sand dune systems). Much of the area supports vegetation in the contracted pattern of growth typical of desert vegetation ("mode contracté" - Monod 1954). Hamadas and regs (stony plateaux) are known for being the driest habitats. The permanent framework of the vegetation communities consists of shrubs and perennial grasses. Ephemerals appear during spring if there has been sufficient rain. Two trees are present, *Acacia raddiana* and *Tamarix aphylla* ; they develop on floors of the larger non-saline and saline wadis respectively.

Grazing areas

In the Béni-Abbès area the most intensive grazing and plant collection occurs in the wadis of the Ougarta region. This is a complex network of djebels and surrounding valleys – the latter consisting of large wadis and smaller related channels. Located just 50 km south-west of Béni-Abbès, the Ougarta Mountains cover approximately 6000 km^2, rising to 600 m and are easily reached by four-wheel drive vehicles. The wadi vegetation is represented by the typical *Acacia raddiana-Panicum turgidum* community (Quézel 1965). This vegetation type, where *Acacia* trees and *Panicum turgidum* play a physiognomically dominant role, has long been described from the Sahara but also from the Sahel and the Asian part of the Saharo-Arabian region (Léonard 2001).

The other habitats: dayas, djebels, erg, saline wadis and hamadas (rocky plateaux) have a much lower potential for grazing and plant collection, but nevertheless harbour several species of high conservation value and/ or interesting traditional uses.

Dayas, medium sized (50-500 m diameter) sand-clay depressions scattered on the Guir Hamada of the Béni-Abbès area, are floristically related to the wadi system. They provide, particularly during wet years, additional fodder or medicinal plants for nomads who are "en route" to the Ougarta valley.

The djebels of the Ougarta Mountains have an impoverished flora and are characterized by a typical desert community featuring chamaephytes such as *Withania adpressa, Gymnocarpos decander, Cymbopogon schoenanthus* and *Rhus tripartita*. Only a few species – e.g., *Limoniastrum feei* and *Cymbopogon schoenanthus* - are used as medicinal plants.

The dunes of the Great Western Erg are mainly valuable for their pastures typified by the famous drin grass (*Stipagrostis pungens)*.

The Saoura wadi, represented by a *Tamarix gallica* community, with *Tamarix aphylla* found on the terraces of this saline wadi, has the sparsest flora of all these habitats. Only a few medicinal plants are known from this habitat but it does provide valuable pasture for camels and goats.

The Guir Hamada, well known for being the most inhospitable habitat, nevertheless harbours a unique plant community characterised by the endemic *Fredolia aretioides*. This is a much appreciated medicinal plant, which has been in severe decline over the last fifty years.

Plant gathering and selling in the Béni-Abbès area

Nomads and "sedentary" nomads are the main provider for medicinal plants. Although plant collecting is still done in a traditional way, means of transport have completely changed with the use of four-wheel drives. Once collected, plants are sold in the market in Béni-Abbès. Perennials are found throughout the year while annuals are only found in rainy years. The quantity is dependent on the rainfall amounts and the main period for annuals is spring or occasionally autumn. Nomads will bring back as much plant material as they can fit in the back of their four-wheel drive. They regard the "available" vegetation as a gift of God and hence take as much as they can. On the other hand, during drought years, they will regard the scarcity of the vegetation as also being the will of God and fatalistically accept it. They may leave some vegetation on the ground when collecting, but the amount they gather is still normally above sustainable offtake levels. The most popular plants bought on the local market in Béni-Abbès are presented in table 1.

Prices soar whenever there is a drought and the plant becomes scarce in the field. The market for plants varies slightly from one oasis to another according to availability. For instance, in El Goléa, a small oasis 900 km south from Algiers, where several highly sought-after plants are locally scarce, medicinal plants are more expensive. *Ammodaucus leucotrichus* and *Matricaria pubescens* are sold respectively for 60 DA /100 g in Béni-Abbès and 70 DA /100 g in El Goléa and 40 DA /100 g in Béni-Abbès and 50 DA/100 g in El Goléa.

Description of the plants

Accounts of certain selected plants are given below focussing on the growth form, the geographical distribution, the habitats in which they are found and the extent to which they are subject to pressure from gathering. The relationship between the habitat of a particular plant, its growth form and its use enables us to assess whether it is likely to be vulnerable to gathering or to be one of those species which can withstand both intensive gathering as well as harsh environmental conditions.

Acacia raddiana (*Fabaceae*)

Acacia raddiana has a trans-Saharan distribution and is well-known as the dominant tree in the classic savannah vegetation type on non-saline wadis. The height of this tree varies between 2 and 10 m and it favours sandy-gravelly substrates. *A. raddiana*-dominat-

Table 1. Commonest medicinal and fodder plants sold in the market in Béni-Abbès.

Plant name	Arabic name	Price	Use
Acacia raddiana	Talha	Wood 800 to 1000 DA* /15 to 20 kg.	Rheumatism, firewood
Anvillea radiata	Nougd	10 DA for 20 g	Diabetes, indigestion
Ammodaucus leucotrichus	Messoufa Moudriga	600 DA/Kg	Stomach ache, colon
Cotula cinerea	Gartoufa	20 DA for 20 g	Stomach ache, diarrhoea Strengthens nursing women
Fredolia aretioides	Degaâ	50 DA for 10 g	Rheumatism
Hammada scoparia	Remt	20 DA for 20 g	Antivenom.
Launaea arborescens	Oum el bina	20 DA for 20 g	Against vomiting
Limoniastrum feei	Milafetelkhadem	10 DA for 20 g	Rheumatism, cold
Marrubium deserti	Jaâda	150 DA for 20 g	Diarrhoea
Matricaria pubescens	Ouezouaza	400 DA /kg	Rheumatism, mixed with food - strengthens convalescents
Panicum turgidum	Morokba	20 DA for 20 g	Fodder
Stipagrostis pungens	Drin	200 DA a bundle of 10 to 15 kg	Fodder
Tamarix aphylla	Tlaya	300 to 400 DA a piece of 5 m	Construction
Zygophyllum gaetulum	Aâgaya	20 DA for 20 g	Diabetes, stomach ache, diarrhoea

* 100 DA is approximately 1 euro.

ed vegetation is particularly well developed in the drainage networks which dissect and surround the Ougarta Mountains, whereas it is completely absent from dayas. *Acacia raddiana* is under considerable pressure in the Béni-Abbès area where it is not only collected for fuel, but also intensively grazed by goats. Furthermore, the gum produced by this tree is collected and sold at the local market (Table 1).

To stop the resulting worrying depletion of local *Acacia* stocks, the national forest conservation agency (Institut National de Recherche Forestière) has taken the following steps: fencing off the most important *Acacia*-rich area in the Ougarta covering several hectares while also paying nomads who live in the vicinity to guard the area.

Ammodaucus leucotrichus (*Apiaceae*)

This small annual, not exceeding 20 cm in height, of Saharo-Arabian distribution, is frequent on gravelly-sandy floors of the drainage network of the Ougarta as well as the dayas of the Guir Hamada. It is a very much appreciated medicinal herb, being very popular as a treatment for easing stomach problems (Table 1).

Anvillea radiata (*Asteraceae*)

This extensively-branched shrub can reach 60 cm high and is endemic to the Sahara. It shows a large ecological amplitude as it is found on sandy-gravelly wadi floors, their nearby terraces and the surrounding stony plateaux. The plant seems particularly well adapted to extreme spells of drought, since it will still flower abundantly during such periods. Not as appreciated as *Ammodaucus leucotrichus*, it is still much in demand for other purposes (Table 1).

Cotula cinerea (*Asteraceae*)

This small woolly annual, with a Saharo-Arabian distribution, can reach 25 cm in height. When there is sufficient rain, there will be an impressively extensive germination and this species will be very prominent on gravelly-sandy floors of the non-saline wadis of the Ougarta and dayas. The Gartoufa is a very popular plant used mixed with food and tea as well as for various medicinal purposes (Table 1). It is also reported to be taken for sunstroke, colic, coughs and colds (bronchitis) (Maiza & al. 1993).

Fredolia aretioides (*Chenopodiaceae*)

This strange cauliflower-like shrub can grow up to 1 m high, though average height is 50 cm. It is endemic to the south-west Sahara, being confined to the south-east of Morocco and the south-west Algerian Sahara (Béni Ounif, Igli and Béni-Abbès areas). It is one of the very few plants particularly well adapted to the extreme conditions of the hamada and thrives on stony-rocky ground. *Fredolia aretioides* forms diffuse populations on the Guir Hamada in the vicinity of Béni-Abbès. The plant is particularly appreciated by nomads who gather it for fuel as well as for medicinal purposes (Table 1). It provides the worst case of depletion through gathering in the region since its population has dramatically decreased over the last fifty years (Kheddache 1999).

Haloxylon scoparium (*Chenopodiaceae*)

This medium sized shrub, not exceeding 70 cm, of Mediterranean distribution has a high ecological amplitude and shows a perfect adaptation to desertic climate. In the Béni-Abbès area the plant is found on stony plateaux as well as on gravelly-sandy to slightly saline wadis. Used mainly as an antivenom, the Remt shows no sign of over-exploitation and even thrives during drought periods.

Launaea arborescens (*Asteraceae*)

Launaea arborescens has a limited distribution in the north-western part of the Algerian Sahara and has its southerly limit in the Béni-Abbès region. It is a common shrub that can easily reach 2 m high with an ecological preference for the sandy-gravelly wadi floors typical of the Ougarta. It is frequent on the dayas of the Guir Hamada wherever there is a substantial amount of sand accumulation. *Launaea arborescens* is also frequently observed along the side-roads of the Béni-Abbès oasis. Despite its apparent medicinal virtues (Table 1), *Launaea arborescens* is not encountered frequently at markets in the area. This shrub is not regarded as threatened by gathering due to its high frequency in wadis and its invasive capacities in oases.

Limoniastrum feei (*Plumbaginaceae*)

This saxicolous plant is found either on rocky djebel slopes or, less frequently, on the floor of rockier non-saline wadis. It is a shrub of 50 cm average height, which, is frequent on the rocky slopes of the Ougarta Mountains. *Limoniastrum feei* is an endemic of rocky habitats in the northern Moroccan and Algerian Sahara. A much appreciated medicinal plant, *Limoniastrum feei* nonetheless seems to escape massive collection due to the difficulties in accessing its stations on the slopes of the Ougarta Mountains (Table 1).

Marrubium deserti (*Lamiaceae*)

This woody shrub, reaching on average 30 to 50 cm in height, is endemic to the northern and central Algerian Sahara. This plant is confined ecologically to gravelly-sandy wadi beds. Its low frequency in the wadis of the Ougarta combined to a high demand for this plant makes *Marrubium deserti* one of the most expensive medicinal plants at the local market (Table 1).

Matricaria pubescens (*Asteraceae*)

Matricaria pubescens is an endemic species found in the northern and central Algerian Sahara. The plant, a small annual not exceeding 20 cm, is very frequent on gravelly-sandy wadi floors of the Ougarta Mountains as well as on dayas where there is a significant cover of sand. Local demand for *Matricaria pubescens* is high since it is very much appreciated as an ingredient in preparing the famous local soup called “Hrira” as well as for various medicinal uses such as for rheumatism, coughs and eye infections (Maiza & al. 1993), (Table 1).

Panicum turgidum (*Poaceae*)

Common in the central Sahara, this plant of Saharo-Arabian and Soudano-Deccanean distribution reaches its northern limit in the Saoura valley and the M’Zab region. *Panicum turgidum* is the most characteristic grass of the savannah vegetation found with *Acacia raddiana*. Of wide ecological amplitude, this grass is found on gravelly, gravelly-sandy to sandy substrates of the non saline wadi floors of the Ougarta. It is a much appreciated fodder plant and when plentiful prices are generally low (Table 1).

Stipagrostis pungens (*Poaceae*)

This grass which has an average height of 1 m is a common psammophile in sandy habitats of the Algerian Sahara and stretches throughout the Sahara. It has a relatively high frequency in the dunes of the Great Western Erg and can also be found on sandy accumulations on non-saline wadis of the Ougarta.

A much appreciated source of fodder, *Stipagrostis pungens* is currently threatened by excessive exploitation and its price on the market is considered by locals to be high (Table 1). The plant community described by Guinet in 1958, where *Stipagrostis pungens* played a dominant role physiognomically on the fringes of the Great Western Erg, is no longer to be found where he reported it; now a walk of several kilometres into the erg is necessary to observe the community again. This has been corroborated by comments and complaints from nomads who now need to go deep into the erg to gather this valuable fodder.

Tamarix aphylla (*Tamaricaceae*)

This tree of Saharo-Arabian distribution favours sandy-saline ground and is mainly observed on the terraces of the Saoura wadi. The tree reaches 15 to 20 m but does not form the impressive "pseudo-forests" described for the central Sahara. This species has become infrequent and the impact of past exploitation on the *Tamarix* trees is noticeable in the field. There is a huge demand for material like this, which can be used for construction, though prices vary according to the quality of the wood (Table 1).

Zygophyllum gaetulum (*Zygophyllaceae*)

This medium sized shrub, of 60 cm average height, and of Saharo-Mediterranean distribution, colonises terraces of the saline Saoura wadi and areas of soft ground scattered with small stones (called regs) which are also relatively saline. The plant is generally very frequent in suitable areas and forms, together with *Suaeda mollis*, a typical plant community of saline habitats throughout the north-western Algerian Sahara.

There is a high demand for this very much valued medicinal plant which is considered by locals to be the best way to combat diabetes. There is no field evidence that this plant is threatened or even significantly affected by gathering. Proposals to locally cultivate this plant should be considered in the light of the sustained demand for *Zygophyllum gaetulum* over the last fifty years.

Discussion

The plants considered in this study are among the most frequently used by residents of the Béni-Abbès region to cure a range of, usually benign, ailments. Other plants known for their medicinal virtues such as *Cleome amblyocarpa* (Lemkhinza), *Gymnocarpos decander* (Djifna), *Pergularia tomentosa* (Roulgua), *Ruta tuberculata* (Mzabiya) and *Thymelaea hirsuta* (Methnane) are no longer found at the Béni-Abbès market. They are, however, still collected, for personal use, by a few of those nomads who have a good knowledge of medicinal plants. This highlights the extent to which much of this ethnobotanical knowledge is being steadily lost.

The pressure on medicinal or fodder plants sold at the market in Béni-Abbès varies greatly from none or low to medium or high levels of threat (Table 2). The level of threat is related in various ways to habitat, life form and the capacity to withstand long spells of drought. This in turn is linked to the "medicinal" value and /or fodder quality of each species. Thus, unpalatable plants or poisonous ones, such as the famous *Hyoscyamus muticus*, are common on terraces of the saline Saoura wadi and the surrounding regs.

One major factor assisting the depletion of the flora and vegetation is the availability of modern means of transport. Nowadays, almost every nomad travels to the desert in a four-wheel drive, usually collects large quantities and can cover considerable distances between sites very quickly. This means that vegetation often is not allowed sufficient time to recover. Intense grazing is probably an equally important negative factor since stock may be taken by lorries from one spot to another, again without letting enough time for the vegetation to recover in between such visits. So far, spells of drought cannot be considered as a negative factor in terms of their impact on plant availability, since long periods of

Table 2. Levels of threat of the main medicinal/fodder plants sold in the Béni-Abbès market.

Plant name	Habitat	Life form	Threat
Acacia raddiana	Wadi	Phanerophyte (tree)	High
Anvillea radiata	Wadi, daya, regs	Chamaephyte	Low
Ammodaucus leucotrichus	Wadi, daya	Therophyte	Low
Cotula cinerea	Wadi, daya	Therophyte	Low
Fredolia aretioides	Hamada	Chamaephyte	High
Haloxylon scoparium	Wadi, daya, hamada	Chamaephyte	Low
Launaea arborescens	Wadi, daya, regs	Chamaephyte	Low
Limoniastrum feei	Djebel	Chamaephyte	Low
Marrubium deserti	Wadi, daya	Chamaephyte	Medium
Matricaria pubescens	Wadi, daya,	Therophyte	Low
Panicum turgidum	Wadi, daya,	Chamaephyte : perennial grass	Medium
Stipagrostis pungens	Erg, wadi	Chamaephyte : perennial grass	High
Tamarix aphylla	Saline wadi	Phanerophyte (tree)	Medium
Zygophyllum gaetulum	Saline wadi terraces	Chamaephyte	Medium

drought have been recorded as being followed by incredible flowering, such as the spring of 1994 and the spring 2007.

Despite the lack of quantitative data and the difficulty in quantifying the amount of plants taken from the field, work undertaken on the vegetation of the area (Benhouhou 2001, 2003) revealed two major findings. Gathering by nomads seems to have no negative impact on the availability of annuals, these being extremely dependent on the amount of rain during the favoured period(s) of the year. Drought years have been followed by a massive germination of annuals when climatic conditions were favourable. On the other hand, perennials seem more sensitive to intense cutting. This is particularly noticeable with *Acacia raddiana* in the Ougarta valley*, Stipagrostis pungens* in the Great Western Erg, and *Fredolia aretioides* on the Guir Hamada.

Conclusion

The precise impact of plant gathering on the vegetation types encountered in the region of Béni-Abbès is difficult to assess. An extensive network of permanent quadrats should be installed by the forest conservation agency in order to obtain quantitative data on the vegetation cover as well as the quality of the flora, in terms of diversity and the frequency of scarcer species.

At the same time, tough measures need to be taken against large-scale plant collection and intensive grazing in order to preserve the valuable natural resources provided by these three major plants (*Acacia raddiana, Fredolia aretioides* and *Stipagrostis pungens*).

Plant nurseries should be considered as potentially key measures not only to help preserve the natural plant communities but also to provide work in desert oases, notorious for their high unemployment rates. This should also serve in helping to ensure that traditional knowledge on wild plants is not lost to future generations and could help to become the basis for detailed scientific investigations to promote the sustainable use of natural plant resources in the Béni-Abbès area.

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Giulia Caneva

The Augustus botanical code: the message of the *Ara Pacis*

Abstract

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The botanical composition of the external fence of *Ara Pacis* (I century BC), that was built to celebrate the Augustus's return from expedition in Gaul and Spain, with a wish for a new peaceful age, is here analysed. The big decoration of the panel, of Hellenistic- Alexandrine derivation, shows a careful knowledge of plant's world and a deep observation of Nature. About seventy different species have been identified, overall bulbous ones, among which, some assume a recurring role (e.g. *Acanthus mollis, Arum* cfr. *italicum*, *Lilium candidum, Nymphaea* sp., *Phoenix dactylifera*, and *Cardueae*), while others are peculiar of the context in which they have been included. The analysis of the used species, of their reciprocal disposition and of the way they are highlighted, seems to confirm their symbolic aim. This looks to be directed to a Nature's representation in its phases of rebirth and of unending renovation, typical of the time when the effect of burns or drought ends. Rebirth, that is possible thanks to peace and unity in multiplicity, has to be intended as the requirement for a new prosperity, a prelude of Augustus's aurea *aetas*. The composition underlines the role of symmetry and of numerical composition that leads the idea of beauty and harmony. A generative element (*Acanthus*), giving rise to all the botanical complexity, shows a model of growth inspired to a combination of elements, such as snake-like and colonial plants, having the structure of "ramets". The perspective of the Roman Empire foundation and the idea of a propagation of its model of order arise from this colonial structure. The synchronous fusion of different element could ideally underline the Unity that exists in Nature.

Introduction

The *Ara Pacis* is one of the most important Roman monuments, projected to celebrate the Augustus's return from expedition in Gaul and Spain (happened the 13 BC, four years before the inauguration), with a wish for a new peaceful age. It is historically located at the end of a difficult period of internal struggle, started with the Julius Caesar killing in 44 BC, at the beginning of a new era of Roman power coincident with the Empire foundation. The monument was placed near the North entrance of Rome, close to *via Flaminia*, in a flat area of *Campus Martius*, in close relationship with other Augustan monuments. They were its future Mausoleum, and especially the solar *orologium*, whose gnomon, formed by an Egyptian obelisk, projected the shadow at the altar's entrance in Augustus date of birth (Fig. 1).

The iconographic project of the monument had to underline the new values of the Augustus power and a senatorial commission approved the choice of subjects represented on the monument (Zanker 1989).

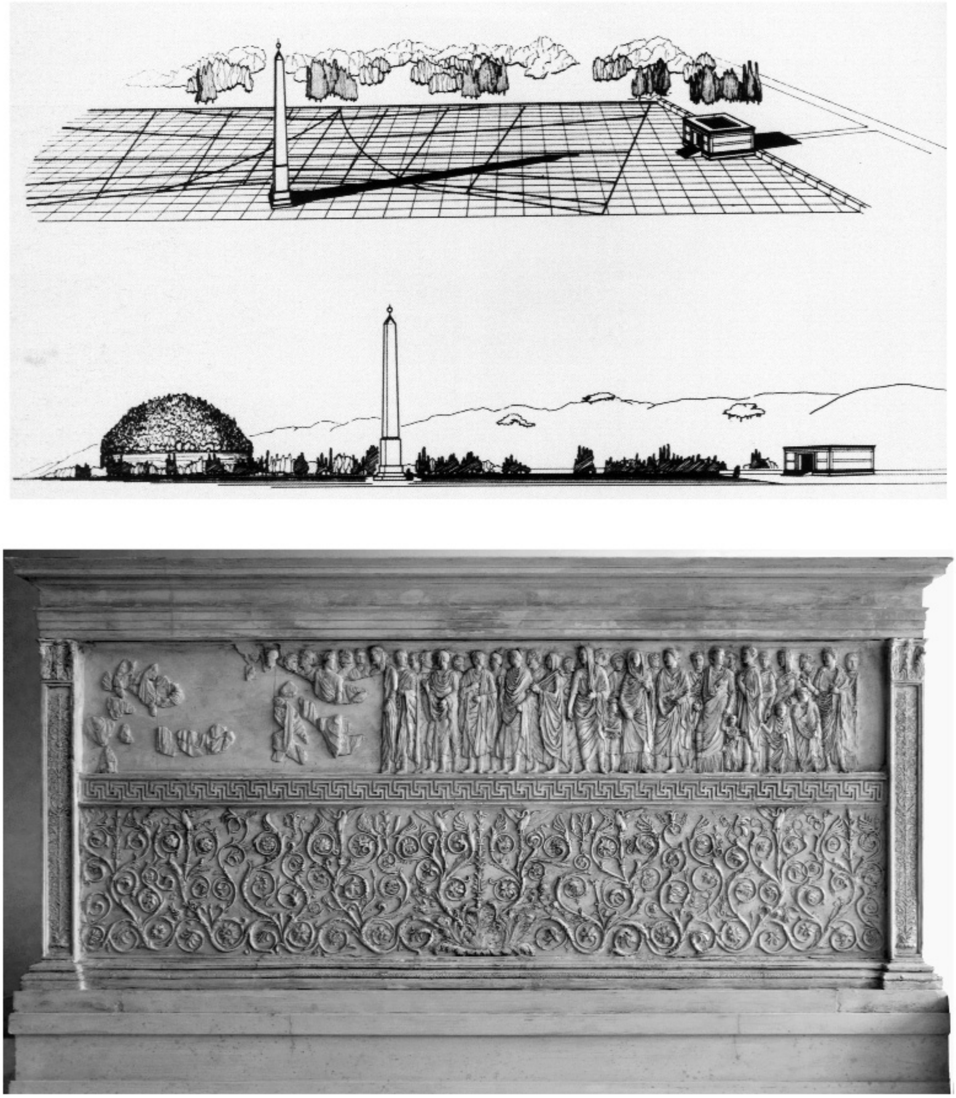

Fig. 1. On the top: the Ara pacis (on the right) and its original relationship with the shadow of the obelisk used as a solar horologium; in the middle: its further relationship with the Augustus Mausoleum (on the left); Bottom: the organization of the external walls (S side, with the phytomorphic panel and on the top the imperial procession). (courtesy from Rossini 2006).

The monument was progressively buried during the centuries and the marble panels constituting the walls were broken and partially disaggregated into collections of pieces of Roman archaeology for different museums. Only at the beginning of the last century it was possible to excavate and reassemble the monument close to the Augustus Mausoleum, near the Tiber River. The long burial and the strong cleaning with acids do no permit anymore to have an idea of the original colour used for painting the marbles, as usually done in the Roman period (Brinkmann 2004).

Looking with a certain attention at the big decoration of the external fence, of Hellenistic and Alexandrine derivation, we can observe a well precise iconographical structure. All four sides of the *Ara pacis* walls have, in fact, a homologous spatial organization: each side is divided into a lower part, made up of phytomorphic panels and an upper part, which is dedicated to the mythological narration of the birth of Rome and the power it has attained; the caesura between the portions is defined by a geometric section, made up of a maze like composition (a series of consecutive swastikas) that goes around the whole monument. The entrance and the exit of the altar subdivide the E and W side in two parts, giving rise to a total of six panels.

Each base panel, constituting more than half of the total external walls, represents a vigorous acanthus plant from which originates a leafy stem, like a great candelabrum at the centre of each one. From the median axes, we notice the spreading of vegetal volutes and shoots, which develop in a continuous circular fashion occupying the entire space (Fig. 1).

Many researchers agree on the fact that the external walls of the *Ara Pacis* hold a unified 'message' and this hypothesis has been upheld by scholarly investigations of geometrical details, spatial relationships, and the analysis of few botanical elements (L'Orange 1962; Pollini 1993; Castriota 1995; Vandi 1999; Sauron 2000).

There are however references to the vegetal world only when the elements in the pictorial representation are entirely recognizable and commonly familiar (e.g. acanthus, palm trees, vine, laurel and ivy shoots), but a detailed botanical analysis does not exist.

The aim of this paper is therefore at first to contribute in a more precise identification of the plants sculptured, in order to recognise the typology and origin of the botanical elements. More importantly, I wish to analyse this particular representation of nature in order to understand if and how it forms a sort of "language" carrying the imperial message.

Material and Methods

The systematic analysis and interpretation of the floral representations, limited to the original fragments, is particularly complex in view of the fact that only very few elements are quite very easily recognizable, whereas the entire representation appears at first to be a fantastic depiction, freely inspired by nature. Observing indeed the single elements, a careful observation of the nature emerges, such as the incredible attention to details, and a rigorous respect for natural proportions. The close analysis of the 'mosaic pieces', hints at the necessity to 'decompose' the representation into different elemental parts, each one individual, in order to engage in the correct interpretation of the visual language.

The botanical identification was carried out trough a photographic comparison of the observable morphologies of sculptured portions and plants in Nature coming from regional area compatible with historical data. The photographic analysis was carried out during the last restoration activities made in occasion of the new Museum, and the hundreds of details of particular inflorescences or portions of a specific plant (stems, or parts of the pistil), fruits or bulbs were elaborated via computer for investigating the existence of any true models (Fig. 2).

Although sometimes the ambiguity of the sculpted forms impedes their precise identification, more often, the morphological peculiarities of small portions of the representation were enough to allow systematic identifications, at least at genus level or family. In the very ambiguous cases, it has been limited to a more general inspirational model with a particular botanical genesis (ex: “carduoide model”).

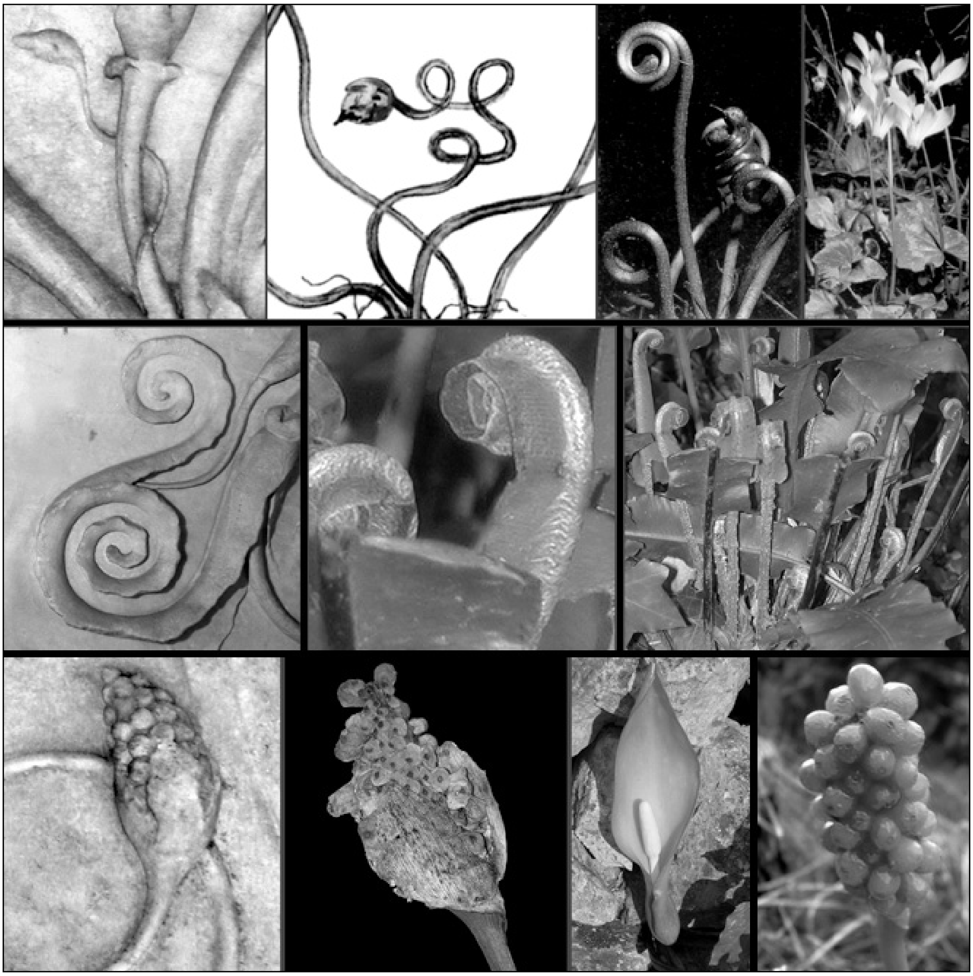

Fig. 2. Examples of comparison between sculptures and natural models, with from the top to the bottom: *Cyclamen* sp., Phyllitis scolopendrium and *Arum* cfr. *italicum*.

Viewing the frieze as a whole, the logic of the representation was also analysed. Nonetheless, when tackling the issue of ‘message’ in the work it becomes necessary first to address the question of what ‘language’ develops it. This artistic ‘language’ was studied in three steps: first, the plant identification (the alphabet), second, understanding the formal rules of the composition, and lastly, linking the modes of association of real elements with abstract concepts.

Results

1. The alphabet= the sculptured plants

Around seventy different ‘vegetal types’ have been recognized. Keeping in mind that a substantial part of the frieze itself has been destroyed over time, it is possible to imagine that the original number would have been larger.

A list of this unusual flora is here presented, evidencing in sequence: the chorological and growth forms used in the analysis, in parenthesis the iconographic elements sustaining the procedures, and finally the habitat from which these plants can derive. The following abbreviation were adopted: P - Phanerophytes: P scap - Scapose phanerophytes; NP - Nanophanerophytes; P caesp - Caespitose phanerophytes Ch – chamaephytes: Ch frut – Frutescent chamaephytes; Ch suff – Suffrutescent chamaephytes H – Hemicryptophytes: H caesp – Caespitose hemicryptophytes; H rept – reptant hemicryptophytes; H scap – Scapose hemicryptophytes; H ros – Rosette hemicryptophytes G – Geophytes; G rad – Root-budding geophytes; G bulb – Bulbous geophytes; G rhiz – Rhizome-geophytes; I – Hydrophytes; T – Therophytes: T caesp – caespitose therophytes; T rept – Reptant therophytes; T scap – Scapose therophytes

n.d. = not defined. The nomenclature, the chorological and the structural data (possible only in case of a precise identification) follow the “Flora d’Italia“ (Pignatti 1982). The suffix cfr. is added the proposed name in case of an approximate identification.

PTERIDOPHYTA

ASPLENIACEAE

***Asplenium ruta-muraria* L.** Wall rue; Circumbor.; H ros; (leaves); Rocks, walls, humid habitats.

***Phylitis scolopendrium* (L.) Newman** Scolopendra, hart’s tongue; Circumbor.-temp; H ros; (leaves); humid forests, caves.

***Pteridium aquilinum* (L.)** Kuhn Brake; Cosmpolit.; G rhiz; (entire plant); pastures.

GYMNOSPERMAE

CUPRESSACEAE

***Cupressus* cfr. *sempervirens* L.** Cypress; E-Medit.(Euri-); P scap; (leaves); cultivated.

ANGIOSPERMAE -DICOTYLEDONES

CARYOPHYLLACEAE

***Silene conica* L.** Catchfly; Paleotemp.; T scap; flower (calyx); arid fields, sandy beaches.

***Dianthus* sp. L.** Carnation; n.d.; n.d.; (flowers); mainly rocky habitats.

***Caryophyllaceae* s.l.** Pink family; n.d.; (leaves); undetermined.

NYMPHAEACEAE

***Nymphaea* sp. L.** Loto, water lily; Eurasiat.; I rad; (flowers); stagnant water, ponds.

Nuphar luteum **(L.) S. & S. cfr.** Yellow water lily; Eurasiat.; I rad; (flowers); stagnant or slowly flowing water (oligotrophic).

RANUNCULACEAE

Anemone **L. sp.** Windflower; n.d,; n.d. (flower); mainly forest and natural pastures.

Aquilegia **L. sp. cfr.** Columbine, n.d; n.d. (flower); n.d.

LAURACEAE

Laurus nobilis **L.** Laurel; Steno-Medit.; P caesp; (fruits, leaves); thermophilous forests, often cultivated.

PAPAVERACEAE

Papaver **cfr.** ***rhoeas*** **L.** Corn poppy; E-Medit.; T scap; (flower); grain fields, ruderal habitats, pastures.

CRASSULACEAE

Sedum **L. sp.** Stonecrop; n.d.; n.d.; (flower), arid places, walls, gravels, rocks.

ROSACEAE

Rosa **cfr.** ***canina*** **L.** Rose (Dog rose); n.d.; NP; (flower); mainly bushes.

Achemilla **cfr.** ***vulgaris*** **L.** Lady’s mantle; Eurasiat.; H ros; (flower); alpine and subalpine pastures.

VITACEAE

Vitis vinifera **L.** Grape; Pontic?; P lian; (stem, leaves and fruits); cultivated and sub-spontaneous.

MALVACEAE

Malva **sp. L.** Common Mallow; n. d.; T scap; (flower); ruderal habitats.

Lavatera **sp. L.** Lavatera, n.d.; H scap; (flower); ruderal habitats.

Alcea **sp. L.** Hollyhock; n.d.; H scap; (flower); ruderal habitats.

Hibiscus **sp. L. cfr.** Rosemallow; n.d.; n.d.; (flower); n.d.

CISTACEAE

Helianthemum **cfr.** ***nummularium*** **Miller** Sun rock rose; Europ.-Caucas; Ch suffr.; (flower); rocky habitats, garigues.

CUCURBITACEAE

Ecballium **cfr.** ***elaterium*** **(L.) A. Rich.** Squirting cucumber; Euri-Medit; G bulb; (flower), ruderal habitats and sandy places.

Bryonia **sp. L.** Bryony; n.d.; G rhiz; (tendrils); ruderal habitats.

Cucurbitaceae s.l. n.d.; n.d.; (stems), n.d.

ARALIACEAE

Hedera helix **L.** Ivy; Submedit.-Subatl.; P lian; (stem, leaves and fruits); Sub-Mediterranean forests, cultivated.

UMBELLIFERAE

Anthriscus **sp. Pers. cfr.** Chervil; n.d.; H scap; (stem); humid ruderal habitats.

Foeniculum vulgare **Miller** Wild fennel; S-Medit.; H scap; (leaves); arid pastures.

PRIMULACEAE

Cyclamen **sp. L.** Cyclamen; n.d.; G bulb; (flowers); thermo and mesophylous forests.

RUBIACEAE

Asperula **cfr.** ***aristata*** **L. fil.** Woodruff; Medit.-Mount.; H scap; (flowers); rocky habitats.

CONVOLVULACEAE

Calystegia **cfr.** ***sepium*** **R. Br.** Hedge bindweed; Paleotemp.; H scand; (leaves and flowers); humid ruderal habitats.

Convolvulus **cfr.** ***arvensis*** **L.** Field bindweed; Paleotemp. (Cosmop.); G rhiz; (whole plant); ruderal habitats.

ACANTHACEAE

Acanthus mollis **L.** Bear’s breech; Steno-Medit.-W; H scap; (whole plant and leaves); humid ruderal habitats.

PLANTAGINACEAE

Plantago **sp. L. cfr.** Plantain; n.d.; H ros; (inflorescence); pastures and ruderal habitats.

CAPRIFOLIACEAE

***Lonicera* sp L.** Honeysuckle; n.d.; P caesp; (fruit); Mediterranean forests and bushes.

DIPSACACEAE

***Dipsacus fullonum* L.** Fuller's teasel; Euri-Medit.; H bienn; (leaves); humid ruderal habitats.

CAMPANULACEAE

***Campanula* sp. L.** Bellflower; n.d.; n.d.; (flowers); rocks and walls.

COMPOSITAE

Chrysanthemum* cfr. *coronarium L. Crown daisy; Steno-Medit.; T scap; (flowers); ruderal habitats.

***Cardueae* s.l.** Thistles; n.d.; H scap; (leaves and flowers); pastures and ruderal habitats.

Cynara cardunculus* L. subsp. *cardunculus Cardoon; Steno-Medit.; H scap; (stems); ruderal habitats, arid pastures.

***Cynara cardunculus* subsp. *scolymus* (L.) Hayek cfr.** Wild artichoke; Steno-Medit.; H scap; (flower head with involucres bracts); ruderal habitats, arid pastures.

***Centaurea cyanus* L.** Cornflower; Steno-Medit (Subcosmop); T scap; (flower); cereal crops.

***Carlina* cfr. *utzka* Hacq.** Acanthus leaved thistle; Orof.S.-Europ.; H ros; (leaves and flowers); arid pastures.

***Sonchus* sp. L.** Sow-thistle; n.d.; T scap; (leaves); ruderal habitats.

ANGIOSPERMAE-MONOCOTYLEDONES

POTAMOGETONACEAE

***Potamogeton* cfr. *natans* L.** Broad-leaved pondweed; n.d.; I rad; (inflorescence); stagnant waters and rivers.

LILIACEAE

***Asphodeline lutea* L.** King's spear; E-Medit.; G rhiz; (flowers); rock habitat.

***Paradisea* sp. L cfr.** Paradisea; n.d.; G bulb; (flowers); subalpine pastures.

***Colchicum* sp. L.** Autumn crocus; Central-Europ.; G bulb; (flowers); arid pastures.

***Bulbocodium* sp. L. cfr.** Spring meadow saffron; Orof. S-Europ.-Caucas; G bulb; (bulbs); mountain pastures.

***Gagea* cfr. *lutea* (L.) Ker-Gawl.** Yellow Star of Betlehem; Euro-Sib.; G bulb; (flowers); forest and pastures.

***Tulipa* cfr. *sylvestris* L.** Wild tulip; Euro-Medit.; G bulb; (flowers); pastures.

***Lilium candidum* L.** Madonna lily; E-Medit; G bulb; (flowers); pastures and cultivated.

***Urginea* cfr. *maritima* (L.) Baker** Sea squill; Steno-Medit.-Macarones; G bulb; (bulbs); rocky habitats and garigues.

***Allium* cfr. *ursinum* L.** Wild garlic; Eurasiat.-Temper.; G bulb; (flower); humid places and forests.

***Asparagus* sp. L.** Asparagus; n.d.; G rhiz; (stem); Mediterranean maquis and forests.

***Sternbergia* sp. W. et K.** Sternbergia*;* n.d.; G bulb; (flowers); arid pastures.

AMARYLLIDACEAE

***Pancratium maritimum* L.** Sea-daffodil; Steno-Medit.; G bulb; (flower); Mediterranean coasts.

***Narcissus* sp. L. cfr.** Daffodil; n.d.; G bulb; (flower); pastures.

IRIDACEAE

***Iris* sp. L.** Iris; n.d.; G rhiz; (flowers); pastures and river banks.

***Crocus sativus* L.** Saffron; n.d.; G bulb; flower (stigma); arid pastures.

***Romulea* sp. L.** Romulea; Steno-Medit.; G bulb; (flowers); humid pastures.

GRAMINEAE

***Graminaceae* s.l.** n.d.; n.d.; (spike lets fragments)*,* n.d..

PALMAE

Phoenix dactylifera* L.** Date palm; Paleo-Subtrop.; P scap; (leaves); desert (cultivated). ***ARACEAE

***Arum cfr. italicum* L.** Arum; Steno-Medit; G rhiz; (inflorescence); humid ruderal places.

Dracunculus vulgaris **Schott** Dragon arum; Steno-Medit; G rhiz; (flower); forest and pastures.

Calla palustris **L.** Water arum; Circum-Bor.; G rhiz; (flower); river banks.

SPARGANIACEAE

Sparganium erectum **L.** Bur reed; Eurasiat.; I rad; (male inflorescences); rivers banks and stagnant waters.

ORCHIDACEAE

Cephalanthera **sp. L.C. Rich.** Helleborine; Eurasiat.; G rhiz; (flower); thermophilous forests.

Spiranthes spiralis **(L.) Koch** Autumn lady's tresses; Europ.-Caucas; G rhiz; (flowers); forest and arid pastures.

Most of the species are sculptured through their floral attributes and only 15 species are represented in all panels, whilst the others are limited to individual segments of the total frieze. The most recurring plants are *Acanthus mollis, Arum* cfr. *italicum, Lilium candidum, Phoenix dactlylifera, Nymphaea* sp., and in particular *Cardueae*. The Northern panel is the one that exemplifies the major variety of vegetal species, due to the highest extension of conserved sculptures.

Even though the impossibility of a precise specific determination of the flora limits the exact phyto-geographic contextualization, nevertheless, the knowledge of their preferential habitats and of the life forms permits an ecological and structural characterization.

This nature representation seems to describe substantially meadows and garigues aspects of Mediterranean habitats, especially of arid and stony environments linked with human activities, particularly sheep farming and fire, which have conditioned this vegetal landscape since millennia (Fig. 3). These are mainly characterized by plant genera, like *Helianthemum, Tulipa, Gagea, Crocus, Colchicum, Lilium, Paradisea, Romulea, Sedum, Dianthus*, typical of rocky habitats and arid pastures, together those of pastoral and arid synanthropic habitats, like *Pteridium* or *Cardueae*, as *Carlina,* and *Cynara*. Others are also frequent, like *Acanthus, Calystegia, Bryonia, Arum,* belonging to humid ruderal habitat, and segetals, like the species *Centaurea cyanus* and *Papaver rhoeas.*

A fair number of elements belonging to the maquis, forests and bushes of the Mediterranean habitats is present, such as *Hedera helix, Laurus nobilis, Cyclamen* sp., *Phyllitis scolopendrium, Dracunculus vulgaris*. Not negligible is the floral component which can be traced back to the humid and riparian habitats of the Mediterranean and middle-east areas, such as the species belonging to the genera *Nymphaea, Nuphar, Iris, Sparganium, Calla, Potamogeton, Anthriscus*, to which frequent elements of the classical artistic iconography belong.

The recurrence of date palm's leaves, a classic representative of desert habitats of the north-African and middle-east areas, seems relevant for its symbolic significance. The beaches flora, with *Pancratium maritimum,* a plant much liked in Hellenistic and Minoan art, is also represented.

Furthermore it is interesting to point out that from the floral structure point of view the herbaceous perennial plants, with subterranean buds (geophytes) or at ground level (hemicryptophytes) or also, even though more rarely, aquatic (hydrophytes) prevail. On the contrary, ephemeral plants (therophytes) as well as the woody perennial ones (phanerophytes) are scarce (Fig. 4).

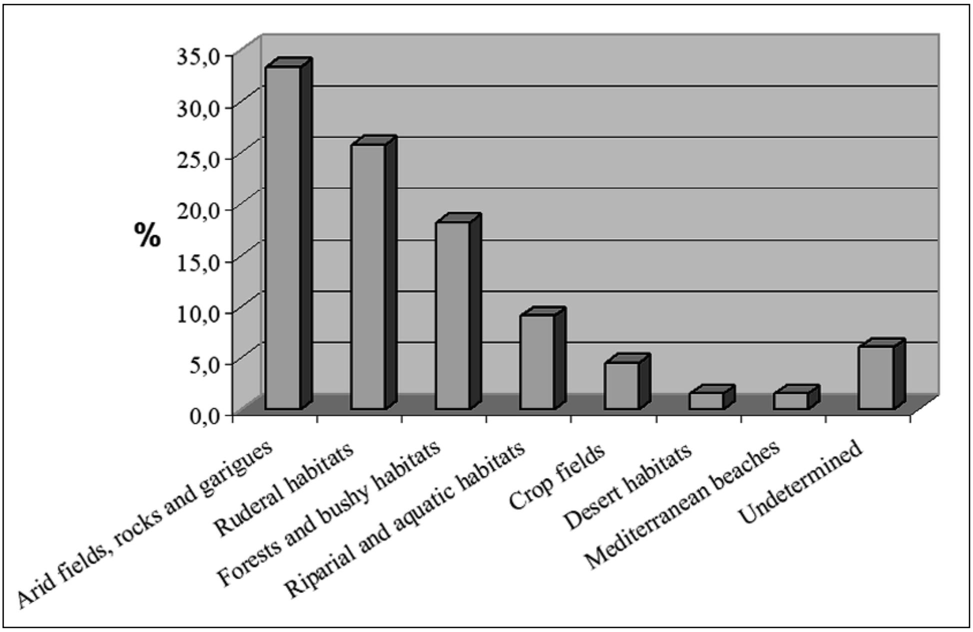

Fig. 3. Ecological spectra of the flora (1-Arid fields, rocks and garigues; 2-Ruderal habitats; 3-Crop fields; 4-Forests and bushy habitats; 5-Riparial and aquatic habitats; 6-Desert habitats; 7-Mediterranean beaches; 8-Undetermined).

This picture represents a quite precise selective choice of an habitat description, because in comparison with the natural reality of Mediterranean garigues and of disturbed habitats, were the ephemeral plants prevail, in this case species having bulbs and subterranean tubers seems better representing “rebirth” when an ecological threshold factor stops (for example fire or after a summer aridity period).

2. The structure of the language

Individual plants can be grouped together on the ground of their position in the visual space. In other words the architectural structure of the image as a whole is based on a hierarchical system of flora (Tab. 1). There is one generative element (Gen.), others make up the shoot (I and II Scr.), others still, make up the columnar (Col.), terminal (Term.) or spiral (Spir.) elements, and finally some others make up the emerging ones (Em.). Some plants, such as *Pteridium aquilinum* and Cucurbitaceae, seems as a sort of “supermodel” (SM.), because their attribution is based on a image “scheleton”, like in an Arcimboldo’s paintings, and also for the observed strategies of survival and conquest of space.

Clearly nothing is haphazard, because it is very rare to see the same plant fulfilling different iconographic functions. This suggests that for each position within the image, there was a well-defined choice of plants. This also sheds light on the working methods used in the development of the *Ara Pacis*. Artists would have had definite models to work from for each position of the panel.

Table 1. *Ara Pacis*: Sculptured plants and their iconographic role.

Scientific name	***Trivial Name***	***Gen.***	***SM.***	***I Scr***	***IIScr.***	***Col.***	***Term.***	***Spir.***	***Em.***
Acanthus mollis	Bear’s breech	*		***					
Pteridium aquilinum	Brake		*						
Cucurbitaceae s.l.	Cucurbits		*						
Cynara cardunculus ssp. *card*	Cardoon			*					
Anthriscus sp. cfr.	Chervil			*					
Phyllitis scolopendrium	Scolopendra				*				
Cyclamen sp.	Cyclamen				*				
Bryonia sp.	Bryony				*				
Hedera helix	Ivy				*			**	
Vitis vinifera	Grape				**				
Laurus nobilis	Laurel				*				
Dracunculus vulgaris	Dragon Arum					**			
Cupressus sempervirens cfr.	Cypress					*			
Dipsacus fullonum	Fullers teasel					*			
Pancratium maritimus	Sea daffodil					*			
Asperula cfr. *aristata*	Woodruff					*			
Silene conica cfr.	Catchfly					*			
Calystegia cfr. *sepium*	Hedge bindweed					*	*		
Campanula sp.	Bellflower					*	**		
Cynara cardunc. ssp.*scolymus*	Wild artichoke						*		
Phoenix dactylifera	Date Palm						**		
Arum cfr. *italicum*	Arum						***		
Asparagus sp.	Asparagus						*		
Plantago sp.	Plantain						*		
Potamogeton cfr. *natans*	Pondweed						*		
Cardueae s.l.	Thistles							***	
Carlina cfr. *utzka*	Acanthus thistle							**	
Chrysanthemum cfr. *coron.*	Crown daisy							*	
Nymphaea sp.	Loto							**	
Nuphar luteum	Yellow water lily								
Lilium candidum	Madonna lily							**	
Anemone sp.	Windflower							*	
Helianthemum cfr. *numm.*	Sun rock rose							*	
Sedum sp.	Stonecrop							*	
Alchemilla cfr. *vulgaris*	Lady’s mantle							*	
Ecballium cfr. *elaterium*	Squirt. cucumber							*	
Narcissus sp.	Daffodil							*	
Rosa sp.	Rose							*	
Dianthus sp.	Carnation								**
Iris sp.	Iris								**
Colchicum sp.	Autumn crocus								*
Lonicera sp.	Honeysuckle								*
Crocus sp.	Saffron								*
Asphodeline lutea	King’s spear								*
Paradisea sp. cfr.	Paradisea								*
Allium cfr. *ursinum*	Wild garlic								*
Calla palustris	Water Arum								*
Spiranthes spiralis	Aut. Lady’s tresse								*
Asplenium ruta-muraria	Wall rue								*
Papaver cfr. *rhoeas*	Corn poppy								*
Convolvulus cfr. *arvensis*	Field bindweed								*
Centaurea cyanus	Cornflower								*
Romulea sp.	Romulea								*
Sparganium erectum	Bur reed								*

Table 1. continued.

Tulipa sylvestris	Wild tulip								*
Urginea cfr. maritima	Sea squill								*
Caryophyllaceae s.l.	Pink Family								*
Aquilegia sp. cfr.	Columbine								*
Malva sp.	Common mallow								*
Lavatera sp.	Lavatera								*
Alcea sp.	Holly hock								*
Hibiscus sp. cfr.	Rosemallow								*
Foeniculum vulgare	Wild fennel								*
Sonchus sp.	Sow-thistle								*
Bulbocodium sp. cfr.	Spring m. saffron								*
Gagea cfr. *lutea*	Y.Star Betlehem								*
Sternbergia sp.	Sternbergia								*
Graminaceae s.l.	Grasses								*

Gen.= Generative element: SM. = Super Model; I Scr. = Primary Scrolls; II Scr.= Secondary Scrolls; Col. = Columnar; Term. = Terminals; Spir. = Spirals; Em. = Emergent.

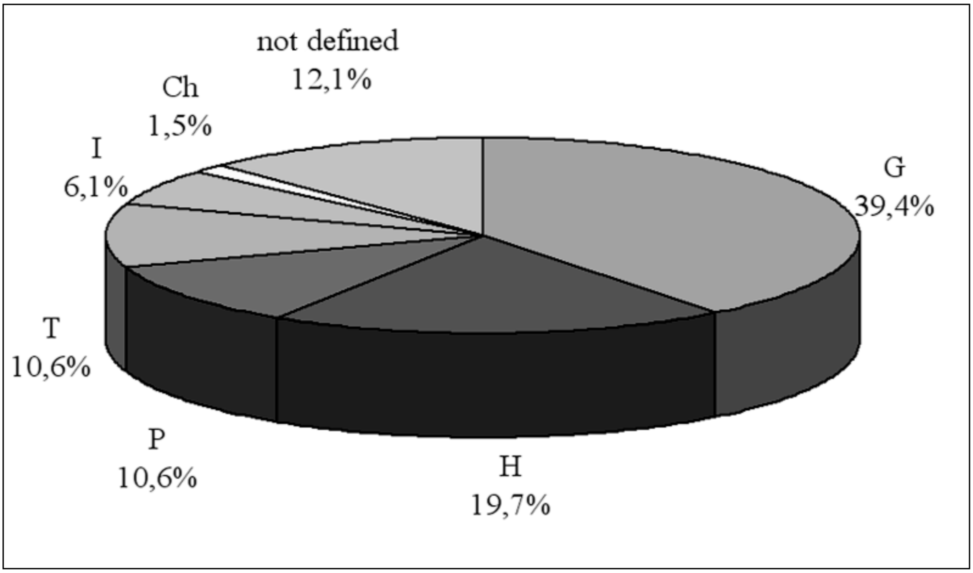

Fig. 4. Structural spectra of the flora (P = Phanerophytes; Ch = Chamaephytes: H= Hemicryptophytes; G = Geophytes; I = Hydrophytes; T = Therophytes).

It seems probable to assume that nothing in this iconographic system was left to chance, and suggest instead that each element had a role in the communication of a topical message in antiquity.

The composition underlines the role of symmetry and of numerical order that leads the idea of beauty and harmony, as in the Pythagoreans theories. A generative element (*Acanthus*), giving rise to all the botanical complexity, shows a model of growth inspired to a combination of elements, such as snake-like and colonial plants, having the structure of “ramets” (Fig. 5). We need to observe that the modular replication of oneself is a process that occurs in the vegetal world during asexual plant reproduction. Plants conquer their surrounding space through their crawling stalks (stolons), which produce individual replicas through buds. Men would have observed stonoliferous plants, such as some Rosaceae (e.g. Potentillas), Graminaceae, or ferns, as the brake, and other ‘invasive plants’ (Fig. 5). The composition’s system of volutes as a whole and the spirals appear inspired from the pastorals of ferns and similarly, the serpentine propagation resemble those of *Cucurbitaceae*.

Another dominating process that is reflected in the panels is that of continual metamorphosis. This goes hand in hand with one of the fundamental notions of Hellenistic philosophy, and in particular of Eraclitus’ pre-Socratic naturalism, the idea that ‘being is flowing’ and that ‘all is transient, nothing is eternal’. The world is understood as being in a state of continuous mutation: everyone lives insofar as he is developing and renovating himself. At the same time, being is inextricably tied to not being but ‘this death is not a final one, but rather a transmutation into something else’.

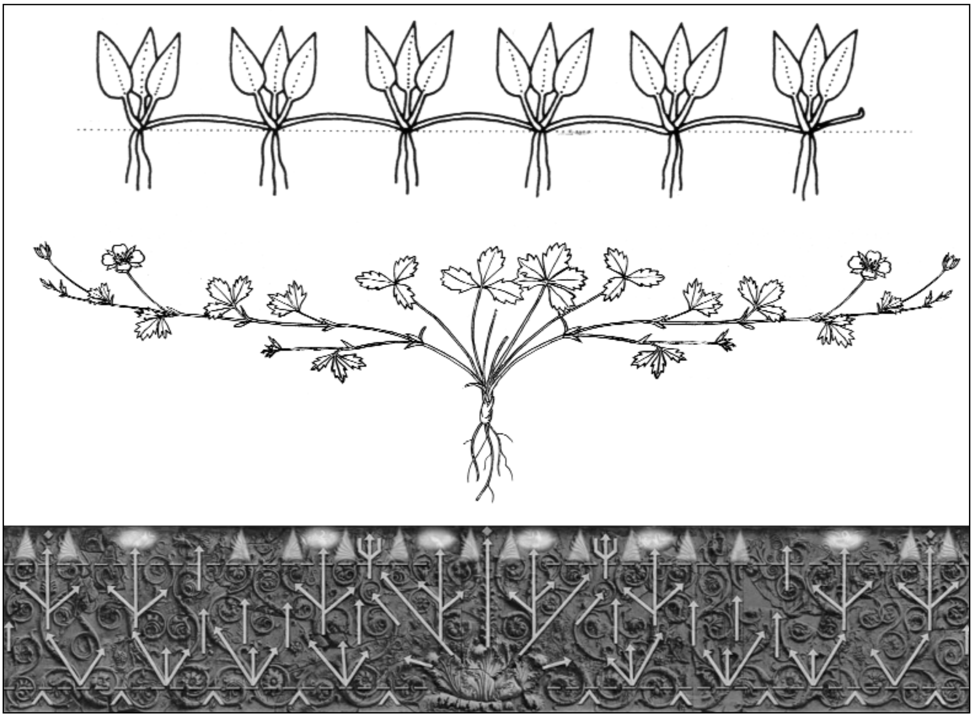

Fig. 5. Examples of colonial plants and modular structure of the Ara Pacis, where the generative element (Acanthus) and its propagation seem to suggest the perspective of the Roman Empire foundation in a beautiful model of symmetry and of numerical composition.

The concept of eternal transformation is at the base of innumerable works, first among which, Ovid's Metamorphosis, emerging only some years after the inauguration of the *Ara Pacis* monument, and probably inspired by the themes that were already present in Hellenistic literature (particularly after the third century BC) (Fig. 6).

Apart flowers, the vegetal elements that dominate are leaves and buds, both representing the initial phase of natural development. The visual direction of this development is both ascendant and terminates in spirals, and there is no truly a final element, because terminal details actually contain further elements that allude to an imminent development (Fig. 6). That seems to allude to a negation of an end, and to a process that will continue for the future.

Conclusions- The Augustus message

In the Pagan world, dominated by a varied and omnipotent Nature, the relationship between men and Gods manifested itself through elements that alluded to transcendental powers. Symbols were omnipresent, and all, not only initiated men, but also by simple people, believed that nothing was casual and their understanding of the world and of the meaning of natural phenomena, was consequently based on a series of associations. The direction of flock of birds, their number, the position of stars in the various constellations, the rise and fall of the moon, as well as the flowering of plants and the birth of fruits on trees

Fig. 6. a) Portions of the external frieze which show the concept of a continuous transformation = metamorphosis b) terminal details containing further elements that allude to an imminent development.

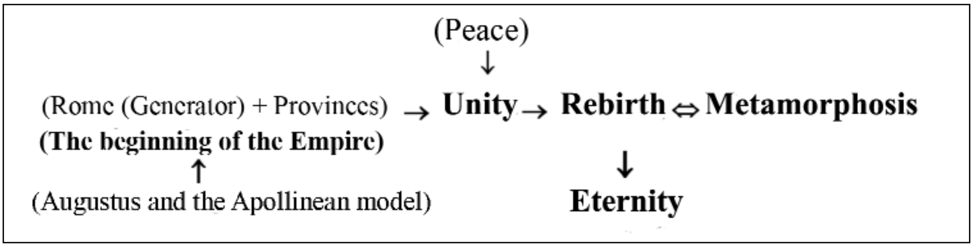

Fig. 7. Hypothesis on the Augustan message of the *Ara Pacis*.

like all other natural manifestations, were interpreted as the result of divine power (Frazer 1992; Baumann 1993).

Why are plants, with their stems, leaves, flowers and fruits, the dominating element of this work? This may be answered by acknowledging the fact that macroscopically, as well as for the men of antiquity, the vegetal element is the one that best expresses the idea of rebirth. This belief is reflected in the mythology of antiquity, starting from the Mysteries of Eleusi and the narration of the divine birth of wheat as well as in the description of the figure of Dionysius, God of lymph, the ‘blood’ of plants that gives birth to trees each spring. Similarly, we must also mention the oriental figures of the Great Mother Cybele and Attis, of Phrygian origin, as well as Adonis, from Syria, that would have been well known to Romans. Finally, the Egyptian cult of Isis and Osyris sheds light on the natural cycles of death and rebirth, and again these cannot be neglected in the context of roman antiquity (Frazer 1992).

Vegetal structures thus appear to be most suitable in the representation of the effects of peace, as in springtime after winter, or after summer draughts, or also after traumatic events, such as wartime devastation, and surely the blooming of flowers can be interpreted allegorically to depict this. Rebirth, that is possible thanks to peace and unity in multiplicity, is therefore going to be intended as the requirement for a new prosperity, a prelude of *Augustus’s aurea aetas*. It is expressed in the development of arid environments, where cardoons and thorny plants prevail, into the final ‘explosion of flowers’ and the enormous blossoming represents the augur of a happy era.

The role of the generative element (*Acanthus*), giving rise to a beautiful model of symmetry and of numerical composition that leads the idea of beauty and harmony, seems here to represent Rome and the propagation of its model of order arises from this colonial structure seems to suggest the perspective of the Roman Empire foundation.

The synchronous fusion of different elements, more than been referred to a fantastic concept, could ideally underline the continuity’s relationship between one species and another, as exists in Nature.

Finally the meaning of a representation in which appears the negation of an end, the absence of a limit, signifies a projection towards eternity. It also seems to allude that the process of birth and growth of the Roman Empire that has begun will be victorious and will have no end.

According to Sauron (2000) and other archaeologists, looking finally to the relationships between upper parts and lower ones, the role of Augustus and of its family, is clearly underlined. It is possible to view the position of the swans (Apollonian and Augustan symbols) on the upper part of the vegetal panels as a symbol of the superiority of Augustus' model, or at least as the symbol of its success.

In conclusion, the phytomorphic panels of the *Ara pacis*, representing a Nature's in its phases of rebirth and of unending renovation takes a complex symbolic message, as summarized in Fig. 7.

Most importantly, this analysis whish to underline the need of deeper interpretation of many other "naturalistic representation" coming back to a loosen way of communication in which Nature was used to bring fundamental messages, through a well known and consolidated symbolic language.

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J. Martín, S. García, N. Garcia-Jacas, T. Garnatje, O. Hidalgo, J. Pellicer, A. Susanna, J. Vallès & R. Vilatersana

Études palynologiques sur des plantes méditerranéennes: vision d'ensemble et études concrètes sur les Astéracées

Abstract

Martín, J., García, S., Garcia-Jacas, N., Garnatje, T., Hidalgo, O., Pellicer, J., Susanna, A., Vallès J. & Vilatersana, R.: Études palynologiques sur des plantes méditerranéennes: vision d'ensemble et études concrètes sur les Astéracées. — Bocconea 23: 79-83. 2009. — ISSN 1120-4060.

A global overview of palynological studies is presented, starting from the first authors who worked on the subject, and accompanied by considerations on the basic objectives of an experimental science. Examples of the author's group's palynological work on Asteraceae (principally of the Mediterranean flora) follow, demonstrating how the study of pollen, used critically, is an important tool to solve taxonomic problems.

Introduction

Probablement, celui qui a observé pour la première fois un grain de pollen fut Nehemiah Grew (1682), qui l'appela "spermatic globule" (Blackmore 2007). Ce qui est certain, c'est que celui qui introduisit le terme "pollen" en son sens actuel a été Linné (1751); en 1760, le terme était déjà d'usage courant parmi les scientifiques.

En choisissant ce terme, Linné avait d'abord observé, ensuite décrit et enfin comparé le microgamétophyte en repos des phanérogames. Il le comparait à la poudre fine qui est la fleur de farine, nommée pollen en latin (de fait, dans la plupart des cas l'origine des mots repose sur une métaphore, c'est-à-dire, une comparaison). Mais quand Grew appelait le grain de pollen "spermatic globule", il avait d'abord observé, ensuite décrit et enfin interprété son objet.

Bien sûr, ce sont là les bases d'une science expérimentale positive: décrire ce qu'on observe et ensuite l'interpréter, vu que la seule description, jetée en l'air, ne fait que tourner dans le vide. Grew voyait les pollens comme des globules, mais il savait aussi qu'ils avaient une fonction spermatique.

Au cours du temps, avec l'évolution de la palynologie (qui reçut ce nom en 1944) comme du reste de la botanique, on passa des descriptions, cependant indispensables, à des interprétations plus poussées, résultant jusque dans la séparation des espèces. Je vais faire ici un incise, passant de la botanique de l'ère baroque à la zoologie du siècle des Lumières: il a été dit que Cuvier savait reconstruire un animal à partir d'un seul os. En admettant bien sûr, que l'animal devait être un vertébré (ou aujourd'hui, Chordé), la possibilité de reconstruction dépendait de l’animal et de l’os. Il semble que, dans le cas concret, l’animal était un opossum du Miocène de Montmartre, et l’os faisait partie du bassin et fut finalement nommé “os marsupial” (Buffetaud 2002).

Le pollen peut parfois permettre de séparer des espèces: il est alors possible de reconstruire une plante entière sur la base de son pollen. Mais il est bien plus commode de partir de critères macromorphologiques plutôt que d’user le “critère pollen”, pour une telle reconstruction. Ainsi, dans l’étude des plantes actuelles, le pollen sert plutôt à définir des tribus ou des sous-tribus et à décider de la classification des taxons de rang inférieur; dans la paléobotanique, quand on dispose du pollen et rien d’autre, c’est le pollen qui est le point de départ.

Incontestablement, l’étude du pollen peut être un instrument utile. Blackmore (2007) souligne les deux qualités qui sont à la base de cette utilité: la diversité et la résistance à la dégradation. Pour ce qui en est de la première, les grains de pollen montrent une série de caractéristiques qui dépendent du taxon auquel la plante en question appartient. En ce qui concerne à la deuxième, le pollen se conserve mieux que toute autre partie de la plante, quelle qu’elle soit, qualité qu’il partage avec les spores. Dans la profondeur des temps, quand la limite entre pollen et spores était encore mal définie, le même Blackmore nous rappelle que souvent les spores furent repérées avant que la plante d’origine ne fût connue. Quelquefois on peut démontrer le lien: Wellman & al. (2003) ont associé le pollen fossile *Apiculiretusispora plicata* à l’organisme *Rhynia gwynne-vaughanii*.

Zavada (2007) énumère les catégories d’information que peut fournir le pollen: (1) s’il se présente en monades ou en poliades; (2) s’il est hétéropolaire ou isopolaire, oblate ou sphérique, lobé ou angulaire, etc.; (3) quel est son diamètre – grosso modo, quand il est supérieur à 40 µm cela indique pollinisation par un vecteur animal, alors qu’en dessous ce serait le vent qui est le porteur; (4) le nombre et la nature des apertures; (5) la structure du tectum; (6) la structure de l’infratectum; (7) de la couche basale ; et (8) de l’intine. Cet auteur mentionne aussi des témoignages palynologiques sur l’origine des angiospermes, qui remonterait à la limite du triasique et jurassien.

Blackmore (2007) confirme la supposition de Wodehouse (1935), que les caractères morphologiques et structuraux du pollen peuvent s’expliquer par son ontogénie: ainsi, le pollen symétriquement diporé de *Dryandra* est le produit d’un certain type de division méiotique. Dès lors, il est possible d’imaginer la façon de la plante d’utiliser, et donc sélectionner, ces caractères, de la manière dont nous les utilisons et sélectionnons en décrivant le pollen et réunissant ou séparant les taxons. Les auteurs y ont en effet songé, au niveau descriptif et d’interprétation.

Après Wodehouse suivirent les travaux d’Erdtman (1943), Faegri & Iversen (1964) et Reitsma (1970), pour n’en mentionner que les principaux. Tous visent à établir, d’une façon très générale, le rapport entre les caractères polliniques et les groupes taxonomiques. Reitsma, de plus, introduit une terminologie. Le livre d’Erdtman (1943) est devenu un classique. Laissez-moi cependant mentionner un curieux article du même auteur (Erdtman 1954), où il explique comment faire des diagrammes polliniques (à cette époque, il fallait savoir dessiner) et des photographies réellement illustratives de ce qu’on veut décrire; et il donne comme exemple négatif d’une photographie celle de l’objet amorphe qui fût nommé par son auteur *Confusopollis confusus* – sans doute en conformité avec sa propre vision de l’objet: confuse. Dans le même article, Erdtman publiait une photographie faite par lui en

1948, en microscopie électronique à transmission, d'un pollen de composée. Je le mentionne en vue des apports palynologiques de notre équipe au champ à cette famille que je présenterai ici.

Parmi les apports à la palynologie des composées antérieurs aux nôtres, il faut mentionner ceux de Skvarla & Turner (1966), qui utilisent les caractères du pollen pour étudier la phylogénie et taxonomie de onze tribus, et de Bolick (1978), qui décrit les types fondamentaux de l'ultrastructure de l'exine dans cette famille: l'Hélianthoïde, pourvu d'une cavea, et l'Anthémoïde, sans cavea, et elle groupe les tribus en fonction de ces types. L'auteur stipule, à partir des Vernoniées, une origine harmomégathique de la cavea.

Voyons maintenant comment nous-mêmes avons séparé ou joint, et finalement assigné, quelques taxons de la famille des Composées. Au départ, sur la base des publications antérieures, les principales caractéristiques polliniques se situent au niveau des tribus, sous-tribus et genres.

Dans les Anthemidées, par exemple, le pollen du type *Anthemis* est très différent de celui du type *Artemisia*. Ainsi, par l'étude du pollen on découvrirait immédiatement n'importe quel taxon du groupe *Artemisia* qui se serait égaré dans le groupe d'*Anthemis*.

Martín & al. (2001) ont simplement appliqué ce principe à l'étude des genres *Kashgaria*, *Mausolea*, *Neopallasia* et *Turaniphytum,* supposément alliés à *Artemisia*. Sur la base de leur pollen (du type, justement, *Artemisia*), ils conservent leur position près du "genre mère" et non pas près de *Tanacetum* (pollen du type *Anthemis*). Qu'on les sépare ou non comme genres indépendants d'*Artemisia* dépend des auteurs; cependant, les caractères du pollen concordent avec d'autres données, comme celles de type moléculaire et morphologique. Continuant sur la même voie, notre équipe, dans un deuxième travail relatif aux Anthemidées (Martín & al. 2003), a établi les rapports, par exemple, du genre *Ajania*. Pour ces études, le microscopique électronique à balayage est devenu l'équivalent de ce qui était auparavant le microscope optique, que nous n'utilisons plus jamais; les résultats étant si clairs qu'il n'est pas nécessaire couper et on peut se passer du microscopique électronique à transmission. Les mesures, prises avec un microscope à projection Visopan de Reichert, Autriche, restent un complément utile, mais ne sont pas, au moins dans notre cas, décisives.

Même avant nos travaux sur les pollens des types *Anthemis* et *Artemisia,* les Centauréines, et notamment le groupe *Jacea*, ont été objet de nos études (Martín & García-Jacas 2000). Ce groupe a résulté être homogène au sens palynologique. Une comparaison du pollen du type *Jacea* avec celui des genres *Zoegea* et *Oligochaeta* a montré que *Zoegea* présente une forme pollinique primitive, plus proche de *Serratula* que de *Centaurea,* tandis qu'*Oligochaeta* semblait combiner les caractères des deux types, avec la présence d'une double strate de columelles comme chez *Serratula*, mais avec perte totale des épines et diminution du diamètre. Provisoirement et dans l'attente de nouvelles études, nous avons conclu que ce genre resterait au dehors du groupe *Jacea*. Dans ce cas, la microscopie électronique à balayage aussi bien qu'à transmission on été utilisées, sur la base aussi de cryofractures qui évitent les déformations par pression dues à la coupe par microtome. Pour les mesures, les mêmes remarques s'appliquent que pour le travail sur les Anthémidées, valables aussi bien pour les cas suivants.

De nouvelles études, récemment complétées (Hidalgo & al. 2008), ont permis d'éclaircir le "cas *Oligochaeta*" en ont apporté des données complémentaires à l'ensemble des

Centauréines. L'examen du groupe *Rhaponticum,* au microscope à balayage et à transmission, a montré que le genre *Rhaponticum* proprement dit présente un pollen du type *Serratula*, alors qu'*Oligochaeta* doit être inclus dans le groupe *Jacea.* Le pollen de *Myopordon* s'insère dans une séquence qui relie le type *Serratula* au type *Jacea*.

Entre temps, dans un autre groupe des Centauréines, nous avons étudié le complexe *Carthamus* (Vilatersana & al., 2001), bien représenté dans la flore méditerranéenne. Nous avons décrit un nouveau type de pollen, nommé justement type *Carthamus,* qui caractérise tout le groupe et diffère du type *Centaurea centaurium* pour les grains prolates et pas oblates. Nous avons aussi formulé une hypothèse sur l'évolution des types alliés, que diverge de celle classique de Wagenitz (1955). Dans ce travail, l'emploi du microscope électronique à transmission a résulté indispensable; la cryofracture fut encore utilisée pour l'étude de quelque échantillon, mais les coupes microtomiques se révélèrent plus utiles pour déterminer la présence ou absence d'une cavea, c'est à dire, un espace qui interrompt la continuité de l'exine, en rapport probablement avec l'harmomégathie – ou, comme soupçonnent Furness (1995) et Rowley & El-Ghazaly (1992), avec le dépôt de lipides.

Comme pour les Anthémidines et Artemisiines, les données moléculaires et morphologiques on été utilisées parallèlement aux polliniques. L'étude du seul pollen peut induire en erreur, comme dans le cas d'*Aegialophila*, à pollen très semblable (bien que non identique) à celui de *Centaurea scabiosa,* où ces données complémentaires nous ont amenés à la conclusion de que cette ressemblance était due à une évolution parallèle. Dans ce cas, les petites différences entre deux pollens semblables permettent de soupçonner une convergence évolutive plutôt qu'une affinité véritable.

Chez les Carduées, en nous fondant sur des données moléculaires, nous avons étudié le genre *Echinops* et le complexe *Xeranthemum* (Garnatje & Martín 2007). Nous avons trouvé deux types de pollen chez *Echinops,* qui cependant ne permettent pas de séparer des sections. Le fait que les deux types polliniques reconnus se fondent sur un caractère quantitatif soulève une question intéressante. Encore une fois, le microscope électronique à transmission a résolu le problème, montrant qu'un supposé pont sur l'exine des taxons pérennes est, en réalité, une multiplication des strates de columelles. Il est bien vrai que les deux types de pollen observés correspondent, respectivement, aux taxons annuels et pérennes, critère macromorphologique que, dans ce cas, l'étude du pollen ne fait que confirmer. Mais le pollen montre, par exemple, qu'*Acantholepis,* non seulement doit être inclus dans le genre *Echinops*, mais, mieux, que c'est simplement une espèce d'*Echinops*. En outre, les Carduées présentent un pollen très similaire, dans sa structure interne, au type Anthémoïde (sans cavea), et ce critère pollinique peut servir de critère pour l'inclusion, dans les Carduées, d'un taxon d'appartenance douteuse. En vue de l'homogénéité, dans cette tribu, de la structure pollinique interne il n'est pas surprenant que les différences polliniques qu'on constate chez *Echinops* ne soient que quantitatives. De même, de petites différences qu'on constate nous ont porté à séparer *Chardinia* et *Xeranthemum*, d'un côté, d'*Amphoricarpos* et *Siebera* de l'autre.

En somme, que les taxons considérés soient méditerranéens ou non méditerranéens, nous poursuivons leur étude à la recherche de ressemblances parmi les pollens différents, ou différences parmi ceux qui se ressemblent.

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Floristic changes in the Mediterranean macroalgal flora

Abstract

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Main kinds of changes in the Mediterranean macroalgal flora are analysed. At a local scale they generally depend on anthropogenic pressure, the most evident effects of which are different kinds of pollution (thermal, radioactive, chemical, organic and bacterial), overgrazing and discharge of inert terrigenous material or debris. At a larger scale they can be due to variations of environmental conditions depending on climatic changes. Recently, different types of changes were registered in some areas of the Mediterranean Sea. For example, at the Egadi Islands (Western Sicily) a per cent increase of species of warm water affinity (mainly *Rhodophyta*) belonging to both Circumtropical and Indo-Pacific phytogeographic elements and a per cent decrease of species of cold water affinity (mainly *Phaeophyceae*) belonging to the Circumboreal phytogeographic element was registered. While in areas of the eastern Mediterranean basin like the eastern coast of Sicily, Pantelleria Island (The Straits of Sicily, Italy) and Linosa Island (The Straits of Sicily, Italy), besides floristic changes a deterioration of the benthic algal vegetation due to the disappearance of stenoecious species of Cystoseira (*Phaeophyceae, Fucale*s) which play the role of canopy algae, with diminutive euryoecious species was registered. Finally, minor floristic changes are also considered like those due both to the description of new species and the introduction (accidental or intentional) of alien species generally resulting in an enrichment of biodiversity.

Introduction

The Mediterranean Sea shows a rather high macroalgal biodiversity especially if related to the area of only 2.5 million km^2 by it covered. In fact, the estimated macroalgal floristic richness is of about 1090 taxa at specific and infraspecific level [about 56 Cyanophyta (Giaccone 1999), more than 550 *Rhodophyceae* (Athanasiadis 2002), 265 Phaeophyceae (Ribera & al. 1992), 214 Chlorophyta (Gallardo & al. 1993)] corresponding to about 15% of world ocean macroalgal biodiversity. In the last years, global climatic change was more and more indicated as the major cause for changes in biodiversity favouring the introduction of warm water alien species, that in some cases behave as invasive spreading throughout very wide areas. However, it should be also considered that at local scale major changes are due to anthropogenic pressure. The human impact on biological diversity in the Mediterranean Sea was classified on the basis of the time necessary to the impact to become reversible (Boudouresque & al. 2006). Clearly, irreversible, at least at human scale, forms of impact like coastal development, species introduction, species extinction and global warming, are causes much greater than the reversible ones within a few year (e.g. most types of pollution and oil spills).

Floristic changes due to anthropogenic pressure

The most evident effects of anthropogenic pressure are coastal development and water pollution.

Coastal development (e.g. reclamation, harbours, groynes, artificial beaches) is one of the most serious forms of human pressure due to the irreversible destruction of benthic communities, at least at human scale, by it caused. In the Mediterranean Sea, such a destruction mainly concerns littoral belts with *Cystoseira amentacea* (C. Agardh) Bory and *Lithophyllum byssoides* (Lamarck) Foslie as well seagrass meadows and communities with *Cystoseira* spp. occurring in deeper waters. Many species of the above communities are protected either by national legislation or by both Berne and Barcelona conventions. In addition to its direct impact, coastal development can lead to indirect effects which may concern a much larger surface area than that actually covered by reclamation and facilities. For example, groynes alter sediment transport by coastal currents, with either upstream oversedimentation (that buries benthic communities) or downstream undersedimentation (resulting in baring benthic communities): in both cases benthic communities may fall into decay.

As concerns water pollution, at least five classes of polluting agents can be considered: discharge of cooling water from factories (thermal pollution); discharge from nuclear plants (radioactive pollution); discharge of industrial water (chemical pollution); discharge of urban waste water rich of organic matter (organic pollution); discharge of inert terrigenous material (detrital pollution).

In this contribution, only the last two types of pollutions will be treated i.e. the organic and the detrital pollutions.

The introduction of organic matter, both dissolved and particulate, from sewage effluents leads to the phenomenon named eutrophication. The eutrophication gives rise to profound changes of the benthic algal vegetation consisting of: i. the disappearance of *Cystoseira* spp. (that are *k*-strategy and long-lived species) with a consequent deterioration in the structure of communities by them characterised; ii. the change of zonation patterns with uplift of lower limits of the vegetation; iii. a decrease of floristic diversity. In slight eutrophication conditions, in the infralittoral fringe, the most obvious changes are the appearance of nitrophilous species [like *Ulva* spp. and *Pterocladiella capillacea* (S.G. Gmelin) Santelices et Hommersand] as well as of other species able to prosper in eutrophicated biotopes like *Cladophora* spp., *Colpomenia sinuosa* (Mertens ex Roth) Derbès et Solier, *Chondracanthus acicularis* (Roth) Fredericq, *Petalonia fascia* (O.F. Müller) Kuntze, etc..

Afterwards, when additional nutrients become available in the water column, the above species become more abundant and tend to mask indigenous communities which eventually disappear.

In heavily polluted sites, with excess of nutrients, only nitrophilous species occur and prosper substituting the disappeared community with *Cystoseira* spp..

Under extreme conditions, only Cyanophyta and Diatoms there occur at this level.

In the upper and mid-infralittoral zones, the species of *Cystoseira* which represent the guide species of phytobenthic communities (e.g. *Cystoseira brachycarpa* J. Agardh*, C. crinita* Duby*, C. sauvageauana* Hamel), disappear and the communities by them characterised are substituted by not well structured communities with Dictyotales and Sphacelariales. Often, species of *Codium*, which as known accumulate nitrate, show explosive development due to the increase of nitrate in seawater. In very sheltered habitats in presence of high level of eutrophication, the bottom can be colonised by aegagropilous or unattached forms of Ulvales and Gracilariales which form drifting beds. But, eutrophication can indirectly cause alterations of deeper communities due to the increase of water turbidity caused by phytoplankton blooms. As a consequence of the increased turbidity (causing a reduction of the irradiance), the depth distribution limits of the communities move upward in response to their minimum light requirements for growth. In other words, communities living in deeper water tend to go up but they result impoverished by a floristic point of view due to the noticeable reduction of photophilic species, only partly balanced by the increased number of sciophilous ones. Moreover, it should be pointed out that changes of depth distribution result, on the whole, in a floristic impoverishment due to both the noticeable reduction of photophilic species, only partly balanced by the increased number of sciophilous ones, and the considerable reduction of the area inhabited by phytobenthic communities. The above mentioned damages on phytobenthic communities can be also caused by the discharge into the sea of inert terrigenous material. Such a kind of pollution is a bit deceitful since, acting only on infra- and circalittoral communities but not causing changes in communities observable from land (i.e. those occurring in both midlittoral zone and infralittoral fringe) leads to suppose the occurrence of good environmental conditions throughout the water column.

An interesting example of damages caused by the last factor of pollution was registered at the Tremiti Islands (Adriatic Sea) (Cormaci & Furnari 1999; Cormaci & al. 2000; Cormaci & al. 2001). In those Islands, an almost total lack of communities with Ulvales in the infralittoral fringe was observed where conversely a well structured community with *Cystoseira amentacea* v. *stricta* Montagne occurred proving a lack of eutrophication at least in shallow water. That, could lead to suppose the occurrence of good environmental conditions down to the bottom. Conversely, a considerable structural deterioration of infra and circalittoral phytobenthic communities was observed. Communities with *Cystoseira* spp. and *Sargassum* spp., which according to literature data were present in seventies, were lacking. They were substituted by degraded, little structured communities with a reduced biodiversity since the settlement of opportunistic and/or sciophilous species doesn’t balance the disappearance of sensitive species like members of *Cystoseira* which host on their fronds a high number of epiphytic species.

The disappearance of communities with *Cystoseira* spp. can be due to different factors like the occurrence of more or less toxic pollutants, overgrazing by sea-urchins often caused by over-fishing of sea-urchin predator fishes (e.g. *Sparus aurata*) (Verlaque & Nédélec, 1983; Lemée & al. 1996), anchoring, etc., but at the Tremiti Islands, neither the occurrence of dense population of sea-urchins causing over-grazing, nor fishery activities and anchoring, sufficiently important to cause heavy damage to the benthic vegetation, were observed. Conversely, a noticeable water turbidity due to the presence of suspended inert terrigenous materials was there observed during that study. Therefore, the above changes are mainly due to the reduction of water transparency.

It should be noted that the disappearance of communities with *Cystoseira* spp., is a very severe environmental damage since, after causes of the decline of the above communities have ceased to operate, their recovery generally takes a very long time since the growth of most *Cystoseira* species is quite slow (Verlaque 1987) and their eggs are rather large, sink rapidly and consequently they do not disperse beyond a few meters from parent individuals.

Changes due to global climate change

The main effect of the global climate change on the Mediterranean Sea consists of sea warming that showed a positive trend since 1960s-1970s (Béthoux & al. 1990; Salat & Pascual 2002). Such a phenomenon mainly resulted in a northward extension of the distribution area of warm-water species (Bianchi 2007; Francour & al. 1994), like the native *Caulerpa prolifera* (Forsskål) J.V. Lamouroux that extended its northern distribution area at the beginning of 1990s from Corsica to Ligury and Provence (Bianchi & Morri 1994). More conspicuous floristic changes dealing with macroalgae, much probably related to sea warming, were registered in some recent studies. For example at Pantelleria Island (the Straits of Sicily, Italy), Alongi & al. (2004) found that the present flora, consisting of 265 taxa at specific and infraspecific level is slightly lower than that registered in 1970s by Giaccone & al. (1972) and Giaccone & al. (1973) (283 taxa), with an increase in *Rhodophyceae* of 7.6% and a decrease in Phaeophyceae and Chlorophyta of 3.6% and 4%, respectively. The most meaningful datum is the disappearance below 12 m depth of communities with stenoecious *Cystoseira* spp., previously present in that area, substituted by communities less structured and showing a lower mean number of species than corresponding communities with *Cystoseira* spp. occurring in other Mediterranean localities. Agreeing with Alongi & al. (2004) we think that such a disappearance combined to the above mentioned increase of *Rhodophyceae* (species of warm water affinity) and decrease of Phaeophyceae (species with cold water affinity) is due to the increase of the temperature of superficial waters reinforced in by changes of the deep circulation of the eastern Mediterranean basin causing the formation in the Aegean Sea of denser deep waters that caused the up welling of warmer, less salty and more nutrient rich mid-depth waters (Lascarotos & al. 1999; Klein & al. 1999). As well, at Linosa Island (the straits of Sicily, Italy), on the basis of collections made in 1999, Serio & al. (2006) registered noticeable changes in the benthic flora with respect to previous data based on collections made in 1973 and published later (Cinelli & al. 1976). As observed at Pantelleria Island, also at Linosa Island the disappearance of upper to lower infralittoral communities with stenoecious species of *Cystoseira* was registered. That produced a lower structural complexity of vegetation with a remarkable reduction of biodiversity. In fact, the 1999 flora was poorer than that of 1973 (233 taxa at specific and infraspecif level compared to 305) with a decrease in the number of *Rhodophyceae, Phaeophyceae* and *Chlorophyta*. But if we consider the per cent composition of floras we can observe that, compared to the 1973 flora, the 1999 flora showed a higher per cent incidence of *Rhodophyceae* (70.82 vs 66.56 registered in 1973) and a lower per cent incidence of *Phaeophyceae* (17.60 vs 20.33).

Consequently, the 1999 flora has an R/P (*Rhodophyceae/Phaeophyceae*) index value (Feldmann 1937) of 4.02 which according to Feldmann (1937) indicates nearly tropical characteristics for the flora not showed by the 1973 flora with an R/P value of 3.27. Moreover, from a phytogeographic point of view, it should be noted that the 1999 flora is characterized by per cent incidence of both Indo-Pacific and Circumtropical elements (both 6.87) (species of warm water affinity) higher than that of 1973 flora (3.61 and 4.92, respectively) and per cent incidence of the Circumboreal element (species of cold water affinity) of 1.29 lower than that of the 1973 flora (1.64). All the above changes, are undoubtedly related to the increase of the temperature of surface waters together with changes in the deep circulation of the eastern Mediterranean basin recorded in the last 30 years.

Finally, also at the Egadi Islands (western Sicily, Italy) meaningful changes in the present flora with respect to that of 1970s were registered by Catra & al. (2006) even though, differently from both Pantelleria Island and Linosa Island, at the Egadi Islands no deterioration in the benthic algal vegetation was observed. Compared to 1970s flora, the present flora of the Egadi Islands shows a significant per cent increase of *Rhodophyceae* (70.18 vs 61.57) and per cent decrease of *Phaeophyceae* (20.35 vs 26.87) with an R/P of 3.4 (2.3 in the previous flora) and from a phytogeographic point of view a higher per cent incidence of both Indo-Pacific (4.93 vs 3.38) and Circumtropical (9.15 vs 7.89) elements. Therefore, also changes in macroalgal flora recorded at the Egadi Islands, mainly consisting in the increase in *Rhodophyceae* and in the decrease in *Phaeophyceae* resulting in a high R/P value (3.4) as well as in the increase of both Indo-Pacific and Circumtropical elements, give evidence of the process of tropicalization that is impacting the Mediterranean Sea due to the global climate change.

Changes due to introduction of alien species

Another factor causing changes in biodiversity is the introduction of alien species linked, directly or indirectly, to human activity. According to Schmitz & Simberloff (1997), after habitat destruction, introduced species are the second greatest cause of biodiversity endangerment and decline worldwide. But, on the basis of literature data, in the Mediterranean Sea the impact of alien macroalgae, apart from those with invasive behaviour that often cause alteration in both structure and composition of local communities, is not always so damaging and in any case it varies according to species as follows: i. zero to slight impact; ii. more or less drastic change in the number and/or abundance of native species; iii. displacement of species occupying a close ecological niche; iv. change in the functioning of native ecosystems (when an introduced species acts as a key-species); v. displacement of native ecosystems, due to the setting-up of a totally new ecosystems (Boudouresque 1999).

Changes of macroalgal diversity of the Mediterranean Sea due to introduction of alien species were strongly highlighted since 1970s. On the basis of papers by Cormaci & al. (2004) and Zenetos & al. (2006), at present about 83 introduced macroalgae are recorded from the Mediterranean Sea. According to Zenetos et al. (2006), only 60 macroalgae can be considered as established that is “Introduced or feral population of species established in the wild with free-living, self- maintaining and self-perpetuating populations unsupported by and independent of humans" (European Commission 2004).

Apart the species of Atlantic origin, the introduction of which even though favoured by human activities falls within natural exchanges between the two basins, it is noteworthy that due to global climatic change, the 55% of established alien macroalgae are warm water affinity species. They belong to Circumtropical and Indo Pacific phytogeographic elements and about the 25% of them came into the Mediterranean Sea through the Suez Canal (lessepsian species). Moreover, it should be noted that most of the above species, previously confined in the south and south-eastern areas of the Mediterranean Sea, are extending their pattern of distribution towards central and northern areas of that Sea. Such a behaviour, similar to that of not introduced species of warm water affinity (e.g. *Caulerpa prolifera*), is as well linked to water warming in the Mediterranean Sea.

New taxa to the Science

Finally, minor changes in the biodiversity come from the description of new taxa. Since 1970s to 2006, 28 taxa at specific and infraspecific level were described from the Mediterranean Sea. In particular 4 were described in 1970s, 4 in 1980s, 14 in 1990s and 6 in 2000s. Such a number, that seems very low, is instead quite significant since the Mediterranean macroalgal flora was accurately studied by almost all ancient great phycologists. Moreover, it is easily predictable that due to the progress in taxonomy and the consequent reassessment of critical groups numerous new species will be described in the near future.

Conclusions

In conclusion, the macroalgal flora of the Mediterranean Sea has changed since 1970s and is still changing at present. Such changes resulted, on the whole, in a slight increase of the biodiversity (83 introduced and 28 new described species) and more significantly in an enlargement of the distribution area of species with warm water affinity (both native and introduced) and a reduction of the distribution area of cold water affinity species, due to global climatic change. At local scale, major changes depend on anthropogenic disturbances mainly causing coastal pollution and resulting in both profound changes of the structure of algal vegetation and a reduction of biodiversity.

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Freshwater algae and their use for safeguarding the Mediterranean basin

Abstract

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The Mediterranean Sea has limited extension and relatively closed nature. The rivers entering it with their massive loads of organic matter, nutrients, and pollutants markedly influence the coastal environment and open water. Italian rivers play a great role in this process and attentive management of all the watercourses flowing into the Mediterranean will surely contribute to the improvement of the marine environment. While an anthropocentric vision dominated past attitudes toward rivers, seeing them as natural recipients for wastes of various origins, recent years have seen the emergence of a progressive cultural maturation toward an ecosystemic vision that values ecological functionality as the primary objective. Consequently, the traditional chemical and physical analyses have been complemented with biological monitoring, as also requested by the Water Framework Directive of the European Community (WFD 2000/60/EC). A role of primary importance as biological indicators is played by rheophilous algae, which are very common in all river habitats and represent, with their thallus completely immersed in the water, the spy of all the vicissitudes involving the aquatic environment. Among the algae, diatoms are preferred at present in the great part of European countries, because they react with higher sensitivity to changes in water quality and their taxonomy and autoecology are very well known. They afford in any situation a very elevated degree of precision in defining the level of pollution and/or the trophic state of a water body. Based on the sensitivity of diatoms to organic matter, nutrients and salt concentration, an index for monitoring rivers in Italy has been proposed and tested in the last two decades: the EPI-D, i.e. the eutrophication and/or pollution index diatom-based. It displayed a very good capacity for synthesis when compared with the most important chemical parameters and the general situation of the rivers examined. Therefore, it seems to represent a valid instrument for assessing the ecological status of running waters entering the Mediterranean, helping, in this way, to the control of its quality.

Introduction

The Mediterranean is a sea of limited extension and relatively closed nature. The rivers entering it with their massive loads of organic matter, nutrients, and pollutants influence the coastal environment and open water markedly, causing serious ecological deterioration, such as the well known phenomena of "red tides" and "dirty sea" or "mucilaginous waters". Without a doubt, Italian rivers play a great role in this process and attentive management of all the watercourses flowing into the Mediterranean will surely contribute to the improvement of the marine environment.

While an anthropocentric vision dominated past attitudes toward rivers, seeing them as natural recipients for wastes of various origins, recent years have seen the emergence of a progressive cultural maturation toward an ecosystemic vision that values ecological functionality as the primary objective. Consequently, the traditional chemical and physical analyses used in the past for river management have been complemented with biological monitoring, as stipulated in the Water Framework Directive of the European Community (WFD 2000/60/EC), which among other requisites, explicitly imposes classification of the ecological status of inland waters based on a number of factors, including the vegetal component.

Among the vegetal component of watercourses, benthic algae certainly play a role of primary importance as bioindicators, because they are very common in all river habitats and, with their thallus completely immersed in the water, they represent the spy of all the vicissitudes involving the aquatic environment.

Algae of Italian watercourses

In this paper, the main algae of Italian rivers are taken into consideration, with particular reference to the watercourses flowing from the central Apennine Mountains and entering the Adriatic Sea. Generalizing grossly, the hydrographic basin of these watercourses may be divided into three main stretches, the upper, middle and lower, where, using an adaptation and simplification of the longitudinal zonation of watercourses proposed by Illies & Botosaneanu (1963), various biozones can be recognized.

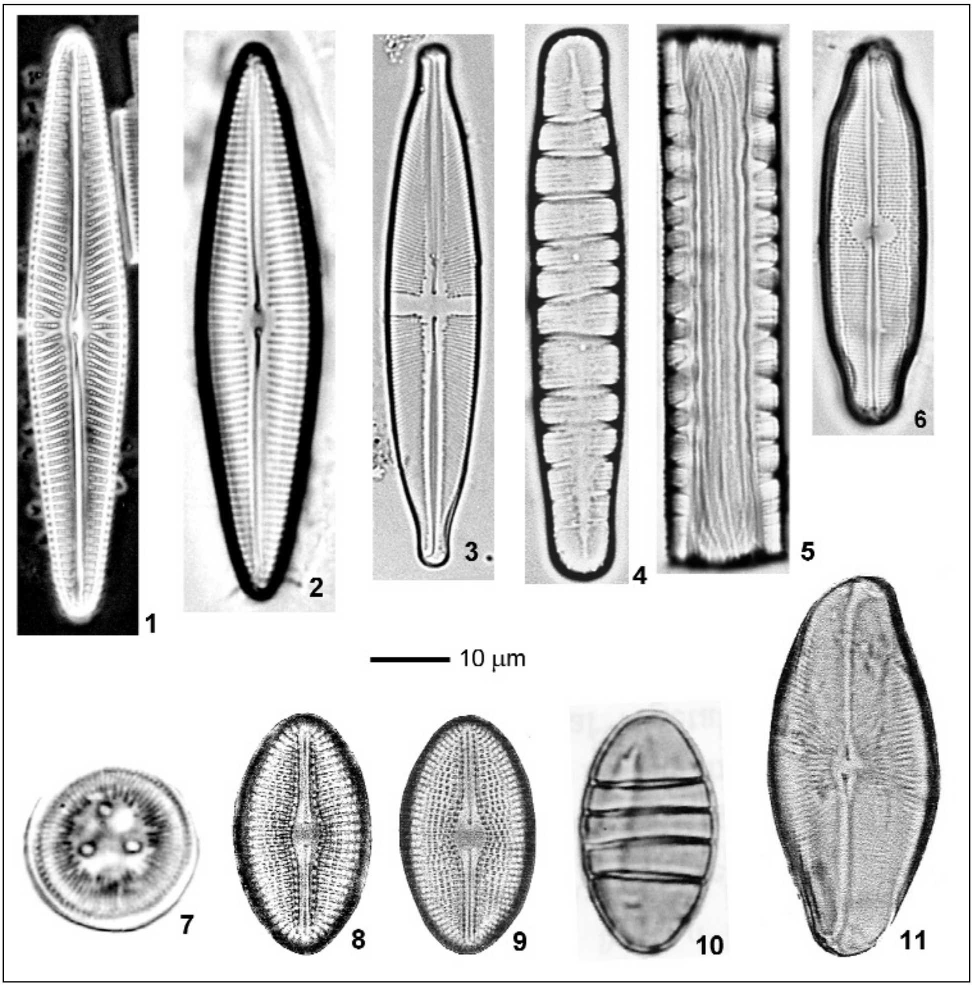
The upper stretch generally lies above 500 m a.s.l. and includes the catchment area (*crenon*) and the mountain torrents (*epirhithron*). The middle river stretch ranges from 500 down to about 100 m a.s.l. and flows through a hilly territory; the *metarhithron* and *hyporhithron* zones follow each other from upstream to downstream along this distance. The lower stretch lies below 100 m a.s.l. and is identifiable as the *potamon* stretch, again divided into three zones: *epipotamon*, *metapotamon* and *hypopotamon*; but the latter is not a typical freshwater zone owing to the ascent of the marine salt water. For this reason, as a general rule, the lists of freshwater algae reported below do not consider the *hypopotamon* zone.

The algae of running waters can be divided on the basis of their morphology into macroscopic and microscopic species, being the latter essentially the diatoms.

Macroscopic or submacroscopic algae are here defined as all those forming a thallus visible to the naked eye, thus unicellular colonial algae, simple or branched filaments, and algae with vesicular, laminar, disciform, crustose, pad-like, or heterothrichous thallus, etc. Some of the most representative macroalgae of Apennine and Italian rivers, in terms of qualitative and/or quantitative aspects, are reported in Table 1 with their prevailing distribution along the hydrographic basin. In accordance with the classification of Lee (1999), they belong to the following classes: *Cyanophyceae*, or *Cyanobacteria*, *Chrysophyceae*, *Xanthophyceae*, *Phaeophyceae*, *Rhodophyceae*, *Charophyceae*, *Chlorophyceae* and *Ulvophyceae.*

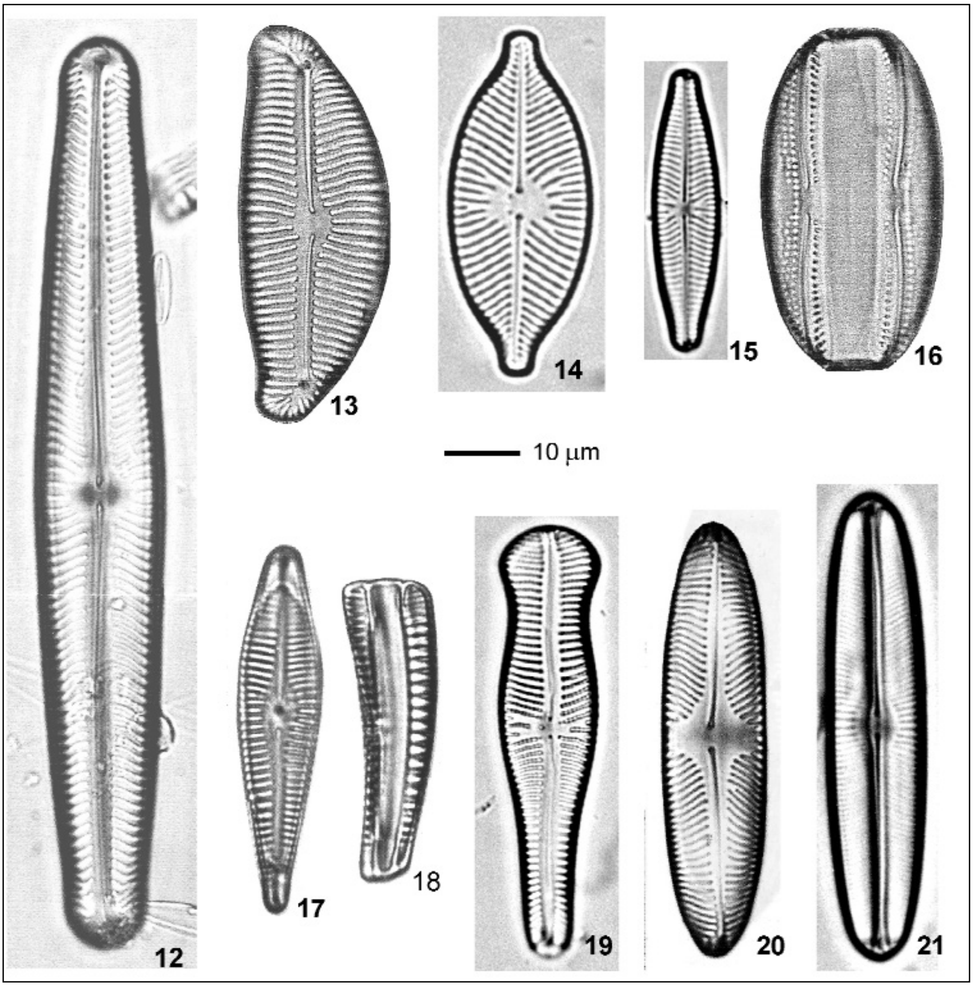
Table 1. Some of the main macroscopic algae of Apennine rivers and their prevailing longitudinal distribution (CY = *Cyanophyceae/Cyanobacteria*; R = *Rhodophyceae*; CR = *Chrysophyceae*; X = *Xanthophyceae*; P = *Phaeophyceae*; CL = *Chlorophyceae*; CA = *Charophyceae*; U = *Ulvophyceae*)

Upper stretch: *crenon* and *epirhithron*	Middle stretch: *metarhithron* and *hyporhithron*	Lower stretch: *epipotamon* and *metapotamon*
R - *Bangia atropurpurea* Roth	**R** - *Audouinella hermannii* (Roth) Duby	**CY** - *Arthrospira jenneri* Stizenb. ex Gomont
R - *Batrachospermun gelatinosum* (L.) D.C.	**CL** - *Chaetophora elegans* (Hudson) Hazen	**U** - *Chlorhormidium rivulare* (Kütz.) Fott
CL - *Chaetophora incrassata* Agardh	**CA -** *Chara vulgaris* L	**CL** - *Chlorotylium cataractarum* Küting
CL - *Draparnaldia glomerata* (L.) Kützing	**U** - *Cladophora glomerata* (L.) Kützing	**U** - *Enteromorpha intestinalis* (L.) Link
P - *Heribaudiella fluviatilis* (Aresch.) Sved.	**CL** - *Draparnaldia mutabilis* (Roth) Bory	**CL** - *Hydrodictyon reticulatum* (L.) Lagerh.
R - *Hildenbrandia rivularis* (Liebm.) Ag.	**R** - *Lemanea fluviatilis* (L.) Agardh	**CY** - *Oscillatoria formosa* Bory
CY - *Homoeothrix varians* Geitler	**CY** - *Lyngbya aerugineo-coerulea* (Kütz.) Gom.	**CY** - *Oscillatoria limosa* Agardh
CR - *Hydrurus foetidus* (Wille) Trèv.	**CY** - *Nostoc verrucosum* Vaucher	**CY** - *Oscillatoria sancta* (Kütz.) Gomont
CL - *Microspora amoena* (Kütz.) Rabenh.	**CY** - *Plectonema radiosum* (Schied.) Gomont	**CY** - *Oscillatoria splendida* Agardh
CA - *Mougeotia* sp.pl.	**CY** - *Phormidium autumnale* (Ag.) Gomont	**CY** - *Oscillatoria tenuis* Agardh
CY - *Phormidium incrustatum* (Näg.) Gom.	**U** - *Rhizoclonium hieroglyphicum* (Kütz.) Stock.	**CL** - *Stigeoclonium tenue* (Ag.) Kützing
CY - *Scytonema myochrous* (Dillw.) Ag.	**CL** - *Tetraspora gelatinosa* (Roth) Agardh	
CA - *Spirogyra* sp.pl.	**CY** - *Tolypothrix distorta* Kützing	
X - *Tribonema elegans* Pascher	**X**- *Tribonema vulgare* Pascher	
CA - *Zygnema* sp.pl.	**U** - *Ulothrix zonata* (Web. et Mohr) Kützing	
	X - *Vaucheria dillwynii* (Web. et Mohr) Ag.	
	X - *Vaucheria geminata* (Vauch.) D.C.	
	X - *Vaucheria racemosa* (Vauch.) D.C.	
	X - *Vaucheria sessilis* (Vauch.) D.C.	
	X - *Vaucheria woroniniana* Heering	



Figs 1-11. Diatoms that are characteristic of excellent water quality (mainly found in the *crenon* and *epirhithron* zones). 1. *Navicula striolata* (Grunow) Lange-Bertalot. 2. *Navicula jakovljevicii* Hustedt. 3. *Stauroneis anceps* Ehrenberg. 4-5. *Diatoma hyemalis* (Roth) Heiberg, valve view and girdle view. 6. *Neidium ampliatum* (Ehrenberg) Krammer. 7. *Cyclotella ocellata* Pantocsek. 8. *Diploneis elliptica* (Kützing) Cleve. 9. *Diploneis ovalis* (Hilse) Cleve. 10. *Diatoma mesodon* (Ehrenberg) Kützing. 11. *Achnanthes flexella* (Kützing) Brun. Scale bar valid for all figures.

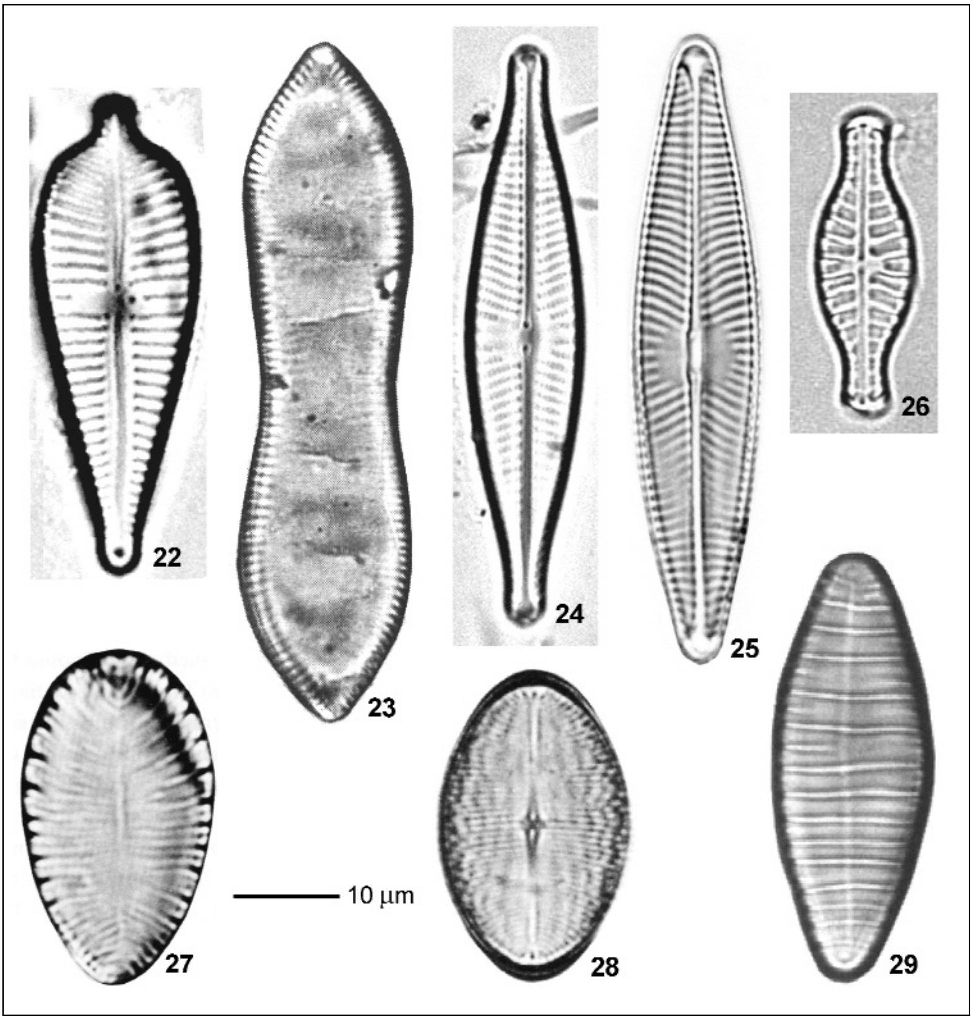
Diatoms (*Bacillariophyceae*) are unicellular, isolated or sometimes colonial algae, e.g. *Diatoma mesodon* (Ehrenberg) Kützing. They are qualitatively dominant in rivers and their distribution along the whole hydrographic basin is uninterrupted. Some of the most characteristic diatoms of Italian rivers will be shown afterwards (Figs 1-49) speaking about their use as bioindicators.



Figs 12-21. Diatoms that are characteristic of good water quality (mainly found in the *metarhithron* zone). 12. *Navicula oblonga* Kützing. 13. *Cymbella prostrata* (Berkeley) Cleve. 14. *Navicula clementis* Grunow. 15. *Navicula splendicula* Van Landingham. 16. *Amphora copulata* (Kützing) Schoem. & Arch. 17-18. *Rhoicosphenia abbreviata* (Agardh) Lange-Bertalot, valve view and girdle view. 19. *Gomphonema truncatum* Ehrenberg. 20. *Pinnularia brebissonii* (Kützing) Rabenhorst. 21. *Navicula bacillum* Ehrenberg. Scale bar valid for all figures.

The role of algae for monitoring rivers

Methods for monitoring inland waters, and particularly rivers, using living organisms started at the beginning of the 20th century with Kolkwitz and Marsson (1902,1908,1909), followed, among others, by Fjerdingstad (1964, 1965) and Sládeček (1973). These methods aim to complement or sometimes even substitute chemical monitoring in order to

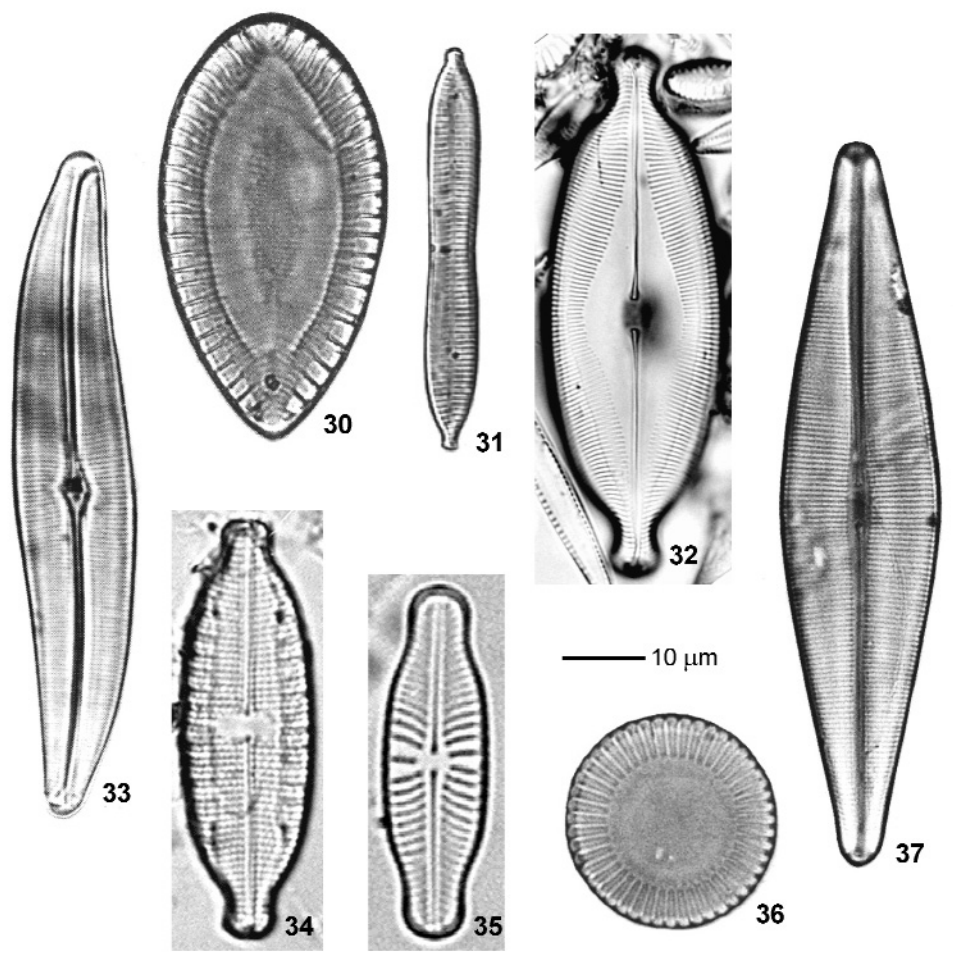


Figs 22-29. Diatoms that are characteristic of mediocre water quality (mainly found in the *hyporhithron* zone). 22. *Gomphonema augur* Ehrenberg. 23. *Cymatopleura solea* (Brébisson) W. Smith. 24. *Navicula rhynchocephala* Kützing. 25. *Navicula lanceolata* (Agardh) Ehrenberg. 26. *Navicula capitata* Ehrenberg. 27. *Surirella brebissonii* Krammer & Lange-Bertalot. 28. *Cocconeis pediculus* Ehrenberg. 29. *Diatoma vulgaris* Bory. Scale bar valid for all figures.

assess the ecological status of water bodies. Some important arguments in favour of biological monitoring are the following:

1. Organisms have an holistic response to variations in water quality, which may be missed by periodic chemical analysis;

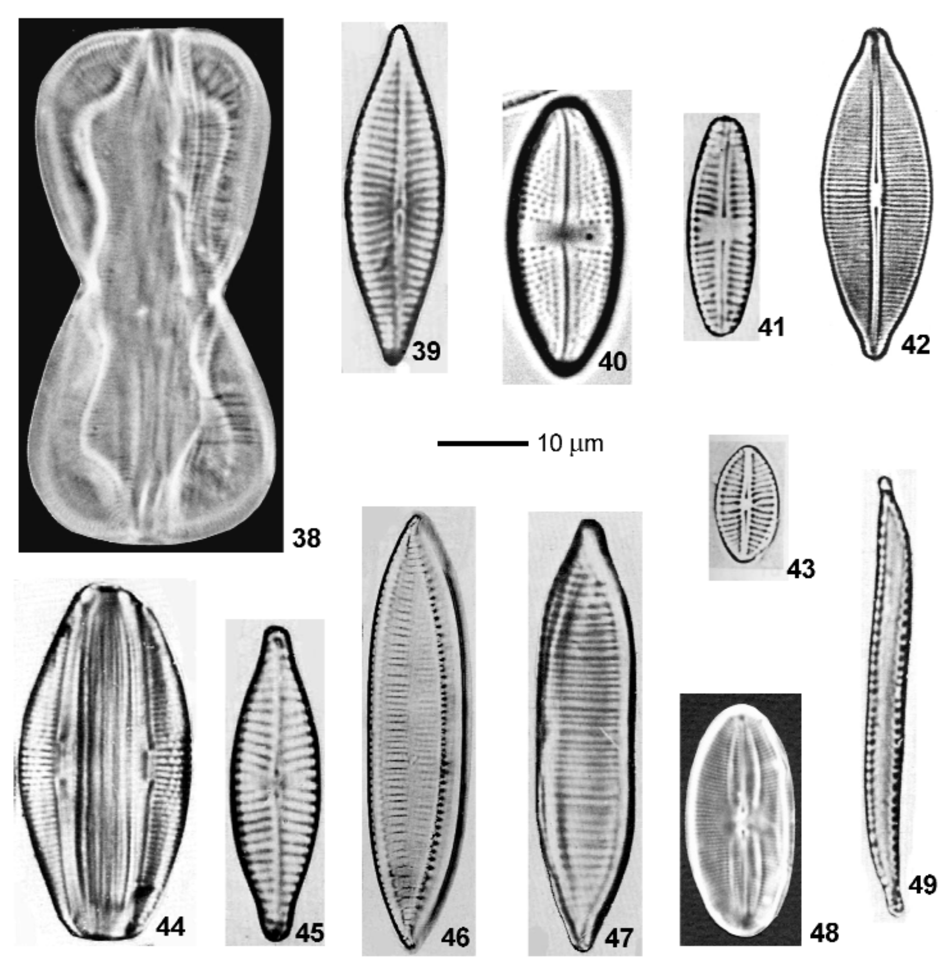
2. Previous entrances of pollutants into flowing water cannot be revealed by chemical analysis, but organisms can do it;



Figs 30-37. Diatoms that are characteristic of bad water quality (mainly found in the *epipotamon* zone). 30. *Surirella ovalis* Brébisson. 31. *Nitzschia constricta* (Kützing) Ralfs. 32. *Caloneis amphisbaena* (Bory) Cleve. 33. *Gyrosigma scalproides* (Rabenhorst) Cleve. 34. *Mastogloia smithii* Twaites. 36. *Cyclotella meneghiniana* Kützing. 37. *Navicula cuspidata* Kützing. Scale bar valid for all figures.

3. Only qualitative and quantitative modifications that occur in biological communities show the real impact of pollutants on the aquatic environment.

As a general rule, all the organisms living in a river may be considered as potential indicators of its ecological quality; however, the advantages afforded by benthic algae are numerous. They are present in rivers under a great variety of forms reflecting, with their thallus completely immersed in the water, its physical properties and chemical composition. They are more or less anchored to a substratum on which they remain for entire seasons, if not for



Figs 38-49. Diatoms that are characteristic of very bad water quality (mainly found in the *metapotamon* zone). 38. *Entomoneis paludosa* (W. Smith) Reimer. 39. *Navicula phyllepta* Kützing. 40. *Navicula goeppertiana* (Bleish) H.L. Smith. 41. *Navicula seminulum* Grunow. 42. *Navicula accomoda* Hustedt. 43. *Navicula subminuscula* Manguin. 44. *Amphora veneta* Kützing. 45. *Navicula veneta* Kützing. 46. *Nitzschia tryblionella* Hantzsch. 47. *Nitzschia calida* Grunow. 48. *Navicula pygmaea* Kützing. 49. *Nitzschia clausii* Hantzsch. Scale bar valid for all figures.

years, overcoming in one way or another unfavourable climatic conditions. Occasionally, as in some rocky-bottomed mountains torrents, they are the only living presence.

Both macroscopic algae and diatoms may be utilized in assessing water quality, but macroalgae are probably the more practical for monitoring shallow and transparent waters, where they can be directly observed by the naked eye and often identified on the spot, e.g. *Phormidium autumnale*, *Nostoc verrucosum*, *Hydrurus foetidus*, *Bangia atropurpurea*, *Lemanea fluviatilis*, *Cladophora glomerata*, *Hydrodictyon reticulatum* and others. In these conditions, algal macrophytes are of great help for making a rapid, preliminary, but by no means superficial assessment of the biological quality of the water. For this reason, a preliminary index for monitoring rivers in Italy based on macroscopic algae was proposed by Dell'Uomo in 1991, and improved in 1999. The use of macroalgae, however, is limited in downstream areas, when they are often hard to observe and sample due to the depth and turbidity of the water.

Diatoms do not have this restraint; on the contrary, they are present and suitable for sampling in practically all river environments. In addition, they react with higher sensitivity to changes in water quality; and their taxonomy and autoecology are very well known. Thus they afford in any situation a very elevated degree of precision in defining the level of pollution and/or the trophic state of a water body. At present, diatoms are by far the preferred photosynthetic organisms for monitoring rivers in the great part of European countries.

A diatom index for assessing the ecological status of Italian watercourses

An index for monitoring Italian rivers based on diatoms has been proposed in the last decade (Dell'Uomo 1996, 1999; Dell'Uomo & al. 1999; Torrisi & Dell'Uomo 2001), and more recently improved and tested (Dell'Uomo 2004; Torrisi & Dell'Uomo 2006; Torrisi & al. 2006). This index is essentially based on the sensitivity of diatoms to nutrients, organic pollution and mineralization of the body of water, especially that caused by chloride, which in freshwater represents a powerful factor of mineral pollution. It uses the formula of Zelinka & Marvan (1961): **EPI-D** = ∑ **a**j **r**j **i**j / ∑ **a**j **r**j, where:

- **EPI-D** represents the overall eutrophication/pollution index of the station;
- **a**j is the relative abundance of the species involved;
- **i**j is the ecological "message" of the species, i.e. its integrated sensitivity to eutrophication and pollution;
- **r**j (= reliability) is the validity of this message, which is inversely proportional to the ecological "range" of the species.

According to European Standard EN 14407 (Cen 2004), the relative abundance "**a**" of a species consists of a typical count size of 300 to 500 units (generally 400), valves or frustules; while a practical method used for attributing an integrated index of sensitivity "**i**" to each taxon is summarized in Table 2, which also expresses the values of "**r**".

With reference to the ecological factors involved in the index, the following authors were above all followed: Lange-Bertalot (1979) and Sládeček (1986) for the system of saprobity; Hustedt (1956), Van Dam & al. (1994) and Dell'Uomo (2004) for the system of salinity; Hofmann (1994) and Van Dam & al. (1994) for the trophic system.

Sampling methods, i. e. the site selection and choice of substratum in the river, as well as the methods for cleaning diatoms and preparing permanent slides for microscopic examination, are those recommended by the European Standard EN 13946 (Cen 2003).

At present, the most practical monograph for identifying freshwater diatoms is that of Krammer & Lange-Bertalot (1986-1991), whose nomenclature is used in this paper.

Table 2. Theoretical scheme showing the correspondence between various types of approaches to diatom ecology and a practical method for attributing to each species the values of sensitivity and reliability: **i** ranges from 0 for a very sensitive taxon, to 4 for a very tolerant taxon; **r** = 5 means an excellent indicator (i_e), **r** = 3 a good indicator (i_g), **r** = 1 a sufficient indicator (i_s). (From Dell'Uomo 2004).

Saprobic degree of the species	Halobic degree of the species	Trophic degree of the environment	$\mathbf{i_e}$ **r** = 5	$\mathbf{i_g}$ **r** = 3	$\mathbf{i_s}$ **r** = 1
xenosaprobic	halophobus	hypotrophic	0		
				0.5	
oligosaprobic	oligohalobous exigent	oligotrophic	1		1
				1.5	
β-mesosaprobic	oligohalobous tolerant	mesotrophic	2		2
				2.5	
α-mesosaprobic	halophilous	eutrophic	3		3
				3.5	
polysaprobic	β-mesohalobous	hypertrophic	4		

The resulting EPI-D value is a whole or decimal number between 0 and 4, whose progression is correlated with decreasing water quality. The proposed relationship, expressed in five main classes, is the following:

$0.0 \leq$ EPI-D < 1.0	excellent water quality
$1.0 \leq$ EPI-D < 1.7	good water quality
$1.7 \leq$ EPI-D < 2.3	critical water quality
$2.3 \leq$ EPI-D < 3.0	bad water quality
$3.0 \leq$ EPI-D ≤ 4.0	very bad water quality

The results falling within ± 0.5 of the threshold values can be considered transition classes.

Some of the most interesting diatoms of the Apennine and Italian watercourses, grouped on the basis of their sensitivity and prevailing presence in the various biological zones above mentioned, are shown in Figs 1-49.

Monitoring of central Apennine rivers using the EPI-D index

During the monitoring of several central Apennine watercourses entering the Adriatic Sea by means of the EPI-D diatom index, Torrisi & Dell'Uomo (2006), Torrisi & al. (2006), and Scuri & al. (2006) were able to assess their general situation and, in particular, to identify:

many sites with excellent or good water quality, not always upstream, that are worth preserving, at least in their current status;

and a similar number of sites that are more or less damaged by anthropogenic activities (sugar refineries, paper and shoe factories, leather tanning facilities, metallurgical and mechanical industries, etc.), not always downstream, which need restoration.

The values of the EPI-D index, compared with some of the most important chemical parameters (BOD_5, total phosphorous, mineral nitrogen, conductivity, chlorides, and sulphates) and the general situation of the rivers examined, such as their hydrological and geo-morphological characteristics and anthropological activities, clearly showed decreasing biological quality when chemical parameters increased, indicating that the EPI-D offers an excellent capacity for synthesis.

Comparisons between the results obtained by the EPI-D and other European diatom indices always indicated very good correlation between them. Rimet & al. (2005), testing various diatom indices in order to verify their response to simulated water quality improvements, found that the EPI-D was among the European diatom indices that gave the best results.

All these reasons suggest that the EPI-D index represents a valid instrument for assessing the ecological status of running waters.

Final considerations

The benthic rheophilous algae are not only very useful bioindicators of the ecological status of rivers, which significantly impact the quality of the marine environment, but they:

- represent in rivers the first level of the trophic chain, just as the algae of plankton and benthos do in lakes and seas, and serve to elaborate unsaturated fat acids, e.g. omega-3;
- contribute, as efficient photosynthetic organisms, to the enrichment of waters in oxygen;
- and provide an important part of the earth's biodiversity. Unfortunately, many that require pure water quality, such as the rheobenthic and xenosaprobic *Diatoma hyemalis* (Roth) Heiberg and *Achnanthes flexella* (Kützing) Brun, are in serious risk of extinction, owing to advance of anthropogenic activities further and further upstream.

The presence of benthic algae in rivers, although necessary, should nevertheless be qualitative and not quantitative or, in other words, moderate, because an exaggerated presence indicates eutrophication and is generally due to a massive entrance of nutrients and organic matter into the body of water. Excessive poverty of species, or their complete lack, on the other hand, is symptomatic of pollution and extreme environmental decay.

It follows that a shrewd management of aquatic resources is well served by the use of biological monitoring with algal indices, in accordance with the above-mentioned Directive of the European Community. With their great confidence in algal indices, Italian biologists serving the regional agencies for environment protection (ARPA) began monitoring rivers with the EPI-D index long before the WFD was applied in Italy.

A good management of the rivers entering the Adriatic Sea, also by means of algal indices, would contribute remarkably to the improvement of this damaged sea, once called "*Mare nostrum*" by ancient Romans, but now, in the "Age of Globalization," a good for all humanity.

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Vernon Heywood

Introduction: perspectives for economically important wild species and neglected crops in the Mediterraneans

Abstract

Heywood, V.: Introduction: perspectives for economically important wild species and neglected crops in the Mediterranean. — Bocconea. 23: 107-114. 2009. — ISSN 1120-4060.

The Mediterranean region is one of the major centres of origin and diversification of cultivated plants and many crop wild relatives are found there. In addition, many native species are still widely harvested from the wild for food, medicine and other uses and some of these have potential for development as alternative crop especially in marginal zones. While there have been several recent initiatives that address the cataloguing and conservation of these species, such as the Network on Identification, Conservation and Use of Wild Plants in the Mediterranean Region (MEDUSA and the Bioversity International (IPGRI) studies on Underutilized Mediterranean Species (UMS), no comprehensive assessment has yet been made and little work undertaken on their agricultural potential. It has been confidently predicted that consequences of global change in the Mediterranean region – population movements and migrations, changes in disturbance regimes, and climate change – will be serious. One the one hand, this will affect the survival prospects of many of these underutilized species and on the other hand it will enhance their importance as the source of potential new crop germplasm The conservation and availability of genetic diversity of both crops and underutilized species is essential if we are to be able to meet the increasing demand for food and other crops that will be adapted to the new ecoclimatic envelopes that will develop in the region as a consequence of global change. The rapid rate of climatic and other change that is expected adds urgency to the task of assessing, conserving and sustainably using this rich diversity of wild species of economic value in the region but new strategies will be need to be developed to achieve this. The Mediterranean region has the potential of becoming a major source of new crop development in the coming decades.

Mediterranean cornucopia

The Mediterranean region is one of the major centres of origin and diversification of cultivated plants (Harlan 1995) and many crop wild relatives are found there (Kell & al. 2005; Maxted & al. 2007). In addition, many native species are still widely harvested from the wild for food, medicine, essential oils, ornamentals and other uses and some of these have potential for development as alternative crop especially in marginal zones. The number of species involved is not fully known although Rivera & al. (2006) estimate that c.2,300 plant or fungal taxa are gathered and consumed in the Mediterranean region. The region is also home to a number of crops that were formerly widely cultivated but are now largely neglected (Hernández Bermejo & León 1992) although some of them, as other papers in this symposium indicate, are attracting renewed interest.

There is an extensive literature on the use of wild plant species in various countries of the Mediterranean, especially in Greece, Italy Turkey and Spain and while there have been several recent initiatives that address the cataloguing and conservation of these species, such as the Network on Identification, Conservation and Use of Wild Plants in the Mediterranean Region (MEDUSA) (Skoula & Johnson 2005) and the Bioversity International (IPGRI) studies on Underutilized Mediterranean Species (UMS), no comprehensive assessment has yet been made and little work undertaken on their agricultural potential.

The MEDUSA Network of Useful Plants of the Mediterranean Region was established by CIHEAM-MAICh, with the support of the European Union Directorate General I, for the identification, conservation and sustainable use of the wild plants of the Mediterranean Region. The Network comprises National Focal Point Coordinators from the countries of the region and also includes representatives of international organizations. The objectives of the network were (Heywood & Skoula 1999):

- The identification of native and naturalized plants of the Mediterranean Region, according to use categories such as food, food additives, animal food, bee plants, invertebrate foods, materials, fuels, social uses, vertebrate poisons, non-vertebrate poisons, medicines, perfumery and cosmetics, environmental uses, and gene sources.
- The creation of a Regional Information System that will include: scientific plant name and authority, vernacular names, plant description, chemical data, distribution, habitat description, uses, conservation status, present and past ways of trading, marketing and dispensing, and indigenous knowledge (ethnobiology and ethnopharmacology), including references to literature sources.
- Preliminary evaluation of the conservation status and potential utilization in agriculture of these plants as alternative minor crops.

The MEDUSA project gathered information on wild food and non-food plants of the Mediterranean region on a country-by-country basis and stored it in a specially designed electronic database (Skoula & al. 2003). In addition, two regional workshop volumes were published containing series of papers on the wild plant resources of Algeria, Egypt, France, Greece, Italy, Morocco, Portugal, Spain, Syria, Tunisia and Turkey (Heywood & Skoula 1997, 1998).

The MEDUSA process remains valid and it would be highly desirable to complete the database.

Recently, work on economically valuable wild plant species in the Mediterranean region has addressed not just ethnobotanical issues such as listing the species and their uses (e.g. Fajardo & al. 2000;) but has increasingly focused on the nutritional and health aspects of wild foods (Heinrich & al. 2006).

A major EU-sponsored project “Local Food-Nutraceuticals” (LFN) involved specialists in fields such as ethnobotany, pharmacognosy, pharmacology and nutritional studies from the UK, Germany, Poland, Spain, Italy, Switzerland and Greece (Heinrich & al. 2005). They formed a consortium whose goals were:

- Ethnobotanical documentation of food products of selected communities in southern Italy, Spain, Greece including Crete.
- Comprehensive understanding of the social, cultural, economical framework of local food use

– Identification of active extracts/pure compounds (leads for new health food supplements)
– Biochemical/pharmacological *in vitro* mechanisms/*in vivo* effects of selected species
– Dissemination of ethnobotanical information in local/national languages

The concept of 'Local Food', according to Rivera & al (2005) involves the whole repertoire of species that characterize the local diet. This includes local cultivars and non-cultivated wild-gathered food plants .

This group of plants has attracted considerable attention recent years as it has been associated with the so-called Mediterranean diet (Keys & Keys 1959) or more properly diets that are rich in fruit, vegetables, legumes and olive oil, as well as fish and poultry, but low in meat and animals fats (Heinrich & al. 2005; Romano 2005). Of particular interest are the so-called 'wild greens' which are considered in detail below. The term 'Local food-nutraceuticals' is applied because of the health benefits conferred by consuming some of these plants.

Diets and lifestyles are, however, changing rapidly in many parts of the Mediterranean region and documentation and publication of information on these locally used plant diet components is of great interest and, as Heinrich (2001) notes, not only a record of earlier times but of importance for any project interested in the sustainable development of the region.

Changes in diet of poor communities in the Lebanon, which rely increasingly on refined cereal grains instead of a more balanced traditional diet, has lead to an increase the rates of cardiovascular disease and diabetes. An IDRC project 'Promoting Dietary Diversity in Poor Communities of Lebanon' is addressing this issue and problems of chronic undernutrition in the region by promoting the preservation and sustainable use of wide diversity of wild edible plants and local food systems at the national and regional level. Modern agricultural practices and the reliance on monocultures, the heavy use of pesticides and changing land tenure regimes and the loss of traditional knowledge about their uses, has led to a decline in the wild- harvesting and use of these native plants.

Traditional leafy vegetables or 'wild greens'

The consumption of traditional leafy vegetables ('wild or leafy greens') is receiving a great deal of attention in tropical countries (Chweya, J.A. & Eyzaguirre 1999) but they also represent a valuable resource in the several Mediterranean countries such as France, Greece, Italy, Spain and Turkey. They are important for human nutrition and can supply most of the necessary daily requirements for vitamins A, B complex and C and supply minerals and trace elements. They may sometimes even be better nutritionally than introduced cultivated vegetables. As noted above, they play a role in the so-called Mediterranean diets.

Detailed inventories of the species involved are known from only a few countries in the region. They are especially important in Greece ('xorta'), especially Crete where over 92 wild greens have been catalogued (Stavridakis 2006) and several studies published, and in others islands such as Corfu, Cyprus (Della & al. 2006), Sicily and Sardinia. In Sicily, Lentini & Venza (2007) report that 188 wild species used in the traditional Sicilian cuisine and Table 1 in their paper lists these species, indicates which parts of the plant are used and gives details of how they are used, prepared or cooked.

Often these wild greens form part of relict traditional cultures as in three Arbëresh ethnic Albanian communities in southern Italy where 130 non-domesticated food vegetables ('liakra'), mostly gathered during the spring season, play a central role as traditional functional food (Pieroni 2002) and in the Graecanic area of Calabria in southern Italy which is part of the cultural and linguistic heritage of the Magna Graecia and the later Byzantine Empire (Nebel & al. 2006; Heinrich & al. 2005). Here the villagers in the area have retained many aspects of this cultural heritage, including their own language Grecanico, in which wild edible greens are called 'ta chòrta'. More than 40 wild food species are regularly harvested. In Turkey, Ertuğ (2004) notes that wild plant gathering for food and other needs is an ongoing tradition and a common practice throughout Anatolian Turkey.

The range of species used as wild greens is remarkable and includes species that one would not normally associate with food. An example is parasitic *Cytinus hypocistis*, which grows on the roots of *Cistus monspeliensis.* According to Ertuğ (2004) some of the villagers in the Bodrum area of Turkey remembered it as a very good sweet and 20-25 years ago they also used it as glue. The fleshy and scaly red and yellow flower heads of this parasite are known as edible in Greece, and have been used as a medicinal (Baumann, 1996).

From a conservation and sustainable use point of view, little is known of the amount of material that is harvested from the wild or of the effect on the populations of the species concerned.

Some of these species are threatened by alien invasive species such as in Crete where the greatest threat comes from *Oxalis pes-caprae* (Stavridakis 2006) which is the commonest naturalized species on the island and covers large areas of olive groves throughout most of the year and is visible from space (Rackham & Moody 1996).

Many of the species used as wild greens also have medicinal properties so that there is a considerable overlap between these two categories of plants. For example, in a study of the wild edible plants of the Bodrum area (Muğla) in Turkey, Ertuğ (2004) noted that over a quarter (35 or 25 %) of all taxa recorded as edible are also considered medicinals, thus indicating a close relationship between health and nutrition. She gives as an example, the stinging nettle *Urtica dioica* which is one of the most commonly used greens, and also considered one of the most commonly used medicinals. The Mediterranean region is rich in medicinal and aromatic plant species which have been widely reported on in the literature and will not be considered further here.

Ornamentals

Ornamentals are a major group that is often overlooked or at least underestimated in considerations of the uses of wild plants. Many species of Mediterranean origin are included in the thousands of species grown as ornamentals in parks and in public and private gardens and in the horticultural trade: notably leguminous shrubs such as *Coronilla*, *Cytisus*, *Genista*, *Retama*, *Spartium* and allied genera, aromatic Lamiaceous shrubs such as *Calamintha*, *Satureja* and related genera, *Rosmarinus*, *Thymus* etc. and Cistaceous shrubs including *Cistus*, *Fumana*, *Halimium* and *Helianthemum*. Another important source of ornamentals is the bulbs and corms such as *Crocus*, *Cyclamen*, *Narcissus*, *Galanthus*, *Tulipa* and *Muscari* (Baser 1997, see Table 1), which are the subject of trade, largely uncontrolled, and export, much of it illegal although efforts are being made to encourage indigenous bulb propagation for export (Entwistle & al. 2002) .

On the other hand, the Mediterranean region still houses a large number of species that show considerable potential for introduction as new ornamentals. This is especially true of the eastern Mediterranean where intensive work is being undertaken in introducing new wild species into cultivation. For example, in Israel, recently introduced species include geophytes: *Oncocyclus* irises*, Uriginea maritima, Scilla hyacinthoides*, annuals: *Lupinus pilosus* and *Centaurea crocodylleum*; and herbaceous perennials: *Eremostachys laciniata* and *Helichrysum sanguineum* (Halevy 2000). Turkey, has long been known as a source of garden ornamentals (Harvey 1976) including the geophytes already mentioned but partly because of its very rich flora and partly because it is less well explored than many other parts of the Mediterranean, remains a promising new source of wild species with horticultural potential (Arslan 2004).

Effects of global change

It has been confidently predicted that consequences of global change in the Mediterranean region – population movements and migrations, changes in disturbance regimes, and climate change – will be serious. One the one hand, this will affect the survival prospects of many of these underutilized species and on the other hand it will enhance their importance as the source of potential new crop germplasm. The effects of these changes on those species that are currently wild-harvested cannot be predicted with any degree of certainty at this stage. However, if we are to be able to meet the increasing demand for food and other crops that will be adapted to the new ecoclimatic envelopes which will develop in the region as a consequence of global change, much more research is needed into ecoclimatic/bioclimatic modelling (Jarvis & al. 2008) and then applied to a wide range of potentially vulnerable species.

Some of the possible consequences of climate change on the biodiversity, flora and vegetation of the Mediterranean basin are reviewed by Médail & Quézel (2003) and Gavilán (2003). The rapid rate of climatic and other change that is expected (SEG 2007) adds urgency to the task of assessing, conserving and sustainably using this rich diversity of wild species of economic value in the region but new strategies will be need to be developed to achieve this (Heywood 2007b). The Mediterreanean region has the potential of becoming a major source of new crop development in the coming decades. This makes it all the more urgent to take steps now to assure the conservation and availability of genetic diversity of both crops and underutilized species.

Water shortages. Water shortage and land degradation have become major threats to the sustainability of the seminatural and cultivated ecosystems in the Mediterranean and pastures and grazing lands are particularly susceptible. A recent WWF report on drought in the Mediterranean (, estimates to become worse and more frequent in the coming years as a consequence of climate change, warns of the need to avoid unsustainable management of water such as increased irrigation in responses to EU subsidies and wasteful low efficiency irrigation in non-EU countries.

Again, the consequences on plantlife and especially on crop wild relatives, medicinal and aromatic plants and those used as wild greens and other food, needs to be assessed as a matter of some urgency

Neglect of economically important wild species

Despite their undoubted value, many economically wild plant species are still overlooked or neglected by the agricultural and development communities (Heywood 2006, 2007a) because of

- a lack of information about the extent of their use and importance to rural economies
- a lack of information, especially statistics, concerning their economic value
- a lack of information and reliable methods for measuring their contribution to farm households and the rural economy
- the lack of wider markets, except for a small number of products
- the irregularity of supply of wild plant products
- the lack of quality standards
- the lack of storage and processing technology for many of the products
- the availability of substitutes
- the bias in favour of large-scale agriculture

Conclusions

The Mediterranean houses a diversity of wild plant species that have the potentiality of improving nutrition, contributing to food security, providing medicinal and aromatic species, enhancing crop germplasm suitable for withstanding stress conditions, creating new markets and increasing incomes. Many new ornamental species are suitable for introduction into the horticultural trade.

The widescale ecoclimatic and social changes that are anticipated as a result of global change over the coming decades makes it urgent that steps should be taken now to preserve this important and valuable heritage, both for the benefit of local communities both within the Mediterranean region and further afield.

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Neglected crops of Al-Andalus

Abstract

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The Al-Andalus was a territory dominated by Hispano-Arabic culture but also a dynamic historical process which is crucial to understanding the history of the introduction, domestication and dispersion of many crops in Western Europe. Many oriental species arrived during this time, or, if known previously, they were consolidated as Iberian crops. The diversity of these species is very extensive: rice, sugar cane, cotton, sorghum, aubergine, cucumber, artichoke, spinach, hemp, safflower, taro, liquorice, citron, lime, lemon, bitter orange, banana trees, mulberry trees, etc. But many others were firstly introduced or domesticated, then cultivated, but, finally, neglected or marginalized.

The marginalization, neglect, and loss of crops have been frequent phenomena throughout the history of humanity, especially in periods of cultural, economic, or political clashes between different ethnic groups, cultures, and religions. Many Andalusi agricultural species were lost after the progressive reduction in territory, the fall of the Nazarí kingdom after the end of the 15th century, the persecution of Andalusí culture and agriculture by the new Christian kingdom and the Inquisition, and, finally, due to the expulsion of the Moslem converts at the end of the 16th century. The arrival of new species and crops from America also contributed to this process negatively, although on the other hand, the transport and agricultural transculturation from Spain to America partly saved the germplasm and the traditional knowledge associated with these crops.

Among the numerous species of al-Andalus agriculture still marginalized or neglected today, we can cite: *Myrtus communis* (as a fruit tree), *Ficus sycomorus, Argania spinosa, Morus alba, Sorbus aria, S. domestica, Ziziphus jujuba, Citrus medica, Eleagnus angustifolia, Crataegus azarolus, Hibiscus esculentus, Silybum marianum, Smyrnium olosatrum, Ocimum basilicum, Coriandrum sativum, Lagenaria siceraria, Atriplex hortesis, Viola* sp., *Chenopodium vulgare, Rumex* spp., *Lathyrus* spp., *Vicia* spp. and *Vigna unguiculata*. Several species have been recently recovered, and, to a certain degree, their importance renewed, generally due to reasons which differ from a reflective review of the marginalization process; among these are, *Eruca vesicaria* subsp. *sativa, Scolymus hispanicus, Borago officinalis, Punica granatum, Celtis australis,* and *Pistacia vera.*

This work will examine the causes of this lost crop process, and the variety of neglected species, based on a comparative review of the works by Andalusi agronomists and botanists with the prior works by Greek, Roman, and Byzantine authors, as well as the agricultural catalogues and treatises subsequent to the 15th century.

Introduction. Causes and processes

The **marginalization**, neglect and loss of crops have been frequent phenomena throughout the history of humanity, especially in periods of cultural, economic, or political clashes between different ethnic groups, cultures and religions. The term “neglected species” refers to that species which, having been the object of cultivation after a more or less intense domestication of its wild ancestors, becomes abruptly or gradually neglected until it finally disappears from the agricultural catalogue of a country or region. These species often become weeds of other crops, or they are conserved in other countries, sometimes with clear transculturation processes. After some time, it is possible for these crops to recover their initial economic interest or respond to new social and cultural frameworks, which permit their recovery.

Marginalization causes can be diverse, among them: a) loss of competitiveness of these species compared with other more productive ones, implying a reduction in their economic or usefulness interest; b) slow and gradual changes in custom, food habits and ways of life, which do not respond to concrete reasons; c) competition established by economic or political interests beyond the reference region and culture; d) religious or cultural persecution generally related to the previous reason; e) disappearance of ethnic groups that understood the techniques and uses of the plants as well as their cultivation methods.

This work aims at recovering the lost component of Andalusi agriculture diversity, which was later neglected or even persecuted after the 15th century with the new Catholic Monarchs [Fernando and Isabel] reigning in Spain. This work examines certain species in particular, analysing the causes and processes that provoked this marginalization, based on a comparative review of works by Andalusi agronomists and botanists with the prior contribution of Greek, Roman and Byzantine authors, as well as the agricultural catalogues and treatises subsequent to the 15th century.

Al-Andalus was the Iberian territory dominated by Hispano-Arabic culture during the Middle Ages. Its surface area progressively diminished from the 8th until the 15th Century and it was not equivalent to any constant area or even to a specific time period in the past. From an ecological point of view, al-Andalus lands mainly occupied the Mediterranean climate area of the Iberian Peninsula, both in their continental expression with cold winters and hot, very dry summers (La Mancha, Extremadura, Aragón, Sistema Ibérico and the Bétic and Penibétic Mountains), and in their gentler variants due to their proximity to the Mediterranean with no winter freezes (Levante, and east coast districts of present-day Andalusia) or to the influence of the humid Atlantic Ocean in the most western areas (Guadalquivir valley, foothills of Cádix, Algarve, Alentejo and the coastal part of Beira). These warmer climes permitted the introduction of highly diverse Eastern and African species, some of them even coming from subtropical environments. In the eastern half of al-Andalus there was a predominance of calcareous soils, and, in its northeastern region (Sierra Morena, Extremadura), of siliceous soils from the Hercinic mountain ranges.

Above all, Al-Andalus was a dynamic historical process which is crucial to understanding the history and essence of Europe. Life during this period was strongly influenced by the East-Mediterranean and North African cultures via the strong Islamic dominance which merged with the deeply rooted Hispano-Roman culture, which had survived during the Visigothic era and which had also received eastern influences from the Phoenician world, Classical Greece, Carthage, and, very especially – although it is less mentioned – from Byzantium, the latter influence acting both before and during the Hispano-Arabic period. In short, al-Andalus was the consequence of the Hispano-Roman times, and, to a lesser degree, of the Visigothic period, but its roots came from the Eastern Roman Empire of Byzantium (González-Ferrín 2007). Al-Andalus stimulated and experienced an authentic cultural, artistic, scientific, and even religious Renaissance, which took place several centuries before the Renaissance in the rest of Europe. It was a period of tradition-based innovation.

From an agricultural perspective, or, better still, from the usage and knowledge of plants, these same guidelines have been observed. Many eastern species arrived, or, if they were known previously, they were consolidated as Iberian crops. Others were the object of intense foreign trade. The list of these species is a very long one: rice, sugar cane, cotton plants, sorghum, aubergine, cucumber, artichoke, spinach, sweet melons, hemp, safflower, taro, liquorice, tiger nut, ginger, aloe, citron, lime, lemon, bitter orange, banana tree, judas tree and paradise tree, etc.

Unfortunately, many Andalusi agricultural species were lost after the progressive reduction in territory, the decline of the Nazari kingdom at the end of the 15th century, the persecution of Andalusi culture and agriculture by the new Christian kingdom and the Inquisition, and, finally, due to the expulsion of the Moslem converts after the end of the 16th century. The arrival of new species and crops from America contributed negatively to this process but, on the other hand, the contact with the New World was positive, since the transport and agricultural transculturation from Spain to America partly saved the germplasm and the traditional knowledge associated with Andalusi crops. In many cases, Spanish colonists imported and conserved species, techniques, and uses of this agriculture into America.

Andalusi agriculture

The Andalusi, besides enriching and consolidating cultural and agricultural Iberian biodiversity, improved watering, fertilization, and pest propagation control techniques. They also developed new ways of using plants, which gave rise to a special gastronomy and enriched Spanish and other Romance languages with countless parallel terms related to plant description and use. This contribution was consolidated in spite of: 1) the simultaneous process of the official persecution of their ways of life and the burning of their books, triggering the loss of a large part of their ethnobotanical heritage, and 2) their definitive expulsion one century later, after the Capture of Granada by the Catholic Monarchs.

The important role that this cultural and historical period played in the introduction and consolidation of many crops is well known; they not only transformed the Western Mediterranean and Iberian agriculture, but also managed to travel to America via Spanish colonization. This is the case of many herbaceous species such as rice, sugar cane, hemp, Asian cotton, African bean, aubergine, spinach, melon or cucumber, and woody species i.e. citrus fruit trees, chinaberry trees, camphor trees, pepper trees and many other food and medicinal species, spices, and fruit trees.

Working method. Sources consulted

This work has been possible thanks to the experience acquired during twenty years by the multidisciplinary team of agronomists, botanists and Arabists who worked in the project "Andalusi Crops Flora", which has already been the source for several publications. (Carabaza 1988; Carabaza & al. 1998, 2001, 2004; Garcia-Sanchez & al. 2008: Garcia-Sanchez & Hernandez-Bermejo 1995, 2007; Hernández Bermejo 1990; Hernández-Bermejo & García-Sánchez 1988, 1998, 2000, 2008, 2009; Navarro & Hernández Bermejo 1994). This work is the result of information gathered from Andalusi agricultural treatises (eight in all), as well as the first of the agricultural calendars drawn up in al-Andalus, the Calendar of Córdoba (*Kitab al-Anwa*, a work from the 10th century written by Arib b. Sa,id).

The following agricultural treatises, in chronological order, have been used for the drafting of this work:

Kiab fi Tartib awqat al-girasa wa-l-magrusat, an anonymous treatise from the 10th-11th centuries.

al-Muqni, fi l-filaha, whose edition was first attributed only to the agronomist Ibn Hayyay (11th century), but also contained the agricultural treatise by Ibn Wafid (11th century).

Kitab al-Qasd wa-lbayan by Ibn Bassal (11th century).

Zuhrat al-bustan wa-nuzhat al-adhan, by the agronomist al-Tignary (11th and 12th centuries).

Kitab al-Filaha by Ibn-al,Awwam (12th and 13th centuries).

Kitab Ibda, al-malaha wa-inha, al-rayaha fi usul sina,at al-filaha, agricultural poem by Ibn Luyun (14th century).

The botanical work attributed to the agronomist Abu l-Jayr, *Umdat al-tabib fi ma,rifat li-kull labib*, should be added to the list above. This is probably the richest and most interesting botanical work known so far. It has recently been translated with enormous effort from its editors and translators, but the species identification cannot be accepted without a previous botanical contrast. As a consequence of directly consulting the original text, which is of great value due to the author's exhaustive morphological description as well as some precise ecological requirements and geographical location of the plant, it has been possible to identify some of the more uncertain species, and the mention of some others, not identifiable only through agronomical treatises, has been verified. In some other occasional cases, works by physicians and pharmacists such as Maimonides and Ibn al-Baytar have been consulted.

As indicated above, the authors consulted are not the only contemporaries of the period considered. In order to have a complete perspective of the history of the introduction, consolidation and, in this case, the falling into oblivion of the crop species, other texts have been reviewed, such as the *Historia Naturalis* by Theophrastus or Plinius, the *De Materia Medica* by Dioscorides, the Agricultural Treatises by Columella, Casiano Baso and Palladio, or the Ethimology by Isidoro de Sevilla, which permits the coverage of the millenium previous to the birth of al-Andalus, in the Mediterranean West. Some of these texts, and very specially the works of Dioscórides, had an enormous repercussion on the botanical knowledge applied in al-Andalus. The *Materia medica* by this author was translated from Greek into Arabic in the 10th century in the geographic and cultural setting of the Caliphate of Córdoba, and this Arabic version was disseminated throughout most of the Western Mediterranean. In our case and work, consulting these Roman, Greek and Byzantine authors has enabled us not only to complete the history of the crops coming from the East, but also to even help us to identify many of them since the Andalusi agronomists read, copied and spread much of their knowledge.

We have also included data from our experience of the study of relictic localities of introduced species, still located around significant archaeological sites such as Madinat al-Zahra, the caliphal city from the 10th century on the outskirts of Cordoba, as well as data from an archaeo-palinologic survey implemented on the same site (Hernández-Bermejo 1987, 1991; Martin-Consuegra & al. 1995, 2000a, 2000b).

Neglected andalusi species. Some case studies

***Lignous crops,* Conifers:**

The absence of any clear forest concept among the Andalusi agronomists does not prevent them from showing interest in many tree species, including certain conifers such as pines, cypresses and cedars. They also mention other species nowadays neglected by forest interests such as junipers (*Juniperus* spp., *Juniperus oxycedrus*), and especially yews (*Taxus baccata*), "*whose seedlings are brought from the mountains at the beginning of February, and they are planted in holes three spans deep"* and which are mentioned for being used in the making of objects such as cups, glasses, bowls and other household stuff (Abu al-Jayr). The araar (*Tetraclinis articulata*) is nowadays almost extinct in the Iberian Peninsula.

Ligneous Angiosperms (fruit trees species and other culinary species)

Many species of trees,which were cultivated for their fruits, oils, timber, spices or even for their medicinal uses, have completely disappeared from the al-Andalus landscape. An example of this case is the "sebestén" (geiger tree, *Cordia sebestena*), a very valuable tree due to its integral use (fruit, leaves, roots, timber, etc.). Other examples are *Tamarix aphylla*, *Caesalpinia sappan*, *Argania spinosa*, *Ficus sycomorus*, *Lawsonia inermis, Liquidambar orientalis* or the storaxes *Styrax officinalis* and *S. benzoin.*

Other species were marginalized until they almost disappeared as crops, such as *Pistacia vera*, *Ziziphus jujuba, Z lotus, Citrus medica* or *Crataegus azarolus.* Certain autochthonous species of the Andalusi flora have been cultivated for their ornamental uses, others being forgotten such as culinary, cosmetic, dyeing or medicinal substances. For example, this is the case of *Myrtus communis* or *Berberis vulgaris.* Some allochthonous species were very important in agriculture, gardening and landscapes of al-Andalus and they have remained irrevocably linked to them because of their escape to wild localities but meanwhile they remain as a neglected or marginalized crops, among these are: *Celtis australis, Ceratonia siliqua* or *Rhus coriaria*. The mulberry tree, *Morus alba,* was even the object of a political-religious persecution during the 16th and 17th centuries. Finally, other species were intensely used as fruit trees, but are only partly exploited nowadays, for example, *Punica granatum, Ficus carica* or *Cydonia oblonga.*

Myrtus communis L.

A circum-Mediterrranean species present in all of the Iberian Levante, the southern half of the Iberian Peninsula and the Balearic Isles. It forms part of the scrubland proceeding from the degradation of the schlerophyllous Mediterranean forest under gentle climates free from heavy freezes, on fresh soils in which the summer drought is dampened. In al-Andalus it was a well known ornamental element in Andalusi gardening. "*It is planted next to the orchard gate or to the zafariche*". In some cases it is inevitably linked to Andalusi toponymy and historical architecture (*Patio de los Arrayanes-myrtles-* in the Alhambra of Granada). But myrtle was also cultivated for its culinary, medicinal, cosmetic, craft and insecticidal uses among many others.

Regarding its culinary uses, Andalusi agronomists mention a "*very rich and nutritive bread*" made with its grain – probably referring to its fruits. Agronomists do not mention the consumption of its fresh fruits or the possibility of being used for making jams or syrups, but these uses are known from other sources. Leaves and seeds are mentioned for having cosmetic and probably deodorant properties, as indicated by more modern authors (Quer, in Font Quer, 1959 and López González, 1982), who tell us that leaves are applied in groins and armpits to avoid bad odours. Its cosmetic properties were also well known; according to Ibn al-,Awwam, it was used in treatments against dandruff and to darken the hair, and he also mentions a new and amazing way to apply the juice of its leaves as ophthalmic eye drops: "it makes blue eyes become black". This same juice mixed with wine, relieved tarantula and scorpion bites, which implies antihistaminic properties.

Medicinal uses of the myrtle have been known for a long time (Dioscórides) to be deodorant, antiseptic, anti-catarrhal, balsamic, astringent and sedative. All these properties are due to its essential oils and its high content in tannins. In the same sense, Isidoro de Sevilla (1982) wrote that "medicine books teach us that this tree is appropriate for numerous women's necessities". The hispanoarabic agronomists also mention insecticidal, antiparasitic (chicken lice) and phytosanitary properties (possibly against fungal diseases in vines and palm trees), as well as its "juice" (that is, its essential oils) as having an attractive capability for bee hiving. Unfortunately, they do not mention its use as a tanning substance, due to the high percentage of tannins in its leaves and stems. However, in this respect, the mention of this use by Laguna (1890) in his *Flora Forestal* has always been well known, neglected or marginalized but the Andalusi agronomists do not say anything about the quality and use of its timber either, although it was appreciated by carpenters and turners, something also referred to by Laguna (1890).

With regard to the variability of this species, our Andalusi authors agree on the existence of wild varieties, as well as other cultivated (garden) ones, whose mention cannot be overlooked. They are not likey to be referring to any different species, and so this mention is indicative of the process and degree of domestication that this species acquired at that time.

Celtis australis L.

A Mediterranean species of a doubtful authochtonous nature in the Iberian Peninsula, where it appears in ravines and borders always related to former human settlements since it was always highly appreciated for its wood. Indifferent to edaphic status, it prefers loose, fresh and deep soils. This tree was widely cultivated as an ornamental, fruit-bearer and especially for its timber, which was very useful in water management. Andalusi agronomists highlighted its great virtues. It was planted near boundaries, hedges, walls and water pipes. It was valued not only because of its shade, beauty and fruits, but also for its pliable and flexible timber, good for turning, and hard and resistant to rotting. All these reasons made it valuable for all kinds of craft activities, mainly for making pitchforks, oars, wheels, buckets, rims and other devices to convey water, such as mills. The 'Umda includes the name *balubunuh*, a term derived from Roman "good stick", alluding to the good quality of its timber. In fact, mulberry trees have been one of those most highly appreciated trees in al-Andalus gardens, farmhouses and agricultural lands, and they are indelibly linked to many of their archaeological and historical remains (for example, around Madinat al-Zahara, in Córdoba), where they mark the layout of water ditches and channels, of roads and boundaries. Other less known uses are also mentioned, for example the use of their ashes for drying and preserving grapes.

Rhus coriaria L.

In the Aramaic language, *sumaq* designates the colour "dark red" and the sumac berries. The name was transported to European languages via Arabic *as-summaq* [السماق] "sumac". This species probably arrived in the Iberian Peninsula under Arab influence, and its cultivation became very extensive in al-Andalus. Some vestiges have remained after populations of sumac were established in the wilds in several places in the Iberian territory, especially in Castilla - La Mancha, Levante and Andalusia (Subbético de Córdoba and Sierra Bermeja, for example, where they characterise the landscape). It was probably economically important, especially being used as a tanning substance due to its high tannin content. During summer, this plant`s branches were cut, dried for a couple of days and tied into bundles, then ground with animal-drawn rollers.

Sumac was also employed as a dye, using its leaves and young stems to obtain a greenish yellow dye, its roots cork red dye and its fruit brown, black and grey dyes (Maciá, 1996). Pharmacological uses are also known, due to its astringent, anti-diarrhoeic, anti-scorbutic and fungicidal properties. However, nowadays interest has been revived in its culinary uses in Eastern Mediterranean countries such as Turkey. Sumac fruits were already used many centuries ago as an acidulant, substituting lemons or vinegar, and they are now used dry in Lebanese and Syrian cooking as a typical condiment for fish. The Iraqis and Turks put them in salads, and the Iranians in skewered meat. Poured on rice, they give it a reddish colour. This fruit is one of the ingredients of the spice mixtures called **zahtar** and **dukka**. These culinary uses are precisely mentioned by Andalusi agronomists such as Abu al-Jayr or Ibn al-Awwam, who indicate, for example, its employment in olive seasoning and turnip and other vegetable pickles. From the *Nabatean Agriculture* on, authors mention the use of its seeds for making a special kind of bread eaten in times of famine.

Pistacia vera L.

The genus *Pistacia* includes ten species distributed throughout the North-East of Africa (including the Canary Islands), South-East of Europe, central and Western Asia and Southern regions of North-America. These are small trees and shrubs, 5-15 m tall, with alternate, compound, pinnate leaves, some of them evergreen and others deciduous. *Pistacia lentiscus* and *Pistacia terebinthus* grow spontaneously in the Iberian Peninsula, while *Pistacia atlantica*. grows in the Canary Islands. The three species are frequent in the North of Africa.

Pistacia vera, the pistachio (also called "alfónsigo" in Spanish, from the Arabic term **fustuq**) has its origin in Central Asia. It soon spread through Western Asia and the whole Mediterranean area, and was undoubtedly known and cultivated in al-Andalus. All the Andalusi agronomists mention it, even the author of 'Umda (11th and 12th centuries), textually, says that he knows about its cultivation in Andalusi lands, although he adds that the best fruits come from Syria. However, its cultivation was probably neglected after the Hispano-Arabic age, and it then became a marginal species not quoted by Alonso de Herrera (16th century), although it reappeared in Dantín Cereceda (1943). López González (1982) considers it to be a recent reintroduction into Iberian agriculture, where it is slowly gaining importance. The exact comments about it in the 'Umda prove the good knowledge about its cultivation. For example, many Andalusi agronomists mention the species's dioecious character or make other accurate comments about cultivation techniques. They know about its longevity and the advantages of seed propagation instead of trying the vegetative way, and they describe rare techniques for obtaining male and female specimens from the same crop, which are difficult to understand in current science. They are also accurate in their description of the most appropriate soils and correct watering and tilling methods, also recognising its powerful root system, which makes them drought-resistant. With regard to grafts, an expected practice nowadays, those authors were also accurate when recommending its combination with mastic tree and terebinth. Among its qualities, it strengthens the stomach, the nerves and the liver, and is used for chest and lung diseases. Mashed and drunk with wine it is used to relieve bug bites. Iran, Turkey and Syria are still today the biggest pistachio-producing countries in the world (together with the USA).

Punica granatum L.

The genus ***Punica*** contains two species *P. granatum* (going from the Eastern Mediterranean region to India) and *P. protopunica* (from the Socotra Island). Pomegranate, called **rumman** in al-Andalus, was intensely cultivated and mentioned by Andalusi agronomists as being agricultural and ornamental species ("*are planted near the well and the zafariche",* recognising flower varieties), as well as growing spontaneously in the field, because, as a consequence of its intense cultivation, it became wild and was then called ***yullanar***. Its fruits were much appreciated as a food, besides having many other uses (insect repellents, dyes). It also has medicinal properties, some of them recognised by current science. Andalusi agronomists also suggested its having antioxidant values, due to the polyphenols contained in the juice of its seeds (Ibn al-Awwam says: "*pomegranates avoid the rancour and envy among men*"). Al-Tignari says: "*sweet pomegranate syrup is good for dry cough, it facilitates expectoration and bowel movements; the one made with the acid variety tones up the hot? stomach and prevents the bile"*. It was also used as a diuretic and for heart palpitations. Nowadays, it is known that pomegranate seeds contain alkaloids, such as punicalagin, used for the control of colon cancer. Pomegranate cultivation has been recently increasing, but it is still a minority fruit tree.

Ziziphus jujuba Lam.**,** ***Z lotus*** Lam.

The genus ***Ziziphus*** contains almost forty species. Only ***Z. lotus*** grows spontaneously in Europe. Another species from China, called *azofaifo*, has also been very well known since ancient times (***Z. jujuba***). ***Z. lotus,*** was used – and still is today - in some regions of the North of Africa, as a thorny hedge to protect crops (for example vineyards). It has been seen in this guise in, for example, Marrakech. In the caliphal city of Madinat al-Zhara in Córdoba, it was probably also used for this purpose, since certain population kernels of this species are still conserved around this archaeological site, which constitutes an unusual locality far removed from its distribution area. In the Andalusi agronomists' texts, both species are mentioned. According to Ibn al-Awwam, *unnab*, *nabq* and *zifzif* –and its variants- are synonyms referring to the same tree, probably corresponding to ***Z. jujuba.*** The rest of the Andalusi agronomists clearly distinguish between the jujube (*azufaifo*), an allochthonous arboreous species used for its fruits, and the lotus (*nabq*), a bushy wild species**.** Abu l-Jayr is the author who best distinguishes both species, and although he did not say much about them, he at least makes it possible to establish a relationship between the term *unnab* and the ***Z. jujuba***, and *nabq* and *sidr* with ***Z. lotus***, *grafted first* (Carabaza & al. 2004). *Azofaifos* are nowadays marginal fruit trees in Iberian agriculture, although they remain in the people's memory, even associated with certain religious holidays in the Christian calendar (*Feria de la Fuensanta* in Córdoba, for example).

Vegetable and industrial species and spices

More than thirty vegetable and grain crops, probably cultivated in al-Andalus with culinary uses in mind and mentioned by Andalusi agronomists, are nowadays neglected or merely marginal. Some of them are considered to be weeds and grow in ditches and slopes of the Iberian agriculture, sometimes even receiving pejorative names in Spanish (*bledos, cenizos, malvalocas, apio caballar, trigo sarraceno*). Among them there are species of *Amaranthus*, *Anchusa, Atriplex, Borago, Chenopodium, Cichorium, Cynara, Eruca, Fagopyrum, Lepidium, Malva, Portulaca, Plantago, Rumex, Scorzonera, Silene, Smyrnium, Silybum. Taraxacum, Tragopogon,* and others. The habit of collecting certain species from their wild populations has been conserved throughout the times (for example *Silene vulgaris, Portulaca oleracea, Taraxacum* sp.). Other species were introduced but not consolidated as wild weeds (ephemerophytes), and so they disappeared almost completely from the Andalusi agricultural landscape (*Colocasia esculenta, Cucumis flexuosus, C. metuliferus, Fagopyrum esculentum, Hibiscus esculentus, Nuphar* sp., *Aloe vera*). There were important spice crops, whose use is almost testimonial, such as *Ocimum basilicum* or *Coriandrum sativum*. Basil pollen appears abundantly cited in the archaeopalinological records of *Madinat al-Zahra*, the old caliphal city from the 10th century in Córdoba (Martín-Consuegra & al. 1995, 2000a, 2000b). Some crops were substituted by others that arrived later from America, i.e. *Lagenaria siceraria, Gossypium herbaceum, G. arboreum* or *Vigna unguiculata*. The disappearance of the cultivation of thorns, a group of species from the *Asteraceae* family, was especially significant, since these were important horticultural crops, for example, *Silybum marianum, Cynara cardunculus, Scolymus hispanicus* or *S. maculatus*. Certain dye species such as *Indigofera indica, Isatis tinctorea* or *Chrozophora tinctoria* contributed to the development of textile industries in fibres like silk (related to *Morus alba,* also a neglected species), linen (*Linum usitatissimum*), hemp

(*Cannabis sativa*) or Spanish broom (*Spartium junceum*).

Part of the importance of these species has been recently revived, for example, in *Aloe vera* or *Eruca vesicaria* subsp. *sativa*. Others are waiting for their chance and are currently localized crops , of only a relative importance because of their medicinal or culinary uses (*Silybum marianum, Ocimum basilicum*). Finally, others were rescued from oblivion after their transport and transculturation to America, taken by Andalusi colonizers (*Cichorium intybus*, *Coriandrum sativus*). The particular case of some of these species is analysed below.

*Horticultural thorns: golden thistles, spotted thistles and other thorny thistles (***Scolymus hispanicus, S. maculatus** *and* **Silybum marianum***)*

Some of these were important crops, like ***Cynara cardunculus*** **L.**, ***C. scolymus*** **L.** *or* ***Carthamus tinctorius***, and many other thorny species of the Compositae family (popularly called thistles) were cultivated for the use of the basal rosette of their leaves, their fully developed leaves (usually whitened by earthing up the plant), or their soft capitula (artichoke-like). These plants had other virtues such as their medicinal or condiment properties.

Scolymus maculatus and ***S. hispanicus***

Spotted and common golden thistles have been used as wild plants for a long time in the entire Mediterranean basin, and also cultivated ones like those in Andalusi agriculture. These are very rustic annual plants, which grow best in clayey soils. They are planted at the end of winter, using their basal rosettes in spring, before blooming. In both cases, this species is widely spread through southern Europe, North Africa and south west Asia on waste land (edges of paths and croplands) They were probably well known in al-Andalus, considering the numerous names they received from the ‘Umda’s author: **aqnitus, bardūnaš**, **burdūn**, **bardāğ, tāġdūt, tāfaddu** *Scolymus hispanicus* L. and *Scolymus maculatus* L. “***cardillos***”, “***tagarninas***”. *T&B nº 190 taġeddut*, Šafīq II 304 *taġeddiwt.***)**, **fadālīq**, **qardāğuh, saqūlūmis**. Among all these names, it seems that the identification of ***Scolymus maculatus*** clearly belongs to **qardāğuh**, due to the morphological description and uses of this plant. The Spanish term *tagarnina* appears to be derived from the Berber term **tāqirnīnah.** Berber village people boiled its leaves and stems with milk *“having the property of quenching one’s thirst, strengthening one’s heart and being useful to relieve high temperatures; it is diuretic, removes underarm odours and urine smelliness”*.

Silybum marianum Gaertn.

This is a species of the *Cardueae* tribe with a similar geographical distribution and ecology to the last two species and is nowadays used for its medicinal properties, which even makes it the object of cultivation, mainly because of the presence of sylimarin, a group of flavonoids which acts as a powerful hepatic protector, regenerating liver cells. It is used in diseases such as cirrhosis, viral hepatitis and jaundice. It lowers cholesterol levels, helps to dissolve gall stones, acts as an anti-hemorrhagic, and is also a powerful antioxidant. Besides its medicinal virtues, milk thistle has been popularly used by eating its soft leaves in salads, or cooked, once its thorns have been removed. Its soft capitula are also eaten like small artichokes. Some Andalusi agronomists mention the growing of this species, which is associated with ***Cynara scolymus***, ***Cynara cardunculus*** and ***Onopordum*** spp. Other

Andalusi authors such as Ibn Bassal or Ibn al Awwam explain its cultivation techniques.

Cereals and leguminous species

Several cereals that are nowadays considered to be secondary ones were very important in Andalusi agriculture: einkorn wheat (*Triticum monococcum*), spelt wheat (*Triticum spelta*) and emmer wheat (*Triticum dicoccum*). Also very important were sorghum (*Sorghum bicolor*), millet (*Panicum miliaceum, Setaria italica)* and possibly other species of *Pennisetum, Echinochloa, Eleusine* or *Eragrostis*).

Among the grainy leguminous species used for human food neglected nowadays are: white pea (*Lathyrus sativus*), sicklefruit fenugreek (*Trigonella foenum-graecum*), vetches (*V. monanthos, Vicia ervilia* and *V. narbonensis*), as well as the blackeyed pea (*Vigna unguiculata*), already mentioned among horticultural species, very frequently used in Andalusi cooking and agronomists even included remedies to relieve the flatulence that they caused.

Neglected ornamental species

Some ornamental species also underwent changes in the catalogue of plants employed. On the one hand, the arrival of species from all over the world as well as the domestication and progressive diversification of cultivars enriched the world of ornamental species. However, on the other, certain species fell into disuse, oblivion or disinterest. Thus, oleasters (*Elaeagnus angustifolia*), chinaberry trees (*Melia azedarach*) and love trees (*Cercis siliquastrum*), which reached the Eastern Mediterranean region during this age, progressively became forgotten. Some species of the genus *Narcissus* were much more important then than nowadays, and the same happened with wallflowers (*Erysimum* spp.), violets and pansies (*Viola* spp.), or lilies (*Lilium candidum*). Trees such as the hackberry were a notable element in gardening and were also neglected for several centuries; they are recovering their value again since they are important substitutes for elms, threatened by Dutch elm disease. It has been attempted to domesticate many wild species, taking them "from the field to the garden", for example. holm oaks, junipers, strawberry trees and yews. A study on the main ornamental species used in al-Andalus can be found in García-Sánchez & Hernández-Bermejo (2007), in which some plants today in disuse are mentioned. Complementary to that work, some information on the introduction and culture of ornamental bulbs (*Narcissus* and *Tulipa* species) can be found in Hernández-Bermejo & García-Sánchez (2009).

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Making the most of wild and relict species - experiences and lessons

Abstract

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Today's narrow agricultural basket is a major concern for the future of humanity. Calls by the FAO for World leaders to devote greater attention to agricultural diversification have so far received very limited response (Swaminathan 2005). Crop choices made during the Neolithic Age still represent today the basis of our global food production systems (Janick 2001). Through its focus on the provision of calories to meet the demands of a burgeoning population, the Green Revolution has neglected the need for minerals, vitamins, micronutrients and other functional properties from food crops, particularly in developing countries. A shift of paradigm of agricultural efforts is advocated through the launching of an "Evergreen Revolution" which would address nutritional and health concerns through a more effective and sustainable use of agricultural biodiversity (Swaminathan 2006). Such an objective would rely heavily on crop genetic resources and on an array of species, variously called neglected or underutilized (Padulosi & Hoeschle-Zeledon 2004), till now largely sidelined by research and development efforts. In this paper, we present examples from a typical underutilized crop, hulled wheats (einkorn, emmer and spelt), which have returned to the limelight in Italy in recent years and that of a multi-purpose species, sumac (*Rhus coriaria* L.), today a relict crop in Italy, but still very popular in the Middle East. Lessons learned from studying these species are proposed along with suggestions for the sustainable promotion of species of similar significance and conditions.

Introduction

From the beginning of the practice of agriculture around 10,000 years ago in the Fertile Crescent and other regions of the world (Zohary & Hopf 1993, Balter 2007), farmers and then scientists have selected crops and varieties with specific traits in order to satisfy a diverse range of human needs, including food and nutritional security, tasty meals, medicinal remedies, fibre for clothing, fodder for feeding livestock and also meeting social, cultural, religious and aesthetic desires (Heywood 2007). Along with these, other factors have also shaped crop production systems around the world. These include the ability of crops to adapt to specific agro-ecological conditions and their capacity to help farmers to seize emerging economic opportunities arising from new trends, market and uses for crop genetic diversity and its products. Such factors still play a profound role today (albeit in different ways than in the past) influencing crop choices and determining continuing change in the preferences of species and varieties grown in the field (Jarvis & Hodgkin 2000). The history of agriculture is characterized by the establishment in various locations and at various times, of crops which have become "major" while others have continued to be cultivated only locally, and have survived until today in a marginalized state (Janick 2001). Some of these crops have disappeared to the extent of becoming true "relicts".

Today, few crops dominate international trade, only around 30 staple crops feed the world, and only three – rice, wheat and maize - provide more than half of the world's food supply despite the fact that over 30,000 plant species are edible and about 7,000 have been or still are cultivated to some extent for food (FAO 1996a). At a national level, these few staple foods are supplemented by a range of other food crops (Prescott-Allen & Prescott-Allen 1990, FAO 1996b). The dependence on this relatively small number of food crops raises serious concerns about the sustainability of feeding the world in the future and feeding it well (Swaminathan 2005, Frison 2005, Raschke & Cheema 2007). The alarming loss of agro-biodiversity at the onset of the Green Revolution led to the genetic resources movement, and in 1974, to the establishment of the International Board for Plant Genetic Resources (IBPGR), today known as Bioversity International (Pistorius 1997), the largest international agency dedicated to the conservation and sustainable use of agro-biodiversity (Bioversity 2006). Thanks to the efforts made by national and international agencies to rescue crop diversity, today some 6 million accessions of germplasm are being maintained in more than 1,300 *ex situ* gene collections (Fowler & Hodgkin 2004). Many other species, variously described as neglected or underutilized have been left out of these "safety nets" and survive only in limited populations thanks to *in situ*/on farm conservation activities (Padulosi & al. 2002b).

More recent trends, including urbanization and increased purchasing power among certain segments of the population in both developed and developing countries, are significantly contributing to raise the demand for food diversity, including new specialty crops, high value and natural/biological products (Heywood 1999a, Senauer 2001, Senauer & Goetz 2003).

Emmer: Resurgence of a Roman staple in Italy

The history of emmer and its uses.- A recent example of a relict crop that is enjoying renewed interest among farmers and consumers in several parts of Europe, particularly in Italy, is that of hulled wheat. In Italy this crop goes by the generic name of *farro*, but in reality this one name covers three different species: einkorn (*Triticum monococcum*), emmer (*T. dicoccon*) and spelt (*T. spelta*). The name *farro* was originally used only for emmer, but now is used indiscriminately for all types of hulled wheat. These are amongst the most ancient cereal crops of the Mediterranean Region (Perrino & Hammer 1982). The cultivation of einkorn and emmer started in the Fertile Crescent about 10,000 years ago where it has continued to be grown (Helmqvist 1955; Harlan 1981; Zohary & Hopf 1993, Nesbitt & Samuel 1996). After Julius Caesar's invasion of Egypt in 30 B.C., emmer was introduced to Italy, where it was referred to as the 'Pharaoh's wheat' (hence '*farro*') and gained popularity in Italian cuisine. The nutritious grain became a staple at every level of Roman society, sustaining the Roman Legions and is said even giving rise to the Italian word for flour *farina*. Because of their adaptation to colder climates, einkorn and spelt spread across the Alps and northern Europe (D' Antuono 1989). Their decline began at different times ranging from 3,000 BC in Eastern Turkey to the 20th Century in Southern Germany and Switzerland (Nesbitt & Samuel 1996). Various hypotheses have been suggested as to the reasons for the decline of hulled wheat species, including economic changes, dietary changes and the introduction of new cereals.

Though there are few detailed studies that provide rigorous analyses of these changing crop patterns in different epochs, we can say that based on our understanding of the decline of spelt during the last 100 years, the two major factors involved in such a process seemed to be mainly economic pressure for higher productivity which led to the selection of free-threshing wheat, which is more responsive to increased inputs; and changes in eating habits as rural populations became more attracted to industrialized food markets (seeing hulled wheat as food of the rural and poor areas). Whatever the reasons, hulled wheats were progressively replaced by free-threshing wheat (*T. aestivum*) and continued to exist only in isolated and remote areas in the Italian Appenines or the Central Anatolian region of Turkey (Karagöz 1996). The cultivation of hulled wheat in Italy, for example, survived only in marginal mountainous areas and there primarily as a fodder crop (D'Antuono & Bravi 1996). Its use as a human food remained established only in the local traditions of two small production areas (Garfagnana and Valnerina in Central Italy) but it was not until the 1980s that such uses became documented and studied by scholars (Perrino & Hammer 1982, Perrino & Hammer 1984). According to Di Napoli & Marino (2001), emmer cultivation in Italy had been reduced to a few thousand square meters in the 1970s. Around the same time, spelt was introduced for commercial purposes to Italy from Germany (D'Antuono & Bravi 1996). Today, the area under hulled wheat production in Italy is predominantly emmer and is estimated at around 2,000-2,500 ha with yields of up to 3.5 t/ha (Troccoli & Codianni 2005; Buerli 2006).

Hulled wheats are processed into a range of modern and convenient products including pasta, biscuits, bread, porridge, gruel, a soup ingredient, cracked wheat or beer (Stallknecht & al. 1996). Today, hulled wheats are no longer considered the food of the poor as they were in the past. They have become an exclusive, fashionable food for which concerned consumers are prepared to pay a premium price (Heller & Padulosi 1996).

Hulled wheat has spread from the traditional growing areas to new sites due to the ability of the crop to adapt to marginal land while providing reliable yields, something modern wheat varieties fail to do. In these new sites, both traditional landraces and new varieties resulting from small breeding programmes are cultivated (Padulosi & al. 1996) and compete successfully on the market with the produce from traditional areas. The success of hulled wheats in Italy has contributed to the improved conservation of their genetic resources, which are under threat; einkorn, considered a true relict crop in this country, is now maintained in the *ex situ* gene bank in Bari together with local populations of emmer. According to the System-wide Information Network for Genetic Resources (SINGER), in October 2007 the world's genebanks contained 8,956 accessions of hulled wheats, made up of 1,502 accessions of emmer, 3,777 of einkorn and 3,677 of spelt. The largest collection of hulled wheats is held in Switzerland (2,392 accessions). The commercial success of this crop is, however, putting the traditional areas cultivated with these species under great pressure. Emmer, which has been typically produced by relatively poor, small-scale farmers in mountainous regions, is now being grown by richer farmers attracted by the high price of the crop, who cultivate it outside its area of popular cultivation. At the same time, market needs favour the cultivation of fields planted with selected varieties in the name of standardized cultivating practices and product uniformity. Emmer fields, traditionally a mix of different landraces, are becoming therefore increasingly uniform and poor in genetic diversity.

Marketing of emmer in Italy and beyond.- The increasing interest shown towards an old crop like emmer is associated with an observed growing attention paid by the public towards old traditions and the search for naturalness (D'Antuono & Bravi 1996). Until a few decades ago, emmer was consumed only by the rural communities who cultivated it. In the 1980s, health-conscious people and gourmets in the cities started to demand emmer. For the last few years now, emmer products have been readily available in traditional Italian food shops and even in modern supermarkets. Between 1998 and 2000 the market in Italy grew by a remarkable 15% per year and at the same time farm-gate prices for the raw material increased by 30% a year. This increase is due largely to the direct marketing of emmer by farmers within the agro-tourism circle, a form of holidays spent on farms where home-grown agricultural food products are served and also sold to tourists (Buerli 2006). From there, consumption has spread to other groups and even other countries, including the United States and Canada (Buerli 2006). Specific marketing strategies such as certified organic production or certification of the geographic origin (Vazzana 1996) have added to the success of emmer products on the market.

An enabling environment for increased emmer consumption.- The success of *farro* in Italy would not have been possible without the support of the research community and policy makers. Alerted by the loss of hulled wheats and their genetic erosion, Bioversity International launched a Hulled Wheat Genetic Resources Network, an outcome of the first international workshop on hulled wheats held in 1995.

The Network's activities contributed to raising the awareness of both growers and scientists about the increasing genetic erosion of hulled wheats taking place in Italy and that led to a number of *ex situ* and *in situ*/on farm conservation activities along with greater collaboration on research activities dealing with characterization, breeding, agronomic improvement, value addition and the sustainable marketing of this crop.

Among the latest research initiatives promoted on hulled wheats in Italy is that of the National Institute for Agro-Economy (INEA) of the Italian Ministry of Agriculture, dealing with a multi-year programme on agri-food chains in the framework of broader intervention on the sustainable re-qualification of urban and rural areas of the Campania Region (Regione Campania 2004). The project includes, *inter alia,* interventions on cereals and hulled wheats, aiming at increasing the adoption of emmer varieties suitable for organic production and the development of transformation technologies to obtain novel food products. The Italian Research Centre for Plant Improvement (CERMIS), in collaboration with other national research institutes, contributes also to maintaining the genetic material of emmer and carrying out crop improvement, adaptation and morpho-physiological studies. This work is financially supported by the Region of Marche (CERMIS s.a.). Among the various Local Municipalities across Italy, which are very active in the promotion of emmer and its products, is that of Monteleone, a small city in the Umbria Region, where the culinary *farro* tradition is still very strong and popular and where the crop is being used as instrument of development and promotion of the hinterland (Porfiri & al. 1998).

These activities have contributed to raising dramatically the visibility of hulled wheats and market demand for it, and for emmer in particular, from consumers in the areas of production as well as at the national level.

A different story in Turkey

Current production.- Emmer continued to be cultivated as a relict crop also in Turkey. Here its production decreased radically from the beginning of the last century, due to the introduction of other wheat types and other cereals such as rice and maize. Today, the area under cultivation is limited to a small zone in the central and western part of the Black Sea Region in Kastamonu and Sinop Provinces. In these areas, the geographic altitude changes very rapidly from sea level to 2000 m a.s.l. within less than 15 km and the areas are considered to be harsh with varying conditions. As in most other countries, farmers in remote mountainous areas belong to the poorest part of the population. In the case of Turkey, 10% of the heads of the farm households that grow emmer are illiterate. Emmer is grown there as pure or mixed stands (with wheat) often on land resulting from deforestation due to overexploitation of forest trees, which is unsuitable for growing other crops as it is at a high altitude. Other small growing areas are found in Anatolia. The total area under emmer cultivation is estimated at 6000 ha with average yields of 1.5 t/ha. It is predicted that this area will be further reduced because of the high labour demand for emmer cultivation, harvesting and processing with no or low levels of mechanization. Growers are typically small–scale subsistence farmers. In average, they dedicate about 1.5 ha to emmer, which is about 25% of their total arable land. All production is rain-fed. It seems that the only reason why emmer is still grown in these areas, despite the low yields, is its high adaptability to poor soils and harsh environments without requiring much external input. For the type of farmers inhabiting these areas, cultivation of other cereals and improved varieties is not an alternative as these would require high inputs to produce reasonable yields (Giuliani & al. 2009). In the absence of a formal seed market, farmers use their own grains as seed for the following season or exchange seed with other farmers (70% of the producers). Knowledge about emmer cultivation is transmitted from generation to generation. No formal training or extension services are available.

The emmer market in Turkey.- Emmer once was a popular grain for human consumption, in particular for bread making Today, emmer is mainly grown for animal feed (three quarters of the total production) as livestock is more important in these areas than agriculture. Farmers harvest the grain and crack it before feeding it to the animals. Sometimes, the crop is also left in the field and the animals are allowed to graze on it. It is rarely used to make bread, but sometimes to make bulgur, which is a parboiled, sun-dried, de-husked and cracked product used in traditional soups, nowadays mainly made using wheat. People who still eat emmer bulgur consider it tastier and healthier than the wheat version. About 25% of the production is designated for human consumption, either for domestic use (farmers) or/and for sale as bulgur (farmers-traders). In Sinop province, farmers grow emmer only for their own consumption. Therefore no value chains exist. In Kastamonou Province, production is also offered on the villagers' market in Kastamonu town, mainly during the month of September, immediately after harvest. Availability of emmer to the consumer is hence also limited to this month. The value chain is as simple as that of emmer in Italy, though much less organized. Farmers are not organized and the chain lacks horizontal and vertical integration.

The overall environment for emmer.-Agricultural policy in Turkey strongly supports the production of wheat as a staple food. Premiums are paid to farmers who use certified seeds. There are no released emmer varieties in Turkey, hence no availability of certified seeds. Emmer growers therefore cannot benefit from these government incentives. Since 2002, a "Direct Income Support" scheme is in place. Under this scheme, farmers can apply for cash support depending on the amount of land they own (Turkish New Lira 120/ha). However, this incentive does not seem to be attractive to all farmers. Applications for this support have to be filed in person at the Agricultural Provincial Directorates, which are not easy to reach for the remote emmer farmers. With their small land holdings they would also receive only a meagre amount. According to Giuliani & al. (2007), in one particular area surveyed in Kastamonu Province, the number of applicants decreased by 20% within a period of six years. This could also be an indication that the poorest farmers with very small land holdings, who are the emmer producers, had left the area and abandoned agriculture.

Since the introduction of modern wheat varieties and the increasing urbanization in Turkey, emmer is considered poor people's food. However, there seems to be a new attitude in the major cities towards healthy food, preferably from organic production. This is reflected in the choice of certified organic whole wheat pasta and bulgur available in supermarkets and shops in wealthier areas of the cities (Giuliani & al. 2009). This new trend and the existence of certifying bodies are an opportunity for the revival of emmer production and consumption in the country.

Tanner's Sumac: A relict multipurpose crop and its fortunes

Sumac (*Rhus coriaria* L.) is a shrub of the *Anacardiaceae* family distributed around the Mediterranean Sea. One of 250 species of the genus *Rhus* occurring in temperate and tropical regions worldwide, *R. coriaria L.* is thought to have originated in the north of Iraq (Aoudat & Barkodah 1979) and today is present in Sicily, Western Asia, parts of the Arabian Peninsula and Central Asia (Polunin & Huxley 1987). The word sumac traces its origins back to the Aramaic language, referring to the red colour of its berries, while in Modern Hebrew it means spice. The species name *coriaria* refers to the use of the plant by the tanning industry (from the Latin corium meaning leather). These two different main uses of the crop (spice and tanning) have contributed to the continued use of the plant since Roman times. However, while the use as spice is today still much practiced in the Middle East, its use as tanning agent is no longer common due to technological innovations developed by the leather industry, which have substituted sumac products. In addition to these two uses, sumac has been popular in the local pharmacopeia thanks to the astringent characteristic of its tannins which act as a traditional remedy for dysentery. Use of sumac as anti-tumour, haemostat and for mouth gargle is also reported (Duke & al. 2003) and infusions made from sumac fruits are used widely to treat stomach upsets and ulcers of the mucous membranes (Turker & Usta 2006). Sumac leaves and fruits have demonstrated properties as anti-bacterial substances (especially for harmful bacteria in the intestine) (Lauk & al. 1998; Fazeli & al. 2004; Rayne & Mazza 2007)

Tanning leather industry and sumac.- The use of sumac as a tanning agent for leather dates back to Roman times. It is believed to have been introduced to Sicily by the Arabs during the 10th Century (Carì 2006) via Turkey where *R. cotinus* L. and *R. coriaria* L. were popular in Turkish markets for dying leather and woollen clothes (Türkmen & al. 2004).

Apart from *R. coriaria L.* (tanner's sumac), tannin is also extracted from the leaves of other species of sumac such as the American sumacs *R. copallina* (dwarf sumac), *R. glabra* L. (smooth sumac) and *R. typhina* L. (lemonade sumac). The tannin from sumac has been much appreciated in the past for its ability to produce gentle tanning of white or light-coloured, soft and supple leathers and because of the fact that the leather treated with sumac has great resistance to ageing, it does not darken upon exposure to light and is less likely to decay than leather processed by other tannins. In Italy, the cultivation of sumac (known as *sommacco* or *corinna* in Italian) was popular particularly in Sicily where it was also used for the dying of yellow clothes and sacks known as "*coffa*" from the Arabic *cuffa* (Ferreira & al 2004) and nowadays many commercial materials are made from plant material, like "RETAN BLK-M", a mixture of tannins obtained from *R. cotinus* L. (smoke tree) and *R. coriaria* L. (SCRD.net 2008) The use of sumac in the tanning industry has nevertheless dramatically decreased over recent decades in view of the development of less expensive tannins.

Sumac, the irresistible spice of Middle Eastern cuisine.- Sumac is an essential spice in Middle Eastern cuisine. It is mentioned in the writing of Dioscorides 2000 years ago, along with a reference to its medicinal properties (Arndt 1988). The spice is obtained from grinding the whole panicle and the dust obtained is used to flavour a vast array of dishes. Its tart, tangy, sour flavour contributed to the popularity of the spice. Because of its lemon-like flavour, sumac was used for centuries by the Romans before the introduction of lemons by the Arabs, which took place in Sicily around 1000 AD along with the introduction of mulberry and sour orange (Carì 2006).

This spice is used to delicately enhance the flavours of foods. It is an excellent substitute for salt and for that reason it is recommended to those suffering from hypertension. It is used as a condiment in everyday cuisine in Syria, Lebanon, Iran, Iraq, Israel, Greece, Turkey and other countries in the Middle East and Central Asia. It is used directly on rice, salads, barbecued meat, mixed with freshly cut onions as an appetizer. Ground sumac fruit is the main component of very popular spice-mix in the Middle East called "*zahtar*" (made of sesame seeds, thyme, marjoram, ground sumac, fennel seeds and salt). *Zahtar* and olive oil spread over freshly baked bread are a common Middle Eastern breakfast.

Historical records of the cultivation of sumac in Italy are numerous: in the 18th Century, its cultivation in Mondello (Sicily) is documented as a very profitable agricultural activity (Lo Cascio 2000-2001, Regione Siciliana s.a.), and there are also records of cultivation in the areas near Trapani (Accardi 2004). In those days, sumac spice was a major commodity exported along with sulphur, wine, wheat, tuna fish and manna sugar (a sugary sap obtained from the bark of *Fraxinus ornus*). Its popularity led also to the development of a cultivation manual (Inzegna 1874). A century later sumac was still an important crop in Sicily, but by the mid 20th Century it was no longer so. In the Parliamentary session of 31 January 1961 a group of Italian politicians called on the Government to give greater attention to the cultivation of sumac and other local crops as a means of strengthening the Italian GDP (Repubblica Italiana 1961).

Today, sumac spice is grown in Italy much less than in the past, only in limited areas of Sicily such as Vizzini and Militello near Catania, and Messagno and Borgetto near Palermo, where it is part of the local production systems along with cereals, prickly pears and local vegetables (Provincia di Catania s.a.). Efforts to reintroduce the cultivation of sumac as a spice have continued, albeit with limited success, over the last 20 years (Di Fazio 1983). Lately, sumac's soil conservation properties have also been exploited for its reintroduction to Italy in anti-erosion forestation projects in the region of Tuscany (Regione Toscana 2000).

Relict vs. popularity.- The case of sumac is interesting from the viewpoint of a crop faced with a dual destiny. The replacement of sumac with other products by the tannin industry has determined its dramatic decline, to the extent of becoming a relict crop in Europe and other North Mediterranean countries. On the other hand, the same species in the South Mediterranean-West Asian area does remain a highly popular spice and its use continues to be strongly embedded in local culinary traditions. That has led to a continued use of *Rhus coriaria L.*, but interestingly enough without an impact on the level of research required to strengthen the sustainable conservation and use of this species.

One of the countries where sumac is today mostly used as a spice is Syria. In this country the majority of production is obtained from wild stands and there are no organized cultivated fields of sumac. Domestication, selection and crop improvement of sumac do not exist, and knowledge of cultivation practices, multiplication and conservation of the genetic diversity of its wild populations is very scarce. The same can be said for most of the countries in the Near East where sumac spice is very popular, including Turkey, where the production of this non wood forest product was estimated at 62 tonnes in 1999, entirely harvested from wild stands (Özuğurlu & Düzgün 2003). It is interesting to notice that until a few years ago, sumac was so commonly found that it was used to adulterate the more expensive herb oregano in Turkey (today this practice is no longer possible due to more rigorous food safety measures present in the country).

Genetic diversity of sumac and cultivation practices.- An eco-geographic survey project was carried out in Syria during the period 2004-2006 (Al-Haj Ibrahim 2007). The research aimed at shedding light on the eco-geographic distribution of sumac, characterizing the diversity of economic traits in its wild populations and documenting local uses and the economic role of sumac in local livelihoods. The study showed that sumac shrubs are highly adapted to a different range of ecological conditions and identified a typical value chain of sumac in Syria related to both uses as a tanning agent and a spice.

In order to understand better the genetic diversity of sumac, a comprehensive morphological characterization based on over eighty characters (10 growth characters, over 70 shoot system characters and several phenological observation characters) was performed. The study revealed that sumac in Syria can be grouped under 2 major taxa, each including other minor taxonomic entities. The ethnobotanic survey indicated also that the majority of people interviewed commonly harvested sumac for home consumption as a spice and at the same time harvested a large amount of fruit clusters for commercial purposes. Uses in traditional medicine, industrial applications, and environmental purposes were also mentioned by the respondents. Among the propagation methods, root cutting had comparative advantages over other methods (such as stem cutting, air layering, budding and grafting) as long as it is executed at the appropriate time and using suitable techniques (Al-Haj Ibrahim 2007).

What can we learn?

Literature is rich in examples of crops which were once well known and extensively cultivated and that have fallen into disuse for one or more reasons (Zohary & Hopf 1993). Similar reasons are also behind the non-domestication and absence of cultivation of other plants that are gathered directly from the wild and which therefore may not strictly speaking be called ‘crops’ (Heywood 1999b).

The reasons behind the abandon and neglect of domesticated species are numerous, including the following:

- Agronomic: e.g. due to the lack of improved genetic material, uneven maturity or low yield potential (e.g. the decrease in cultivation of lupin and grass pea, which can be reversed through breeding of new varieties containing lower levels of alkaloids and so which do not cause lathyrism)
- Technological: e.g. due to lack of efficient cultivation methods, lack of processing technologies, low potential for mechanization of production and processing, low shelf life of harvested produce, lack of recognized quality standards (e.g. the decrease in the cultivation of quinoa and little millet which can be reversed through development of technology to remove the labour intensive processing)
- Cultural and social: e.g. due to the introduction of modern crops, urbanization, changing of traditional food trends, loss of indigenous knowledge;
- Economic: e.g. due to low economic returns from cultivation, low competitiveness with new introduced crops, labour intensive cultivation and processing, limited uses;
- Political: e.g. due to the presence of subsidies for competitive cash crops, lack of focus in national development strategies.

The process of declining attention on a certain crop can be gradual or take place over a short period of time. When the reduced attention is not accompanied by the documentation or transmission of indigenous knowledge related to the use of that crop, it falls into a state of abandon and eventually become a relict crop, growing only in a few populations in some home gardens. Future prospects of such crops may well include their complete extinction. This is the case of the vegetable garden rampion *Campanula rapunculus* reported as extinct in the 1820s (Mabberley 1997) or the Hausa bean *Kerstingella geocarpa*, a highly neglected crops described as occurring in the Guinean/Sudanian Woodland (Central-West African States) (Dalziel 1937, Verdocurt 1982), but currently found growing only in few populations.

One particular group of crops is that of medicinal species, for which the knowledge needed for continuing the appreciation and use of the plants, requires more attention than that given today (Padulosi & al. 2002a). The fact that 80% of the world’s population relies still today for their primary health care on traditional medicine and herbal remedies (WHO 2002), makes the loss of medicinal plants (which is among the greatest in absolute numerical terms), one of the worst problems affecting biodiversity and its sustainable use.

On the other hand, as the case of emmer in Italy demonstrates changes in food habits and lifestyle can lead to the rediscovery of a crop previously fallen into abandon and neglect. The emmer case in Italy clearly shows that this process is demand-driven and not initiated by the producers. The producers react on a specific demand from a particular powerful consumer group (health conscious, trendy people prepared to pay premium prices for specialty products). From this group the trend is steadily passing on to the "normal" consumers thus getting the crop out of the niche status. The role of the national and international media cannot be over-stressed. In addition to the private processors, they give the crop and the products made from it, wide publicity in newspapers, special journals and magazines. Emmer products received a further push as they were picked up by renowned restaurants all over the country, giving them a prestigious image. However, the producers would not have engaged in expanded emmer production without the strategic engagement of researchers and the private sector, as the inherent disadvantages of the crop remained unchanged. The technological support from the processors to farmers and their enthusiasm in the development of new products and processing technologies represent the driving forces in satisfying growing consumer demand and overcoming production constraints. Research has contributed with programmes on the conservation of landraces, the development of improved varieties and looking at agronomic problems. Support from the policy level is given through providing internationally recognized certification schemes such as Protected Geographic Indication and organic production. Producers who qualify for these labels benefit from higher returns from their production. Policy also supports the involvement of farmers in tourist activities and sales of agricultural produce on farm. This contributes to a higher awareness by consumers of traditional products. A combination of all these factors led to the resurgence of emmer in Italy and to its growing production and consumption.

In Turkey, the reasons for the decline in emmer production and consumption were the same as in Italy. However, there are no clear signs yet to allow the forecast of a change in the current situation. Turkey lacks the driving forces behind a potential change – strong consumer demand. This demand can only be stimulated by a reversal of the low image that emmer products currently have. This is where the role of the media and health and education policy-makers is crucial. Unless the available information about the dietary advantages of emmer compared to other grains is diffused by inclusion into the basic education, university curricula, health programmes and in the mass media, consumers will not demand it. There is also a lack of innovativeness among the private companies producing cereal based foods. They need to start experimenting with new products that include emmer.

With regard to the sumac situation, the fact this crop has been used by people in several ways, has been in itself a sort of insurance policy for its continued existence. In particular, its use as a spice has ensured that the crop did not fall into oblivion after the drop in its use by the leather industry in the 20th century.

A number of general lessons could be drawn from these examples, and other cases reported in the literature, on the "fall and (possible) rise" of agricultural crops:

Diversity of uses: The more diverse the spectrum of uses of a species, the higher the likelihood of surviving changes in agricultural policies, life styles, dietary trends. Diversity in uses, just like genetic diversity, is key to the continued survival of crops. This is closely linked to the following lessons, viz.

Cultural erosion: The widespread erosion of local traditions and knowledge is the root cause of the loss of hundreds of species worldwide. Such a loss can be stemmed through proper interventions such as appropriate, timely documentation of indigenous knowledge, empowerment of local communities to increase their self-esteem and recognition of their own identity and culture which is safeguarded also through the continued use of local crops and species.

Conservation of genetic diversity: Ups and downs in the popularity of a crop are a common feature in crop usage patterns over time. The ultimate appreciation of a crop by people is the result of several factors such as the utility of the crop in satisfying specific needs, the convenience provided by the crop compared to other crops and products, fashion trends, cultural and historical background of people, etc. The loss of both genetic diversity and indigenous knowledge should be prevented through strategic interventions using *ex situ* and *in situ* conservation methods;

Getting the evidence: The various values of crops (economic, nutritional, medicinal, cultural etc) call for greater attention by research and development. Detailed studies to provide scientific and empirical evidence and to document information about the crops would allow better advocacy for the conservation and sustainable use of biodiversity, particularly neglected and underutilized species, and hence contribute to their valorization over time.

Role of users: Contrary to the past, nowadays, consumers play a more active and pivotal role in defining the level of use or neglect of agricultural biodiversity. They can contribute through the initiation of new trends in consumption or following or not trends promoted by industry and/or media. Conservation efforts led by R&D should be better linked to consumers and that raises the issue of how effective we are in conveying our messages on the benefits from biodiversity to consumers. More effective public awareness campaigns are therefore needed, including those targeting younger generations. Greater linkages between R&D and Fair Trade or other movements sensitive to sustainable use of biodiversity should be promoted;

Enabling policies: National and international policies have so far aimed at the protection mainly of crop varieties that are uniform, distinct and stable (in line with the requirements needed to fulfill plant breeders' rights). Legal protection of wild, neglected, underutilized or relict species, typically represented by landraces and ecotypes, is very limited and should receive greater attention. The suggestion, for instance, of expanding the list of species in Annex I of the International FAO Treaty for PGRFA during the anticipated review of this list to include such species would be an important step in that direction and should be further promoted and supported.

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U. Plitmann, E. Plammer, L. Hanus & O. Cohen

Domestication of native Mediterranean spices with an emphasis on apiaceous condiments

Abstract

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Over 70 species of indigenous condiments are grown in cultivation, locally or widely, in the Mediterranean Region, the Near East and the surrounding countries. Over 30 belong to the *Lamiaceae* (leaf condiments), a dozen or more to the Apiaceae (fruit/seed and leaf condiments), the rest belong to several other families. Most have been known as useful (particularly medicinal) plants since Greek-Roman times, or even before, i.e. for over twenty centuries. Yet, there is no study on their domestication pathway or the selection trends during this process. Accordingly, our aim has been to find out such evolutionary changes. We hypothesized that selective changes would be revealed in the productivity of the species, in their germinability and dispersal, and in their chemical constitution.

To test the hypothesis, 7 species and varieties of the Apiaceae family were chosen: *Coriandrum sativum* (wild populations vs. cultivated variety), *Apium graveolens* (wild and cultivated), *Apium nodiflorum* (wild populations), *Anethum graveolens* (cultivar) as compared with the phenetically resembling *Ridolfia segetum* (wild). All are considered herbaceous self-compatible units.

The methods used were in accordance with the purposes: field surveys, censi and collections, growing the plants in a net-house, studying their life-cycle and productivity (numbers of flowers, fruits and seeds), measuring fruit and seed dispersal, chemical analyses of aromatic compounds and essential oils in both leaves and seeds with gas chromatography/mass spectrometry (GC/MS).

The results substantiate our hypotheses: (1) In all treatments, germinability of the cultivated species is considerably higher than that of the wild populations (over 70% vs. 0-60% respectively); (2) Seed-/fruit- set in the cultivars is usually higher (25-45%) than that of the wild populations (1.2-20%) with the exception of coriander (65% seed-set in the supposedly wild populations); (3) The chemical spectra of the wild species or populations are rather wider, with numerous aromatic compounds, than those of the cultivated plants, whereas the later feature fewer compounds but with higher concentrations in both leaves and seeds. In this respect, one of the conclusions is that taste, combined with the olfactory sense, could function as important selection factor in the breeding of condiments, and very probably in the domestication of other food plants.

Introduction

Based on data compiled from various sources (French 1971; Rosengarten 1973; Morton 1976, 1977; Bailey & Bailey 1977; Purseglove & al. 1981; Duke 1985, 1992; Heywood & Zohary 1995; Small 1997; NIIR Board 2006) and relevant Floras, we have compiled a database of the indigenous condiments that are cultivated in the Mediterranean region. It stores information on over 70 species grown in cultivation, locally or widely, indigenous to the Mediterranean region and the Near East. The families and the life-form of the species are shown in Table 1. Alien cultivars, which amount to a few dozens, and wild condiments with no related cultivars were excluded.

Many of the species belong either to the Lamiaceae (usually leaf- or flower-condiments) and the Apiaceae (usually leaf- or seed/fruit condiments). Over 90% are annual, biennial, hemicryptophytes and shrublets, a few are tall shrubs and trees (e.g. *Laurus nobilis*).

Beside their usage for food flavoring and preservation, they are used for other various purposes: food additives (e.g. parsley), medicinal plants (e.g. fennel), tea flavors, and even as ornamental plants (e.g. *Salvia officinalis, Ruta,* species of *Artemisia*) .

Most of the cultivated condiments have been domesticated centuries ago (celery, for example, and see Helm 1972, Smartt & Simmonds 1995), especially during the Greek-Roman times or even before (e.g. garlic and onion, *Nigella sativa*). It means that hundreds of generations have been subjected to artificial (directional) selective pressure.

We consider that the first condiments had been collected from nature, as "folk condiments" (much like medicinal plants), later they were grown methodically and regularly (= domesticated) for permanent self-usage and for trade.

Unlike domesticated plants of staple food and several vegetables, there is no study focusing on the domestication modes of condiments and the trends of selection during this process. There are, however, many studies concerning the present agricultural and commercial situation (e.g., Diederrichsen 1996), and numerous investigations of the chemical elements responsible for the flavoring and medicinal effects, particularly the

Table 1. Families and life-forms of native Mediterranean condiments.

Family	Number of species	usable organs
Lamiaceae	31-32	leaves, sometimes flowers
Apiaceae	14-15	fruits/seeds, leaves
Compositae	6	leaves and flowers
Brassicaceae	6	seeds or leaves
Others	20	
Life forms		
Annual & perennial herbs	53%	
Shrublets	40%	
Tall shrubs & trees	7%	

diverse aromatic compounds and their bio-activity (e.g., Simon 1990, Singh & al. 2002, Kubo & al. 2004).

The family Apiaceae is replete with such investigations. Thus, multitudes of new compounds have been revealed since the summations in Heywood (1971) and the comprehensive study of Hegnauer (1973).

This family contains economically important species, several of which are multi-purpose (e.g. celery, carrots, even *Conium)*. All produce typical essential oils as well as other chemicals, some of which are highly toxic.

A few years ago, we have carried out a project for the Israeli Gene Bank, on the wild relatives of Apiaceous condiments (and medicinal plants) growing wild in Israel. Part of this project was dedicated to comparisons between wild taxa and their cultivated counterparts. These comparisons, by which we could deduce which changes had occurred in the process of condiment's domestication, are the basis of this study.

Hypotheses and aims

We assumed *a priori* that the selection pathways in the domestication of herbaceous Apiaceous condiments could have followed three main trends:

1. Higher rates of germination, particularly in annual/biennial species.
2. Higher reproductive rates expressed as number, size or dispersability of fruits (when seeds are the usable organ).
3. Higher relative concentrations of certain (aromatic) compounds, with reduction of other chemicals.

The first two trends are typical of other herbaceous domesticated plants (Smartt & Simmonds 1995; Plitmann & Kislev 1989). The third trend might characterize condiments and medicinal plants in general.

Other possible trends could include: seasonality and (later, mainly in modern times) augmentation of vegetative biomass, especially in condiments consumed also as vegetables.

Thus, our principal aims have been to reveal particular changes that occurred during the domestication of Apiaceous condiments. By these, we could learn the trends of selection in this process. Specifically, we have focused our investigations on changes in reproductive, physiological and chemical characters of the fruits (seeds), being the main target of selection, and also compared the chemical constitution of the leaves.

Materials and methods

Materials

There are almost 120 species of Apiaceae in Israel and Jordan (Zohary 1972). According to our database, 18 species are considered useful plants and/or related to economic cultivars. For our study, we have chosen five species that present wild and domesticated taxa, as follows:

1) *Apium graveolens* L.: 11 wild populations, phenetically much resembling the cultivat-

ed stocks. The populations were located near rivers and springs, growing on more or less salty soils.

A. graveolens cultivars: 2 identical cultivars.

This species is annual or biennial.

A. (Helosciadium) nodiflorum (L.) Lag.: 8 populations.

It is a perennial herb, growing in or close to fresh water, with strong vegetative propagation.

2) *Coriandrum sativum* L.: 7 wild populations [Fig. 1], one of which (from the Golan Heights) is suspected as feral, two others could be escaped from cultivation becoming feral/wild. Mt. Carmel populations are very probably wild, growing in clearings among the natural Mediterranean vegetation.

C. sativum cultivars: 2 identical cultivars.

All are annual, short-living plants.

3) *Ridolfia segetum* (L.) Moris: 11 populations. It is an annual selfer, rather common, growing as post-harvest weed in dense populations in fields. It is common in the East Mediterranean and used locally as a substitute for dill (*Anethum graveolens*)

4) *Anethum graveolens* L.: 2 different cultivars from S European origin but grown in Israel

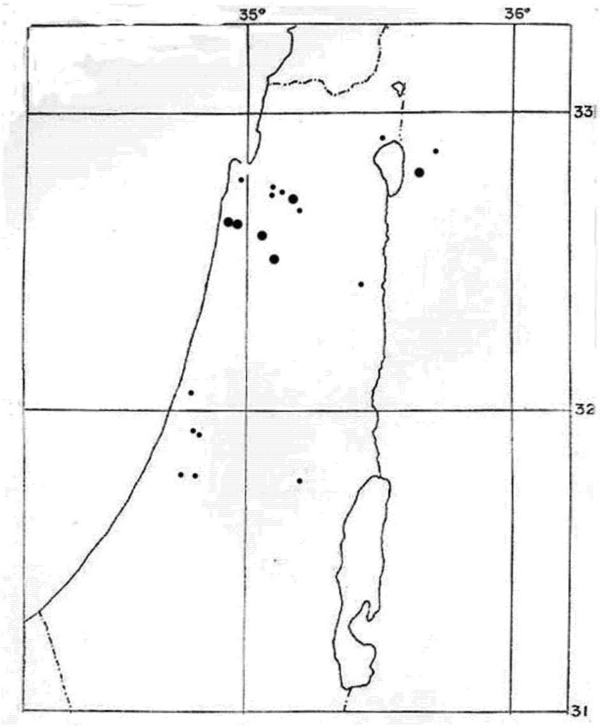

Fig. 1. Distribution of *Coriandrum sativum* in Israel. **O** = investigated sites, **o** = herbarial sites.

for local consumption. This annual taxon is resembling *Ridolfia* (common in the E Mediterranean) in vegetative morphology, scent and usage.

All are self-compatible and produced seeds in insect-proof nethouse.

Pituranthos and *Foeniculum*, though similar in flavor and usage, have been early excluded, for various reasons: they differ in life-forms from the rest (tall hemi-cryptophytes or shrubs) with unknown breeding system, and the latter is not a typical cultivated condiment, being under intensive chemical-medicinal investigations. Besides, one of the two *Pituranthos* (Deverra) species, *P. triradiatus*, is known as very poisonous plant, especially for cattle.

Methods

Field work included collections of material and surveys to prepare a "passport" that characterizes each wild population (phenology, density, morphological variability, and ecological conditions in the habitat). The collected plants and fruits were used for further examinations such as diaspore behavior, germinability, chemical analyses.

The plants were grown in an insect-proof nethouse, in pots (with rich soil, about 3 plants per pot), 15-40 plants of each species, in two successive years. These plants served for phenological (life-cycle) observations, as well as for the above-mentioned examinations. Since seeds of wild *Coriander* from the Carmel did not germinate, we grew young plants transplanted from their natural habitat.

Besides, in 5 plants of each population or cultivar, numbers of umbels, flowers, fruits and seeds were scored in order to calculate their seed-set.

In the germinability test, we have used Petri dishes with 20 seeds in each, for each of four sets: darkness - cold pretreated and not pretreated seeds, day light – cold pretreated and not pretreated seeds (the latter used as control), with 2-3 repetitions at different dates.

For the chemical analyses we have adapted the methods of Barazani & al. (1999). For the extracts (cold extractions), we have measured 40-50 g of dried matter or seeds, and the solvents were ethanol, petroleum ether or hexane. The various extracts were analyzed in gas chromatography/mass spectrometry (GC/MS) for their aromatic compounds or essential oils.

The results of the life-cycle and phenological comparisons are excluded from this paper being out of its scope, and are reported and discussed elsewhere (E. Plammer, MSc Thesis).

A detailed list of populations and their "passports", and procedures of extractions are available from the Authors.

Results

The results are summarized in Tables 2-5.

Germinability (Table 2): lower germination rates are experimentally obvious in the wild populations. The difference between the wild populations and the cultivar is noticeable in *Coriandrum* but also significant between other pairs. Seeds of the wild coriander did not germinate in any of the usual treatments and probably need special treatments or

Table 2. Rates of experimental germination.

SPECIES	WILD POPULATIONS (%)	CULTIVARS (%)	STATISTICS (ANOVA)
Coriandrum sativum	0 10 (probably escaped)	80-90	significant difference
Apium graveolens	30-45	55-70	significant difference
Ridolfia segetum	36-55		
Anethum graveolens		56-74	

climatic conditions in order to germinate. The feral population retained some germinability yet significantly lower than the cultivar.

Reproductivity (Table 3): in general, there is a significantly higher seed-set in most cultivars, seemingly not at the expense of the vegetative biomass. This situation exists even in leaf-condiments (where lots of seeds are needed for raising the next annual crop). Such a goal was readily achievable in multi-flowered plants like *Apium, Anethum* and *Ridolfia*. It is more problematic in *Coriandrum* in which the wild and the feral types produce relatively more seeds, as compared with a leaf-cultivar.

On the other hand, disengagement of the diachene into two units is almost nil in coriander, and most of the ripened fruits remain for long attached to the mother plant. In this species, non-dispersal seems to be a pre-adaptation. Separation (disengagement) of the two units is higher in the wild type of *Apium graveolens* and similar in *Ridolfia* and *Anethum*, both actually being leaf condiments. In the latter species the plants shed most of their fruits but always few to many (up to 30%) remain attached to the drying umbels.

Table. 3. Seed set and dispersability.

SPECIES	PRODUCTIVITY R = SEEDS/FL %	% OF DETACHED MERICARPS	NOTES
Coriandrum sativum (wild)	64.8 *	0	
C. sativum (cult.)	44.6 *	0	leaf condiment
Apium graveolens (wild)	15.5 *	55	
A. graveolens (cult,)	24.6 *	45	leaf condiment
A. nodiflorum	1.1 *	-	vegetative propagation
Ridolfia segetum	18.5 *	>70	leaf
Anethum graveolens	29.0 *	>70	leaf

*) difference significant at $\alpha = .05$

Chemical analyses (Tables 4, 5a, 5b): some of the results of the chemical analyses are partial or just indicative and we are working at present to complete these analyses. Moreover, it is known that several factors may affect the expression and variability, even the intensity of the smell, of the plant's (defense/ secondary) substances (e.g. biological - the population genetic structure; the developmental phase; the organ; environmental – habitat's ecology; season). In spite of these handicaps, certain indications are quite obvious, as follows.

Diversity of compounds (Table 4): the number of peaks in the output graphs of the chemical profiles of each species served as an estimate of the diversity of compounds. Note, however, that there are more peaks than the number of determined substances since many compounds could not be identified (e.g. over 7 compounds in the seeds of wild/escaped coriander, over 7 compounds in the leaves of *Ridolfia segetum*). Some of those compounds are probably intermediate in the biosynthetic pathway.

Generally, wild types feature higher chemical diversity than cultivars. There is a higher diversity in the leaves of the wild types of *Coriandrum* and *Apium* (but lower diversity of

Table 4. Diversity of compounds.

SPECIES	EXTRACT	ABUNDANCE (lower) LEVEL	NUMBER OF PEAKS
Coriandrum sativum – wild	leaves-organic	1/1000000	27
	“ ethanol	1/1000000	9-10
C. sativum – cult.	leaves-organic	1/1000000	15-16
	“ ethanol	1/1000000	8
C. sativum – escaped?	fruits-organic	4/1000000	5-6
	“ ethanol	2/100000	13
C. sativum – cult.	fruits-organic	4/1000000	6-7
	“ ethanol	2/100000	10
Apium nodiflorum	leaves-organic	1/1000000	4
	“ ethanol	3/100000	8-9
A. graveolens - wild	leaves-organic	1/1000000	15
	“ ethanol	3/100000	11-12
A. graveolens – wild	fruits-organic	2/1000000	6
	“ ethanol	2/100000	7-8
A. graveolens – cult.	fruits-organic	2/1000000	4
	“ ethanol	2/100000	3-4
Ridolfia segetum	leaves-organic	2/1000000	19
	“ ethanol	1/1000000	16
Anethum graveolens	leaves-organic	2/1000000	5-6
	“ ethanol	1/1000000	2-3
Ridolfia segetum	fruits-organic	1/1000000	1-2
	“ ethanol	4/100000	2
Anethum graveolens	fruits-organic	1/1000000	5
	“ ethanol	4/100000	2

aromatic compounds in *Apium nodiflorum*). Likewise, the chemical diversity of the seeds is higher in the wild populations of *Apium graveolens*, probably in *Coriandrum*. In the latter species, the chemical diversity of the fruits of the "escaped" population is almost equal to that of the cultivar.

The diversity in the leaves of the cultivars is lower than in the leaves of the wild plants, in organic/ethanol extracts; the fruits of the cultivars feature lesser diversity than in the wild types. Exceptions are *Apium nodiflorum* (low diversity in the leaves) and *Anethum graveolens* (chemical diversity of the fruits is higher than in *Ridolfia segetum*, both leaf condiments).

Chemicals: Tables 5a, 5b sum up the identified (mostly aromatic) compounds abundant in the investigated taxa. In order to simplify the table, we have omitted common fatty acids (like palmitic and linoleic acids) as well as several compounds present in minor concentrations (lower than 0.5 %) even if some of them may be species-specific or biologically functional.

Cultivars usually contain fewer compounds, some in concentrations higher than their wild counterparts, some even missing in the wild types. For example, selinene and b-caryophyllene have much higher concentrations in the leaves of *Apium* cultivars, the aromatic ethylebenzene is significantly more abundant in the leaves of the cultivated *Coriandrum*, and a-phellandrene is present in the leaves of *Anethum graveolens* in 43-48.8 % vs. less than 7.1 % in *Ridolfia segetum*. Likewise, in the seeds of the cultivated *Apium*, 4-vinyl-2-methoxy phenol has 1.0 % vs. less than 0.15 % in the wild type; in the seeds of *Coriandrum,* linalool is present in the cultivar with 32.5-72.7 % vs. less than 13.3 % in the wild type; and *Anethum* seeds have 96.7 % carvone, vs. 2.1 % in *Ridolfia.*

On the other hand, certain compounds, probably with biological activity, are more abundant in the wild types. Some of these may function as attractants, several others as defense mechanisms (e.g. in the species of *Pituranthos*).

Discussion and conclusions

In this study we have tried to reveal the differences between wild and cultivated Apiaceous condiments, from which we can deduce the evolutionary trends and pressures in their initial domestication.

The results substantiate our hypotheses that during the domestication process of herbaceous Apiaceous condiments, selection pressures were directed towards (1) higher germinability, (2) higher seed reproduction being beneficial to both growers of seed- or leaf-condiments, and (3) augmentation (higher expression) of particular chemical compounds, or certain secondary metabolites, leading to evolutionary changes of the chemical spectra.

Considering these trends in the investigated Apiaceae, what were the pathways or mechanisms of condiment's domestication? Since we have not dealt with recent, "professional" breeding activities (e.g. formation of leaf– and rootstock varieties of *Apium graveolens*), our conclusions apply to the initial, "ancient", domestication. Likewise, our conclusions may not apply to shrubby perennials: this life-form has been difficult to grow and reproduce on the one hand, and such plants (like *Foeniculum)* present a more or less permanent and constant supply of usable material from nature.

At those ancient times, people have already had a long history of experience of collecting seeds and fruits, picking leaves, uprooting underground organs, plucking (tearing off) whole plants (like lentils and coriander), and – as farmers – growing them in cultivation. The growers used their senses and former knowledge to select plants from the wildlife around them and introduce those into cultivation. For spices, the sense of taste, naturally combined with the olfactory sense, should have been the major selective means.

As noted, other characters selected for were originally reproductive (e.g. larger fruits

Table 5. Identified aromatic compounds abundant in the leaves (a) and fruits/seeds (b) of wild and cultivated apiaceous condiments.

(a) Leaves

Taxon	ethanol extraction		hexane or petroleum ether extraction	
Apium graveolens wild	limonene [70.7]	β–selinene [9.8-12.5]	limonene [6.9-36.3]	β–selinene [16.4-34.6]
	benzenacetyldehyde [2.3]		ethylbenzene [2.0]	β–caryophyllene [<1.0]
	myrcene [1.0]	-decanes [6.4]	neophytadiene [1.6-21.1]	xylenes [<1.0]
			α–terpinene + terpinolene [0.9-2.9]	
			hexahydrofarnesyl acetone [2.9]	
			-decanes [1.7-5.3]	
Apium nodiflorum	β–caryophyllene [15.5-19.2]		β–caryophyllene [15.8-31-8]	
	α–caryophyllene [1.1]		α–caeyophyllene [<1.0-1.9]	
	caryophyllene oxide [13.9]		caryophyllene oxide [21.3]	
	dillapiole [33.3]	neophytadiene [10.8-19.5]	dillapiole [8.9-14.9]	neophytadiene [8.7-17.2]
	hexahydrofarnesyl acetone [4.2]		bicycloelemene [3.6]	γ–elemene [5.2]
	bicycloelemene [1.2]		limonene [2.0-6.9]	aromadendrene [1.9]
	β–selinene [<1.0]	α–copaene [<1.0-2.6]	α–copaene [2.1-3.4]	germacrene D [1.8-2.1]
	bicyclogermacrene + germacrene D [3.1]		bicyclogermacrene [4.4-6.4]	
	aromadendrene [1.0]	-decanes [6.3]	α–terpinene + terpinolene [3.8]	
			-decanes [2.3-4.1]	penta-nonacosane [1.5]
Coriandrum sativum - wild	oleoamide [7.1]	γ–sitosterol [1.4]	oleoamide [4.1]	1-docosene [3.3]
	undecanoic acid [<1.0]	-decanes [1.2]	n-nonane [2.5]	-decanes [6.8]
			decanal [1.2]	n-nonanal [<1.0]
			dodecanoic + tridecanoic acids [2.6]	
Coriandrum sativum – cult	stigmasterols [1.8]	myristic acid [<1.0]	stigmasterol [1.8]	ethylbenzene [5.9]
	linolates [2.3]	neophytadiene [<1.0]	linolates [8.9]	xylenes [2.7]
			decanals [<1.0}	-decanes [3.2-19.4]
			neophytadiene [<1.0]	γ–sitosterol [<1.0]
Ridolfia segetum	dillapiole [>2.5]	p-cymene [8.5-14.4]	p-cymene [2.1-9.9]	p-cymen-8-ol [2.9]
	α–phellandrene epoxide [5.6-7.1]		α–phellandrene epoxide [4.3-5.3]	
	p-cymen-8-ol [1.0-2.4]	-decanes [1.0]	dillapiole [3.6-12.4]	α + β–pinenes [2.0]
	(acetic acid [11.8-15.5])		α/β–phellandrenes [3.7]	limonene [2.4]
			pentacosane [2.7-6.7]	nonacosane [1.7]
			xylenes [10.5]	-decanes [2.4-7.1]
			trans-caryophyllene [<1]	
Anethum graveolens cult	α–phellandrene [48.8]	o-cymene [11.0]	α–phellandrene [43.0]	β–phellandrene [2.5]
	p-cymene [2.7]	sabinene [3.7]	o-cymene [4.3]	α–pinene [1.5]
	cyclohexanone [7.3]	myristicin [2.2]	cyclohexanon [2.7]	myristicin [2.9]
	β–myrcene [1.1]		limonene [<1.0]	decanes [<1.0]
			dill ether [<1.0]	dillapiole + apiole [<1.0]

Table 5. Continued.

(b) fruits/seeds

Taxon	ethanol extraction		organic extraction	
Apium graveolens – wild	limonene [20.5]		limonene [11.9] naphthalene [13.4]	α–selinene [<1.0]
Apium graveolens – cult	4-vinyl-2-methoxy phenol [1.0] carvone [1.7]		limonene [6.3]	carvone [<1.0]
Coriandrum sativum – feral	n-undecane [33.0] trans-2-heptanal (13.0]	n-decanal [1.1] butyrolactone [1.5]	geranyl acetate [2.7]	
Coriandrum sativum – cult	linalool [8.2-13.3] α–terpinolene [59.3] eicosane [1.8] tetra- octa-decanes [27.4]	dodecanoic acid [4.3] geranyl acetate [2.4] DL-camphor [<1.0]	linalool [32.5-72.7] borneol [5.3] ethylbenzene [1.4]	geranyl acetate [11.2-21.4] n-octane [3.4] un- do-decanes [19.1]
Ridolfia segetum	apiole/isodillapiole [27.4] carvone [2.1]	dillapiole [29.9]	dillapiole [95.5]	
Anethum graveolens – cult	carvone [96.7] cis-dihydrocarvone [<1.0]	limonene [<1.0]	carvone [93.1] oleic acid ethyl ester [1.8]	ethyl octacanonate [1.7] limonene [<1.0]

[in brackets - % in the specific extract(s)]

in the feral population of coriander, originally raised for seeds; inhibited disengagement of the fruit) or physiological (germinability, phenology).

However, in accordance with the function/utilization of condiments, the selection was principally chemical, i.e. expressed in chemical differences. The explanation for the chemical differences is that wild populations have to retain a diversity of defense compounds (as, for example, in. *Apium* species), whereas the domesticated units have been subjected to directional selection for particular flavoring compounds, probably concurring with reduction or elimination of others, which may result in a lower chemical diversity. By raising the concentration level, higher efficiency and value of the crop are achieved. Accordingly, it is obvious from our analyses, that certain compounds are present in higher concentrations in cultivated condiments than in their wild counterparts, as detailed in the Results (Table 5).

By such selection, particular defense mechanisms (namely, defensive substances and attractants), which are rather common in *Apiaceae*, have been enhanced, augmented. This situation is in contrast to the selection trends “against nature” in many staple crops and edible fruits (and see Pickersgill & Heiser 1976, Smartt 1980, Plitmann & Kislev 1989, among others).

Summing up the typical and special identified compounds found in the investigated taxa, as based on our results (Table 5), relevant literature (Duke 1992, Miraldi 1999, Diederrichsen & Hammer 2003, Eyres & al. 2005, Pala-Paul & al. 2005, among others) and Internet reliable data, it seems that certain aromatic compounds are common to systematically different taxa thus featuring parallel homology, an evolutionary phenomenon which is rather common in Apiaceae at all levels. For example: limonene in the leaves of *Apium nodiflorum* and *Coriandrum sativum*, cymene and pinene in *Ridolfia* and *Anethum*; carvone in the seeds of *Apium graveolens*, *Ridolfia* and *Anethum*.

Certain taxa contain unique or comparatively highly abundant compounds which can be used for taxonomic determination and systematic evaluation. For example: selinene is typical of *Apium graveolens*, dillapiole of *Ridolfia* and linalool of *Coriandrum sativum*. For instance, according to such differences, we could identify *Apium nodiflorum* and distinguish it from *A. graveolens*.

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On the taxonomy and nomenclature of *Gnaphalium angustifolium* Lam. and *Helichrysum litoreum* Guss. (*Compositae*)

Abstract

Aghababyan M., Greuter, W., Mazzola P. & Raimondo F. M.: On the taxonomy and nomenclature of *Gnaphalium angustifolium* Lam. and *Helichrysum litoreum* Guss. (*Compositae*). — Bocconea 23: 157-163. 2009. — ISSN 1120-4060.

Taxonomic and nomenclatural aspects of a *Helichrysum* species scattered along the Tyrrhenian coasts of Italy are discussed. The problems of status and typification of the two names that refer to it, *Gnaphalium angustifolium* and *Helichrysum litoreum*, are solved. *H. litoreum* Guss., accepted as correct, is treated as an avowed substitute for *H. angustifolium* (Lam.) DC. [non (Lam.) Pers.]. Somewhat similar plants that have arguably arisen from hybridisation between *H. litoreum* and *H. italicum* are also discussed. They are best considered as a maritime ecotype of *H. italicum*, for which the name *H. italicum* subsp. *pseudolitoreum* is available.

Introduction

In their recent revision of the Mediterranean taxa of *Helichrysum* sect. *Stoechadina* (DC.) Gren. & Godr., Galbany-Casals & al. (2006) recognised as "*H. angustifolium* (Lam.) DC." a taxon spread along the Tyrrhenian coast of Italy, southward to the Eolie Islands, also sporadically extending, toward the N and E, to Istria and Dalmatia. The distinction between their *"H. angustifolium"* and *H. italicum* (Roth) G. Don is not always easy, as there are plants that present intermediate characters and have sometimes been considered as hybrids. The nature of these presumed hybrids is still open to some doubt. There is also the question of whether the fragmented area from which *"H. angustifolium"* has been recorded may have led to geographical differentiation into taxonomically recognisable taxa, and whether indeed the species as a whole is a natural unit or might have arisen repeatedly through parallel adaptation of the widespread *H. italicum* to maritime cliff habitats.

In addition to these problems of a taxonomic nature, which we consider as yet not fully resolved, there appear to be a number of nomenclatural inconsistencies in the treatments published so far, requiring clarification. They concern both the Tyrrhenian species itself and its presumed hybrids with *Helichrysum italicum.*

Taxonomy

As circumscribed by Galbany-Casals & al. (2006), *“Helichrysum angustifolium”* essentially consists of three geographically disjunct maritime, Tyrrhenian populations, growing, respectively, on the Eolie Islands NE of Sicily, in the surroundings of Naples including the island of Ischia, and in the coastlands and archipelago of Tuscany. In addition, isolated localities in Istria, Dalmatia and in the northern Apennines were mapped by these authors.

The species as a whole is variable, but any morphological boundaries that might be construed between the three Tyrrhenian populations are blurred by the conspicuous variation observed between their geographically discrete subpopulations (particularly those on individual islands). We therefore coincide with Galbany-Casals & al. (2006) in recognising the three Tyrrhenian populations as a single species, bearing in mind that future studies, notably those using molecular techniques, might eventually result in a clearer picture and justify a formal infraspecific classification.

By its involucral features (numerous, regularly imbricate, ± closely appressed bracts, the outer ones woolly on the back), this species is similar to *Helichrysum italicum,* from which it differs in capitulum shape (ovate-campanulate rather than conical-cylindrical at full anthesis) and flower number (23-30 against (13-) 15-18, on average). The differences in the vegetative parts are more pronounced: a more robust stem and thicker peduncles, longer, firmer leaves and a thick, felted indumentum of all parts permit a ready visual distinction from the slender *H. italicum* with its almost filiform, relatively short leaves and thinner indumentum, especially on the adaxial side of the leaves (see Fig. 1).

Outside of the well documented Tyrrhenian distribution area, a few published records of *“Helichrysum angustifolium”* from the Adriatic coast exist. Bedalov & Gaži-Baskova (1987) mention it, as *H. litoreum,* from Kornat Island, and Galbany-Casals & al. (2006) from the southern tip of Istria (two further mapped occurrences of theirs, which are not covered by their stated taxon distribution, we disregard as being likely due to misplaced symbols). We have not yet been able to study the corresponding specimens but are unconvinced that they really belong to the Tyrrhenian species. The taxon widespread in Croatia is *H. italicum,* which indeed may show some of the (particularly vegetative) features of the Tyrrhenian species when growing in cliff habitats under strong maritime influence. A definite conclusion must await the study of natural populations in the field, but for the time being we doubt the occurrence of *“H. angustifolium”* in Dalmatia.

A related problem is the existence of alleged hybrids between the Tyrrhenian species and *Helichrysum italicum*. Galbany-Casals & al. (2006) report them from three widely distant localities: Mt. Argentaro on the coast of Tuscany and, on or close to the Adriatic coast of Italy, the Gargano Peninsula and San Marino. Mt. Argentaro lies well within the area of *“H. angustifolium”,* but it is doubtful whether either of the presumed parents exists on the Argentaro promontory itself; rather, the postulated hybrids appear to form a separate population on Mt. Argentaro, in the absence of their possible progenitors. In the two other localities, from where we have not seen material, *H. italicum* is present close by – but not the Tyrrhenian species. Mt. Titano, the citadel rock of San Marino, is not far off the coast and might provide a suitable habitat for the latter. The same might be said for the Gargano Peninsula, were it not for the habitat mentioned (perhaps incorrectly?) on a corresponding label: sandy shores. In addition in Sardinia, where the Tyrrhenian species is absent, there

Fig. 1. Specimen of the Naples population of *Helichrysum litoreum*, collected just west of Gaeta. reproduced by kind permission of the Herbarium, Museo di Storia Naturale, Università di Firenze (FI).

is a further population of plants that cannot be told apart from the Mt. Argentaro taxon. It is reported by Bacchetta & al. (2003), under the name *H. italicum* subsp. *pseudolitoreum* (Fiori) Bacch. & al., from near Buggerru on the island's south-western coast, The only other *Helichrysum* present in that area is *H. saxatile* subsp. *morisianum* Bacch. & al.

Whereas morphology would support the hybrid nature and proposed parentage of these plants, the biological context does not. The obvious interpretation, to us, is that they originated from *Helichrysum italicum* as a coastal ecotype of rocky habitats that is best recognised as a distinct subspecies, because at least on Mt. Argentaro and presumably also in Sardinia it forms autonomous populations. The question of whether the plants from Gargano and St. Marino belong to it or, rather, are aberrant individual variants of otherwise typical *H. italicum,* as one may well suspect, can be answered only by population studies in the field.

Nomenclature and typification

The problem of establishing the correct nomenclature of the Tyrrhenian species is surprisingly complex. The following names have been applied to representatives of *"Helichrysum angustifolium"* in the sense of Galbany-Casals & al. (2006).

Gnaphalium angustifolium Lam., Encycl. 2: 746. 1788 ≡ *Helichrysum angustifolium* (Lam.) DC. in Lamarck & Candolle, Fl. Franç. ed. 3, 5: 467. 1815 [non (Lam.) Pers. 1807]. – Lectotype (Hilliard & Burtt 1981: 238): "*Gnaphalium angustifolium* Lam. Dict. / *Elichrysum umbellatum, maritimum* 452 / *Chrysanthemum* [+ description] // *Elichrys. umb.* Barr. / Ex Mont. Paucilypo ex agro Neap. / Chev." (P-JU No. 8536 [IDC microfiche No. 627-A4!]).

The type specimen undoubtedly belongs to the Tyrrhenian species, but the name is unavailable in *Helichrysum,* being a later homonym of *H. angustifolium* (Lam.) Pers. The latter is based on *Xeranthemum angustifolium* Lam. and designates a S African species. Furthermore, *H. angustifolium* is a confused name, because Candolle (1838) and subsequent authors applied it to the species now known as *H. italicum*. Gussone (1844) was therefore doubly right in rejecting *H. angustifolium,* under what are now Art. 53 and 57 of the Code (McNeill & al. 2006), when publishing the following name.

Helichrysum litoreum Guss., Fl. Sicul. Syn. 2: 468. 1844 ≡ *Gnaphalium litoreum* (Guss.) Bertol., Fl. Ital. 9: 133. 1853 ≡ *H. saxatile* var. *litoreum* (Guss.) Fiori in Fiori & Paoletti, Fl. Italia 3: 282. 1904. – Here defined as being an avowed substitute for *Gnaphalium angustifolium* Lam., based on the same type as the latter (see above).

Galbany-Casals & al. (2006) erred in considering *Helichrysum litoreum* an illegitimate substitute name for *Gnaphalium angustifolium* Lam. (see above). The question, then, is whether *H. litoreum* is to be considered as the name of a new species, to be typified by Gussone's original material (Code, Art. 9), or is technically a *nomen novum* based on *G. angustifolium* and typified by the latter's type (Art. 7.3). The Code is remarkably taciturn with regard to criteria to tell apart a replacement name or *nomen novum* from the name of a new species. The definition (so to say) of a replacement name is that it is an "avowed substitute", when the meaning of avowed, according to dictionaries, is "openly acknowledged" or "positively stated".

The distinction is easy when the later author does not provide a definition (description or diagnosis) of his or her own, or includes exactly the same elements as the earlier author in the newly named taxon. This is not so in the present case. On the one hand Gussone, in order to avoid confusion, explicitly (and legitimately) refuses to adopt the name *Helichrysum angustifolium* as it had been used for the wrong taxon *(H. italicum)* by Candolle (he ignored the existence of Persoon's earlier homonym), and he therefore adopted a different name – a procedure coming as close to "avowed" substitution as is possible without using the standard phrase *nom. nov*. On the other hand he does not refer to any material from near Naples, his description being based on the material he himself collected or observed on seven of the Eolian Islands.

There thus appear to be two ways to deal nomenclaturally with *Helichrysum litoreum* Guss.: as the legitimate name of a new species or as an avowed substitute for *Gnaphalium angustifolium* Lam. In such cases it is appropriate to follow established custom, in conformity with Preamble 10 of the Code. As it is customary to apply Gussone's name to the plants from the Eolian Islands, our conclusion must depend on the consequences of the application of either alternative for the typification of the name.

When treating *Helichrysum litoreum* as the name of a new species one must consider what original elements are available for the purpose of lectotypification. Gussone's original material consists of 5 specimens he collected in various of the Eolian Islands, preserved in his Sicilian Herbarium (at NAP!); a cited illustration of *"Chrysocoma marina, umbellata"* in Barrelier (1714: t. 1125); and a specimen cited in the following terms: "*Elichrysun, sive Stoechas citrina, minor,* Tourn. herb. in Mus. H. Paris". For the Eolian Islands Gussone only gives distribution data but no collector's name nor any other detail referring to an actual specimen. Therefore, the Tournefort element is the only one to have syntype status (Code, Art. 9.4) and, therefore, would be the obligatory lectotype (Code, Art. 9.10). This specimen (P-TRF No. 4090 [IDC microfiche No. 197-C1!]), unfortunately, does not belong to the present species. It bears an inscription that reads: "*Stoechadi citrini species, flore majore* / Ex Hispania circa Alicant / Collect. J. Petiver R.S.R". As far as is possible to tell from the IDC photograph, it belongs to *Helichrysum fontanesii* Cambess.

In the interest of nomenclatural stability we therefore prefer to consider *Helichrysum litoreum* as a replacement name for *Gnaphalium angustifolium,* as which it is typified by the plant of the Posillipo hill in Naples that is the type of the latter name. While not from the Eolian Islands, it at least belongs to the same species as Gussone's own material.

Galbany-Casals & al. (2006, 2006a) consider that the holo-, lecto- or neotypes of three validly published names belong to what they consider the hybrid between *"Helichrysum angustifolium"* (i.e., *H. litoreum*) and *H. italicum*:

"Gnaphalium glutinosum" sensu Galbany-Casals & al. (2006, 2006a) [non *Gnaphalium glutinosum* Ten., Semina 1830 Coll. Hort. Neapol.: 14. 1830; nec *Helichrysum glutinosum* A. Braun in Flora 24: 277. 1841].

Tenore published the name *Gnaphalium glutinosum* for plants from the sandy shores of Vieste and Peschici on the Gargano peninsula. (The protologue was reprinted unchanged, but with reference to the original place of publication, in Tenore, Fl. Napol. 4: (121). 1830[?], and Tenore, Syll. Pl. Fl. Neapol.: 424. 1831.) Galbany-Casals & al. (2006a) designated a neotype specimen from the same area (locality "Campo", presumably referring to Baia dei Campi south of Testa del Gargano). However, this neotype has no standing since original material exists, among which are syntypes from Sicily ("*G. crassifolium* et *G. ambiguum* Guss. pl. exsicc. ex Sicilia") which take preference for lectotypification purposes. As Tenore's name is anyway unavailable in *Helichrysum* (A. Braun's *H. glutinosum* is based on plants grown in Karlsruhe from Abyssinian seeds), the question of its typification is unimportant in the present context.

Galbany-Casals & al.'s (2006) hypothesis, that Tenore's plant from the shores of the Gargano Peninsula corresponds to the same biological taxon as the population on Mt. Argentario, has been discussed and rejected above.

Helichrysum italicum var. *pseudolitoreum* Fiori in Fiori & Paoletti, Fl. Italia 3: 283. 1904 ≡ *H. pseudolitoreum* (Fiori) Brullo in Arch. Bot. Ital. 65: 116. 1989 ≡ ***H. italicum*** subsp. ***pseudolitoreum*** (Fiori) Bacch. & al. in Inform. Bot. Ital. 35: 222. 2003. – Lectotype (Baldini 1995: 151): "Monte Argentario, Torre Maddalena, 3 June 1892, *Sommier* (FI!).

This name has priority at subspecies rank – which, as explained above, we consider to be the appropriate rank for the taxon in question – and also at the ranks of species and variety.

Helichrysum italicum f. *intermedium* Pamp. in Boll. Repubbl. San Marino 4: 118. 1920. – Holotype (fide Galbany-Casals & al. 2006a): Repubblica di San Marino, Monte Titano, vers. or., 15.10.1916, *Pampanini* (FI).

The rank of forma is seldom used nowadays, but some might feel it to be appropriate if our hypothesis holds, that Pampanini's plant is merely an aberrant individual in an otherwise "normal" population of *Helichrysum italicum*.

Conclusions

The *Helichrysum* taxon growing on littoral cliffs and small islands along the Tyrrhenian coast of Italy, forming three disjunct populations with several geographically isolated subpopulations, belong to a single species, the correct name of which is *H. litoreum* Guss. It is doubtful whether morphologically similar plants found further to the east, along the coasts of Istria and Dalmatia, are phylogenetically related to the Tyrrhenian species or rather, as would make better sense biogeographically, correspond to coastal ecotypes arisen locally, perhaps with concomitant gene introgression involving *H. stoechas* subsp. *barrelieri*.

The population growing on Mt. Argentario in Tuscany, and similar plants found on the coast of SW Sardinia, are morphologically intermediate between *Helichrysum litoreum* and *H. italicum,* but cannot possibly result from direct hybridisation between these two species. Rather, they derive from differentiation of coastal population of the second named species and are best considered as a subspecies of it, to be named *H. italicum* subsp. *pseudolitoreum.* Some plants from the Adriatic coastlands of Italy are said to show similar features morphologically, but it is unlikely that they form part of the latter taxon. They may represent local expressions of the overall variation of *H. italicum* proper.

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M. Ansaldi, M. F. Palla, G. Bedini & F. Garbari

Infraspecific variation in fragmented populations of *Rhododendron ferrugineum* (*Ericaceae*)

Abstract

Ansaldi, M., Palla, M. F., Bedini, G., Garbari, F.: Infraspecific variation in fragmented populations of *Rhododendron ferrugineum* (*Ericaceae*). — Bocconea 23: 165-176. 2009. — ISSN 1120-4060.

Rhododendron ferrugineum L. is mostly distributed in the Alps where it is distinctive of the subalpine vegetation belt. In the prealpine hills at the foot of Alps it grows in the lower part of the valleys in sciaphilous habitats such as chestnut woods or other deciduous broadleaved forest types, with an oceanic climate. Outside the Alps it is known only in few fragmented relic spots mostly on the summit of the Tuscan-Emilian Apennine (Pignatti 1982); the southern limit of its distribution is represented by a very small population recently discovered in the Apuan Alps (Ansaldi & al. 2004).

Because of its rarity in the Apennines, *Rhododendron ferrugineum* is protected (Alessandrini & al. 2003) under the Regional Laws of Emilia-Romagna (n. 2/1977) and Tuscany (n. 56/2000). It is also included as Vulnerable (VU) in the Red List of Emilia-Romagna and in that of Tuscany (Conti & al. 1997).

The Apuan population, confined to a very small area, has been compared with the other ones of the species range.

Distribution and demography of the Apuan and Apennine populations are described.

The results of morpho-anatomical analysis carried out to identify possible adaptative strategies to different environmental conditions, are also reported.

Moreover, biometric measures of the seeds collected from different populations are given and germination protocols elucidated, in the frame of *ex-situ* conservation of these fragmented populations.

Further observations on karyology are in progress.

Introduction

Rhododendron ferrugineum L. is an alpine-pyrenaic orophyte, characteristic of subalpine vegetation belt, common in the Alps range from 1900 m to 2200 m a.s.l.

It grows also in sciaphilous habitats in the Prealpine Hills at the foot of Alps, such as dense chestnut forests or other deciduous broadleaved communities under an oceanic climate: Sassina Valley, Ticino Canton (Mt. Ceneri down to 230 m a.s.l.), Lake Maggiore and near Ivrea (down to 300-350 m a.s.l.) (Pignatti 1982).

In the Apennines *Rhododendron ferrugineum* is very rare and confined to the summit of the Tuscan-Emilian Apennine (1750 – 2054 m a.s.l.) in few fragmented relic spots: Alpe di Mommio, Bocca di Scala, Mt. Vecchio, Mt. Prado, Mt. Libro Aperto, Mt. Tre Potenze, Mt. Spigolino (Ferrarini 1973; 1974; Pignatti 1982) (Fig 1).

During 2004 *Rhododendron ferrugineum* has been discovered in the Apuan Alps (Ansaldi & al. *2*004; Palla, 2005), in a sciaphilous stand at low altitude, under an oceanic climate. This habitat greatly differs from those of the populations of Alps and Apennines, while it shows great similarity with the Prealpine ones (Fig. 2 and 3).

Fig. 1. *Rhododendron ferrugineum* from Mt. Libro Aperto.

Fig. 2. *Rhododendron ferrugineum* from Fosso delle Rondini (Apuan Alps).

Fig. 3. *Rhododendron ferrugineum* from Fosso delle Rondini (Apuan Alps).

Conservation

Due to its fragmented distribution S of the Alps, the species is enclosed in the Regional Red List of the Italian flora, and is considered VU (Vulnerable) in Tuscany and in Emilia-Romagna (Conti & al. 1997). It is under protection in accordance with the Tuscan Regional Law (n. 56/2000, Annex. C), the Regional Law of the Emilia Romagna (n. 2/1977) and the Regional Law of the Lombardy (n. 33/1977); it is also listed in the Repertorio Naturalistico Toscano [Tuscan Naturalistic Inventory] (Di Fazio & al. 2004; Sposimo & Castelli 2005).

Aims of the research

This investigation aims to evaluate the size and the distribution of the populations present in the Apuan Alps and in the Apennines.

Comparison between morpho-anatomical measures of leaves from specimens of different populations, characterised by different environmental conditions, are carried out.

The germination protocols, in the frame of *ex-situ* conservation of these fragmented populations have been elucidated.

Materials and methods

Field surveys and collection of leaves and seeds from different populations were performed in the Summer 2004, 2005, 2006 in the Apuan Alps, Apennines, Prealpine Hills and Alps.

For the morpho-anatomical analyses, slides of leaf sections (fixation in FAA, dehidration with alcohol, inclusion in resin, section by Leica microtome) were set up.

Micrometric measures of some typical structures of dorso-ventral leaves, as cuticle, epidermis, palisade layer, vascular tissues, glandular scales, foliar thickness, were performed, and data were tested by statistical analyses to point out any significant differences beetween all the investigated populations.

According to APAT (2006) protocol, after cleaning and drying, seeds have been placed in suitable containers, and then in a –20ºC coldroom for two months. Mt.Vecchio seeds have been stored at room temperature for two years. 50 seeds, for 6 of the 7 populations studied (Alps population not tested), have been sown in Petri dishes with agar gel (1%) and incubated in a chamber set at costant temperature (21ºC) under a daily photoperiod (12/12h light/dark). Two additional replicates (Apennines and Apuan Alps) were first prechilled for one month at 5ºC. All germination tests were run for 42 days and seed germination was recorded every two days until the end of the experiments, considering germinated any seed with at least 2 mm of root-tip growth. During the germination tests the number of normal and abnormal seedling (APAT, 2006) has been recorded.

Results

The investigated populations (Fig. 4) are in the Apuan Alps (Fornovolasco, Lucca province), in the Apennines (Mt. Libro Aperto in Modena province and Mt. Vecchio in

Fig. 4. Map of the studied populations.

Lucca province), in the Prealpine Hills (Lugano in the Swiss Ticino Canton, Alpe Bess near Crandola Valsassina in Lecco province, Sueglio in Lecco province) and in the Alps (Lucmanier Pass in the Swiss Ticino Canton). Their altitude, aspect and habitat are given (Tab. 1).

Statistical analyses (ANOVA and Kruskal-Wallis test) show significant differences in all the examined leaf characters. Moreover multiple comparisons (Bonferroni and Dunn test) show that the populations with the highest number of different characters (10-12/17) are the ones of Lucmanier Pass (Alps - n. 5) and Apuan Alps (Fosso delle Rondini - n. 6), fol-

Table 1. Characteristics of *Rhododendron ferrugineum* stations.

Mountain range	**Altitude (m a.s.l.)**	**Aspect**	**Locality**	**Habitat**
Prealpine Hills	630	W	Lugano	Mixed forest with *Castanea sativa, Ilex aquifolium, Betula pendula* and *Pinus* sp.
Prealpine Hills	800	W	Alpe Bess	Deciduous broadleaved forest with *Quercus pubescens*, *Sorbus aria* and *Sorbus aucuparia*
Prealpine Hills	780	W-NW	Sueglio	Mixed forest with *Castanea sativa, Tilia* sp., *Betula pendula, Sorbus aria* and *Picea abies*
Apennines	1800-1900	N-NW	Mt. Libro Aperto	Grassland on debris and occasionally in the *Vaccinium* heathland
Alps	1900	N	Lucmanier Pass	Pastures
Apuan Alps	500	W-NW	Fornovolasco	Deciduous broadleaved forest with *Castanea sativa* prevailing
Apennines	1750-1980	N	Mt. Vecchio	*Vaccinium* heathland with *Empetrum nigrum, Geranium argenteum* and *Vaccinium vitis-idaea*

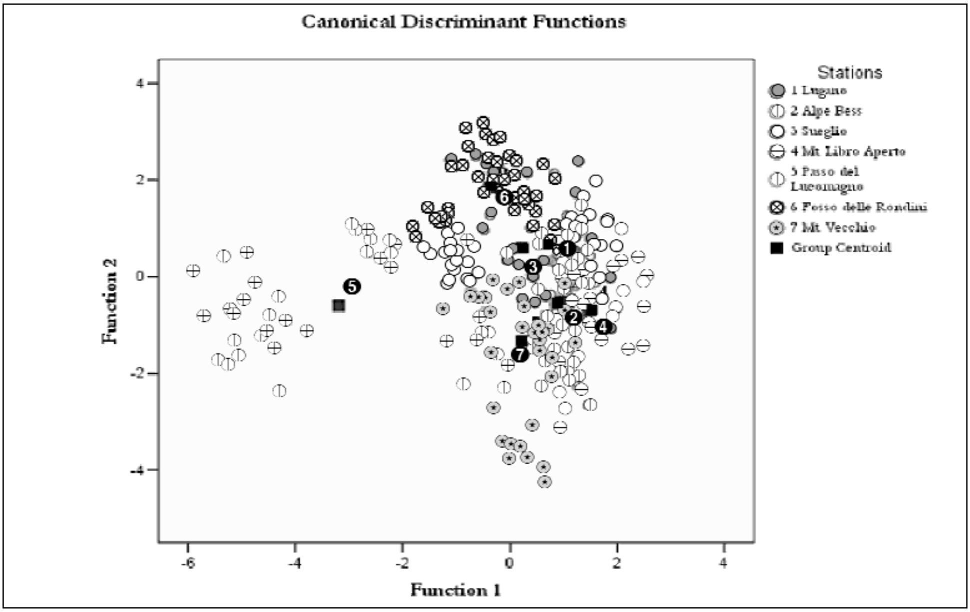

Fig. 5. Discriminant analisys.

Table 2. Measures (Mean ± Standard Deviation) of the dorso-ventral leaves structures (µm).

Station	**Prealpine Hills - Lugano**	**Prealpine Hills - Alpe Bess**	**Prealpine Hills - Sueglio**	**Apennines - Mt. Libro Aperto**	**Alps - Lucmanier Pass**	**Apuan Alps - Fosso delle Rondini**	**Apennines - Mt. Vecchio**	**statistically significant differences, %**
foliar thickness - on central vein	393,9±77,4	419,6±11,6	357,5±52,1	450,0±43,5	230,4±62,7	353,4±60,8	385,5±51,7	52,4
foliar thickness - far from central vein	212,4±21,9	248,1±37,0	226,6±24,2	275,5±29,8	251,3±63,2	177,7±22,3	266,4±41,7	**61,9**
palisade layer	91,2±18,5	119,5±30,6	92,2±13,3	129,2±36,4	147,2±79,4	66,8±9,0	131,2±39,5	**66,7**
upper cuticle - on central vein	9,0±2,0	9,6±1,8	7,9±1,6	6,8±4,3	9,6±6,5	6,8±2,2	6,3±2,6	42,9
upper cuticle - far from central vein	6,9±1,7	6,2±2,2	4,5±1,5	6,0±3,3	9,7±7,1	3,8±1,6	6,3±3,0	38,1
lower cuticle - on central vein	8,1±2,2	8,2±1,9	7,0±2,1	5,9±3,1	9,1±6,0	4,0±1,4	5,7±2,1	52,4
lower cuticle - far from central vein	3,6±1,4	3,0±0,0	3,0±0,0	3,1±1,6	6,3±3,7	1,7±0,6	2,3±0,7	**61,9**
upper epidermis - hight	10,3±2,9	12,0±1,5	12,3±1,7	11,5±4,1	18,0±6,3	14,8±2,4	13,2±2,2	33,3
upper epidermis - width	23,4±4,5	19,7±3,8	21,3±4,2	19,7±4,4	33,5±14,4	26,4±3,7	24,9±3,6	52,4
lower epidermis - height	10,6±3,0	11,3±2,1	11,2±2,3	12,0±2,9	18,5±7,0	11,8±2,9	11,9±3,4	28,6
lower epidermis - width	19,1±4,3	16,6±4,1	18,8±3,7	15,8±4,2	28,1±12,2	19,8±4,1	18,4±5,0	19,0
central vein - hight	236,8±36,3	232,9±17,6	213,3±51,7	244,6±30,6	134,5±42,8	192,3±29,2	202,9±34,8	57,1
central vein - width	291,4±45,6	268,5±45,9	261,3±40,1	334,3±75,1	183,2±62,7	291,6±62,7	231,4±34,2	52,4
secondary vein - hight	95,3±39,7	89,4±19,7	103,4±17,1	100,0±20,3	104,6±51,0	79,1±19,8	82,8±15,1	28,6
secondary vein - widht	51,9±16,4	58,3±11,7	62,2±15,3	70,3±25,8	83,2±35,2	68,6±19,0	58,5±18,3	28,6
glandular scale - hight	45,9±10,0	45,9±12,5	49,3±14,1	48,1±12,5	87,6±37,3	63,5±13,7	56,2±13,6	47,6
glandular scale - widht	223,5±36,8	217,3±28,7	236,3±44,1	251,2±30,8	326,3±36,2	243,9±47,1	243,7±40,8	19,0

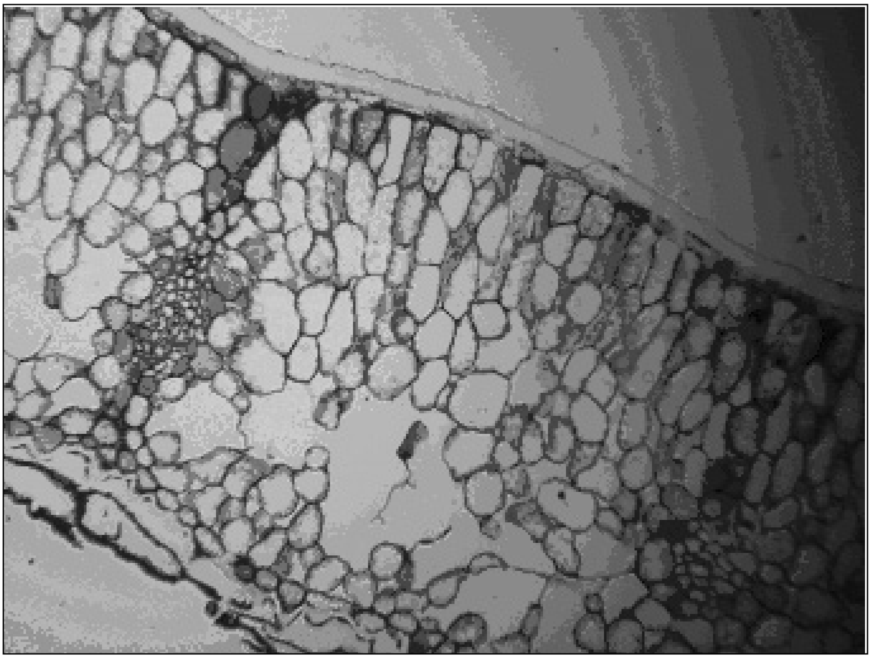

Fig. 6. Foliar sections (Mt. Libro Aperto, Apennines). ×25.

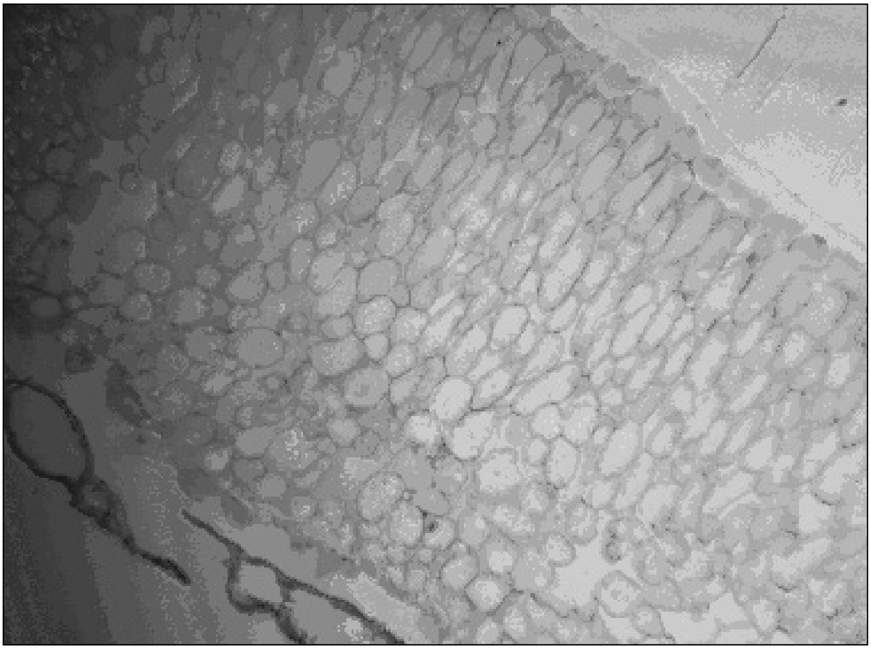

Fig. 7. Foliar sections (Mt. Vecchio, Apennines). ×25.

lowed by the one of Mt. Vecchio (Apennines – n. 7). This result is confirmed by the discriminant analysis (Fig. 5).

Statistical analisys also points out that the more divergent characters are: palisade layer, foliar thickness and cuticle (Tab. 2; Figs. 6, 7 and 8).

Statistical analisys also points out that the more different characters are: palisade layer, foliar thickness and cuticle (Figg. 6, 7 and 8).

Germination tests

Germination tests (Fig. 9) gave positive results with percentages between 60% and 80% for 4 out of 6 stations. No germination was recorded in Mt. Vecchio seeds. According to Leach (1961), this seedlot lost its viability as a result of conservation at room temperature.

The prechilling does not induce a considerable increase of germination percentage in both tested populations (Fig. 10); according to Romancier (1970), mature seeds of *Rhododendron ferrugineum* possess no dormancy and will germinate shortly after sowing.

Instead, prechilling enhances the percentage of normal seedlings (Figs. 11, 12); that is important for the *ex situ* and *in situ* conservation of this threatened species.

According to Flynn & al. (2006), *Rhododendron ferrugineum* seeds can be defined orthodox since they well sustained dehydration and conservation at low temperatures; these conditions are necessary for a long-term conservation of the germplasm. That allows to confirm the possibility to preserve this species *ex situ* in germplasm banks. This result is especially important for the populations of Tuscany and Emilia-Romagna that are subject to extinction risk.

Discussion and conclusions

Rhododendron ferrugineum is included in the Regional Red List of Tuscany and Emilia Romagna as a VU (Vulnerable) species because these populations are being in geographic isolation and at the boundaries of the fragmented distribution of the species; these populations are in fact relics of the ice age.

Especially the recently discovered Apuan population of *R. ferrugineum* needs to be considered from the point of view of the preservation. Its slenderness and its microclimatic characterisation call for actions of minitoring and preservation (Palla & al. 2009). The low number of individuals and their reproductive isolation induce their uneasy condition and the need of *in situ* and *ex situ* conservation plans.

Even if the populations of the Apennines have a higher number of individuals, they need monitoring plans. The climate change can be a threat, because an increase of temparature should cause a decrease of the snow cover (Rasetti 1980) required to resist to the winter, and should expose the plants too earlier to the freezing cold (Theurillat & al. 1998) and consequently should cause their regression (Pasche & al. 2004).

Because of *Rhododendron ferrugineum* is considered as a quite hydrophile species (Rameau & al. 1993), an other climatic threat should be linked to the increase of the summer dryness, that can damage the little seeds, as had be proved for other species (Brown & Archer 1989; Roques & al. 2001).

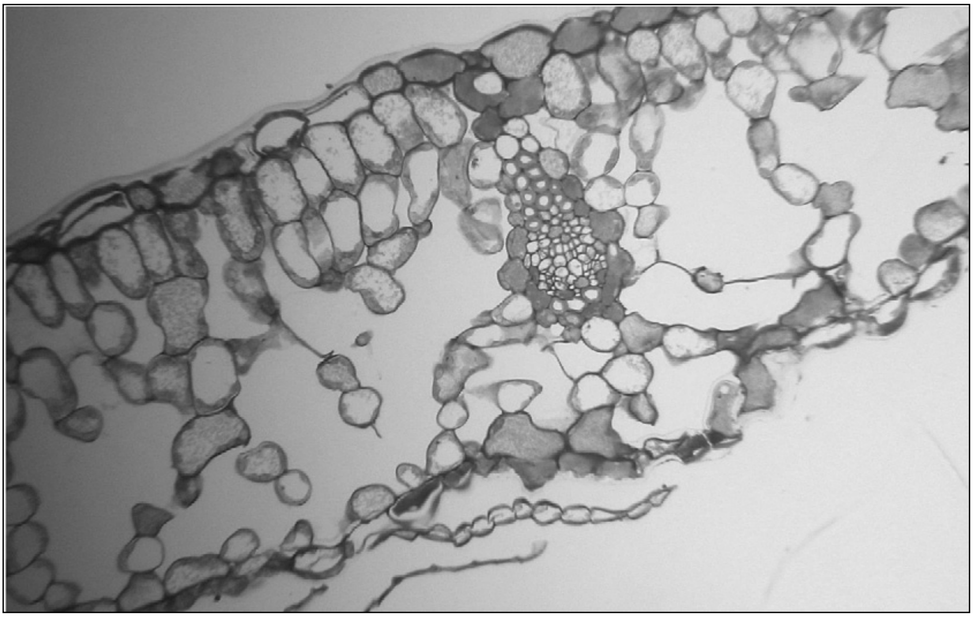

Fig. 8. Foliar sections (Fosso delle Rondini, Apuan Alps). ×25.

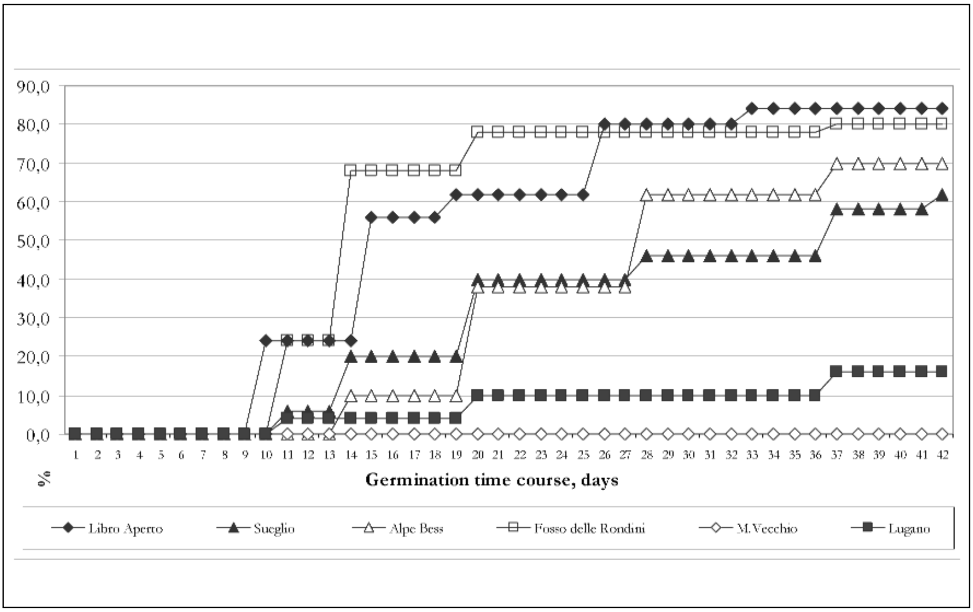

Fig. 9. Germination test without prechilling.

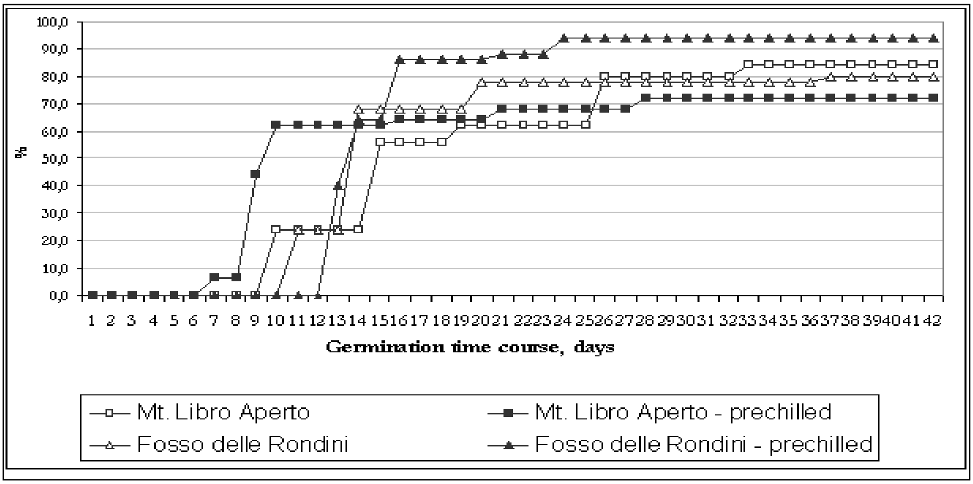

Fig. 10. Comparison of germination percentages of two seedlots (with and without prechilling).

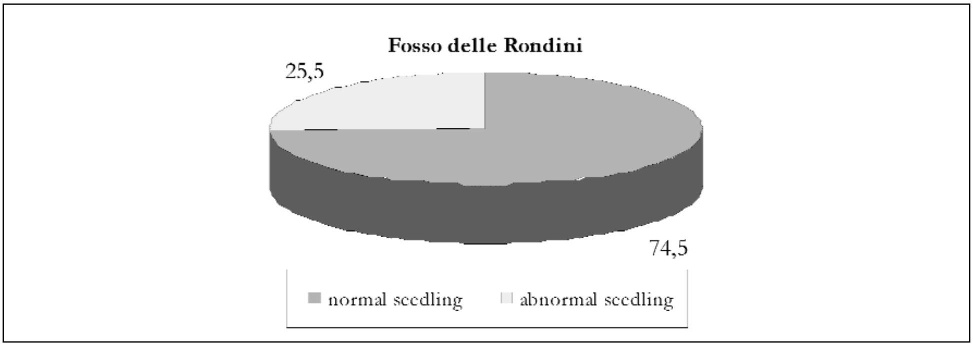

Fig. 11. Seedling growth after prechilling.

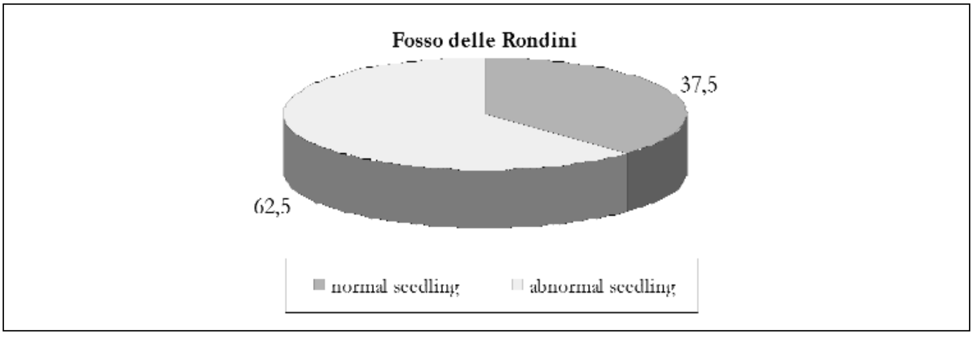

Fig. 12. Seedling growth without prechilling.

The germination protocol have been elucidate. The seeds of this species can be defined orthodox because they tolerate the dehydratation and the storage at low temperature. Germination tests gave positive results; tests carried out from the Millennium Seed Bank of Kew (London), in the same conditions of temperature and photoperiod, on non Italian populations, gave positive results (high percentage of germination) too. Thus the present work confirms that it is possible the *ex situ* conservation in seed bank for this species.

Further investigations should be carried out about different condicions of temperature and photoperiod; moreover other germination tests should be check in order to test the possibility to employ seeds of *Rhododendron ferrugineum* for *in situ* conservation plans (restocking or reintroduction).

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Gianniantonio Domina & Pietro Mazzola

Notes on the genus *Orobanche* in Italy: 2. Taxa described by Gussone

Abstract

Domina, G. & Mazzola, P.: Notes on the genus *Orobanche* in Italy: 2. Taxa described by Gussone. — Bocconea 23:177-185. 2009. — ISSN 1120-4060.

In the framework of the revision of the genus *Orobanche* in Italy, the taxa described as new by Gussone, and by Reuter on Gussone's material, 9 and 1 respectively, are here examined. For each, of them,, synonymies and taxonomic status are given. Original material for their names has been analysed, and typification is discussed. For 9 of the 10 names, lectotypes are here designated (the tenth being holotypified), three of which are illustrated.

Introduction

Taxonomy and distribution of *Orobanche* (including *Phelipaea*) in Italy must still rely on Beck (1890, 1930), whose treatments, however, are based on incomplete herbarium data (mainly FI and PRC), and on literature. What information has been added in recent floristic surveys is not very reliable.

In order to update our knowledge, a revision of this genus is being undertaken, based on extensive field surveys and herbarium studies. Taxa described by Bertoloni, Tineo and Lojacono have been discussed earlier (Domina & Mazzola 2005, 2007). Here, the taxonomic status of those described by Giovanni Gussone himself, and by Reuter on material collected by Gussone, are discussed, and their names are typified.

Gussone (1828, 1844, 1854) described 2 new species and 6 new varieties from Sicily and Ischia (Inarime): *Orobanche canescens* var. *flavidiflora, Orobanche carnea, O. litorea, O. minor* var. *lutescens, O. pubescens* var. *divaricata, O. punctata* var. *glabrata, O. rapum* var. *flavescens,* and *O. spartii* var. *rubra.*

Reuter (1847) published *O. glaberrima*, based on material and handwritten description sent by Gussone to Boissier and kept in the Geneva herbarium.

Materials and Methods

Original material of the names published by Gussone was studied in the *Herbarium Neapolitanum* (NAP), where Gussone's herbarium is kept, divided in two sections: "Gussone-Generale" and "Gussone-Sicilia". The specimens for each species are included

in a folder but not fixed to the sheets. Usually they bear a "fair copy" label with a reference to the Florae Siculae Synopsys (1842-1844, 1845), a field label, and sometimes a label with a description of the plant (see also La Valva 1993). When there is more than one sheet in the same species folder, only the first has the "fair copy" label; the others sometimes bear a label added later by Loreto Grande (1878-1965). The material studied by Reuter was searched for in the Herbarium of the Conservatoire et Jardin botaniques de la Ville de Genève (G), where the Boissier's herbarium is incorporated. Other visited herbaria are B, BOLO, FI, P, PAL, PRC, RO, W, and WU.
For the transcription of the labels the following conventions have been followed:
Different labels fixed on the same sheet are distinguished by small letters (a, b, c, etc.), disregarding hierarchy.
Typographical transcription symbols:
/ = line break;
Italic script corresponds to handwritten text (underlined as in original);
Roman script denotes handwriting printed by lithography;
Bold script denotes printed text, **roman** or ***italicised*** as in original;
{...}= text deleted;
[…] = illegible word(s);
the present authors' comments are added in square brackets.

Orobanche canescens var. *flavidiflora* Guss., Fl. Sic. Syn. **2:** 748 (1844).
[= ***O. canescens*** C. Presl in J. Presl & C. Presl, Delic. Prag.: 72 (1822)].
- *Orobanche canescens* var. *pedicellata* Guss. ex Reut. in DC., Prodr. **11:** 34 (1847) [nom. illeg.]
Ind. loc. [cum typo] Ad radices *Chrysanthemi coronarii*, aliarumque *Syngenesicarum* in Sicilia et in Salina, Lipari, Ustica. Aprili, Majo.
Lectotype (here designated): NAP-Gussone Sicilia
a) *N. 1 Orobanche canescens b / Radix carnosa [...] Scapus [...] triangulares folis bracteis villosis. / Folia lanceolata, ad radices squamiformis regulariter dilatatae / Flores flavidis, linearis interioribus fragrans, frutiferi et inferiores pedunculati. Bracteae lanceolata / integerrima largiores bifidis vel una tantum dentata, corolla non excedentibus corollae tubus basiconstricto angulatus. Labium superiore emarginatum, inferiore / trilobum, lobo medio concaviusculo, lateralibus majore / omnibus crenulatis. Stamina / latere interna villosi antherarum lobis / [...] Stylus undique glaber cum stigma plano bilobo lobis rotundatis. / Species ab habitus et flores inferiores pedun / culatis singularis / 1828 maggio Sferracavallo* [Manu Gussone].
b) *Or. foetida nobis / ad rad. Chrysanthemi coronari* [Manu Gussone].
c) *{O. elatior / conf. O. minor var. procerior / Reich. p. 880} O. minor var. procerior ob / icones flores peduncolatos non / hac coincidit / In Reich. cent. 7. p. 880* [manu Gussone].
d) *(Orobanche flavidiflora Guss.) / = O. canescens J. et C. Presl / Grande, 1916* [Manu Grande].
Note: This sheet contains 3 plants in part damaged but still suitable for identification.
Individuals with yellow and pedicellate flowers are sometimes found together with "normal" individuals, forming mixed populations. This taxon described by Gussone is not worthy of taxonomic recognition at any rank.

Orobanche canescens occurs in the CW- Mediterranean, infecting *Composiate*. It is distinguished from *O. minor* by diffuse pubescence, including the basal part of stamens, and its spreading flowers with yellow, not violet, stigma.

Orobanche carnea Guss., Enum. Pl. Vasc. Is. Inarime: 246 (1854)
[***O. rapum-genistae*** Thuill., Fl. Env. Paris, ed. 2°: 317 (1799)]
Ind. loc. Ad radices *Cytisi trifloris* et candicantis utraeque varietates parasiticae in sylvis boream spectantibus. Aprili, Junio.
Lectotype (here designated): NAP-Gussone Generale
a) *Orobanche rapum / planta pallide et sordide undique carnea / In Ischia aprili ad radices Leguminosarum* [Manu Gussone].
b) *O. n 1° / spica florum nubili comosa, sepalis lanceolato-acuminatis, irregulariter bipartitis, bracteae lanceolate, acuminate, atrofuscae, corollae sordide carneae, stigmate didymo luteo / Ischia / O. carnea appellanda?* [Manu Gussone].
Note: This sheet contains 2 plants, partially damaged but still suitable for identification. Synonymy proposed by Beck (1890), on the basis of the protologue and of a single specimen collected by Lojacono, is here accepted.
Orobanche rapum-genistae is parasitic on woody *Leguminosae* (several species of*Genista* and *Cytisus*, *Spartium junceum*, etc.). This species is quite common in peninsular Italy as well as on the islands. The colour of the whole plant varies from light yellow to purple red.

Orobanche glaberrima Guss. ex Reut. in DC., Prodr. **11:** 719 (1847)
[***O. hederae*** Duby, Bot. Gall.: 350 (1828)]
Ind. loc. Prope Neapolim ad radices *Dianthi plumarii*. (v. s. in h. Boiss. a cl. Guss. Comm.).
Holotype: G, ex herb. Boissier.
a) *Orobanche glaberrima Guss. ined. / Napoli / ad radices Dianthi / plumarii* [Manu Gussone].
b) *Orobanche glaberrima Guss. ined. / O. undique glaberrima lutescens ! scapo squamoso / nudo inferne squamis paucis remotis ovato-acumi- / natis luteo, [...] apice attenuatis / corolla aequaliter biloba corollam aequantibus, / sepalis inaequaliter bibifidis. laciniis acuminatis, [...] stigmate / bilobo lutescens, genitalis glabris/ Confer O. nudiflora Riech. cent. 7 p. 883. / Flores inodori: filamenta ac stilos candida: antherae lateritiae* [Manu Gussone]
c) *Orobanche glaberrima Guss ! / Reut. in DC. prodr.*
Note: This sheet contains a single plant, partly damaged. Synonymy by Beck (1890) is here accepted. Indeed glabrous plants are the most common in wild populations. *O. hederae* is widespread throughout Europe and the Mediterranean region. It occurs, affecting *Hedera helix*, both in woods and in shaded gardens.

Orobanche litorea Guss., Fl. Sic. Prodr. **2:** 184 (1828)
Ind. loc. Ad radices *Syngenesicarum*, uti *Chrysanthemi coronarii, Anthemidis secundiramea*, et *A. maritimae,* in sabulosis maritimi. Aprili, Majo.
Lectotype (here designated): NAP-Gussone Sicilia. (Fig. 1).
a) *9 (6) Orobanche litorea Nob. Syn. Pl. 2 p. 184 / Aprili, Majo / Ad radices Anth. mariti-*

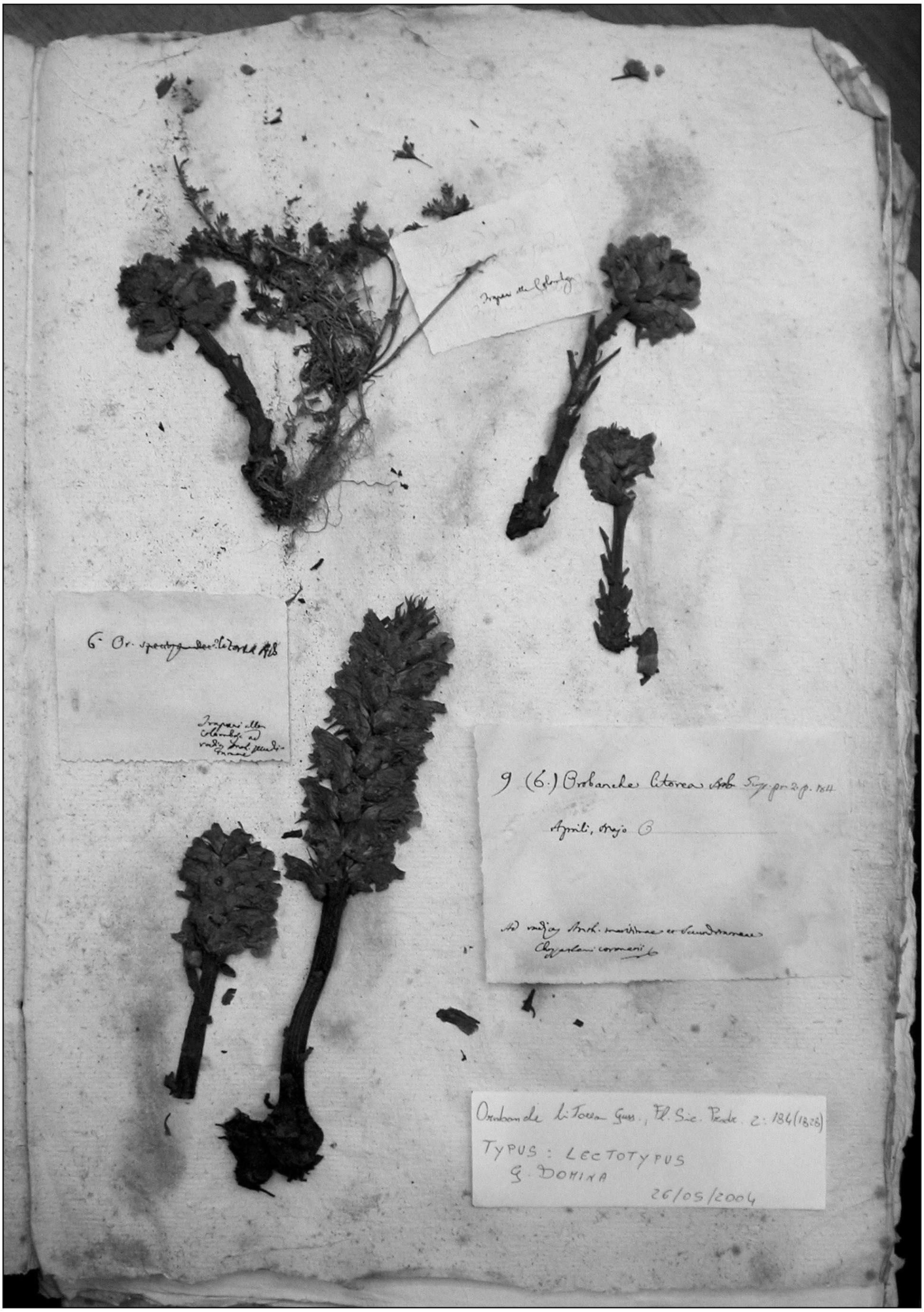

Fig. 1. The specimen in NAP-Gussone Sicilia designated in this paper as the lectotype of *Orobanche litorea* Guss.

mae et secundirameae / Chrysanthemi coronarii [manu Gussone].
b) *6 Or. {speciosa Dec.? } litorea Nob. / Trapani alla / Colombaia ad / radic. Anth. mariti / mae* [manu Gussone].
c) *Trapani alla Colombaia* [manu Gussone].
Note: This sheet contains 5 well conserved individuals, one of them is still connected to the host plant: *Anthemis maritima* L..
CW Mediterranean species with coastal distribution. Erroneously included by Beck (1930) in synonymy with *O. canescens* C. Presl, *O. litorea* is distinguished from this by patent, not spreading, flowers, subglabrous rather than pubescent habit and the violet rather than yellow stylus. *O. litorea* also differs from *O. minor* by its denser spike, the one-toothed rather than two-toothed calix elements and the flattened rather than roundish corolla (for further details see Domina & Mazzola 2004).

Orobanche minor var. *lutescens* Guss., Enum. Pl. Vasc. Is. Inarime: 249 (1854)
[***O. canescens*** C. Presl in J. & C. Pres, Delic. Prag.: 72 (1822)]
Ind. loc. Ad radices *Carlinae involucratae*. Aprili, Majo.
Lectotype (here designated): NAP-Gussone Generale (Fig. 2).
a) *Orobanche minor c lutescens / radices Carlinae / involucratae* [Manu Gussone].
b) Orobanche 2 / Squamae sparsae, [...] laciniis corollam aequantes aut / superantes, acutae vel acuminatae / sepala bipartita, laciniis ex ovata basi acuminato-attenuatis, corolla / brevioribus / Corolla biloba vix curvata, lobis crenato-crispatis, in lobo medio / labii inferioris gibbae due obsoletae / Stami supra basim corollae inserta, filamenta albida basi villosa apice gla / bris. Stilus albidus vix ad apicem pubescenti-glandulosus; stigmata / sordide albida !
Flores ingrati odoris et uti pars su / perior plantae pallide albo-lutescens / bracteae acuminatae fuscae / 25 Majo 1849 / Ischia ad radices Carlinae / involucratae [Manu Gussone]
Note: Seven well conserved plants are included in this sheet. This name applies to a taxon which is not worthy of any taxonomic recognition, but falls within the infraspecific range of *O. canescens* C. Presl and not of *O. minor* Sm.

Orobanche pubescens var. *divaricata* Guss., Enum. Pl. Vasc. Is. Inarime: 248 (1854)
[***O. pubescens*** d'Urv., Mem. Soc. Linn. Paris: 332 (1822)]
Ind. loc. In apricis, et ad vaporia humendia ad radices *Crepidis bulbosae*. Aprili, Majo.
Lectotype (here designated): NAP-Gussone Generale (Fig. 3).
a) Orobanche pubescens D'Urvill. Consp. 76 / Dec prodr. p. 27 In Ischia [Manu Gussone].
b) Or. barbata Poir. = Reut. in / Dec pr. 11 p. 28 n. 32 / Or. pubescens d'Urvill. / Reut. in Dec. l.c. p. 27 n 46 / Syn. ex Wallr. [Manu Gussone].
c) var. b divaricata [Manu Gussone]
d) 1321. / Orobanche [Manu Heldreich] / *confer O. angustisepala Wlap. 3 p. 466 / O. pubescens d'Urv.* [Manu Guss.] / *ad radices Cichoracearum / Retimo / April 1846 / Heldreich*
e) Il piccolo saggio [...] il sinonimo *O. angustisepala* Schultz !! i sepali sono piccolissimi / M. Lojacono.

Fig. 2. The specimen in NAP-Gussone Generale designated in this paper as the lectotype of *Orobanche minor* var. *lutescens* Guss.

Fig. 3. The specimen in NAP-Gussone Generale designated in this paper as the lectotype of *Orobanche pubescens* var. *divaricata* Guss.

f) *O. pubescens !! È la stessa quella che [...] teste a Palermo !! M. Lo Jacono / La corolla [...] / come Reich. dipinge / la sua O. cervariae* [Manu Lojacono].
Note: This sheet includes 2 well conserved plants, one of them shorter with approximate lower lip lobes, the other taller with divaricated lower lip lobes. Individuals with approximate lobes of the lower lip occasionally occur in natural populations. This feature falls within the variation range of the species.
O. pubescens is widespread from the Euro-Mediterranean region to the Caucasus, infecting *Compositae*.

Orobanche punctata var. *glabrata* Guss., Enum. Pl. Vasc. Is. Inarime: 247 (1854)
[***O. crenata*** Forrsk., Fl. Aegypt.-Arab.: 113 (1775)]
Ind. loc. In apricis; Bagno ad radices *Leguminosarum*. Aprili, Majo.
Lectotype (here designated): NAP-Gussone Generale
a) *24 Maggio 1949 / Ischia al Bagno / Orobanche / Scapi atrorubens uti calicis ubique sparse pilosis / squamae ac bracteae lanceolato-acuminatae sparsae, inferiores / approximatae: bracteae corollam aequantes / flores caryophyllum olentes: corolla alba, ad lobos coerulescens / varis interioribus notata, lobi corollae [...] stigmate bilobo sanguineum! / Sepala bipartita, lacinis linearis apice attenuatis* [Manu Gussone]
b) *Orobanche punctata Schultz / var. glabrata Guss. / Corollae pilis sparsis glabris tectae/ in Ischia aprili* [manu Gussone].
c) *Niente affatto / è la Orob. tommasini / an forma Orob. / pruinosae / M. Lojacono*
Note: Three plants, in fairly good conditions, are included in this sheet. This taxon falls within the variation of *O. crenata* Forssk. and not of *O. alba* Steph. (= *O. punctata* Schultz). These 2 species were imperfectly known by Gussone. In fact several specimens of *O. crenata* labelled as *O. alba by Gussone* are kept in NAP and PAL.

Orobanche rapum var. *flavescens* Guss., Enum. Pl. Vasc. Is. Inarime: 245 (1854)
[***O. rapum-genistae*** Thuill., Fl. Env. Paris, ed. 2°: 317 (1799)]
Ind. loc. Ad radices *Cytisi trifloris* et candicantis utareque varietates parasiticae in sylvis boream spectantibus. Aprili, Junio.
Lectotype (here designated):
a) *Orobanche rapum c flava/ In Ischia aprili ad radices Leguminosarum* [Manu Gussone]
b) *Differt ab O. n 1 / fl. sordide carneis; bracteis corollas subaequantibus, ideoque spica nubilis non comosa, mi / nus acuminatis, florum color, staminibus / glabribus, stigmate aureo profunde bilobo, non glaber / bilobo [...] albido non roseo / N. 2 / Ad radices Cytisi trifloris / Ischia* [Manu Gussone].
Note: This sheet contains 4 plants, only one of them is in good conditions.

Orobanche spartii var. *rubra* Guss., Fl. Sic. Prodr. **2:** 182 (1828)
[***O. variegata*** Wallr., Orob. Gen.: 40 (1825)]
Ind. loc. Ad radices *Spartii infesti*, et *S. juncei*, nec *Cytisi triflori*; sat raro in illis *Thymi capitati*; Nicosia, Terranova. Aprili, Majo.
Lectotype (here designated): NAP-Gussone Generale
a) *4 Orobanche spartii Vauch. b. floribus valentibus / Aprili, Majo / Terranova* [manu Gussone].

b) *fl. rubro / aprile – Terranova* [manu Gussone].
c) *Confer O. crenata di Reich.* [manu Gussone].

Note: Four plants in good condition are kept on this sheet. *Orobanche variegata* is polymorphic in colour, from light yellow to dark brown, and in corolla size, from 13 to 25 mm. This high variation can probably explain the large amount of names given to this taxon, including Gussone's.

O. variegata grows on woody *Leguminosae* (*Spartium junceum, Calycotome* sp. pl., *Cytisus* sp. pl., *Genista* sp. pl., etc.). In Italy it is common in western peninsular regions and in the islands.

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L. Feoli Chiapella, T. Cusma Velari, V. Kosovel & L. Pellizzari

Karyological notes on some genera of *Genisteae* from the Mediterranean region

Abstract

Feoli Chiapella, L., Cusma Velari, T., Kosovel, V. & Pellizzari, L.: Karyological notes on some genera of *Genisteae* from the Mediterranean region. — Bocconea 23: 187-202. 2009. — ISSN 1120-4060.

A karyological study of four xerophytic genera of *Genisteae* (*Fabaceae*) was carried out on 54 wild populations of 13 infrageneric taxa. *Retama* is a Mediterranean genus with distribution centred in the western part; for all the taxa, the chromosome number $2n = 48$ (sometimes with some B chromosomes) was counted, with the basic number $x = 12$. The genus, eutetraploid, results very homogeneous karyologically. *Echinospartum* is distributed in the Iberian Peninsula and in S France. The species result all aneuploid: the calcicolous *E. horridum* and *E. boissieri*, being hypoaneuploid, present $2n = 44 + 0\text{-}2B$, with secondary basic number $x = 11$; the silicicolous *E. ibericum, E. barnadesii* ($2n = 52 + 0\text{-}4B$) and *E. algibicum* ($2n = 54$) are hyperaneuploid with $x = 13$. *Erinacea* is a monospecific genus, with the W Mediterranean species *E. anthyllis*, which presents $2n = 52$ and is hyperaneuploid with $x = 13$. *Spartium* is monotypic as well, with the Mediterranean species *S. junceum*; the taxon, karyologically heterogeneous, presents the numbers $2n = 48$, (50), 52, 54 (sometimes with some B chromosomes), with $x = 12$, and consists of both eutetraploid and hyperaneuploid populations.

Introduction

A detailed karyological analysis on four xerophytic genera [*Retama* Raf., *Echinospartum* (Spach) Fourr., *Erinacea* Adanson and *Spartium* L.] of *Genisteae* (*Fabaceae*) from the Mediterranean region was carried out. Thirteen out of *ca* 16 infrageneric taxa were examined on the basis of the analysis of 54 wild populations.

Another xerophytic genus, *Gonocytisus* Spach, with an eastern Mediterranean distribution, was already studied in a former note (Cusma Velari & Feoli Chiapella 1996).

These genera present a systematic position intermediate between the *Cytisus* and *Genista* groups, the most complex and differentiated of the *Genisteae* tribe. Among these genera, on the basis of morphologic and serologic characters, *Erinacea* appears to present a greater affinity with the *Cytisus* group, while *Echinospartum*, *Retama* and, to a lesser extent, *Spartium* and *Gonocytisus* have a greater affinity with the *Genista* group (Polhill 1976; Bisby 1981; Cristofolini & Feoli Chiapella 1984; Feoli Chiapella & Prodan 1989). On the basis of genomic analysis Käss & Wink (1997) have noticed that a series of genera of *Genisteae* “take a position between the *Cytisus* and *Genista* complexes”. *Retama*, *Spartium* and *Echinospartum* are clearly part of the *Genista* line of diversification; the position of *Erinacea* cannot be established with certainty, being related either to *Cytisus* or *Genista* group (Käss & Wink 1997; Cubas & al. 2002; Pardo & al. 2004).

Materials & Methods

Karyological investigations were carried out on seeds collected in the field. The localities of the collection are given in Tables 1-3. Voucher specimens of the seeds collected by the Authors are deposited in the Herbarium of the Department of Biology, University of Trieste (TSB).

Mitoses were observed on root tips of seedlings, pretreated with 8-hydroxiquinoline and stained using the routine Feulgen method. For each population 5 to 15 metaphase plates were examined. Only numbers of chromosomes can be given here, because of the size of the chromosomes, many of which too small for effective karyotyping.

The nomenclature of the taxa follows Greuter & al. (1989), Talavera (1999a, b, c, d) and Maire (1987), the last for the North African ones.

Results and Discussion

Retama Raf.

The genus *Retama* has a mostly Mediterranean distributional range, with diversification centre in the western part, especially in northwestern Africa (Lems 1960; Maire 1987; Greuter & al. 1989).

Retama monosperma (L.) Boiss. occurs in southwestern Iberian Peninsula, Morocco and Algeria; var. *webbii* (Spach) Maire is present along the Atlantic littoral of Morocco (Maire 1987; Talavera 1999b).

Retama rhodorhizoides Webb & Berth. (=*R. monosperma* subsp. *rhodorhizoides* (Webb & Berth.) Ceb. & Ort.) is endemic to Canary Islands (Santos Guerra 1983; Bramwell & Bramwell 1990; Rivas Martínez & al. 1993).

Retama raetam (Forsskål) Webb subsp. *raetam*, a Saharo-Arabian taxon, is spread in northern Africa, Israel, Lebanon, Syria and Arabian Peninsula; subsp. *gussonei* (Webb) Greuter occurs only in southern Sicily and on the Ionian coast of Calabria (Pignatti 1982; Maire 1987; Greuter & al. 1989; Peruzzi & Cesca 2003).

Retama sphaerocarpa (L.) Boiss. is distributed in the Iberian Peninsula, Morocco, Algeria and Tunisia; var. *atlantica* (Pomel) Batt. occurs in central and eastern Morocco, and in western Algeria (Maire 1987; Talavera 1999b).

Retama dasycarpa Cosson is endemic to Morocco, Great Atlas and Antiatlas (Maire 1987).

The chromosome somatic number $2n = 48$, sometimes with some B chromosomes (up to 6), was releved constantly both in present study and in literature for all the taxa of the genus (see Table 1, Fig. 1-2). Chromosome size ranges between 0.55 and 3.50 µm. The numbers $2n = 24$ and $2n = 52$ are only reported respectively by Labadie (1979) for *Retama raetam* subsp. *raetam* and by Gilot (1965) for *R. sphaerocarpa*, the

Table 1. Chromosome numbers of the *Retama* taxa, bibliographic references and geographical origin of the studied populations.

Taxon	n	2n	Reference	Locality	Source
Retama monosperma		48+(0-4B)	**Present paper**	Tarifa, Cádiz, (Spain)	B.G. Berlin- Dahlem
		48	"	Meãs do Campo, Coimbra (Portugal)	B.G. Coimbra
	24		Sañudo1973a (sub *Lygos monosperma)*	Almería (Spain)	
		48	Santos 1944-45 (sub *Genista monosperma)*	cult.	
		48	Berger & al. 1958 (sub *Genista monosperma)*	cult.	
		48	Fernandes & Queirós 1978	Serra de Monsanto, Lisboa (Portugal)	
Retama monosperma var. *webbii*		48+(0-4B)	**Present paper**	Tiznit, Tizi Mbil, Tafraoute (Morocco)	B. G. National de Belgique
		48+(0-6B)	"	Anti Atlas (Morocco)	lg. L. Feoli Chiapella
Retama rhodorhizoides		48+(0-2B)	**Present paper**	Montes de Teno, Tenerife, Canary Islands (Spain)	B.G. Berlin- Dahlem
		48+(0-2B	"	Tayaya, La Palma, Canary Islands (Spain)	B.G. Amsterdam
		ca.48	Borgen 1969 [sub *R. raetam* var. *raetam* (*R. monosperma* ssp. *rhodorhizoides*)]	cult.	
Retama raetam ssp. *raetam*		48	**Present paper**	Wadi Rüm, Aqaba (Giordania)	B. G. Bayreuth
		48	"	Tripoli – Gharyan, Tripolitania (Libya)	lg. M. Bencivenga
		48+(0-3B)	"	M.Scopus, Jerusalem (Israel)	B.G. Jerusalem
	ca. 24		Reese 1957	Beni Ounif - A. Sefra (Algeria)	
		24	Labadie 1979 (sub *Lygos raetam*)	Hauts Plateaux, Djelfa (Algeria)	
		48	Bhattacharya & al. 1971	Leptis Magna (Libya)	
Retama raetam ssp. *gussonei*		48+(0-2B)	**Present paper**	Punta Braccetto, Ragusa (Italy)	B.G. Catania
		48+(0-2B)	"	Litorale Scogliti, Ragusa (Italy)	B.G. Palermo
		48+(0-6B)	"	Manfria, Gela, Caltanissetta (Italy)	B.G. Catania
		48+(0-6B)	"	Isole Pelagie, Lampedusa, Agrigento (Italy)	B.G. Palermo
		48+(0-6B)	"	Litorale di Gela, Caltanissetta (Italy)	B.G. Palermo
		48	Peruzzi & Cesca 2003	Loc. Marinelle, Punta Alice-Crucoli Torretta, Crotone (Italy)	

Table 1. Continued.

Retama sphaerocarpa		48	**Present paper**	Valle del Padre Eterno, Orgiva, Granada (Spain)	lg. G. Bacchetta
		48	"	Parla, Madrid (Spain)	B.G. Madrid
		48+(0-2B)	"	La Almunia de Doña Godina, Aragón (Spain)	B.G. Barcelona
		48+(0-2B)	"	Torremolinos, Málaga (Spain)	B.G. Malaga
		48+(0-4B)	"	El Higueral, Almería (Spain)	B.G. Malaga
		48+(0-4B)	"	Estepona (Spain)	lg. L. Feoli Chiapella
		48+(0-6B)	"	Motril-Granada (Spain)	lg. L. Feoli Chiapella
	24		Sañudo 1973a (sub *Lygos sphaerocarpa*)	Jaén (Spain)	
	24	48	Gallego Martín & al. 1986	Almenara de Tormes, Salamanca (Spain)	
		48	Fernandes & Santos 1971 (sub *Lygos sphaerocarpa*)	Sintra (Portugal)	
		48	Fernandes & Queirós 1978	Alijó, Pinhão (Portugal)	
		52	Gilot 1965 (sub *Genista sphaerocarpa*)	cult.	
Retama sphaerocarpa var. *atlantica*		48+(0-4B)	**Present paper**	Haut Atlas (Morocco)	lg. L. Feoli Chiapella
Retama. dasycarpa		48+(0-6B)	**Present paper**	Vallée du Dräa, Ouarzazate-Zagora (Morocco)	lg. E. Feoli

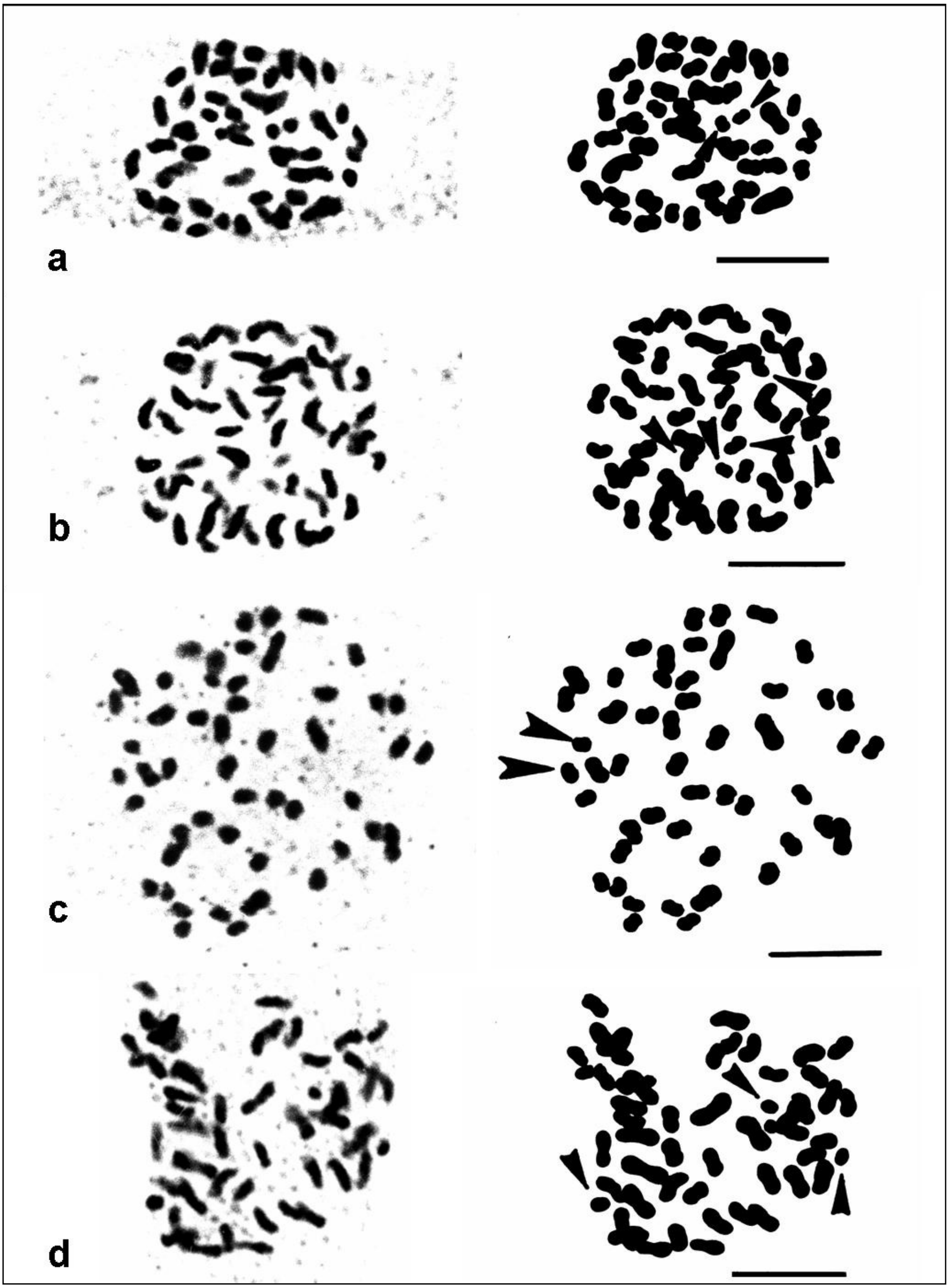

Fig. 1. Photomicrographs and relative drawings of somatic metaphase plates of: **a,** *Retama sphaerocarpa* (La Almunia de Doña Godina), 2*n* = 48 + 2B; **b,** *R. monosperma* (Cádiz), 2*n* = 48 + 4B; **c,** *R. monosperma* var. *webbii* (Anti Atlas), 2*n* = 48 + 2B; **d,** *R. dasycarpa* (Vallée du Dräa), 2*n* = 48 + 3B. — Arrows indicate B-chromosomes. Scale bars = 5 μm.

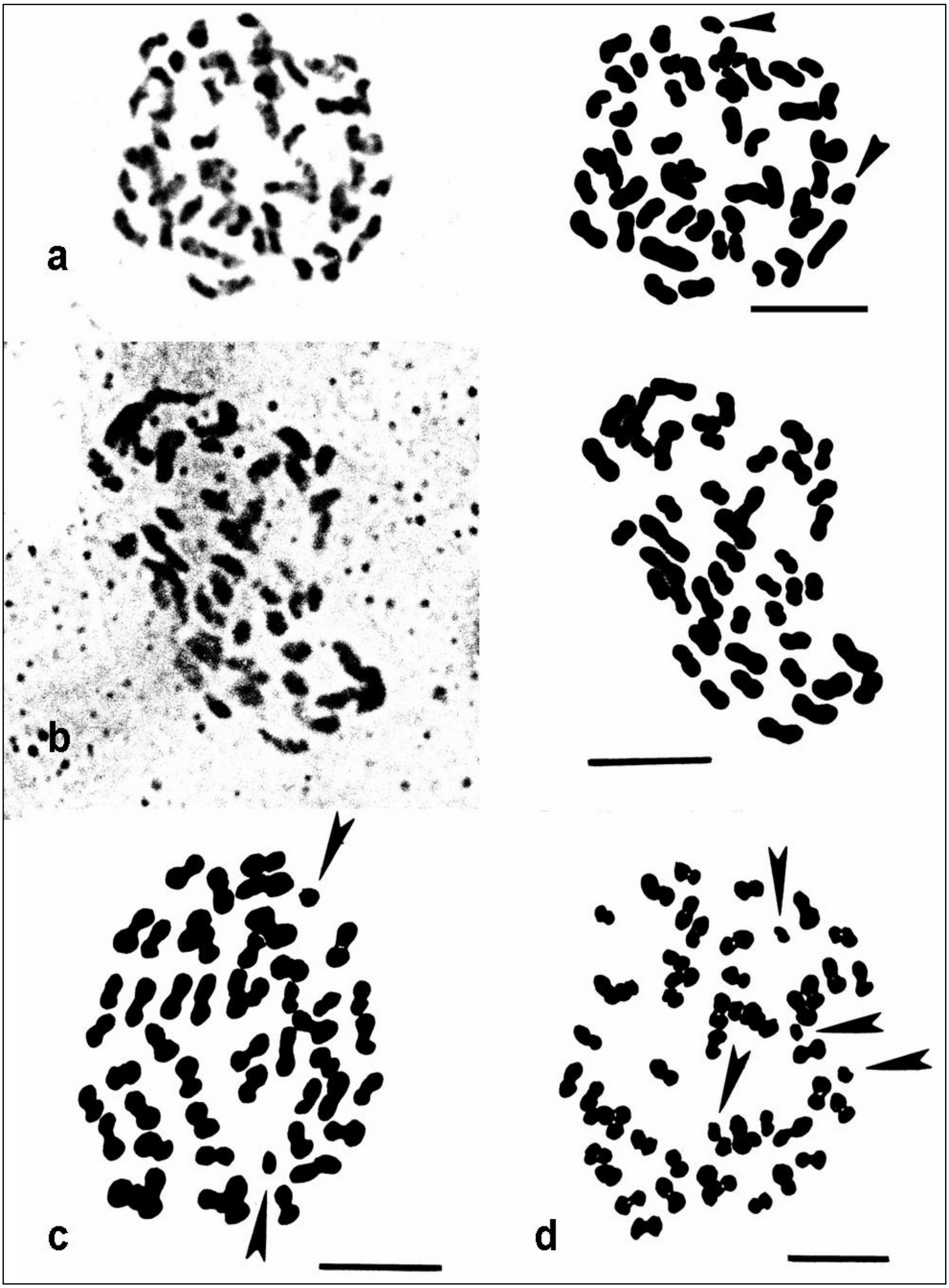

Fig. 2. Photomicrographs and relative drawings of somatic metaphase plates of: **a,** *Retama raetam* subsp. *gussonei* (Lampedusa), 2*n* = 48 + 2B; **b,** *R. raetam* subsp. *raetam* (Jerusalem), 2*n* = 48; drawing of somatic metaphase plates of: **c,** *R. rhodorhizoides* (Tenerife), 2*n* = 48 + 2B; **d,** *R. sphaerocarpa* var. *atlantica* (Haut Atlas), 2*n* = 48 + 4B. — Arrows indicate B-chromosomes. Scale bars = 5 µm.

latter from cultivated material (see Table 1). The number 2n = 48 may be traced back to the basic number x = 12, which is by far the most common secondary basic number in *Genista*, *Cytisus* and generally in *Genisteae* (Sañudo 1979; Goldblatt 1981a; Cusma Velari & Feoli Chiapella 1994; Cusma Velari & al. 2003). Thus the genus is eutetraploid and results very homogeneous karyologically.

Echinospartum (Spach) Fourr.

Echinospartum is distributed in the Iberian Peninsula and in southern France (Greuter & al. 1989; Talavera 1999a).

Echinospartum horridum (Vahl) Rothm., which occurs in northern Spain and in southern France, and *E. boissieri* (Spach) Rothm., endemic to southern Spain (Sierras Béticas), both present the number 2n = 44 + 0-2B (see Table 2, Fig. 3).

Echinospartum ibericum Rivas Mart., Sánchez-Mata & Sancho, distributed in the northwestern and central Iberian Peninsula, has the number 2n = 52 + 0-4B. The same number is reported for both subsp. *ibericum* and subsp. *pulviniformis* (Rivas Mart.) Rivas Mart. (Sañudo 1974; Fernandes & al. 1977; Cubas & al. 1998). The more rare numbers 2n = 24 and 2n = 48 are reported respectively by Santos (1944/45) and De Castro (1949), both from cultivated material of *E. ibericum* s.l. (see Table 2, Fig. 3).

Also the allied species *Echinospartum barnadesii* (Graells) Rothm., endemic to a small region of central Spain, presents the number 2n = 52 (Sañudo 1974; Cubas & al. 1998). The number 2n = 24, reported by Gallego Martín & al. (1984) in a preliminary note but not in the following paper (Gallego Martín & al. 1985), may be considered as doubtful (see Table 2).

Talavera & Aparicio (1995) found n = 27 for *Echinospartum algibicum* Talavera & Aparicio, endemic to Sierra de Grazalema (Málaga) (see Table 2).

In this analysis chromosome size ranges between 0.77 and 3.63 µm.

Thus, the species of this genus result all aneuploid; while *Echinospartum horridum* and *E. boissieri* are hypoaneuploid with secondary basic number x = 11, *E. ibericum*, *E. barnadesii* and *E. algibicum* are hyperaneuploid with secondary basic number x = 13.

It is worth noticing that the two different basic numbers correspond to a different ecology of the species of the genus: while *Echinospartum horridum* and *E. boissieri* are both calcicolous species, *E. ibericum*, *E. barnadesii* and *E. algibicum* are silicicolous (Talavera 1999a). Aparicio & al. (2002, Pp. 196-197), using allozyme evidence, found that "*E. ibericum*, *E. barnadesii* and *E. algibicum* form a genetic group of taxa", while "the calcicolous *E. boissieri* is genetically unrelated to the set of silicicolous species". Finally Pardo & al. (2004), on the basis of nucleotide sequences of nrDNA and cpDNA, underline that *Echinospartum* is formed by two separated clades: the former comprehending *E. horridum* and *E. boissieri*, the latter *E. ibericum* and *E. barnadesii*.

Thus, *Echinospartum***,** which appears quite homogeneous morphologically, results heterogeneous from the ecological, karyological, genetic and molecular point of view.

Erinacea Adanson

Erinacea is a monospecific genus, with *E. anthyllis* Link distributed in the eastern Iberian Peninsula, southern France (eastern Pyrenees) and northwestern Africa (Morocco, Algeria and Tunisia) (Maire 1987; Greuter & al. 1989; Talavera 1999d).

Table 2. Chromosome numbers of the *Echinospartum* taxa and of *Erinacea anthyllis*, bibliographic references and geographical origin of the studied populations.

Taxon	n	2n	Reference	Locality	Source
Echinospartum horridum		44+(0-2B)	**Present paper**	Vielsa-Tella, Huesca (Spain)	B.G. Bordeaux
		44	De Castro 1945	Oroel-Jaca (Spain)	
	22		Sañudo 1974	San Juan de la Peña, Huesca (Spain)	
		44	Cubas & al. 1998	Monrepós-Jaca, Huesca (Spain)	
Echinospartum boissieri		44+(0-2B)	**Present paper**	Sierra de la Pandera, Jaén (Spain)	lg. L. Feoli Chiapella
		44	De Castro 1945	Sierra de Alfacar, Granada (Spain)	
	22		Sañudo 1974	Sierra de Alfacar, Granada (Spain)	
	22		Cubas & al. 1998	Alcaraz-Riopar, Albacete (Spain)	
	22		"	Yelmo-Hornos, Jaén (Spain)	
Echinospartum ibericum		52+(0-4B)	**Present paper**	Bemposta, Mogadouro, Trás os Montes (Portugal)	B.G. Porto
		52+(0-4B)	"	Nave do S.to António, Serra da Estrela, Beira Alta (Portugal)	B.G. Coimbra
		24	Santos 1944-45 (sub *Cytisus lusitanicus*)	cult.	
		48	De Castro 1949 (sub *Cytisus lusitanicus*)	cult.	
	26	52	Gallego Martín & al. 1984 (sub *E. barnadesii* ssp. *dorsisericeum*)	Barruecopardo, Salamanca (Spain)	
Echinospartum ibericum ssp. *ibericum*		±52	De Castro 1945 (sub *E. lusitanicum*), *fide* Cubas & al. 1998	Monsanto, Coimbra (Portugal)	
		52	Sañudo 1974 (sub *E. lusitanicum* ssp. *lusitanicum)*, *fide* Cubas & al. 1998	Puerto Manzanal, León (Spain)	
	26		Cubas & al. 1998	Villardeciervos-Mombuey, Zamora (Spain)	
	26		"	Covilha-Torre, Beira Alta (Portugal)	
Echinospartum ibericum ssp. *pulviniformis*		ca. 52	Fernandes & al. 1977 (sub *E. lusitanicum*), *fide* Cubas & al. 1998	Nave do S.to António-Torre, Serra da Estrela (Portugal)	
	26		Cubas & al. 1998	Serra da Estrela, Lagoa Comprida- Torre, Beira Alta (Portugal)	
		52	"	Sierra de Béjar, Solana de Ávila, Ávila (Spain)	
Echinospartum barnadesii		±52	De Castro 1945	Sierra de Gredos, Ávila (Spain)	
	26		Sañudo1974 (sub *E. lusitanicum* ssp. *barnadesii*)	Sierra de Gredos, Ávila (Spain)	
	12?	24?	Gallego Martín & al. 1984	Candelario, Sierra de Béjar (Spain)	
	26		Cubas & al. 1998	Puerto de Mijares - Mijares, Ávila (Spain)	
	26		"	Casillas - Alto del Mirlo, Ávila (Spain)	
Echinospartum algibicum	27		Talavera & Aparicio 1995	Ronda - Grazalema, Los Alcornocales, Málaga (Spain)	
Erinacea anthyllis		52	**Present paper**	Sierra Nevada (Spain)	lg. L. Feoli Chiapella
	26		Sañudo 1973b	Granada (Spain)	

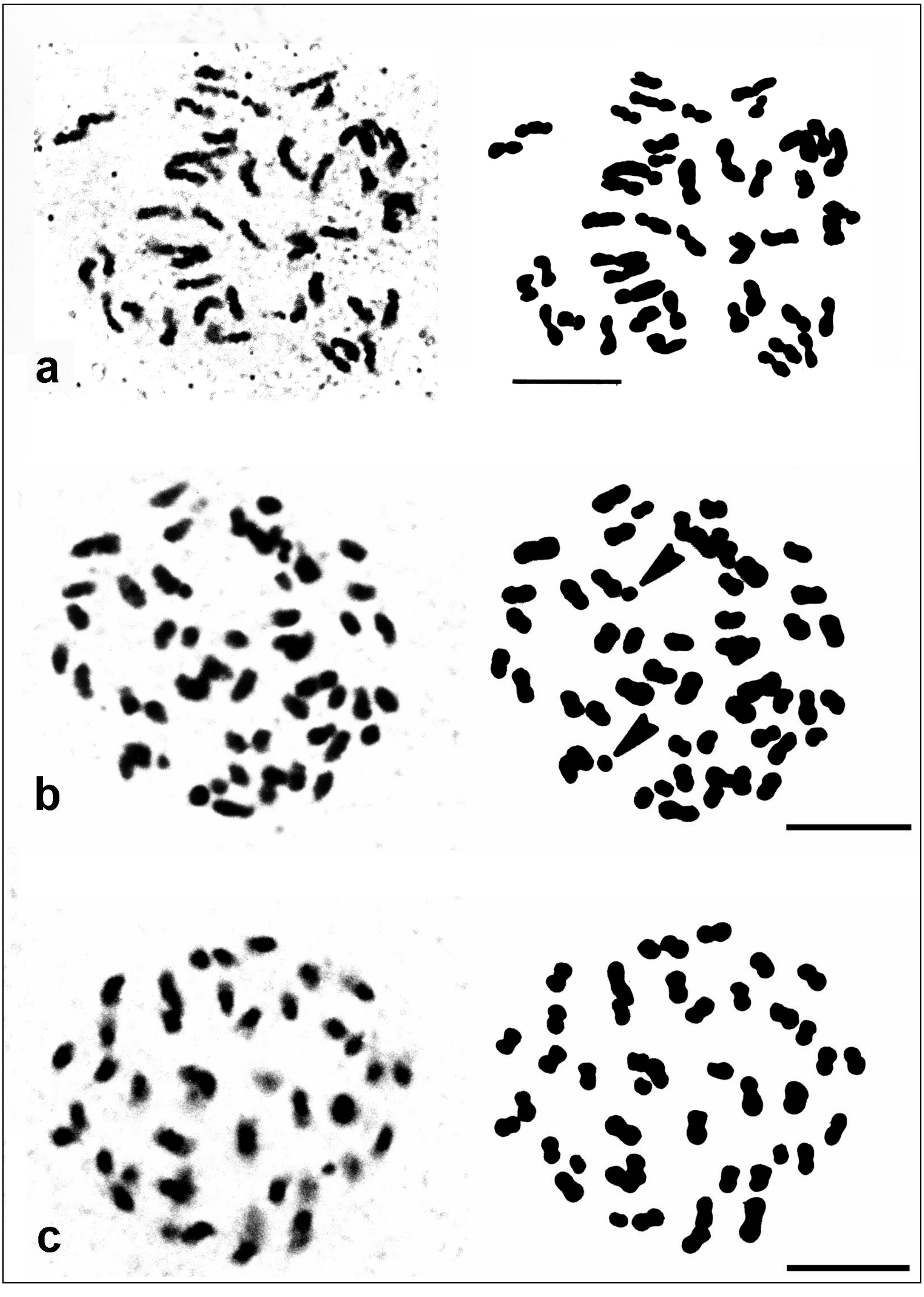

Fig. 3. Photomicrographs and relative drawings of somatic metaphase plates of: **a,** *Echinospartum horridum* (Vielsa–Tella)*,* 2*n* = 44; **b,** *E. ibericum* (Serra da Estrela)*,* 2*n* = 52 + 2B; **c,** *E. boissieri* (Sierra de la Pandera), 2*n* = 44. — Arrows indicate B-chromosomes. Scale bars = 5 µm.

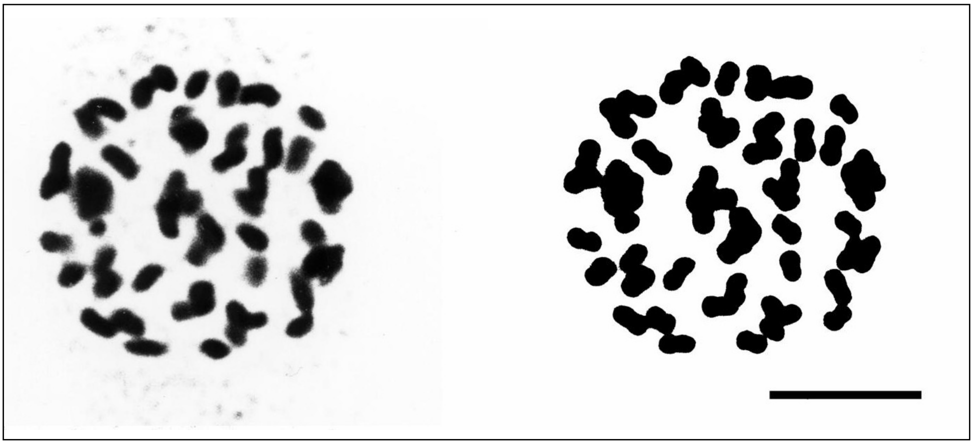

Fig. 4. Photomicrograph and relative drawing of somatic metaphase plate of *Erinacea anthyllis* (Sierra Nevada), $2n = 52$. — Scale bar = 5 µm.

The species presents the chromosome number $2n = 52$ (see Table 2, Fig. 4), resulting thus hyperaneuploid with secondary basic number $x = 13$. Chromosome size ranges between 0.88 and 3.63 µm.

Spartium L.

Spartium is a monotypic genus with *S. junceum* L. growing in the Mediterranean region, introduced and naturalized in the Canary Islands (Heywood 1968; Santos Guerra 1983; Greuter & al. 1989).

The taxon results quite heterogeneous karyologically, with the numbers $2n = 48$, 52, 54, (56), sometimes with some B chromosomes, up to 4 (see Table 3, Fig. 5). Chromosome size ranges between 0.60 and 3.41 µm.

The species, which has the basic number $x = 12$, consists of both eutetraploid and hyperaneuploid populations. Different numbers, both euploid and aneuploid, were found in some populations. Apparently, there is no correlation between the chromosome number and the distribution pattern of the populations.

As regards the other xerophytic genus, *Gonocytisus* Spach, the only karyologically studied species is *G. angulatus* (L.) Spach; Goldblatt (1981b) reported the number $2n = 50$, Cusma Velari & Feoli Chiapella (1996) $2n = 48$.

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Table 3. Chromosome numbers of *Spartium junceum*, bibliographic references and geographical origin of the studied populations.

Taxon	n	2n	Reference	Locality	Source
Spartium junceum		48	**Present paper**	Rovinj, Istria (Croatia)	B.G. Graz
		48	"	Tarragona (Spain)	B.G. Liège
		48	"	Sant Quintí de Mediona, Barcelona (Spain)	B.G. Barcelona
		48	"	Tentugal, Coimbra (Portugal)	B.G. Coimbra
		48+(0-2B)	"	Nebida, Carbonia - Iglesias (Italy)	lg. L. Feoli Chiapella
		48+(0-3B)	"	Aude (France)	B.G. Liège
		48+(0-4B)	"	Parque Florestal de Monsanto, Lisboa (Portugal)	B.G. Lisboa
		48, 54	"	M. Scuderi, Messina (Italy)	B.G. Palermo
		48, 54	"	Lisciano Niccone, l.Trasimeno, Perugia (Italy)	B.G. Berlin
		48+(0-3B), 54	"	Limone sul Garda, Brescia (Italy)	B.G. Graz
		48+(0-3B), 54	"	Baone, Calaone, Padova (Italy)	B.G. Padova
		48+(0-2B), 54	"	Krk (Croatia)	B.G. Graz
		54	"	Pierrefeu, "Végautier", Alpes-Maritimes (France)	B.G. Nice
		54	"	Omisalj, Krk (Croatia)	B.G. Graz
		54	"	Boka Kotorska (Montenegro)	B.G. Sarajevo
		54	"	Neum (Bosnia-Herzegovina)	B.G. Sarajevo
		54	"	Burgas (Bulgaria)	B.G. Halle
		54	"	Erese, Hierro (Canary Islands)	B.G. Oslo
		54	"	Porto (Portugal)	B.G. Portucalensis
		54	"	Sierra de la Contraviesa, Granada (Spain)	B.G. Cordoba
		54	"	Pian del Lago, Siena (Italy)	B.G. Siena
		54	"	Ponte di Petriolo, Grosseto (Italy)	B.G. Siena
		54	"	Alcara Li Fusi, Messina (Italy)	B.G. Palermo
		54+(0-2B)	"	Granarolo, Genova (Italy)	B.G. Genova
		54+(0-2B)	"	Montescuro, Filago, Palermo (Italy)	B.G. Palermo
		54+(0-2B)	"	Živogošće, Dalmatia (Croatia)	B.G. Sarajevo
	24	48	Afzal Rafii & al. 1985	Lubéron (France)	
	24	48	Afzal Rafii & al. 1986	Combe de Lourmarin, Cucuron, Lubéron (France)	
		52	"	Montagne de Lure (France)	
		54, 56	"	Mt.Ventoux (France)	
		48, 52	Tschechov 1931	cult.	
	26		Delay 1969	Ile d'Oléron (France)	
	26		Sañudo 1973a	Izbor, Granada (Spain)	
		52	Fernandes & Santos 1971	s. loc. (Portugal)	
		52	Fernandes & Queirós 1978	Serra de Monsanto, S. Clara, Coimbra (Portugal)	
		52	Gilot 1965	cult.	
		52	Löve & Löve 1982	Garfagnano, Ponte a Moriano, Lucca (Italy)	
		54	Horjales 1975	cult.	
		54	Maugini & Moskova 1971	Grezzano, Borgo San Lorenzo, Firenze (Italy)	
		54	Moskova 1975	Belovo, Varna (Bulgaria)	
		54	Natarajan 1978	Bel-Air, Montpellier (France)	
		54±2	Diers 1961	Surco, Lima (Perù)	

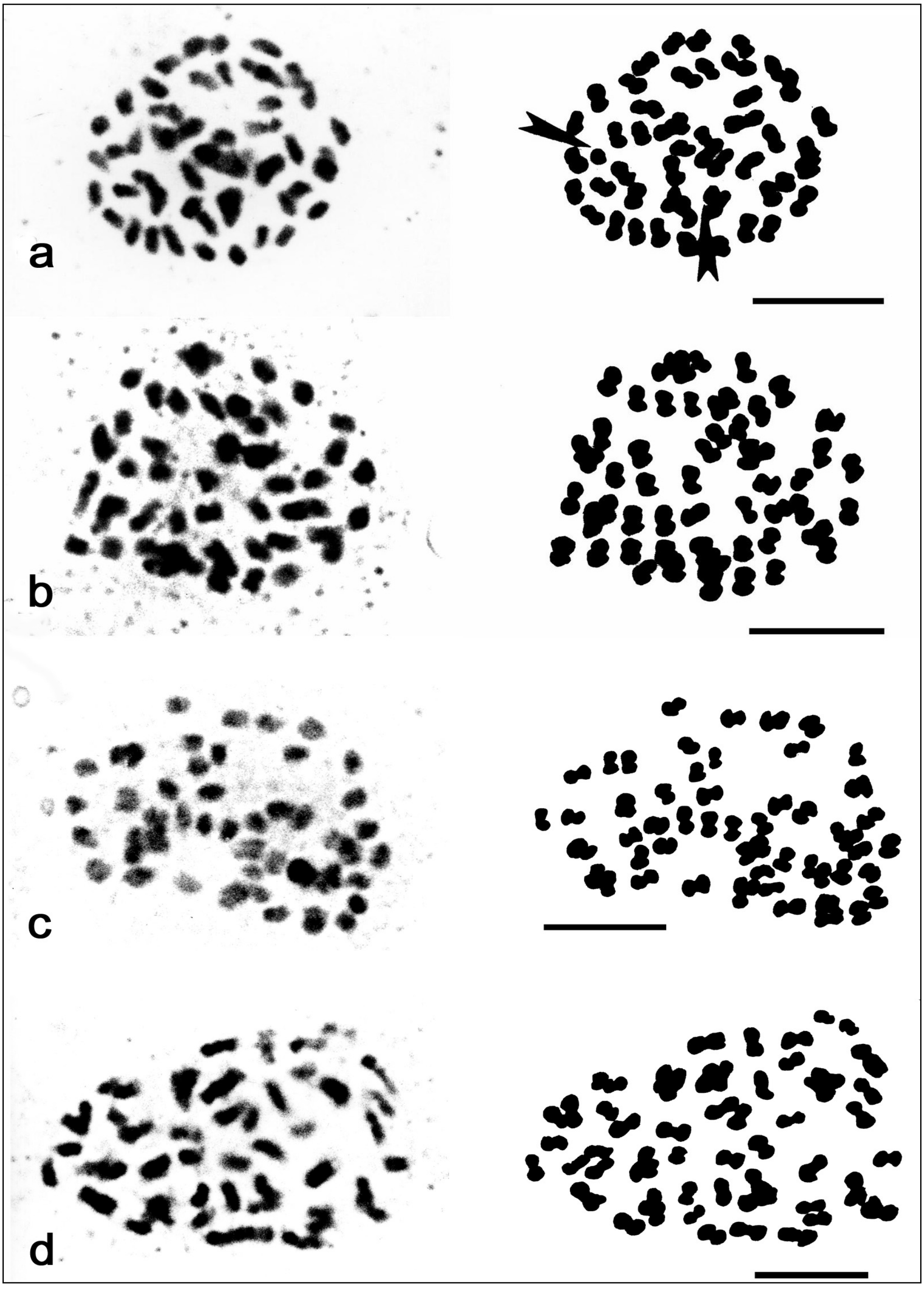

Fig. 5. Photomicrographs and relative drawings of somatic metaphase plates of *Spartium junceum* from: **a,** Limone, $2n = 48 + 2B$; **b,** Hierro, $2n = 54$; **c,** Krk, $2n = 54$; **d,** Živogošće, $2n = 54$. — Arrows indicate B-chromosomes. Scale bars = 5 µm.

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Appendix

List of voucher specimens of the seeds collected by the authors:

Retama monosperma (L.) Boiss. var. ***webbii*** (Spach) Maire — Morocco, western Anti Atlas, 600 m, 25 Jun 1987, *L. Feoli Chiapella* (TSB).
Retama sphaerocarpa (L.) Boiss. — Spain, Málaga, Estepona, 120 m, 9 Aug 1989, *L. Feoli Chiapella* (TSB).
Retama sphaerocarpa (L.) Boiss. — Spain, Granada, Motril–Granada, 200 m, 11 Aug 1983, *L. Feoli Chiapella* (TSB).
Retama sphaerocarpa (L.) Boiss. var. ***atlantica*** (Pomel) Batt. — Morocco, Haut Atlas, Ouarzazate-Marrakech, 1500 m, 30 Jun 1987, *L. Feoli Chiapella* (TSB).
Retama dasycarpa Cosson — Morocco, Vallée du Dräa, Ouarzazate-Zagora, 950 m, Oct 1997, *E. Feoli* (TSB).
Echinospartum boissieri (Spach) Rothm. — Spain, Jaén, Sierra de La Pandera, 1300 m, 8 Aug 1989, *L. Feoli Chiapella* (TSB).

Erinacea anthyllis Link — Spain, Granada, Sierra Nevada, 1950 m, 5 Aug 1989, *L. Feoli Chiapella* (TSB).
Spartium junceum L.— Italy, Carbonia Iglesias, Nebida, 150 m, 14 Jul 2002, *L. Feoli Chiapella* (TSB).

Lorenzo Gallo

Sedum ser. Rupestria Berger (*Crassulaceae*): work in progress toward a checklist of taxa and their distribution

Abstract

Gallo, L.: S*edum ser. Rupestria Berger* (*Crassulaceae*): work in progress toward a checklist of taxa and their distribution. — Bocconea 23: 203-205. 2009. — ISSN 1120-4060.

The author proposes a provisional list of the taxa included in the series *Rupestria* Berger of the genus *Sedum* (*Crassulaceae*), hybrids included, with the known distribution. Also major taxonomical and chorological problems are quoted.

Sedum series *Rupestria* Berger (*Crassulaceae*), well known for the peculiar "reticulated" evolution, very important in the development of the adaptation skills to environmental opportunities ('t Hart 1978; 't Hart & al. 1993; van Ham & 't Hart 1994), is only partially known taxonomically. This series, with the ancestral *taxa* located in the Iberian Peninsula (van Ham & 't Hart 1994), spread in all the Mediterranean region and also in Western and Central Europe.

Fifteen accepted *taxa* (species, subspecies and hybrids) have been so far described, but five new hybrids were discovered by the author in the French-Italian Alps. In the table 1 an up-to-date checklist of these *taxa* is reported along with their presently known distribution.

An outstanding result of the work is the synonimization of *S. rupestre* subsp. *erectum* 't Hart with *S. montanum* subsp. *orientale* 't Hart, supported by the inconsistency of the alleged morphological differences between them; the taxonomical consequences are important and involve also the *nothotaxa* which it gave origin to as one of the parental taxa.

This taxon, raised to specific rank *sub Petrosedum* (Grulich 1984) and more recently *sub Sedum* (Gallo & Bracchi 2005), is here definitively named *S. thartii* Hebert.

The identification of the *nothotaxa* in this series, in part performed by Henk 't Hart (1978, 1979, 1987), is a difficult task, requiring more field studies, especially in France and Italy, where the sympatric presence of many species (see e.g. Durance Valley in France) make hybridization very easy; specific researches are also in progress in *herbaria*, as at G and at ZSS, where 't Hart's collection was transferred some years ago from Utrecht (Eggli *in litt.*). The true identity of *S. hegnaueri* 't Hart *pro hybr.* and *S. hommelsii* 't Hart *pro hybr*. is in fact still obscure today, because *S. rupestre* subsp. *erectum* 't Hart, one of the parents, is an enigmatic *taxon* never collected by anyone in the French Alps. Table 1 lists all the names of the *taxa* found

Table 1. Checklist of the taxa with synonyms and provisional distribution.

Taxa	**Taxonomical synonyms/hybrid formulas**	**Provisional distribution**
Sedum amplexicaule DC. subsp. *amplexicaule*	*Sempervivum anomalum* Lag. *Sedum tenuifolium* subsp. *ibericum* 't Hart	Tunisia, Algeria, Morocco, Portugal, Spain, France, Italy.
S. amplexicaule subsp. *tenuifolium* (Sm.) Greuter	*Sedum rostratum* Ten.	Portugal, Spain, Italy, Yugoslavia, Bulgaria, Albania, Greece, Turkey, Anatolia, Lebanon/Syria.
S. brevierei Chass. *pro hybr.**	*S. forsterianum* × *S. rupestre*	France.
S. forsterianum Sm.	*S. elegans* Lej.	[Azores], Algeria, Morocco, Portugal, Spain, France, Belgium, Germany, [Netherlands], Great Britain, [Ireland], [Sweden].
S. hegnaueri ‘t Hart *pro hybr.**	*S. sp.* × *S. sediforme*	France.
S. hommelsii ‘t Hart *pro hybr.**	*S. sp.* × *S. ochroleucum*	France.
S. lorenzoi ‘t Hart *pro hybr.**	*S. ochroleucum* × *S. rupestre*	France, Italy.
S. luteolum Chaboiss. *pro hybr.**	*S. rupestre* x *S. sediforme*	France, Italy.
S. montanum Songeon & Perr.		Spain, France, Italy, Switzerland, Austria.
S. montanum × *S. ochroleucum* * (n)		France, Italy.
S. montanum × *S. thartii* * (n)		Italy.
S. montanum × *S. rupestre* * (n)		Spain (?), France (?), Italy.
S. montanum × *S. sediforme* * (n)		France, Italy.
S. ochroleucum Chaix	*S. anopetalum* DC. *S. verloti* Jordan	France, Switzerland, Italy, Slovenia, Croatia, [Czech Rep.], Yugoslavia, Albania, Bulgaria, Greece, Romania, Turkey, Anatolia.
S. ochroleucum × *S. sediforme* * (n)		France, Italy (?)
S. pruinatum Brot.		Portugal, Spain
S. thartii L.P. Hebert *	*S. montanum* subsp. *orientale* ‘t Hart *S. rupestre* subsp. *erectum* ‘t Hart *S. pseudomontanum* Holub *S. pseudorupestre* Gallo	France (?), Switzerland, Italy, Germany, Austria, Slovenia, Croatia, Hungary (?), Czech Rep (?).
S. rupestre L. *	*S. reflexum* L.	Widespread in W-C Europe and W Mediterranean (also not native).
S. sediforme subsp. *dianium* (O. Bolos) O. Bolos		Spain (value and taxonomic rank to be verified).
S. sediforme (Jacq.) Pau subsp. *sediforme*	*S. altissimum* Poiret	Libya, Tunisia, Algeria, Morocco, Portugal, Spain, France, Italy, Yugoslavia, Albania, Greece, Turkey, Anatolia, Lebanon/Syria, Israel/Jordan.

* = *Taxon* of hybrid origin.
(n) = *Taxon* cited here for the first time.
[ ] = *Taxon* not native in a specific country.

through field, *herbaria* and bibliographical researches, but in the future, some of them could be treated as synonims.

Many taxonomical, nomenclatural and chorological problems remain to be solved; the current taxonomic and chorological knowledge is insufficient to propose a conclusive checklist. More studies are required to clarify some major problems, such as the correct taxonomical rank of the Mediterranean populations of *S. rupestre* and *S. ochroleucum,* and the re-evaluation of some neglected names such as *S. nicaeense* All.

By the nomenclatural view-point, the typification of *S. rupestre* L. by 't Hart & Jarvis (1993) was superseded by that of Heath of 1992, as recently stated (Jarvis 2007: 836; http://www.nhm.ac.uk/research-curation/projects/linnaean-typification/index.html); the consequences are noteworthy, because the Linnean binomial *S. rupestre* at present is the correct name for the well known *S. forsterianum* Sm., with unavoidable nomenclatural changes and a resuming of obsolete binomials, if a proposal for its conservation is not made.

Lastly, from the chorological view-point, many problems remain to solve, as the boundaries of the areas of *S. rupestre* and *S. thartii,* frequently confused; their distribution, especially in Central Europe, must be revised and perhaps major changes in the European floras will be made in the future.

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Genetic diversity on *Pyrus* L. (*Rosaceae*) in Sicily

Abstract

Schicchi, R., Geraci A. & Marino P.: Genetic diversity on *Pyrus* L. (*Rosaceae*) in Sicily. — Bocconea 23: 207-212. 2009. — ISSN 1120-4060.

The genetic diversity on six *Pyrus* species (*P. amygdaliformis, P. pyraster, P. communis, P. vallis-demonis, P. sicanorum, P. castribonensi*s) from Sicily was investigated using isozymes. Atotal of 26 alleles was found in 8 loci of 5 enzyme systems (IDH,MDH, 6-PGD, PGI and SKD). The allelic frequencies and the genetic variability values for each population were calculated. The greatest rate of polymorphism was found in *P. sicanorum, P. castribonensis* and *P. amygdaliformis* from Sicani Mts. The relationships among the populations were computed by Nei's genetic identity/distance and the obtained dendrogram shows a remarkable genetic distance of *P. vallis-demonis* from of all other investigated taxa; *P. sicanorum* appeared enough distinguished; the other examined taxa formed a clade in which *P. castribonensis* and *P. amygdaliformis*, resulted more similar than *P. communis* and *P. pyraster*.

Introduction

Pyrus L. in Sicily is a very polymorphic genus and several taxonomical studies based on field periodical surveys and selected collections (branchlets, buds, flowers, fruits) have been in progress for some years in order to understand and evaluate the variation affecting such critical genus in Sicily. In particular, *Pyrus amygdaliformis* Vill. (= *P. spinosa* Forssk.), *P. pyraster* Burgsd. and *P. communis* L. are involved in these surveys. Related to these three species indeed, several taxa which are not enough delimited were described in the past (Gussone 1826, Lojacono 1891). The critical revision of the genus in Sicily has so far led to identify three new species: the first, *P. vallis-demonis* Raimondo & Schicchi, located on Nebrodi Mounts; the second, *P. sicanorum* Raimondo, Schicchi & P. Marino occurring on Sicani Mounts; the third, *P. castribonensis* Raimondo, Schicchi & Mazzola distributed mainly on Madonie Mounts (Raimondo & Schicchi 2004, Raimondo & al. 2006a, 2006b).

As caryology is concerned the genus is characterized by $2n = 2x = 34$, suggesting the hypothesis that *Maloideae* subfamily arose in the remote past as allopolyploid hybrid from *Spiraeoideae* ($x = 9$) and *Prunoideae* ($x = 8$) (Chevreau & al. 1985, Morgan & al. 1994). This is also confirmed by Chevreau & al. (1997) in their results about inheritance of isozyme loci in *P. communis*.

The aim of the present contribute is to assess the genetic variability in the three new species, and also in *P. amygdaliformis, P. pyraster* and some *P. communis* cultivars, using a molecular approach. There is not, in fact, a genetic information known about Sicilian species of the genus *Pyrus*. Several studies have been realized with isozymic method to analyze a large number of cultivars of *P. communis*, a lot of Asian species of pears in order to characterize them genetically (Cerezo & Socias 1989, Jang 1991, Sharifani & Jackson 2002). Several eastern Asian species and related cultivars have been recently examined with analyses based on DNA markers providing informations regarding the immediate ancestor of cultivated pear, the influence of hybridation and the genetic diversity (Iketani & al. 1998, Monte-Corvo & al. 2000, Yamamoto & al. 2002, Kim & al. 2005). In our study we chose the allozymic analysis which is very useful to describe allelic variation and to assess the range of genetic similarity among these species.

Materials and methods

Six species of pear were investigated and the plants were collected from their natural localities in Sicily (Fig. 1). A sample of 15-20 individuals was tested except for *P. vallis-demonis* (6 individuals). The following enzyme systems were examined: IDH – isocitrate dehydrogenase (E.C.1.1.1.42), MDH – malate dehydrogenase (E.C.1.1.1.37), 6PGD – 6-phosphogluconate dehydrogenase (E.C.1.1.1.44), PGI – phosphoglucoisomerase (E.C.5.3.1.9) and SKD – shikimic dehydrogenase (E.C.1.1.1.25). Enzymes were extracted from the buds because of phenolic compounds in pear leaves which make difficult the enzyme extraction (Sharifani & Jackson 2002). The buds collected before their opening were crushed in 150 µl buffer containing TrisHCl pH 7.1 and 3% w/v PVP, 65 mM DTT,

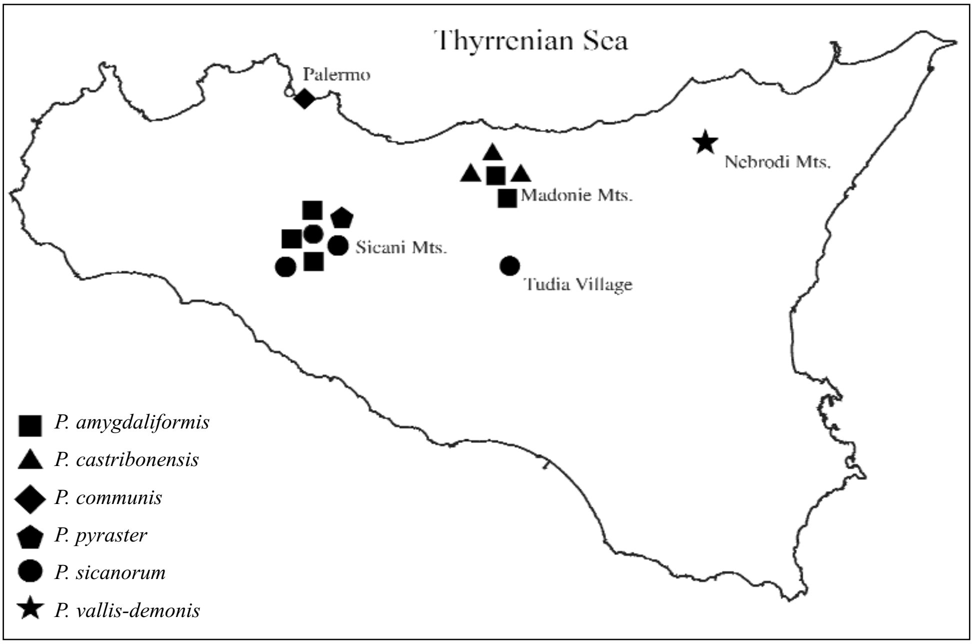

Fig. 1. Distribution of collected material of *Pyrus* populations.

8 mM EDTA, 7 mM β-mercaptoethanol. Crude extracts for each sample were absorbed on paper wicks and stored at -80°C until use. Horizontal electrophoresis was performed on 11% starch gel (Sigma, St. Louis, MO. USA) according to Kephart (1990). Two buffer systems were used: Tris-citrate, pH 7.0 (Meizel & Markert 1967) for PGI, SKD, and Morpholine-citrate, pH 6.1 (Clayton & Tretiak 1972) for IDH, MDH and 6-PGD. After migration gel slices were incubated in a staining solution following Wendel & Stuber (1984). The loci and alleles were counted and numbered from the anode to the cathode.

For the data analyses Biosys-2 software (Swofford & Selander 2000) was utilised and the following parameters were considered: the allozyme frequencies, the mean number of alleles per locus (A), the mean percentage of polymorphic loci (P), the observed (Ho) and expected (He) heterozygosity (according to the Hardy-Weinberg law). The chi-square test was used to evaluate the significance of the deviation from the Hardy-Weinberg law.

Genetic relationships among populations were calculated computing the genetic distance (Nei 1972, 1978). Cluster analysis was performed by UPGMA method using Nei's genetic identity measure.

Results

Twentysix alleles were found in 8 loci of 5 examined enzyme systems. The loci with the highest variability result: *Pgi-2* (6 alleles), *Idh-1* and *Mdh-2* (4 alleles). The locus *6Pgd-1* is monomorphic for all populations. Five exclusive alleles were found: allele "a" in *Idh-1* locus in *P. sicanorum*, allele "a" in *Mdh-1* locus in *P. communis*, alleles "e" and "f" in *Pgi-2* locus in *P. sicanorum* and *P. castribonensis* respectively, allele "a" in *Skd-1* locus in *P. sicanorum*. Only a rare allele was found in *P. castribonensis* (allele "d" in *Pgi-2* locus).

The genetic variability parameters in all investigated populations are shown in Table 1. The mean number of alleles per locus ranges from 1.5 in *P. pyraster* and *P. vallis-demonis* to 2.6 in *P. sicanorum*. The greatest rate of polymorphism (75%) was found in *P. sicanorum, P. castribonensis, P. amygdaliformis* from Sicani Mts.; the lowest in *P. vallis-demonis, P. pyraster* and *P. amygdaliformis* from Madonie Mts. High levels of expected and

Tab. 1. Genetic variability at 8 loci in all populations investigated. (A) mean number of alleles per locus; (P) percentage of loci polymorphic at 99% (P99); (Ho) heterozygosity observed (direct-count); (He) heterozygosity expected (Hardy –Weinberg law).

Population	**A**	**P 99**	**Mean heterozygosity**	
			Ho	**He**
P .amygdaliformis (Madonie Mts.)	1.8	37.5	0.188	0.210
P. amygdaliformis (Sicani Mts.)	1.9	75.0	0.314	0.253
P. vallis-demonis (Nebrodi Mts.)	1.5	37.5	0.313	0.250
P. sicanorum (Sicani Mts., Tudia Village)	2.6	75.0	0.563	0.443
P. castribonensis (Madonie Mts.)	2.1	75.0	0.432	0.350
P. communis (Palermo, Botanical Garden)	1.9	62.5	0.150	0.173
P. pyraster (Sicani Mts.)	1.5	37.5	0.225	0.206

observed heterozygosity were detected in several examined populations; in particular *P. sicanorum* and *P. castribonensis* show the highest values of both Ho (0.563 and 0.432) and He (0.443 and 0.350).

The dendrogram based on Nei's genetic identities shows the relationships among the studied populations of *Pyrus* (Fig. 2). The lowest genetic distance was detected between the two populations of *P. amygdaliformis* (0.004) which showed also low values of distance with *P. castribonensis* (0.067 and 0.016), *P. communis* (0.054 and 0.091) and *P. pyraster* (0.048 and 0.047). The distance value between *P. pyraster* and *P. communis* was 0.061 while the value between *P. castribonensis* and *P. communis* resulted 0.118.

The highest values were found between *P. vallis-demonis* and the other populations of the examined species, in particular with *P. castribonensis* (0.354).

Discussion

The allozyme analysis carried out in this study allowed showing the genetic variability in these wild populations of pear recently described and well characterized under the morphological and ecological aspects. A high level of polymorphism and heterozygosity was detected in the examined populations. These results agree with the ancient allopolyploid origin of the Maloideae that causes structural heterozygosity. A large contribution at the variability is also determined by the mating system. *Pyrus* is characterized, in fact, by allogamy and cross pollination is realized by insects; individuals have got a very high degree of self-incompatibility (Chevreau & al. 1997). Past studies on the variation of seed content in fruits in pear varieties showed that proofs about apomictic seeds do not exist and natural autogamy occurred with low fruit set and very few viable seeds (Nyéki & Soltész 1998). The enzyme PGI showed a large range of variation within these species (6 different alleles at *Pgi-2* locus, two of them exclusive) and revealed the most discriminative characterization of *Pyrus*. This datum agrees with Sharifani & Jackson (2002) who obtain a significant relatedness among wild species and cultivars of *P. communis*. Moreover the loci *Mdh-1* and *6Pgd-2* play a great role in the differentiation of populations.

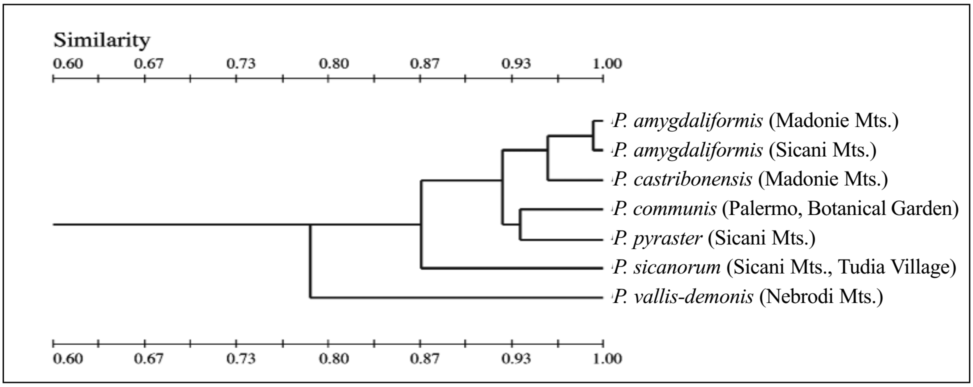

Fig. 2. Dendrogram (UPGMA method) showing the relationships among 7 populations of *Pyrus*.

Concerning to the relationships among the different populations, in our work a remarkable genetic distance of *P. vallis-demonis* in comparison of all other investigated taxa was discovered; *P. sicanorum* appeared enough distinguished; the other examined taxa formed a clade in which *P. castribonensis* and *P. amygdaliformis* resulted more similar than *P. communis* and *P. pyraster*.

Correlation between allozymic analysis and morphological classification

P. vallis-demonis is enough morphologically distinguished by other taxa: it is characterized by small fruits and deciduous calyx and its separation was also noticed with the genetic analysis. *P. castribonensis* differs from *P. amygdaliformis* in the crenulate leaf margin and in the bigger fruits, while it is more related to *P. pyraster*, species that Aedo & Aldasoro (1998) included in *P. communis*. Nevertheless *P. castribonensis*, althought it shares with these taxa the leaf lamina shape and the leaf margin, differs in the leaf width/lenght ratio, in the pome shape which is globose with flattened poles and bigger than the *P. pyraster* fruit, and in the deciduous or semi-persistent calix. In this analysis, *P. castribonensis*, althought it belongs to the same group in which also *P. communis* and *P. pyraster* were found, results more related with *P. amygdaliformis*. *P. sicanorum*, included for its morphologycal features in the group characterized by pomes with persistent calyx comprising also *P. communis* and *P. pyraster*, results rather differentiated from these last species under the genetical aspects and a clear separation with *P. amygdaliformis* is here also confirmed.

In conclusion, this analysis, realized from enzyme extraction out of buds, even though working with isoenzymes in pear is more difficult than other taxa (Stephan & al. 2003), appeared valid. The results permitted showing the variability in these taxa, but they reflect partially the relationships detected on morphological characters. Morphological and molecular data, however, do not always correspond. Other studies, in fact, on genetic diversity in EastAsian species of *Pyrus*, based on RFLP markers and cpDNA (Iketani & al. 1998) showed the incongruences between RFLPs and morphological classification or geographical distribution among oriental pear species. Further extensive studies using both several molecular markers and micromorphological characters can be useful to improve the knowledge of the diversity in these Sicilian species and to understand the evolution and their taxonomical relationships.

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G. Venora, C. Ravalli, M. Ruffini Castiglione, R. Cremonini & M. Frediani

Karyomorphological data as phylogenetic markers in species of *Vicia* subgenus

Abstract

Venora, G., Ravalli, C., Ruffini Castiglione, M., Cremonini, R. & Frediani, M.: Karyomorphological data as phylogenetic markers in species of *Vicia* subgenus. — Bocconea 23: 213-220. 2009. — ISSN 1120-4060.

The relationships within and among sections *Bithynicae*, *Narbonensis* and *Faba* have been investigated by karyological and molecular approaches and the results of the analysis confirmed the classification of Maxted, emphasizing the remoteness of *V. faba* and *V. bithynica* from the species of *Narbonensis* section. Later karyomorphological and molecular phylogeny of section *Hypechusa* have been investigated starting from Maxted classification, that subdivided the section *Hypechusa* in two series, *Hyrcanicae* and *Hypechusa,* and pointed out the heterogeneity of these series. A multivariated analysis using 34 new karyomorphological parameters in addition to TF%, SYi and Rec indices was carried out and the dendrogram of linkage distance was more resolved compared to previous elaborations. This analysis confirms the grouping of the species of section *Hypechusa* according to the chromosome number but highlights different clusters corresponding to the two series.

Introduction

The relationship between *Vicia faba* and its putative allies of the subgenus *Vicia* has always been controversial. Following the classification of Kupica (1976) and Hanelt & Metting (1989), Maxet & al (1991) divided the subgenus *Vicia*, after cytotaxonomic studies, into nine sections. He substituted the section *Faba sensu* Kupica with three distinct sections: *Bithynicae* and *Faba*, monospecific, and *Narbonensis* containing the species before referred to as *Narbonensis* complex. The remaining six sections were *Atossa* (Alef.) Asch. & Graebner, *Microcarinae* Maxted, *Hypechusa* (Alef.) Asch. & Graebner, *Peregrinae* Kupicha, *Wiggersia* (Alef.) Maxted and *Vicia* L.. The present study is undertaken to obtain karyomorphological details and karyotipic affinities within subgenus *Vicia*, to use karyological data in projecting species relationships.

In spite of the accumulating molecular data, chromosome information continues to be important in assessing phylogenetic relationships and allow the elaboration of phylogenetic trees, comparable to molecular dendrograms. These considerations strongly support the idea to study the phylogenetic relationships among *Vicia* species by employing different approaches and using as large a number of data as possible, so as to obtain sets of complementary data to be integrated with traditional taxonomic studies.

Materials and Methods

Plant materials

The names, source and accession numbers of the selected species are listed in Table 1 and Table 2.

Cytophotometric analysis

Squashes of root tips were prepared according to Caputo & al (2006); squashes of *V. faba* were stained concurrently with each group of slides and used as internal standard. Feulgen absorptions were measured by a Leitz MPV3 integrating microdensitometer (Wetzlar, Federal Republic of Germany); absorption measured in *V. faba* preparations was used to convert relative Feulgen arbitrary units into picograms of DNA.

Karyomorphometry

The microscopic investigation was conducted with a Zeiss Axioplan 2 microscope (Carl Zeiss Jena GmbH, Jena, Federal Republic of Germany) connected to an image analysis system KS 400 Zeiss, with dedicated software for karyotyping IKAROS 3.40 (Metasystem Gmbh, Altlussheim, Federal Republic of Germany), which enables more reliable results than the traditional hand-made karyotype. Slides were prepared and analyzed according to Venora & al. (1991). For each species at least five metaphases for each of five seedlings were analyzed. The total chromosome length of short arms, long arms, and satellites was measured with the computer system. The TF% index (Huziwara 1962), and the Rec and SYi indices (Greilhuber & Speta 1976) were used to perform the analysis. The description of the indices is explained in a previous report (Venora & al. 2000). A hierarchical cluster analysis using Euclidean distances (SPSS release 13 Inc 1989–2003, statistic package) was also employed to compare all the karyological data of the species belonging to *Vicia* subgenus.

Results and Discussion

The present work shows two examples of utilization of cytological and karyological paramenters in the study and in a further reconsideration of phylogenetic relationships inside the subgenus *Vicia*. The first set of data concerns the sections *Narbonensis*, *Bithynicae* and *Faba*. All karyological data from the analyzed species are reported in Table 1, including Rec, SYi, TF%. The spatial representation of symmetry indices, obtained by means of dedicated software and with high degree of accuracy, may be, as generally accepted (Pasko 2006), a good indication of the karyotype evolution. Figure 1a and 1b illustrate the spatial representation of the karyological indices of the species belonging to *Vicia* sect. *faba*, according to Kupicha (1976) and the seven species of the *Narbonensis* complex, respectively. Fig. 1a evidences three distinct groups: the *V. narbonensis* complex, *V. faba* and *V.* b*ithynica*. The recognition of three distinct units in *Vicia* sect. *faba* is in line with the classification of Maxted & al. (1991) and with molecular sequence data derived from the alignment of ITS regions (Venora & al. 2000). Moreover it is to underline that *V. bithynica* can be considered closely allied to *V. faba*, confirming the biochemical and cytological data of Perrino & Pignone (1981). In Fig. 1b the spatial representation of the *Narbonensis* complex highlights four distinct groups: two monospecific (*V. hyaeniscyamus* and *V. serratifolia*), one composed of two species (*V. galilaea* and *V. johannis*) and

Table 1. Accession, source, chromosome number, mean nuclear DNA content, karyotype formulas, mean set lengths and indices in *Vicia* (*Narbonensis*, *Bithynicae* and *Faba* sections). [a] A= Istituto per il Germoplasma, CNR, Bari, Italy; B= *Viciae* Genebank, University of Southampton, U.K.; C= Institute of Plant Genetics and Crop Plant Research, Gatersleben, Federal Republic of Germany. [b] For each species results are the mean of fifty determinations carried out in five root meristems.

Species	**Accession nr.**	**Source**[a]	**DNA amount (pg)**[b]	**Karyotype Formula**	**Total length of haploid set (µm)**	**Rec index**	**SYi index**	**TF% index**
V. narbonensis L [d]	105786	A	29.10 ± 0.3	sm^{sc}+2m+4sm	27.15±2.28	84.60	56.05	34.57
V. eristalioides Maxt. [d]	877321	B	38.58 ± 0.5	sm^{sc}+3m+3sm	33.38±0.37	83.02	56.76	34.07
V. galilaea Plitm. et Zoh. [f]	112018	A	26.09 ± 0.2	sm^{sc}+6sm	40.34±1.71	85.94	47.69	31.18
V. hyaeniscyamus Mout. [f]	112008	A	31.24 ± 0.1	sm^{sc}+2m+4sm	29.21±2.85	65.99	57.64	35.32
V. johannis Tamasch. [f]	112019	A	25.08 ± 0.3	sm^{sc}+6m	33.56±3.19	86.33	48.12	31.31
V. kalakhensis Khatt. [d]	867095	B	42.22 ± 0.4	st^{sc}+3m+3sm	42.28±0.10	85.02	55.52	33.73
V. serratifolia Jacq. [e]	NAR 121/77	C	39.59 ± 0.4	sm^{sc}+5sm+m	38.16±2.06	89.69	52.44	32.68
V. bithynica L. [f]	VIC 303/79	C	18.03 ± 0.2	st^{sc}+6st	24.07±1.83	86.99	23.72	18.49
V. faba major L.[c]	113064	A	53.12	sm^{sc}+3st+2t	58.11±5.04	46.05	23.08	17.70

[c] Ceccarelli & al. 1995; [d] Cremonini & al. 1998a; [e] Cremonini & al. 1998b; [f] Venora & al. 2000.

Table 2. Accession, source, chromosome number, mean nuclear DNA content, karyotype formulas, mean set length, indices in *Vicia* samples (*Hypechusa* section). [a] For each species results are the mean of fifty determinations carried out in five root meristems.

Species	**Accession nr.**	**DNA amount (pg)[a]**	**Karyotype formula**	**Total length of haploid set (µm)**	SYi Index	TF% index	Stebbins categories
Sect. *Hypechusa* series *Hyrcanicae*							
V. assyriaca Boiss. [c]	IG 64098 ICARDA	26.31±0.38	$2m^{sc}+2sm+st^{sc}+st$	42.55 ± 0.30	71.02	43.86	26.77
V. tigridis Mout. [c]	IG 63488 ICARDA	25.81±0.45	$m^{sc}+2sm+3st$	35.07 ± 0.30	71.07	34.07	23.00
V. galeata Boiss. [c]	PI 602380 USDA	30.55 ±1.10	$m^{sc}+2sm+3st$	36.43 ± 2.43	77.93	35.88	23.74
V. hyrcanica Fish. & Mey. [c]	PI 561419 UDSA	46.91±0.84	$m^{sc}+2sm+3st$	33.59 ± 1.80	76.00	35.37	23.57
V. noeana (Re. in B.) Boiss. [c]	IG 63757 ICARDA	52.95±0.37	$sm^{sc}+2sm+3st$	39.91 ± 2.08	69.18	33.82	22.17
V. esdraelonensis Warb. & Eig [d]	Univ. Jerusalem	30.89±0.36	$sm^{sc}+5sm$	38.79 ± 1.96	77.73	38.63	28.52
Sect. *Hypechusa* series *Hypechusa*							
V. melanops Sib. & Smith[c]	IG 64074 ICARDA	27.52±0.27	$m^{sc}+sm^{sc}+3st$	39.91 ± 2.20	56.45	38.91	24.23
V. ciliatula Lipsky [c]	IG 63373 ICARDA	26.48±0.19	$m^{sc}+3sm+st^{sc}$	35.12 ± 2.89	60.00	39.54	24.00
V. anatolica Turrill [c]	IG 64625 ICARDA	30.18±0.19	$2m^{sc}+sm+2st^{sc}$	35.07 ± 3.04	59.47	50.99	30.08
V. mollis Boiss.& Hausskn. [b]	IG 62649 ICARDA	31.31±1.42	$m^{sc}+4st$	38.12 ± 1.41	48.31	38.12	25.81
V. pannonica Cranz. [c]	PI 369156 ICARDA	39.92±0.77	$m^{sc}+3sm+st^{sc}+st$	30.13 ± 1.82	79.28	38.75	25.02
V. hybrida L. [c]	IG 60008 ICARDA	27.93±0.49	$m^{sc}+st^{sc}+4st$	40.73 ± 3.01	80.44	36.60	24.28
V. sericocarpa Fenzl [c]	IG 64103 ICARDA	48.52±0.05	$m^{sc}+sm+st^{sc}+3st$	39.44 ± 3.00	74.47	36.26	24.57
V. lutea L. [c]	PI 201994 USDA	35.90±0.26	$sm+st^{sc}+2sm+3st$	49.37 ± 5.83	91.46	32.73	23.98

[b] Frediani & al. 2005; [c] Caputo & al. 2006; [d] Ruffini Castiglione & al. 2007

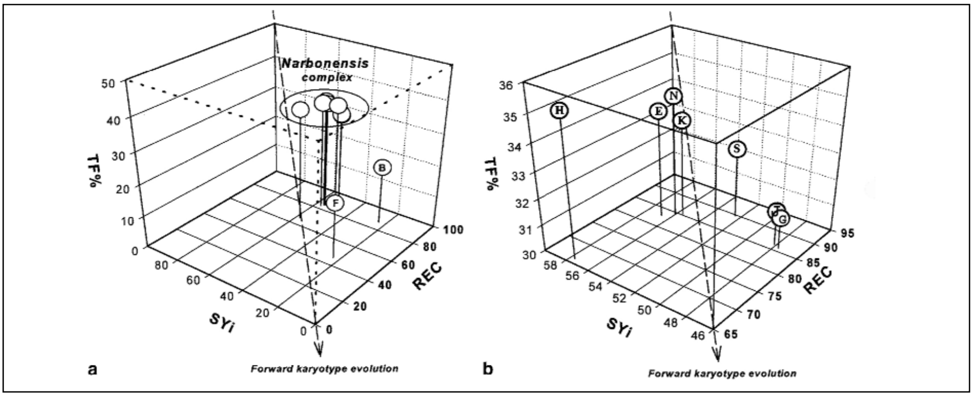

Fig. 1. **a** Karyotype symmetry of *Vicia* sect. *faba* and *Narbonensis* complex with Rec, SYi and TF% indices. B, *V. bithynica*; F, *V. faba*. **b** Karyotype symmetry of the *V. narbonensis* complex with Rec, SYi and TF% indices. N, *V. narbonensis*; E, *V. eristalioides*; G, *V. galilaea*; H, *V. hyaeniscyamus*; J, *V. johannis*; K, *V. kalakhensis*; S, *V. serratifolia*. (Redrawn from Venora & al. 2000).

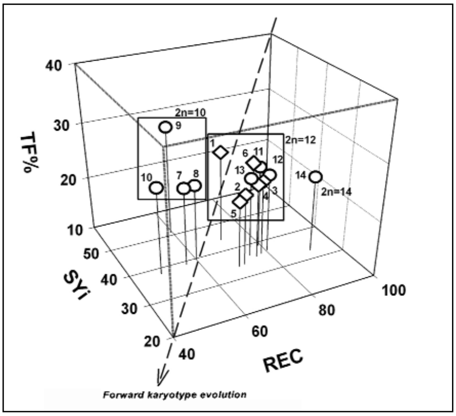

Fig. 2. Karyotype symmetry of the species of section *Hypechusa*: ◇ = series *Hyrcanicae (*1- *V. assyriaca*; 2- *V. tigridis*; 3- *V. galeata*; 4- *V. hyrcanica*; 5- *V. noeana*; 6- *V. esdraelonensis*); ○ = series *Hypechusa* (7- *V. melanops*; 8- *V. ciliatula*; 9- *V. anatolica;* 10- *V. mollis*; 11- *V. pannonica*; 12- *V. hybrida*; 13- *V. sericocarpa*; 14- *V. lutea),* with Rec, SYi and TF% indices. Boxes include species with the same chromosome number. (Redrawn from Ruffini Castiglione & al. 2007).

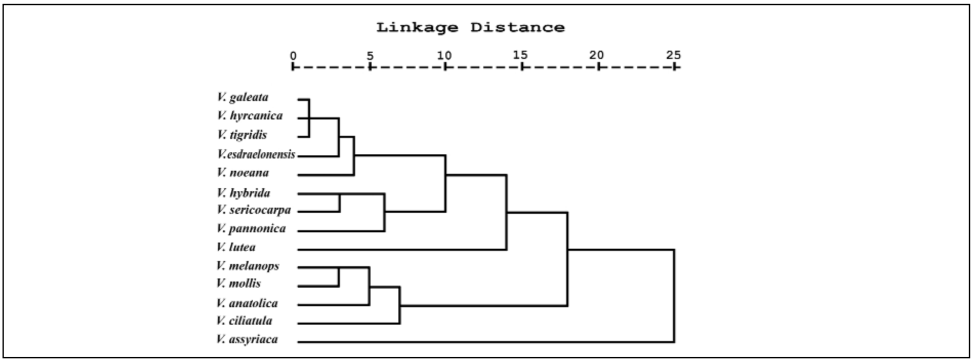

Fig. 3. Hierarchical cluster analysis: dendrogram of *Vicia* species (using average linkage between group) based on the 37 chromosome parameters as reported in Table 3 . (Redrawn from Ruffini Castiglione & al. 2007).

Table 3. Parameters used in cluster analysis, recorded in any plate of every analysed accession.

Parameters	Code n.	Description
TF%	1	Total Form (%)
Rec	2	Resemblance among chromosomes
SYi	3	Symmetry index
Cl	4	Total length of haploid complement
2n	5	Chromosomes diploid number
N. cro. sat	6	Number of satellited couples
1st satellite	7	Length of the 1st satellite
1st Sat. Pos.	8	Satellite position, short or long arm
2nd satellite	9	Length of the 2nd satellite
2nd Sat. Pos.	10	Satellite position, short or long arm
3rd satellite	11	Length of the 3rd satellite
3rd Sat. Pos.	12	Satellite position, short or long arm
N. cro. m	13	Number of metacentric couples
N. cro. sm	14	Number of submetacentric couples
N. cro. st	15	Number of subtelocentric couples
N. cro. t	16	Number of telocentric couples
C1 L	17	Chromosome 1st length
C1 ar	18	Chromosome 1st arm ratio
C1 CI	19	Chromosome 1st Centromeric Index *
C2 L	20	Chromosome 2nd length
C2 ar	21	Chromosome 2nd arm ratio
C2 CI	22	Chromosome 2nd Centromeric Index
C3 L	23	Chromosome 3rd length
C3 ar	24	Chromosome 3rd arm ratio
C3 CI	25	Chromosome 3rd Centromeric Index
C4 L	26	Chromosome 4th length
C4 ar	27	Chromosome 4th arm ratio
C4 CI	28	Chromosome 4th Centromeric Index
C5 L	29	Chromosome 5th length
C5 ar	30	Chromosome 5th arm ratio
C5 CI	31	Chromosome 5th Centromeric Index
C6 L	32	Chromosome 6th length
C6 ar	33	Chromosome 6th arm ratio
C6 CI	34	Chromosome 6th Centromeric Index
C7 L	35	Chromosome 7th length
C7 ar	36	Chromosome 7th arm ratio
C7 CI	37	Chromosome 7th Centromeric Index

- The Centromeric index is the ratio of the short arm and chromosome length.

the last with *V. narbonensis*, *V. eristalioides* and *V. kalakhensis.* The diversity within the *Narbonensis* complex, partially illustrated in the past by the distribution of the Fok1 repeats (Yakura & al 1987), on the contrary can not be evidenced by the analysis of ITS regions (Venora & al 2000); and this fact, once more, demonstrate the importance of the karyomorphometric approach in the study of phylogenetic relationships.

More recently the use of many karyological parameters has even allowed the elaboration of phylogenetic trees, comparable to molecular dendrograms. With regard to this subject, we report the second set of data, that includes *Vicia* species belonging to *Hypechusa* sect. with their accession, chromosome numbers and DNA contents, (Table 2). Sect. *Hypechusa* now includes 14 species, divided into two series, *Hyrcanicae* and *Hypechusa,* on the basis of their peduncle length, corolla shape and size, and standard pubescence (Kupicha 1976). Also in this case, from the asymmetry indices (Table 2) a spatial representation of Sec. *Hypechusa* is reported (Fig. 2): it evidences three clusters, depending on the chromosome number (2*n*= 10: *V. melanops*, *V. ciliatula*, *V. anatolica*, *V. mollis*; 2*n*= 12: *V. assyriaca*; *V. tigridis*; *V. galeata*; *V. hyrcanica*, *V. noeana*, *V. esdraelonensis*, *V. pannonica*, *V. hybrida*, *V. sericocarpa*; 2n= 14: *V. lutea*), but does not meet entirely the classical division in the two series (Caputo & al. 2006). This fact also emerges from the ITS sequence analysis, evidencing that neither series of sect. *Hypechusa* is monophyletic and a somehow closer affinity among species belongong to different sections exists (Caputo & al. 2006). A multivariate analysis using 34 new karyological parameters (Table 3), in addition to the indices TF%, SYi and Rec, was also carried out. The dendrogram of linkage distance (Fig. 3) is more resolved as compared to previous elaborations. From these data we conclude that cytological and karyomorphological results indicate that sect. *Hypechusa* is so highly heterogeneous as to raise a strong doubt about its justification and its infrasectional taxonomy (i.e., the two series).

The use of karyomorphological traits as characters in reconstructing phylogenies is a relatively recent phenomenon strongly supported by the more sophisticated and repeatable phylogeny-producing algorithms available today. Moreover, together with molecular data, karyomorphological parameters used in cluster analysis allow to draw further considerations about the phylogenetic relationships among the analyzed species.

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A. Kurtto, P. Uotila & A. Sennikov

Alchemilla in Mediterranean Europe as revealed by Atlas Florae Europaeae

Abstract

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A phytogeographical analysis of the *Alchemilla* (*Rosaceae*) flora of Mediterranean Europe is presented on the basis of maps in *Atlas Florae Europaeae* vol. 14. In Mediterranean Europe, *Alchemilla* species are confined to the mountains, and 92% of them (346 species) are endemic to Europe. Many of them have very small ranges, limited to one or to only a few 50 km × 50 km *AFE* grid cells. The known diversity and endemism are especially high in the Alps (149 species, of which 61% are endemics) and in the Cordillera Cantábrica – Pyrenees (79 species, 46% endemics). The Mediterranean is therefore well represented in the country-specific totals for *Alchemilla* species, with three countries in the European top ten: (1st) France 121, (3rd) Italy 92 and (6th) Spain 81. Many of the species concentrated in the Alps have additional stations further south along the Apennines, but only 3 species are known to be endemic to the Apennines. The Balkan *Alchemilla* flora (60 species) includes the southernmost outposts of many of the Alpine and/or Carpathian species. In total there are 24 Balkan endemics (40%). In Crimea 16 of the known 20 species are endemic to the territory.

Introduction

Atlas Florae Europaeae (AFE) is a programme for mapping native and naturalized vascular plants of Europe. Furthermore, information on taxonomy, nomenclature, chromosome numbers, biosystematics and total ranges of the taxa are added alongside the maps. For the history of the project and the mapping system, see Uotila & al. (2005) and Kurtto & al. (2004). *AFE* volume 14, published in late 2007 (Kurtto & al. 2007), covers the genera *Alchemilla an*d *Aphanes.* Reproduction mode in *Alchemilla* is almost obligate apomixis; according to established tradition the smallest taxonomic entities recognised by constant differences in morphology are given specific rank there. *Alchemilla* has 433 species in Europe (231 in *Flora Europaea;* Tutin & al. 1968) and well over 1 000 in the world. Most species are confined to various types of meadow habitats; on lowlands many of them are apophytes with uncertain natural limits of distribution areas, whereas in montane regions they are less dependant on the human activity. In *AFE* 14 the genus is mapped for the first time in its entirety on a European scale. There are many possible approaches to the analysis of the *AFE* dataset, including numerical classifications of distributions and regional comparisons. The present paper is the first attempt to use the *AFE* 14 data in such a way.

Floristic elements of the *Alchemilla* flora of Mediterranean Europe

Due to the fact that in Mediterranean Europe the genus *Alchemilla* is restricted to high mountains, the following chorological classification is principally based on presence or absence of species in distinct mountain ranges or their divisions. The elements have been arranged in a sequence roughly running west to east. Only records of native species and only records of native occurrences with certain identifications and localities are accepted as basis for the classification and comparison, but dubious

records are discussed when they may, if substantiated, change the classification. Taxonomy and nomenclature follow Kurtto & al. (2007). Delimitation and subdivision of the mountain ranges follow Tutin & al. (1968), except that in this paper the southwestern Alps include S. Jura and the central Alps include the rest of Jura and Vosges.

Iberian mountains

55 species (12.8%) of European *Alchemilla* are confined to the Iberian mountains (including French Pyrenees; Fig. 1). 27 of these species are endemic to the Pyrenees, some being present all along the range, others restricted to shorter or longer stretches of it (for details, see Fröhner 1998). The number of endemics of the Cordillera Cantàbrica is 11, and eight Iberian endemics are present only in the Pyrenees and Cordillera Cantàbrica. Thus, the pooled number of endemics present on the two ranges alone is 46.

Alchemilla atropurpurea is concentrated in the Pyrenees but has disjunct occurrences over 400 km to the south and southwest in the mountains of Avila and León. *A. spectabilior* has occurrences in both the Cordillera Cantàbrica and Pyrenees, as well as outside them

Fig. 1.

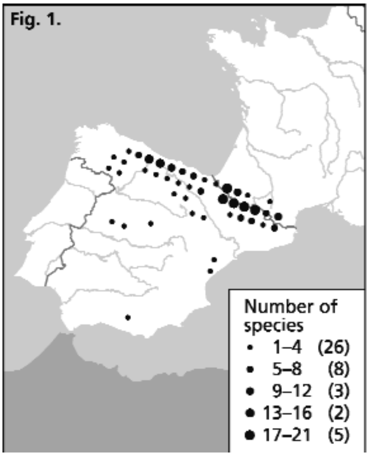

Fig. 1. Species richness for the *Alchemilla* species confined to the Iberian mountains (incl. French Pyrenees; N=55).

Fig. 2.

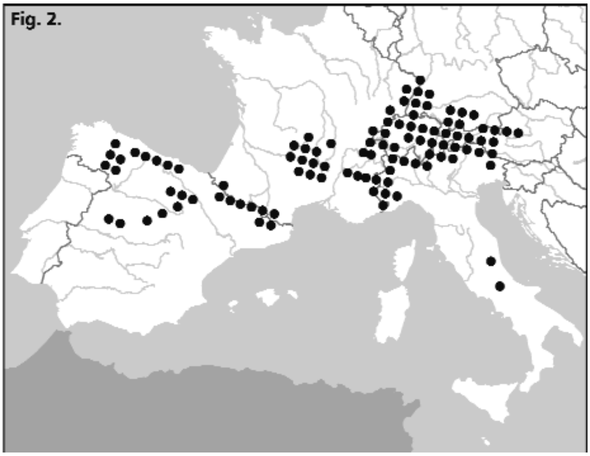

Fig. 2. Verified distribution of *Alchemilla coriacea* according to Kurtto et al. (2007).

in Sierra de la Demanda some 100 km south of the eastern end of the Cordillera Cantàbrica. *A. hypercycla an*d *A. perspicua* are present in Sierra de Satrústegui in addition to sites about 100 km further north in the Pyrenees and Cordillera Cantàbrica, respectively. The mainly Pyrenean *A. oscensis* has a disjunct additional outpost in the mountains of Castellón near the east coast, c. 250 km south of the Pyrenees.

Four Iberian endemics are present only in mountains south of the Cordillera Cantàbrica and Pyrenees: *A. atriuscula* in Sierra de Andía less than 40 km south of the western end of the Pyrenees, *A. crenulata* in the mountains of León just south of the western end of the Cordillera Cantàbrica, *A. serratisaxatilis* in Sierra de Béjar and Sierra de Guadarrama in the central inland region, and *A. font-queri* in the Sierra Nevada.

Mountains from N.W. Spain to the Alps, Apennines or Balkan Peninsula

The range of *Alchemilla hybrida* (syn. *A. lapeyrousii)* extends from the Cordillera Cantàbrica and the mountains of Castellón to the western central Alps, with core areas in the Pyrenees and French Massif Central, whereas *A. inconcinna* is mainly a species of the Cordillera Cantàbrica – Pyrenees range and western central Alps but is also present in the Massif Central. The range of *A. lucida* has its core in the southwestern Alps, and only widely scattered occurrences are known from other mountains from the Cordillera Cantàbrica to the central Italian Alps.

The ranges of five species extend from N.W. Spain to the Alps and further to the Apennines. *Alchemilla coriacea* has a wide and coherent distribution in and around the Alps (north to the Vosges and Schwarzwald; Fig. 2) and in the Massif Central, complemented by numerous occurrences in N. Spain in the Pyrenees and further westwards to the mountains of León and southwestwards to the mountains of Avila. Furthermore, the

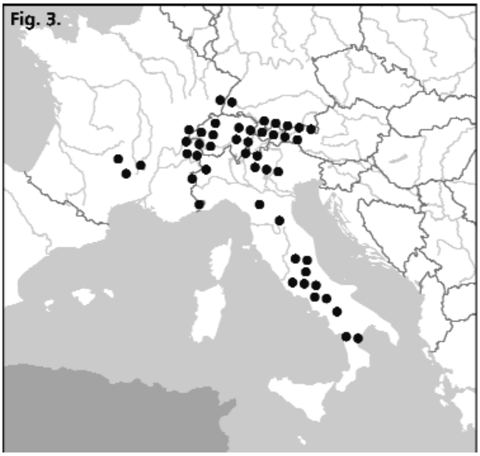

Fig. 3. Verified native distribution of *Alchemilla nitida* according to Kurtto et al. (2007).

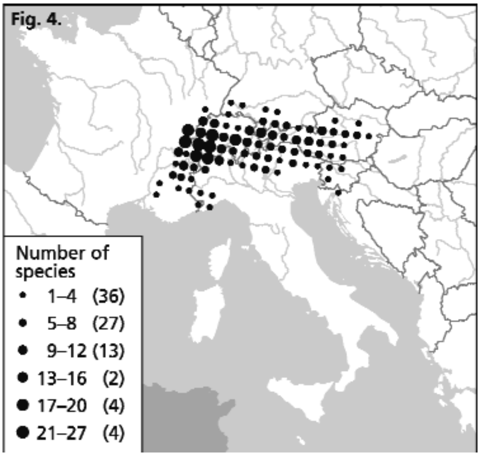

Fig. 4. Species richness for the *Alchemilla* species endemic to the Alps (N=91).

species is known from the highest peaks of central Apennines, some 500 km from the nearest stations in the Alps. The range of *A. saxatilis* is quite similar in the Iberian Peninsula and Massif Central, but the species is also present far to the south in the Sierra Nevada. In the east, the species reaches its northern limit in southern Switzerland and its southern limit in the Ligurian and Tuscan-Emilian Apennines. *A. saxatilis* was once present also in Corsica. *A. transiens* has a more scattered distribution than the two previous species, but it extends from Sierra de Guadarrama and the Cordillera Cantàbrica to the eastern Alps, Corsica and the Apennines (Ligurian and Tuscan-Emilian Apennines, as well as Abbruzzi). *A. alpigena* is widely present in the Cordillera Cantàbrica, Pyrenees and Alps, but absent from the Massif Central, and has additional stations in the Ligurian and Tuscan-Emilian Apennines.

Alchemilla lunaria has a peculiar distribution comprising central parts of the Cordillera Cantàbrica, the Pyrenees and central parts of the Alps, as well as one very disjunct (by more than 1000 km) station in western Rodopi Planina of Bulgaria.

Mountains from the Pyrenees to the Alps or Apennines

Five of the eight species of this element have intermediary stations in the Massif Central of France, viz. *A. demissa, A. rubristipula, A. tenuis, A. trunciloba* and *A. vetteri. A. tenuis* is also present in Sierra Cebollera southwest of the western Pyrenees and *A. vetteri* in mountains of Castellón in E. Spain (for details of the distribution of the latter species, see Kalheber 1982). The ranges of *A. demissa, A. tenuis an*d *A. trunciloba* extend even to the Apennines as scattered occurrences.

*A. conjuncta, A. pentaphyllea an*d *A. tenerrima* are absent from the Massif Central and Apennines and thus present only in the Pyrenees and Alps. *A. conjuncta* is principally a species of the western central Alps and *A. pentaphyllea* a species of the southwestern and central Alps. Both have only one verified station in the Pyrenees (Pyrénées Atlantiques of France and Valle de Boí of Spain, respectively). *A. tenerrima* is a rare species of the eastern Pyrenees and southwestern Alps (one station in Turin, Italy).

The elements of the three first groups seem to belong to the *Erysimum duriaei* element of the scheme of Finnie & al. (2007) based on a wide selection of species mapped in *AFE.*

Massif Central of France and its connections to the east

Only one species, *Alchemilla grenieri,* is certainly endemic to the Massif Central, since records of the Alpine *A. amphisericea* from the Pyrenees may be referable to *A. charbonneliana,* which has hitherto been considered endemic to the Massif Central.

A. saxetana, a species previously known only from a couple of localities in Unterwallis, Switzerland, was found in the Massif Central in 2001. *A. nitida an*d *A. pallens* both show in their distributions unique combinations of mountain ranges. *A. nitida* is known from the Massif Central, Alps, Vosges and Schwarzwald, as well as along the Apennines as far to the south as northern Calabria (Fig. 3). *A. pallens* shows a rather similar distribution pattern, but has only one station in the Apennines (Tuscan-Emilian Apennines) and a remarkably disjunct (by c. 1000 km) occurrence in the Pirin Planina of Bulgaria.

Endemics of the Alps or/and Apennines

The Alps are extremely rich in *Alchemillae:* a total of 149 species, of which no less than 91 are endemic (Fig. 4; for further details, see the regional comparison below and Fröhner 1990). 52 of the endemic species of the Alps either extend to Mediterranean Europe or are endemic to it (e.g. the recently described endemics of the Italian Alps *A. federiciana, A. lasenii an*d *A. nydeggeriana;* see Fröhner 2005).

Only three species are endemic to the Apennines: *A. ceroniana* of the Tuscan-Emilian Apennines, *A. marsica* of the Abruzzo, and *A. austroitalica* of Aspromonte (Fig. 5).

The total ranges of eight species are confined to the Alps and Apennines. *A. compta an*d *A. hoppeana* occur discontinuously almost all along the Alps and have only a single known locality in the Apennines (Abruzzo and Tuscan-Emilian Apennines, respectively). *A. subserica h*as a more continuous distribution from the Maritime Alps to the Ötztaler Alpen of W. Austria and two widely disjunct stations in the Apennines. *A. strigosula* is included in this element, though its area extends in the north from the Alps proper to the lower mountains of S. Germany and it may also be present in the Massif Central and even in the Pyrenees. In the Apennines, the species is present in Liguria and in a rather wide area from Marche in the north to Abruzzo in the south. *A. undulata* is mainly a plant of the eastern Alps, but it has fairly numerous occurrences in the central Alps and disjunctly in the Abruzzo, as well as a few localities in the northern parts of the soutwestern Alps (Fig. 6). Records of the species from the central Balkans are dubious.

Alchemilla cinerea (excl. *A. lanuginosa)* is confined to the southwestern Alps, Tuscan-Emilian Apennines and Abruzzo. *A. sinuata* is principally a plant of the central Alps but has very disjunct localities in the Tuscan-Emilian Apennines and far to the south in Monte del Papa of Basilicata. According to the current view, *A. cataractarum* seems to be restricted to the eastern Alps and Tuscan-Emilian Apennines.

The species treated in this section, as well as many of the mountain species of the fol-

Fig. 5.

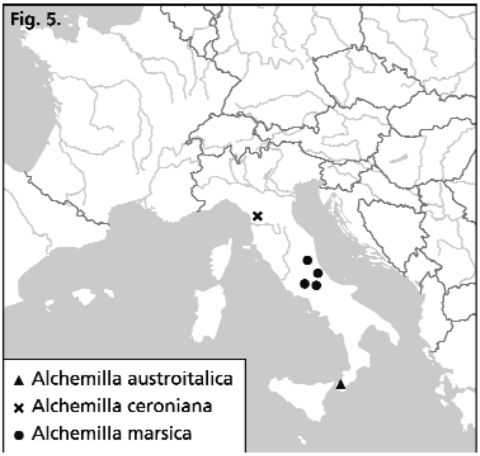

Fig. 5. Distribution of the Apenninian endemics of *Alchemilla.*

Fig. 6.

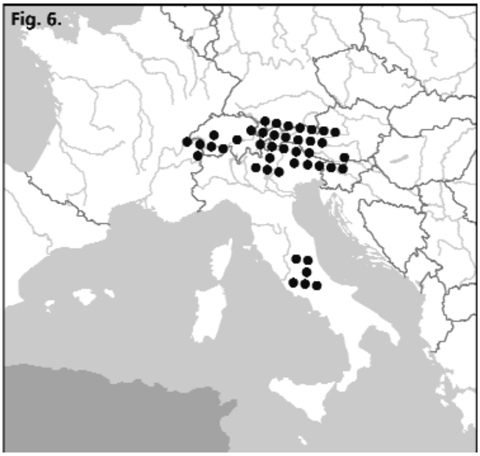

Fig. 6. Verified distribution of *Alchemilla undulata* according to Kurtto et al. (2007).

lowing sections, belong to the *Salix serpillifolia* element of Finnie & al. (2007). However, mountain species with easterly bias seem to be best included in their *Rumex alpinus* element, *Dianthus moesiacus* element, or *Ranunculus psilostachys* element.

Alps and the Balkan Peninsula

A large number of *Alchemillae* with their main ranges in the Alps have been recorded from the Balkan Peninsula. However, most of the records are erroneous or at least dubious. The floristic connection between the Alps and the Balkan Peninsula, as reflected by *Alchemilla,* is therefore much weaker than was previously thought.

Perhaps only six species have ranges which cover exclusively parts of the Alps and parts of the Balkan mountains, but even the taxonomy and chorology of this small group is much in need of further elucidation. *A. croatica* is a poorly understood species with very scattered localities in the Italian Alps, northwestern Croatia and central Bosnia-Herzegovina. *A. obtusa* belongs to a taxonomically very intricate species group and therefore its exact distribution is not known. It may be a plant of only the Alps and the highest mountains of the central parts of the Balkan Peninsula. *A. lineata* has a wide range in the central and eastern Alps and perhaps only one station in the Balkan Peninsula (Prokletije). *A. racemulosa* is known from widely scattered stations along the Alps and a single locality in Bosnia-Herzegovina. *A. venosula* was earlier regarded as endemic to the eastern Alps but the plant of the central Balkans called *A. gracillima* Rothm. is now considered conspecific with it.

Alchemilla exigua is principally a plant of the central and eastern Alps but has scattered localities in the central Balkans. The species is also recorded from the Romanian Carpathians, but the identification of this material should be checked.

Balkan Peninsula

Currently, *24 Alchemilla* species endemic to the Balkan Peninsula are known (Fig. 7). However, the actual number of endemics is evidently much higher, since Fröhner (1999) estimated that about 50 new species remain to be discovered in the area.

*Alchemilla velebitica an*d *A. amphiargyrea* are restricted to the western mountains of the Balkan Peninsula, the former species extending from southernmost Slovenia to southern Pindhos of Greece, the latter from southern Bosnia-Herzegovina to Sterea Ellas of Greece. *A. malyi an*d *A. vranicensis* are endemic to the mountains of Bosnia-Herzegovina. The range of *A. lanuginosa* covers mountains from southern Bosnia-Herzegovina and Albania through southern Serbia, F.Y.R.O. Macedonia and the northernmost mountains of Greece to southwestern Bulgaria. The distribution of *A. heterophylla* is fairly similar but reaching central Croatia in the northwest and southern Pindhos in the southeast. The species is present on Anatolian mountains, too, and thus does not belong to the Balkan endemics proper.

The high Prokletije mountains on the borders of Albania, Montenegro, Serbia and F.Y.R.O. Makedonia host several local endemic species of *Alchemilla: A. albanica, A. bertiscea, A. montenegrina* Plocek [nomen illeg.], *A. rubidula an*d *A. vincekii* (see Plocek 1998).

In central parts of the Balkan Peninsula, *A. bulgarica, A. catachnoa, A. heterotricha, A.*

indivisa and *A. viridiflora* have fairly wide distributions, but only the range of *A. bulgarica* appears continuous. *A. indivisa* extends farthest to the south, reaching northern Peloponnisos, and all the five species attain their northern limit in the southern half of Serbia. *A. bandericensis* (Jakupica, Pirin Planina), *A. damianicensis* (Sar Planina, Pirin Planina), *A. peristerica* (Perister) and *A. pirinica* (Sar Planina and surroundings, Pirin Planina) are much rarer endemics of the central Balkans. *A. pawlowskii* is restricted to the Rila Planina, and *A. achtarowii, A. jumrukczalika* and *A. sirjaevii* are known only from the Stara Planina.

Alchemilla aroanica, a local endemic of the Chelmós mountains of northern Peloponnesos, is, with *A. font-queri* of Sierra Nevada and *A. austroitalica* of Aspromonte, the southernmost of the European endemics in the genus.

Carpathians and the Balkan Peninsula

The floristic connection between the Carpathians and the Balkan Peninsula, as reflected by *Alchemilla* species restricted to the two mountain chains, is roughly as weak as that between the Alps and the Balkan Peninsula, since only seven species seem to have a Carpathian – Balkan total range.

Alchemilla gorcensis is centred in the central Balkans and the western Carpathians (Tatra Mts. and surroundings) and has only two known localities between the centres in the highest mountains of the Romanian and Ukrainian Carpathians (Fig. 8). *A. obsoleta* completely lacks such intermediary stations by being present only in the western Carpathians and highest mountains of Bulgaria. A parallel disjunction is shown by *A. czywczynensis,* restricted to the high mountains of the eastern Carpathians on both sides of the Ukrainian – Romanian border and to the Rodopi Planina of southern Bulgaria, and by *A. zapalowiczii,* which is possibly extinct in the Tatra Mts. but certainly present in the same part of

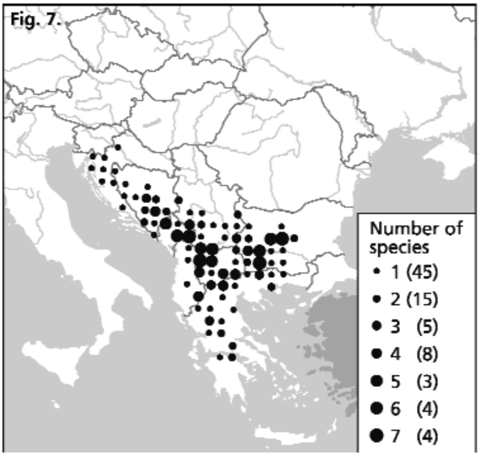

Fig. 7. Species richness for the *Alchemilla* species endemic to the Balkan Peninsula (N=24).

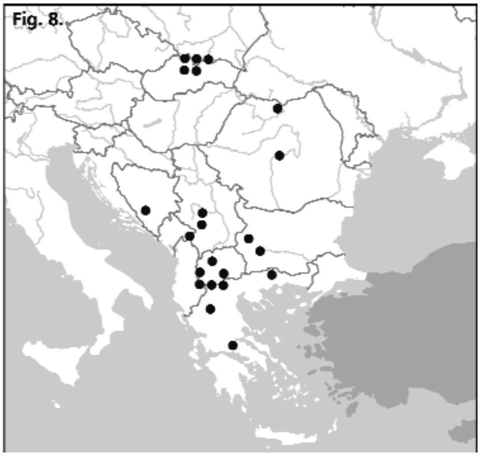

Fig. 8. Distribution of *Alchemilla gorcensis* according to Kurtto et al. (2007).

the eastern Carpathians as the previous species and additionally in Jakupica of F.Y.R.O. Macedonia. *A. serbica* is widespread in the central Balkans and also seems to have one locality in the southern Carpathians. *A. asteroantha,* which is still in need of taxonomic clarification, is mainly a species of Stara Planina of Bulgaria but has also been recorded from the same Romanian mountain area as *A. serbica.*

Alchemilla mollis, which is widely cultivated for ornament and widely naturalized in western and central Europe, also belongs to the species restricted to the Romanian Carpathians and the Balkan Peninsula (Stara Planina and northern Greece) in Europe. However, this species is also native to Anatolia, the Caucasus and Iran.

Crimea

The Crimean mountain flora includes a total of 20 species of *Alchemilla.* At least 16 of them are Crimean endemics. *A. aemula an*d *A. taurica* are present also in Caucasia, and *A. lithophila an*d *A. stevenii* have been reported also from northern Anatolia. The Crimean species belong to the *Dianthus capitatus* element of Finnie & al. (2007)

Widespread mountain species

*Alchemilla colorata, A. connivens, A. fissa, A. flabellata an*d *A. straminea* belong to the floras of all or almost all the principal mountain chains of South and Central Europe. Of the five species, *A. flabellata* has the most coherent distribution, though with notable gaps in the western Cordillera Cantàbrica and western Pyrenees (Fig. 9). The range of *A. connivens* is of the same kind but more scattered especially in the Carpathians and the Balkans. *A. colorata* is not known from the Cordillera Cantàbrica and has only a few stations in the Carpathians, whereas *A. fissa* is commoner in the Carpathians but absent from the Massif Central and almost absent from the Apennines. *A. straminea* has an extensive distribution centre in the Alps, but the species is also present in all other principal mountain areas, as well as in the Sierra Nevada, several sierras of the northern inland region of Spain, Bóhmerwald and Krkonose.

*Alchemilla efusa an*d *A. fallax* differ notably from all the five above-mentioned species in being totally absent from the Carpathians and from all the five except *A. fissa* in being absent also from the Massif Central. *A. crinita, A. incisa (s.* lato) and *A. reniformis* in turn are absent from the Iberian mountains (incl. French Pyrenees). *A. crinita* is known also from Morvan, a northerly extension of the Massif Central, but the other two are absent from the Massif Central too. The distribution of *A. crinita* probably also includes north-eastern Anatolia, although the Anatolian populations show slight differentiation from the European ones.

Widespread species with their southernmost localities in Mediterranean Europe

Quite a number of the *Alchemilla* species of the temperate lowland areas and medium altitudes of more northern European countries reach Mediterranean Europe as occurrences in the mountains. However, we do not know where each species originally evolved, and

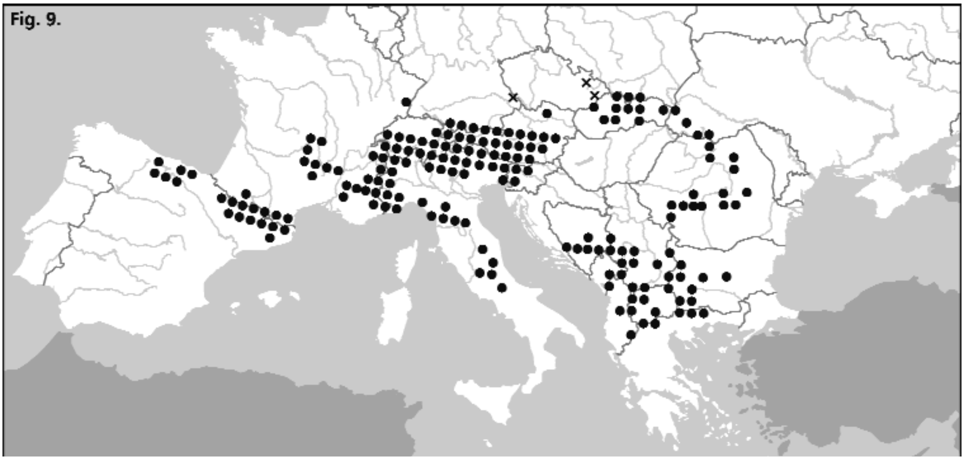

Fig. 9. Verified distribution of *Alchemilla flabellata* according to Kurtto et al. (2007).

therefore it is possible, and due to the Pleistocene history of Europe in many cases even probable, that the modern distributions of these species are the result of northward migrations, with or without man's help. Therefore, the following account (and the above accounts) must be considered merely descriptive and do not imply any particular distributional history.

The distribution of *A. xanthochlora* (Fig. 10) is unique in its suboceanic and nemoral to boreonemoral nature and in at least approaching the *Ranunculus bulbosus* element of Finnie & al. (2007). In the south, the species is present in all the principal mountain ranges and extends as far south as Somosierra of the Sistema Central in Spain, Monte Pollino of Basilicata in Italy and Sterea Ellas in Greece. The distribution of *A. subglobosa* is also the only one of its kind. The species has a strong centre in southern Scandinavia, numerous localities in the Baltic Countries and a smaller centre in Bóhmerwald, Erzgebirge and surroundings. Towards the southwest its distribution ends at disjunct localities in the Savoie Alps in southeastern France and towards the south at a locality in the Dolomites of Italy.

Of the numerous eastern boreonemoral species, only *A. cymatophylla an*d *A. propinqua* reach Mediterranean Europe, the former with one locality in the Dolomites in Italy and one in the mountains of Primorska in southwestern Slovenia, the latter with a very disjunct population in the same area of the Dolomites where the former is present. Fröhner (1965) deliberated upon the history of the very similar overall distributions of the two species.

The seven most widespread species of the genus in Europe – *A. monticola, A. micans, A. subcrenata, A. acutiloba, A. glabra, A. filicaulis an*d *A. glaucescens* – are also members of the mountain flora of Mediterranean Europe. *A. filicaulis an*d *A. glabra* have a prominently oceanic type of distribution in northwestern Europe, and at least the first-mentioned species belongs to the amphiatlantic element *(A. glabra* is better tending to elevated areas in Northern Europe and is probably introduced in northeastern North America). Both species extend as far south as Sierra Nevada and the central Apennines. *A. filicaulis* is almost absent from the Balkan Peninsula, but *A. glabra* has numerous localities there, the

Fig. 10.

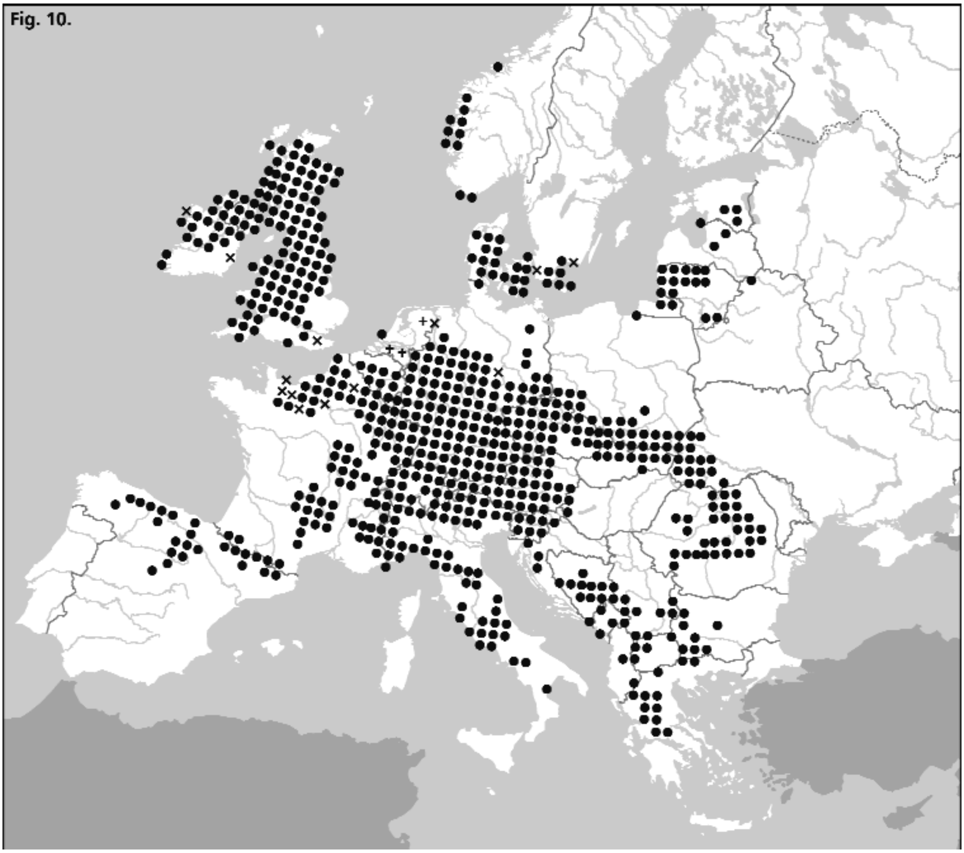

Fig. 10. Verified native distribution of *Alchemilla xanthochlora* according to Kurtto et al. (2007).

southernmost in Sterea Ellas. The other five species of the top seven have more continental distributions and clearly belong to the Eurosiberian element or, on the scheme of Finnie & al. (2007), best fit the *Lychnis flos-cuculi* element. The southern limits of these species vary somewhat, as follows: *A. acutiloba* has a very disjunct occurrence in the central Pyrenees but otherwise the southern limit runs from southernmost fringes of the Alps to Sterea Ellas; *A. glaucescens,* a more xerophilous and thermophilous species, reaches the Cordillera Cantàbrica and Pyrenees in the west, Monte Pollino of Basilicata in the Apennines and the northernmost mountains of Greece in the east; *A. micans* stops on the Alps in the west, but extends to Sterea Ellas in the east; *A. monticola* reaches the Pyrenees (only one verified locality), the Apennines and the northern mountains of Greece; *A. subcrenata* extends to the Massif Central, central Apennines and Rodopi Planina.

A. plicata is endemic to the nemoral – southern boreal zones of Europe. It reaches Mediterranean Europe as only one rather disjunct station in the southwestern Alps in the Italian province of Cuneo.

The amphiatlantic *A. glomerulans* is widespread in the boreonemoral to arctic zones of northwestern Europe. It is also present in many of the principal mountains of central and southern Europe, including the Cordillera Cantàbrica, Pyrenees, French, Italian and Slovenian Alps, and highest peaks of the Balkan group of mountains from Prokletije in the north to Jakupica in the south. *A. alpina* is also an amphiatlantic plant but of the arctic-alpine type and belongs to the *Oxyria digyna* element of Finnie & al. (2007). In southern Europe, the distribution of *A. alpina* covers mountains from the Cordillera Cantàbrica and Sistema Central of Spain in the west to western Austria and highest parts of the Apennines in the east. The species is also one of four found in the mountains of Corse.

3. Regional comparisons

Out of the total of 430 native European species of *Alchemilla,* 374 (87%) are endemic to Europe (Table 1). The mountains of southern and central Europe host a total of 346 species, of which the proportion of endemics is as high as 92%. The Alps are richest in species, then come the Carpathians, especially the western Carpathians, and the Cordillera Cantàbrica – Pyrenees -range. The *Alchemilla* floras of the Pyrenees and mountains of the Balkan Peninsula have a quite similar amount of endemism. The *Alchemilla* floras of the Apennines and Massif Central are much poorer and less distinctive. The isolated and distinct mountain areas of Crimea have the most differentiated *Alchemilla* flora with 20 species, of which at least 80% are endemic. – The species richness for *Alchemilla* on the mountains of southern and central Europe closely parallels the taxon richness for 501 predominantly alpine species and subspecies mapped in the first 11 volumes of *AFE* (see Väre & al. 2003).

Pair-wise similarities between the mountain ranges and their divisions (Table 2), based on all the native species of the genus, also show the relatively poor differentiation of the *Alchemilla* floras of the Apennines and the Massif Central and imply that the latter mountain area may have functioned as a ‘stepping stone’ in the immigration of species between the Alps and the Iberian mountains. The very low similarities between the Carpathians and the other ranges, as well as the fairly low similarities between the western Carpathians and the two other divisions of the Carpathians, are mainly due to the large number of endemics of the western Carpathians (mainly the Tatra Mts.). The high similarities between the divisions of the Pyrenees, as well as between the divisions of the Alps and between the eastern and southern Carpathians, indicate that the divisions as defined in *Flora Europaea* are better regarded as practical or descriptive rather than as phytogeographically justified regions. Comparisons based on smaller divisions combined with more accurate chorological data would certainly yield more meaningful results, especially for the Alps. – Using 501 alpine taxa mapped in *AFE,* Väre & al. (2003) calculated a Jaccard’s similarity index value of 25 between the Pyrenees and Alps. By using the *Alchemilla* species, the value is lower (16), which indicates that their ranges are, on average, smaller. This is also evident by visual inspection of the maps of Vàre & al. (2003) summarizing the pooled distributions of alpine plants present on each of the principal mountain ranges of Europe. The predominantly small ranges of *Alchemillae* are apparently largely due to the apomictic nature of the genus.

Another way to compare species numbers and similarities of *Alchemilla* floras is to use

Table 1. Total number of species and number of endemics of *Alchemilla* in various areas of Europe.

AREA	ALL N	ENDEMIC N	ENDEMIC %
EUROPE	430	374	87
S. & C. EUROPEAN MOUNTAINS	346	319	92
Cordillera Cantábrica & Pyrenees	79	46	58
Cordillera Cantábrica	39	11	28
Pyrenees	67	27	40
Western Pyrenees	43	7	16
Central Pyrenees	50	3	6
Eastern Pyrenees	45	4	9
Massif Central of France	26	2	8
Alps	149	91	61
Southwestern Alps	81	11	14
Central Alps	106	27	26
Eastern Alps	87	23	26
Apennines	37	3	8
Balkan Peninsula	60	24	40
Carpathians	113	80	71
Western Carpathians	100	67	67
Eastern Carpathians	37	3	8
Southern Carpathians	24	0	0
Crimea	20	16	80

Table 2. Jaccard's similarity index values (as %) between mountain ranges and divisions of mountain ranges. Values exceeding 30 are given in bold.

	Pyrenees	MC	Alps	Apennines	BP	Carpathians
Cordillera Cantábrica	**34**	25	10	21	13	4
Pyrenees		27	16	25	13	7
Massif Central = MC			16	**40**	13	7
Alps				23	16	8
Apennines					21	9
Balkan Peninsula = BP						16

	C. Pyren.	E. Pyren.
W. Pyrenees	**55**	**44**
C. Pyrenees		**64**

	C. Alps	E. Alps
S.W. Alps	**54**	**42**
C. Alps		**44**

	E. Carpath.	S. Carpath.
W. Carpathians	23	17
E. Carpathians		**45**

countries as the geographical units. In the country-specific species numbers of *Alchemilla,* Mediterranean Europe is well represented in the richest end, with France as the winner and also Italy and Spain in the top 10 (Table 3; Kurtto & al. 2007). Regarding the numbers of country-specific endemics, Spain, France and Italy are among the eight richest countries. The similarity indices between countries (Table 4) are, on average, higher than those between mountain ranges, which simply reflects the facts that borders between countries often follow crests of mountain ranges and that plants do not need passports to cross the borders.

The European *Alchemilla* flora includes a great number of local or regional endemics (e.g. Fröhner 2002). No less than 185 species are restricted to only one or two *AFE* grid cells with an average size of 50 km × 50 km, and 290 species are restricted to at most 10 such grid cells. The distribution of the latter species group (Fig. 11) neatly reveals the main European centres of endemism of the genus: the Cordillera Cantàbrica – Pyrenees -range, Alps (especially Unterwallis of Switzerland and Savoie of France), Jura, Tatra Mts., central parts of the eastern Carpathians, and Crimea. Regarding southern Europe, weaker centres appear especially in the Apennines and Balkan mountains. In comparison to the taxa with a narrow distribution area in the data set of 501 alpine taxa not including *Alchemilla* (Väre & al. 2003), the rarest European *Alchemilla* endemics are weakly represented in the Sierra Nevada, the southern Carpathians and some parts of the Balkan Peninsula, as well as on the Mediterranean islands, on which the genus is present only on Corsica. In the set of 501 taxa, about 10% of the species and subspecies occurred in a single *AFE* cell. In *Alchemilla,* the proportion is much higher, almost 35%.

Finally, it has to be emphasized that all the above comparisons suffer from the still uneven exploration of the *Alchemilla* floras of various mountain areas. Numerous more or

Table 3. Number of *Alchemilla* species in *AFE* territories of Mediterranean Europe, with the species numbers and proportions of chorological groups specified. NE = not endemic to Europe, EE = endemic to Europe, TE = endemic to the territory. The genus is absent from Balearic Islands, Crete, Malta, Portugal, Sardinia, Sicily and Turkey-in-Europe.

	Total	**NE**		**EE**		**TE**	
	N	**N**	**%**	**N**	**%**	**N**	**%**
France	121	14	12	107	88	13	11
Italy	92	12	13	80	87	10	11
Spain	81	6	7	75	93	29	32
Serbia and Motenegro	36	10	28	26	72	4	11
Bulgaria	34	10	29	24	71	2	6
F.Y.R.O.M.	34	11	32	23	68	0	0
Greece	26	8	31	18	69	1	4
Slovenia	26	9	35	17	65	0	0
Crimea	20	4	20	16	80	16	80
Bosnia and Herzegovina	19	5	26	14	74	2	11
Albania	13	3	23	10	77	1	8
Croatia	9	5	56	4	44	0	0
Corsica	4	2	50	2	50	0	0

Table 4. Jaccard's similarity index values (as %) between countries. Values equaling or larger than 30 are given in bold face

	Ga	He	It	Au	Sl	Ct	BH	SM	Al	Mk	Bu	Gr
Spain = Hs	**35**	15	18	16	10	4	8	11	6	11	8	8
France = Ga		**52**	**43**	**33**	17	6	8	15	5	14	13	11
Switzerland = He			**56**	**46**	22	7	10	18	6	17	14	12
Italy = It				**53**	28	8	12	20	7	19	17	14
Austria = Au					**32**	8	14	23	9	22	18	15
Slovenia = Sl						27	26	**40**	24	**35**	25	**30**
Croatia = Ct							**30**	23	26	21	20	22
Bosnia-Herzegovina = BH								**35**	**42**	**39**	26	**32**
Serbia-Montenegro = SM									**33**	**67**	**49**	**52**
Albania = Al										**35**	21	26
F.Y.R.O. Macedonia = Mk											**50**	**57**
Bulgaria = Bu												**43**

Fig. 11.

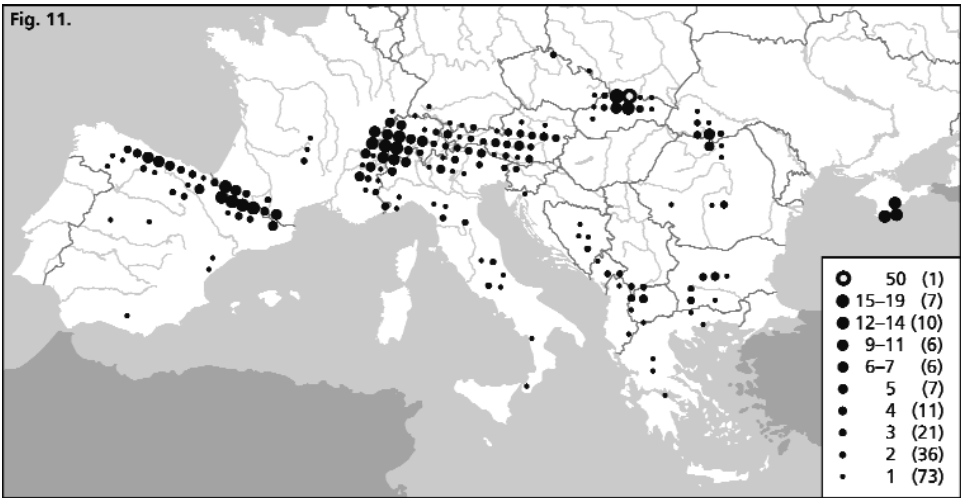

Fig. 11. Number of European narrow endemics of *Alchemilla* in southern and central Europe. The map includes species recorded from at most 10 *AFE* grid cells (N=290).

less local or regional endemics and also more widespread species of the genus still wait to be discovered or described from, at least, the Iberian and Balkan mountains (Fröhner 1999) and the Apennines (see Tondi 2001), not to mention the Urals (which are outside the scope of this article).

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Giuseppe Bonanno

Impact of anthropogenic activities on riverine and coastal habitats in the Salso river at the town of Licata (S Sicily)

Abstract

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This study shows the results concerning a survey conducted along the urban stretch of the Salso river, at the town of Licata, in the southern coast of Sicily. In the last years, this area was subject to increasing human alterations whose effects on riverine and coastal habitats were pointed out. One of the most important anthropogenic factors of disturbance was the unsuitable construction of civil engineering works which caused the reduction or disappearance of riverine vegetation elements. The current natural vegetation is mainly represented by specialized phytocoenoses such as the psammophilous communities of *Cakiletea maritimae* and *Ammophiletea*, the halophilous communities of *Saginetea maritimae, Sarcocornietea fruticosae* and *Pegano-Salsoletea* as well as the helophytic associations of *Phragmito-Magnocaricetea*. Hygrophilous associations of *Galio-Urticetea* and *Nerio-Tamaricetea* were also found. Management suggestions aiming at the habitat safeguard are provided too.

Introduction

Over the last thirty years, river and coastal environments have been altered by anthropogenic activities such as urbanization, growth of tourist settlements, intensive agriculture, wastewater discharges, industrial facilities, etc. All these factors contribute to the deterioration and fragmentation of such environments and this may result in the destruction of typical natural phytocoenoses. Therefore, it has become urgently necessary not to consider any more river and coastal environments as places where to discharge household and industrial waste into but as entities to defend, safeguard and manage. In Italy, in the last decades, the widespread concern for the safeguard and the restoration of areas at environmental risk has prompted quite a number of authors (e. g. Brullo & Furnari 1976; Raimondo & Rossitto 1978; Bartolo & al. 1982; Gèhu & al. 1984; Brullo & al. 1988; Brullo & Spampinato 1990; Raimondo & al. 1990; Biondi 1992; Arrigoni 1996; Brullo & al. 1998; Biondi 1999; Garbari 2000; Biondi & al. 2001; Brullo & al., 2001; Ilardi & al. 2001; Tomei & al. 2005; Sani & Tomei 2006) and private institutions (WWF, Legambiente, AIPIN) to study the manifold and complex aspects regarding river and coastal ecosystems. This survey is to be placed within research programmes about riparian and coastal environment protection. In this study, the anthropogenic degradation factors and their effects on the phytocoenoses of the strech of the Salso, at the town of Licata (Fig.

1), are considered. Effective actions are proposed aiming at the perspective of sustainable development and habitat restoration.

Physiographical, geomorfological and climatic characteristics of the territory

The Salso river is named like that because of the high salty concentration in its waters. This is due to the fact that the river goes through a huge zone belonging to the so called "gessoso-solfifera formation", a geological formation rich in gypsum and halite, dating back to the Messinian (Upper Miocene). The Salso, whose sources are located on the Madonie Mountains between the towns of Petralia Sottana and Petralia Soprana, flows through the heart of Sicily and empties into the Strait of Sicily (southern Sicily), at the town of Licata. The Salso is 144 km long and this makes the river the longest one among the Sicilian rivers. From a cartographic point of view, the studied area is included in the map E 642080, 1:10000, edited by the Sicilian authorities, and also in the map 271 II NE, 1:25000, realized by the Italian Military Geographic Institute.

Fig. 1. The study area.

As regards the geology, the study area is characterized by sandy and slime-clay substrata awash going back to the marine and continental Quaternary. The marine Quaternary, largely made up of yellow sands, may reach remarkably deep layers. Above the marine Quaternary, there is the continental Quaternary which is constituted of drifts whose thickness is variable.

The climatic characterization has been realized by prosessing data from the Licata weather station (142 m a.s.l.) (Brullo & al. 1996). The average yearly temperature is 18 °C; the thermal regime presents the lowest winter value in January whereas the highest summer one in August (absolute minimum temperature: -1,6 °C; minimum average temperature in the coldest month: 7,5 °C; absolute maximum temperature: 39,4 °C; maximum average temperature in the hottest month: 28,4°C). The annual rainfall is 430 mm. Lastly, on the basis of the bioclimatic indices proposed by Rivas-Martinez (1995), the area around Licata belongs to the upper thermomediterranean belt with inferior dry ombrotype.

Anthropogenic factors

The main disturbance factors which affect river and coastal habitats of the surveyed area are:

- incompatible constructions with the place; in particular, the inappropriate presence of a bridge with many piers in the river-bed must be reported. In fact, such a bridge, built just on the most external part of the mouth, apart from the devastating environmental impact, puts at risk the whole existence of the nearby coastal and riparian habitats. Indeed, hydraulics teaches that the presence of an obstacle in the river-bed alters the normal river flow and creates whirlpools that accelerate the bank erosion which is one of the main causes for the riparian phytocoenosis disappearance;
- trampling and passing of vehicles; the excessive disturbance brings about the mechanical removal of sand resulting in the crisis of the dune system. Therefore, motor vehicles are a remarkable obstacle to the natural dynamics aiming at consolidating sandy coasts;
- household and industrial waste discharges; the presence of nitrates fosters those species linked to the anthropogenic activities; as a result, native riparian and coastal flora is seriously put in jeopardy in many stretches;
- introduction of exotic species; the new biological relationships among exotic and native species can reduce or, at worst, cause the disappareance of the latter; some of the detected exotic species are: *Ailanthus altissima* (Mill.) Swingle (Eastern Asia), *Carpobrotus acinaciformis* (L.) L. Bolus (South Africa), *Cuscuta campestris* Yunck (North America), *Conyza bonariensis* (L.) Cronq. (Centro-Southern America), *Conyza canadensi*s (L.) Cronq. (North America), *Eucalyptus camaldulensis* Dehnh. (Australia), *Mirabilis jalapa* L. (South America), *Nicotiana glauca* L. (South America), *Oxalis pes-caprae* L. (South Africa), *Robinia pseudoacacia* L. (North America);
- herbicide and pesticide run-off coming from farming and nearby greenhouses; chemicals used in agriculture are rich in sulphur and phosphorous which may bring about eutrophication;
- artificialization of some stretches of embankment through reinforced concrete; not only is the aesthetical impact rather remarkable but also the whole biodiversity is irreparably compromised;

On the whole, morphological changes regarding river and coast, due to both anthropogenic and natural causes, determine the alteration or the disappearance of typical biocenoses growing along riparian and coastal habitats.

Floristic remarks

The surveyed area represents an enclave with a remarkable naturalistic peculiarity and it is also part of an environment which is heavily influenced by human actions. From a floristic point of view, typical plants of coastal and river habitats were detected. It deals with psammophytes, halophytes, helophytes, hygrophytes, some of them rare in the Sicilian flora such as:

Chenopodium botryoides Sm.; Sub-cosmopolitan species growing in salty environments, widespread along the coasts of the following Italian regions: Veneto, Friuli, Lazio, Campania; recently, this species was found in a nearby wetland called "Biviere di Gela" (Brullo & Sciandrello 2006);

Rumex palustris Sm.; Eurasian species, also widespread in north-western Africa; favourite habitats are marshy places where water can stagnate for a long time during the winter and the spring; in Italy, such a species is widespread in a discontinuous way; indeed, it can be found along the coasts of Veneto and Emilia Romagna (Northern Adriatic), Gargano (Puglia, Southern Adriatic), Trasimeno and Fucino Lakes (central Italy); its presence is thought to be doubtful in the last check-list of the Italian vascular flora (Conti & al. 2005).

Species growing in sandy and brackish environments, less widespread in Sicily, were also found like *Juncus subulatus* Forssk., *Juncus maritimus* Lam., *Imperata cylindrica* (L.) P. Beauv., *Launea resedifolia* (L.) Kuntze, *Ononis mitissima* L. and *Malcolmia nana* (DC.) Boiss.

Vegetation

The analysis of vegetation was conducted through the classic method of the Zurich-Montpellier Sigmatista School. The cover of the taxa was estimated according to the following scale + < 1%; 1 = 1÷10%; 2 = 10.1÷25%; 3 = 25.1÷50%; 4 = 50.1÷75%; 5 = 75.1÷100%. Because of the considerable degradation, in a few stretches, different vegetation typologies superimpose each other and mix with anthropogenic communities. The syntaxonomical nomenclature mainly follows Brullo & al. (2002). As regards the nomenclature of species, the reference is Conti & al. (2005) and Giardina & al. (2007). Below, some examples of natural phytocoenosis of the area under examination are mentioned. This area regards the banks of the river in its urban stretch (3 km) and a short stretch of shore (about 100 m) (Fig. 1).

Annual psammophylous vegetation of sea drifts

Salsolo-Cakiletum maritimae Costa & Mansanet 1981 *corr*. Rivas-Martínez *et al.* 1992 (Table 1)

Nitrophilous pioneer association, dominated by *Salsola kali* and *Cakile maritima*, settling on organic drifts along the beach and forming a narrow belt close to the shoreline. It can

Table 1. *Salsolo - Cakiletum maritimae* Costa & Mansanet 1981 *corr*. Rivas-Martinez & al. 1992.

		Rel. n.	1	2	3
		Altitude (m)	1	1	-
		Exposure	-	-	-
		Slope (%)	-	-	-
		Area (mq)	20	5	25
		Coverage (%)	80	30	30
		Charact. and diff. species of the ass.			
Paleotemp.	T scap	Salsola kali L.	2	1	1
Medit.-Atl.	T scap	Cakile maritima Scop. subsp. maritima	3	2	2
		Charact. and diff. species of the upper units (*Cakilion maritimae*, *Cakiletalia integrifoliae*, *Cakiletea maritimae*)			
Subcosmop.	H rept	Polygonum maritimum L.	+	+	.
Euri-Medit.	T rept	Chamaesyce peplis (L.) Prokh.	1	.	+
Circumbor.	T scap	Atriplex prostrata Bouchez ex DC.	.	.	+
Euri-Medit.	T scap	Beta vulgaris L. subsp. maritima (L.) Arcang.	2	+	.
		Other species			
Steno-Medit.	T scap	Matthiola tricuspidata (L.) R. Br.	+	.	.
Cosmopol	T scap	Suaeda spicata Moq.	.	.	+
Paleotemp.	T scap	Salsola soda L.	.	.	+
Subcosmop.	G rhiz	Phragmites australis (Cav.) Trin. ex Steud.	.	+	.

be found together with perennial dune communities (*Ammophiletea*) or, in those stretches where the erosion has completely removed the coastal dunes, with communities of brackish depressions (*Sarcocornietea*).

Perennial psammophylous vegetation of coastal dunes

Cypero capitati-Agropyretum juncei Kühnholtz-Lordat (1923) Br.-Bl. 1933 (Table 2)

Sub-nitrophilous pioneer association, distinguished by *Elytrigia farcta*, *Cyperus capitatus,* plants with long stolons which are able to hold the sand subject to the wind action, and *Otanthus maritimus*. Because of the degradation, the vegetation belt of *Ammophila arenaria* ssp. *australis*, typical of the shifting dunes, usually living among *Cypero capitati-Agropyretum juncei* and retrodune communities, is absent.

Spring ephemeral vegetation of salty environments

Parapholido-Frankenietum pulverulentae Rivas-Martínez *ex* Castroviejo & Porta 1976 (Table 3)

Sub-nitrophilous and halophilous association, physiognomically dominated by *Parapholis incurva*, *Frankenia pulverulenta*, and *Plantago coronopus*, growing on modest clay-sandy depressions near the coast and on retrodune and retrobank areas along those stretches of river being subject to flooding in the winter and in the spring.

It deals with late-spring ephemeral meadows living in zones highly influenced by various kinds of anthropogenic pressure.

Table 2. *Cypero capitati-Agropyretum juncei* Kühnholtz-Lordat (1923) Br.-Bl. 1933.

		Rel. n.	1	2	3
		Altitude (m)	4	4	3
		Exposure	-	-	-
		Slope (%)	-	-	-
		Area (mq)	25	25	10
		Coverage (%)	40	40	80
		Charact. and diff. species of the ass.			
Euri-Medit.	G rhiz	Elytrigia farcta (Viv.) Holub	2	2	3
Medit.-Atl.	Ch suffr	Otanthus maritimus (L.) Hoffmanns. & Link subsp. maritimus	+	+	1
Steno-Medit.	G rhiz	Cyperus capitatus Vand.	+	.	+
		Charact. and diff. species of the upper units (*Agropyrenion farcti*, *Ammophiletalia, Ammophiletea*)			
Euri-Medit.	Ch rept	Medicago marina L.	1	1	1
Steno-Medit.	Ch suffr	Lotus creticus L.	.	1	1
Subtrop.	G rhiz	Sporobolus arenarius Duval-Jouve	.	+	+
Steno-Medit.	G bulb	Pancratium maritimum L.	.	+	1
Cosmop.-litorale	G rhiz	Calystegia soldanella (L.) Roem. & Schult.	1	.	.
Euri-Medit.	G rhiz	Ammophila australis Mabille	.	+	.
Saharo-Sind	Ch frut	Launaea resedifolia (L.) Kuntze	.	+	.
		Other species			
Euri-Medit.	T scap	Beta vulgaris L. subsp. maritima (L.) Arcang.	.	+	+
	H rept	Cynodon dactylon (L.) Pers.	.	1	+
Medit.-Atl.	T scap	Cakile maritima Scop. subsp. maritima	1	.	+
Euri-Medit.	H scap	Glaucium flavum Crantz	+	.	+
Steno-Medit	T scap	Ononis variegata L.	.	.	+
Paleotemp.	T scap	Salsola kali L.	+	1	.

Perennial shrubby vegetation of brackish swamps

Junco subulati-Sarcocornietum fruticosae Brullo 1988 (Table 4)

Halophilous and sub-nitrophilous vegetation, with *Sarcocornia fruticosa* and *Juncus subulatus* as dominant species, colonizing both silty-clay soils of the flood plain, far-off from the river banks, and retrodune swamps which are subject to prolonged floodings. The occupied space is rather reduced and, because of numerous human actions, the community is likely to disappear.

Hygrophilous vegetation of helophytes and hemicryptophytes

Calystegio silvaticae-Arundinetum donacis Brullo, Scelsi & Spampinato 2001 (Table 5)

Sub-hygrophilous and sub-nitrophilous community living on a rearer zone than *Phragmitetum communis* and growing on wet soils, rather rich in nitrates, subject to periodic dessication. The physiognomy is characterized by *Arundo donax* and *Calystegia sylvatica*.

Helophyte marsh vegetation of stagnant or weakly flowing waters

Phragmitetum communis (Koch 1926) Schmale 1939 (Table 6)

Monophytic community, widespread along river and canal banks. It lives in slow, eutrophic and relatively brackish waters. Favourite soils are silty-sandy and short drying periods are possible.

Scirpo lacustris-Phragmitetum australis Koch 1926 (Table 7)

Table 3. *Parapholido-Frankenietum pulverulentae* Rivas-Martínez ex Castroviejo & Porta 1976 .

		Rel. n.	3	4
		Altitude (m)	4	4
		Exposure	-	-
		Slope (%)	-	-
		Area (mq)	1	1
		Coverage (%)	60	70
		Charact. and diff. species of the ass.		
Medit.-Atl.	T scap	Parapholis incurva (L.) C.E. Hubb.	2	2
Euri-Medit.	T scap	Plantago coronopus L. subsp. coronopus	1	2
		Charact. and diff. species of the upper units (*Frankenion pulverulentae* , *Frankenietalia pulverulentae, Saginetea maritimae*)		
Stenom.-Centroas.-Sudafr.	T scap	Frankenia pulverulenta L. subsp. pulverulenta	2	2
Subcosmop.	T scap	Spergularia salina J. & C. Presl	.	1
Paleosubtrop.	T scap	Polypogon monspeliensis (L.) Desf.	+	1
Subcosmop.	Ch suffr	Spergularia media (L.) C. Presl	.	+
Steno-Medit.-Macar.	T scap	Polypogon maritimus Willd.	+	.
		Other species		
S-Medit.-Sudafr.	T scap	Mesembryanthemum nodiflorum L.	.	+
Euri-Medit.	T scap	Beta vulgaris L. subsp. maritima (L.) Arcang.	1	.
Subcosmop.	T rept	Anagallis arvensis L.	+	+
Subcosm.	T scap	Sonchus oleraceus L.	+	.
S-Medit.	T scap	Melilotus siculus (Turra) Steud.	1	.
Circumbor.	T scap	Atriplex prostrata Bouchex ex DC.	1	+
Paleosubtrop.	T scap	Phalaris minor Retz	.	1

This association, dominated by *Schoenoplectus lacustris* and *Phragmites australis*, replaces *Phragmitetum communis* along marshy depressions and river banks characterized by deep and less eutrophic waters. In those stretches where embankments are made with reinforced concrete or are subject to erosion, this phytocoenosis, like the previous one, has disappeared.

Halo-nitrophilous shrubby vegetation with dominance of succulents

Atriplici halimi-Artemisietum arborescentis Biondi 1986 (Table 8)

Sub-halophilous and sub-nitrophilous association growing on clay-silty soils of the external and less flooded part of the flood plain. Such a community occupies those zones of the central urban stretch of the river. The dominant species are *Artemisia arborescens* and *Atriplex halimus.*

Chamaephyte and phanerophyte hygrophilous vegetation

Tamaricetum gallicae Br.-Bl. & O. Bòlos 1958 (Table 9)

This association settles on alluvial soils rich in silt and clay, along the upper and central stretch of the study area. It develops as scrub on the highest part of the flood plain, often completely dried. *Tamarix africana* and *Tamarix gallica* mark out this community.

Table 4. *Junco subulati-Sarcocornietum fruticosae* Brullo in Brullo & al. 1988.

		Rel. n.	1	2	3	4
		Altitude (m)	3	3	3	4
		Exposure	-	-	-	-
		Slope (%)	-	-	-	-
		Area (mq)	9	9	9	15
		Coverage (%)	50	90	50	40
		Charact. and diff. species of the ass.				
S-Medit.	G rhiz	Juncus subulatus Forssk.	1	+	1	1
		Charact. and diff. species of the upper units (*Sarcocornion fruticosae*, *Sarcocornietalia fruticosae, Sarcocornietea fruticosae*)				
Euri-Medit. e Sudafr.	Ch succ	Sarcocornia fruticosa (L.) A.J. Scott	3	5	3	1
Circumbor.	Ch frut	Halimione portulacoides (L.) Aellen	+	.	+	1
Medit. Macar. e Mes.	Ch succ	Arthrocnemum macrostachyum (Moric.) Moris	.	.	.	2
Euri-Medit.	H caesp	Elytrigia scirpea (K. Presl) Holub.	.	.	+	.
		Other species				
Subcosmop.	G rhiz	Phragmites australis (Cav.) Trin. ex Steud.	+	.	+	+
Subcosmop.	T scap	Spergularia salina J. & C. Presl	.	.	1	1
Cosmopol.	NP	Suaeda vera J.F. Gmel.	1	.	.	+
S-Medit.	T scap	Melilotus siculus (Turra) Steud.	.	.	.	+
Medit.-Atl.	T scap	Parapholis incurva (L.) C.E. Hubb.	+	.	.	.
Paleosubtrop.	T scap	Polypogon monspeliensis (L.) Desf.	.	+	.	.
Cosmop.	T scap	Suaeda spicata Moq.	.	.	.	+
Neotropic.	T scap	Symphyotrichum squamatum (Spreng.) G. L. Nesom	.	.	.	+
Eurasiat.	H bienn	Tripolium pannonicum (Jacq.) Dobrocz.	+	.	.	.

Table 5. *Calystegio silvaticae-Arundinetum donacis* Brullo, Scelsi & Spampinato 2001.

		Rel. n.	2	2
		Altitude (m)	4	4
		Exposure	E	-
		Slope (%)	3	-
		Area (mq)	2	2
		Coverage (%)	100	100
		Charact. and diff. species of the ass.		
SE-Europ.	H scand	Calystegia sylvatica (Kit) Griseb.	2	1
		Charact. and diff. species of the upper units (*Senecionion fluviatilis, Convolvuletalia sepium, Galio-Urticetea*)		
Subcosmop.	G rhiz	Arundo donax L.	5	5
Eurasiat.	T scap	Galium aparine L.	1	+
		Other species		
Neotropic.	T scap	Symphyotrichum squamatum (Spreng.) G. L. Nesom	+	+
Subcosmop.	G rhiz	Phragmites australis (Cav.) Trin. ex Steud.	+	1
Euri-Medit.	H scap	Dittrichia viscosa (L.) Greuter	+	+

Table 6. *Phragmitetum australis* (Koch 1926) Schmale 1939.

		Rel. n.	1	2	3	3
		Altitude (m)	1	0,5	1	1
		Exposure	-	-	-	-
		Slope (%)	-	-	-	-
		Area (mq)	100	100	100	100
		Coverage (%)	100	100	100	100
		Charact. and diff. species of the ass. and the upper units (*Phragmition, Phragmitetalia, Phragmito-Magnocaricetea*)				
Subcosmop.	G rhiz	Phragmites australis (Cav.) Trin. ex Steud.	5	5	5	5

Table 7. *Scirpo lacustris-Phragmitetum australis* Koch 1926.

		Rel. n.	1	2	3
		Altitude (m)	4	4	3
		Exposure	-	-	-
		Slope (%)	-	-	-
		Area (mq)	20	20	10
		Coverage (%)	90	70	80
		Charact. and diff. species of the ass.			
Subcosmop.	G rhiz	Schoenoplectus lacustris (L.) Palla	1	1	+
		Charact. and diff. species of the upper units (*Phragmition, Phragmitetalia, Phragmito-Magnocaricetea)*			
Subcosmop.	G rhiz	Phragmites australis (Cav.) Trin. ex Steud.	4	3	4
Cosmop.	G rhiz	Bolboschoenus maritimus (L.) Palla	+	+	.
		Other species			
S-Europ.	T scap	Xanthium orientale L. subsp. italicum (Moretti) Greuter	+	+	+
Subcosmop.	G rhiz	Arundo donax L.	1	.	+
Euri-Medit.	H caesp	Juncus acutus L. subsp. acutus	1	1	.
Circumbor.	Ch frut	Halimione portulacoides (L.) Aellen	.	.	+
S-Medit.	T scap	Melilotus siculus (Turra) Steud.	+	.	.
Steno-Medit.-Macar.	T scap	Polypogon maritimus Willd.	.	.	+

Willow scrub riparian vegetation

Salicetum albo-purpureae (I. & V. Karpati 1961) Barbagallo, Brullo & Fagotto 1979 (Table 10)

A remnant of *Salicetum albo-purpureae* colonizes the upper stretch of the river, at the suburbs of Licata, on alluvial and silty-clay soils. This community has been seriously affected by human activities such as farming and construction of river engineering works.

Table 8. *Atriplici halimi-Artemisietum arborescentis* Biondi 1986.

		Rel. n.	1	2
		Altitude (m)	4	4
		Exposure	-	-
		Slope (%)	-	-
		Area (mq)	20	10
		Coverage (%)	70	70
		Charact. and diff. species of the ass.		
S-Medit.	NP caesp	Artemisia arborescens (Vaill.) L.	2	3
		Charact. and diff. species of the upper units (*Artemision arborescentis* , *Salsolo-Peganetalia, Pegano-Salsoletea*)		
Sudafr.-Atl.-Steno-Medit.	P caesp	Atriplex halimus L.	3	2
Cosmop.	NP	Suaeda vera J.F. Gmel.	1	.
		Other species		
Euri-Medit.	H scap	Dittrichia viscosa (L.) Greuter	+	+
Circumbor.	Ch frut	Halimione portulacoides (L.) Aellen	.	2
Subcosmop.	G rhiz	Phragmites australis (Cav.) Trin. ex Steud.	.	+
Euri-Medit.	NP	Rubus ulmifolius Schott	.	+
Neotropic.	T scap	Symphyotrichum squamatum (Spreng.) G. L. Nesom	+	.
Subcosmop.	T scap	Daucus carota L.	+	.
S-Medit. - Macarones	T scap	Medicago intertexta (L.) Mill.	.	+
Australia	P scap	Eucalyptus camaldulensis Dehnh.	+	.
Eurasiat.	T scap	Galium aparine L.	1	.
Subcosmop.	G rhiz	Arundo donax L.	1	.

Conclusions

This survey about the influence of anthropogenic factors along the final stretch of the Salso river, at the town of Licata, enabled to analyze the current status of riparian and coastal vegetation.

In 1937, Frei and later, in 1974, Sortino & Marcenò detected the presence of *Centaureo-Ononidietum ramosissimae* Br.-Bl. & Frei in Frei 1937 association which colonized retro-dune sites characterized by consolidated sands along the shore of Licata together with *Crucianella maritima* facies. This community was not found anymore and consequently it could be considered extinct in this area.

The results highlighted that the psammophylous succession suffered various alterations owing to anthropogenic factors which jeopardized the dune system typologies. Moreover, both the phytocoenosis of the brackish swamps and the hygrophilous communities showed symptoms of degradation. Therefore, in the study area, the only possible vegetation seems to be the pioneer one with low probabilities for further development. Despite the massive anthropogenic influence, some communities belonging to sensitive environments, such as dune habitats, brackish marshes and wetlands can be still found. In table 11, critically endangered habitat codes according to CORINE European classification (1991), EUNIS (APAT, 2004) and Natura 2000 (Dir. 92/43/CEE) are shown.

Table 9. *Tamaricetum gallicae* Br.-Bl. & O. Bolòs.

		Rel. n.	1	2	3	4
		Altitude (m)	5	5	5	5
		Exposure	SE	SE	SW	-
		Slope (%)	10	5	5	-
		Area (mq)	20	20	20	50
		Coverage (%)	60	60	90	90
		Charact. and diff. species of the ass. and upper units (*Tamaricion africanae, Tamaricetalia, Nerio-Tamaricetea*)				
W-Medit.	P scap	Tamarix africana Poiret	3	3	4	4
W-Medit.	P scap	Tamarix gallica L.	1	.	1	1
		Other species				
Euri-Medit.	H scap	Dittrichia viscosa (L.) Greuter	+	.	.	+
Subcosmop.	G rhiz	Phragmites australis (Cav.) Trin. ex Steud.	1	+	.	+
Euri-Medit.	NP	Rubus ulmifolius Schott	1	.	+	1
Eurasiat.	T scap	Galium aparine L.	+	1	1	.
Subcosmop.	G rhiz	Arundo donax L.	1	1	1	2
S-Medit.	NP caesp	Artemisia arborescens (Vaill.) L.	+	+	.	.
Sudamer.	NP	Nicotiana glauca Graham	.	+	1	.
Subcosmop.	T scap	Sonchus oleraceus L.	+	+	.	.
America tropic.	T scap	Erigeron bonariensis Hort. ex Link	.	.	.	+
Subcosmop.temper.	T scap	Chenopodium botryoides Sm.	.	+	.	.
Subcosmop.	T scap	Chenopodium album L.	.	+	.	.
Subcosmop.	G rhiz	Juncus maritimus Lam.	.	.	+	.
Cosmop.	T scap	Chenopodium ambrosioides L.	.	+	.	.
Subcosmop.	T scap	Sonchus asper (L.) Hill	.	+	.	.
Neotropic.	T scap	Symphyotrichum squamatum (Spreng.) G. L. Nesom	.	.	.	+
Subcosmop.	T scap	Daucus carota L. subsp. maritimus (Lam.) Batt.	.	.	.	+
Australia	P scap	Eucalyptus camaldulensis Dehnh.	+	.	.	.

The precarious balances regarding such habitats prompt to take realistic and rapid actions. Restoring these habitats means adopting suitable management strategies as to meet the needs of the society without modifying the stability of the ecosystems.

Management choices have to take into account mainly bank and coast defence, monitoring of water chemical-physical characteristics, regulation of anthropogenic activities and safeguard of wetlands. All this must be planned with the perspective of restoring the ecological complexity of the habitats where engineering and ecology must be combined (eco-engineering).

Concrete actions of intervention should include:

- a new approach that combines sustainable management and conservation of species with their habitats;
- consolidation of the river bank and shoreline with natural material to prevent excessive erosion;
- implementation of hydrological and habitat restoration works;

Table 10. *Salicetum albo-purpureae* (I. & Karpati 1961) Barbagallo, Brullo & Fagotto 1979.

		Rel. n.	1
		Altitude (m)	6
		Exposure	W
		Slope (%)	5
		Area (mq)	30
		Coverage (%)	30
		Charact. and diff. species of the upper units (*Salicion albae, Salicetalia purpureae, Salicetea purpureae*)	
Euras.temp	P scap	Salix purpurea L. subsp. lambertiana (Sm.) Macreight	1
Paleotemp.	P scap	Salix alba L.	1
		Other species	
Medit.-Turan.	P scap	Ficus carica L.	+
W-Medit.	P scap	Tamarix africana Poiret	1
Euri-Medit.	H scap	Dittrichia viscosa (L.) Greuter	1
S-Europ.	T scap	Xanthium orientale L. subsp. italicum (Moretti) Greuter	+
SE-Europ.	H scand	Calystegia sylvatica (Kit) Griseb.	+

- training courses and seminars of environmental education;
- involvement of the local community in safeguard projects;
- development and implementation of a visitor guidance concept aimed at reducing disturbance, while at the same time offering optimal conditions for discovering wildlife;
- making the area an eco-tourism destination.

Syntaxonomic scheme

CAKILETEA MARITIMAE R. Tx. & Preising in Br.-Bl. & R. Tx. 1952
Cakiletalia integrifoliae R. Tx. ex Oberd. 1949 corr. Rivas-Martínez, Costa & Loidi 1992
Cakilion maritimae Pignatti 1953
Salsolo-Cakiletum maritimae Costa & Mansanet 1981 corr. Rivas-Martínez et al. 1992
AMMOPHILETEA Br.-Bl. & R. Tx. ex Westhoff et al. 1946
Ammophiletalia Br.-Bl. 1933

Tab. 11 - Habitats of European community interest .

	CORINE code	Natura 2000 code	EUNIS code
Annual vegetation of marine deposits	17.2	1210	B1.1
Salicornia pioneer vegetation and other annual species of muddy and sandy zones	15.1	1310	A2.651
Embryonic mobile dunes	16.211	2110	B1.3

Agropyrenion farcti Rivas-Martínez, Costa, Castroviejo & Valdes Bermajo 1980
Cypero capitati-Agropyretum juncei (Kühnholtz-Lordat 1923) Br.-Bl. 1933

SAGINETEA MARITIMAE Westhoff, Van Leeuwen & Adriani 1962
Frankenietalia pulverulentae Rivas-Martínez ex Castroviejo & Porta 1976
Frankenion pulverulentae Rivas-Martínez ex Castroviejo & Porta 1976
Parapholido-Frankenietum pulverulentae Rivas-Martínez ex Castroviejo & Porta 1976

SARCOCORNIETEA FRUTICOSAE Br.-Bl. & R. Tx. ex A. & O. Bolòs 1950
Sarcocornietalia fruticosae Br.-Bl. 1933
Sarcocornion fruticosae Br.- Bl. 1933 em. Brullo & Furnari 1988
Junco subulati-Sarcocornietum fruticosae Brullo 1988

GALIO-URTICETEA Passarge ex Kopecky 1969
Convolvuletalia sepium R. Tüxen 1950
Senecionion fluviatilis R. Tüxen 1950
Calystegio silvaticae-Arundinetum donacis Brullo, Scelsi & Spampinato 2001

PHRAGMITO-MAGNOCARICETEA Klika in Klika & Novák 1941
Phragmitetalia Koch 1926
Phragmition Koch 1926
Phragmitetum communis (Koch 1926) Schmale 1939
Scirpo lacustris-Phragmitetum australis Koch 1926

PEGANO-SALSOLETEA Br.-Bl. & Bolòs 1958
Salsolo-Peganetalia Br.-Bl. & O.Bolòs 1954
A*rtemision arborescentis* Géhu & Biondi 1986
Atriplici halimi-Artemisietum arborescentis Biondi 1986

NERIO-TAMARICETEA Br.-Bl. & O. Bòlos 1958
Tamaricetalia Br.-Bl. & O. Bòlos 1958
Tamaricion africanae Br.-Bl. & O. Bòlos 1958
Tamaricetum gallicae Br.-Bl. & O. Bòlos 1958

SALICETEA PURPUREAE Moor 1958
Salicetalia purpureae Moor 1958
Salicion albae (Soó 1936) R. Tx. 1955
Salicetum albo-purpureae (I. & V. Karpati 1961) Barbagallo, Brullo & Fagotto 1979

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M. A. Padrón Mederos, I. R. Guma, A. Santos-Guerra, J. A. Reyes-Betancort

Genetic resources of *Atriplex*, *Salsola* and *Suaeda* shrubby species from Canary Islands: a taxonomic survey for agronomic purposes

Abstract

Padrón Mederos, M. A., Guma, I. R., Santos-Guerra, A., Reyes-Betancort, J. A.: Genetic resources of *Atriplex*, *Salsola* and *Suaeda* shrubby species from Canary Islands: a taxonomic survey for agronomic purposes. — Bocconea 23: 253-260. 2009. — ISSN 1120-4060.

The Chenopodiaceae family comprises numerous species considered of high interest in arid and semi-arid regions. In this sense we present our first investigations in shrubby species of the genera *Atriplex*, *Salsola* and *Suaeda* native of Canary Islands. In order to preserve *ex situ* its genetic diversity in Canary Islands, we carried out different collecting missions. As a good knowledge of the target species is an important fact to undertake conservation programmes, a preliminary taxonomic survey is proposed. Eight species (*Atriplex halimus*, *Salsola divaricata*, *S. tetrandra* and *S. vermiculata*, *Suaeda fruticosa*, *S. ifniensis*, *S. mollis* and *S. vera*) were selected. For each one of them full citation of names, basionyms, synonyms, local names, flowering period, authoecology, and distribution data are given. In many cases critical taxonomic remarks are made. Finally a tentative key to the Canarian shrubby chenopods treated in this work is presented.

Introduction

In sensitive island ecosystems, where the introduction of non-native plants and animals, the habitat destruction by human activities and the overgrazing are the main causes of environmental degradation, conservation of genetic diversity of populations is crucial for long-term survival of most species.

The Chenopodiaceae family comprises numerous species considered valuable forage plants, especially in arid and semi-arid regions (Correal 1982, Correal & al. 1987, Le Houérou 1991). Several of these, also have been successfully used in the colonization of desert and semi-desert zones. Therefore, the conservation of native plants of this family and the study of the potential of the species for use as forage and for regeneration-restoration of degraded lands is highly justified.

In this context, our aim is to study autochthonous *Atriplex, Salsola* and *Suaeda* shrubby species in Canary Islands. The objectives of the ongoing project are: a) To establish the taxonomic status of the species of the Canary Islands and its relations with species from the North of Africa and the Iberian Peninsula. b) To analyse the genetic structure of the populations. c) To analyse the chemical composition of these species to determine the nutritive value. d) To conserve germplasm of *Atriplex, Salsola* and *Suaeda* species at the Genebank of the *Instituto Canario de Investigaciones Agrarias (ICIA)*.

In view of the fact that a good taxonomic knowledge of the target species is essential for subsequent genetic characterization and agronomic evaluation, in this paper we present a taxonomic account of them.

Materials and methods

Several expeditions were planned from June 2006 to July 2007 to collect germplasm of *Atriplex halimus*, *Salsola divaricata, S. tetrandra, S. vermiculata, Suaeda fruticosa, S. ifniensis, S. mollis* and *S. vera* populations in Tenerife, Gran Canaria, Fuerteventura and Lanzarote.

Passport descriptors include taxonomic, ecogeographic and phytosociological data. For the later we follow to Rodríguez Delgado & al. (1998) and Rivas-Martínez & al. (2001, 2002). Photographic records of sites and soil samples were also taken.

Herbarium voucher specimens are conserved at ORT and seeds are stored under controlled conditions at the ICIA Genebank.

Results and discussion

A total of 13 collecting trips were made in four Canary Islands (Tenerife, Gran Canaria, Fuerteventura and Lanzarote) in different dates depending on the time of flowering and fruiting of the species, which were variable. For example, *Salsola divaricata* presents a peak collection period in the end of autumn and early winter and *S. vermiculata* in autumn (September-November). *Suaeda* species present a period of collection at the end of spring and early summer. The peak collecting period for *Atriplex halimus* is November-January, similar to that of *Salsola divaricata*. The scarce amount of rain in some areas in 2007 affected seriously to the flower development in *Suaeda mollis* and *S. ifniensis*.

A total of 62 accessions were collected. Geographical location of collecting sites is shown in Fig. 1. The number of populations and individuals prospected per taxon and island are summarized in Table 1.

Table 1. Number of populations / individuals prospected of each species per island.

	Lanzarote	**Fuerteventura**	**Gran Canaria**	**Tenerife**	**TOTAL**
Atriplex halimus	3 / 27	-	1 / 1	-	4 / 28
Salsola divaricata	8 / 117	3 / 68	2 / 4	12 / 159	25 / 348
Salsola tetrandra	1 / 8	-	-	-	1 / 8
Salsola vermiculata	3/17	1/7	-	-	4/24
Suaeda fruticosa	-	-	-	1 / 1	1 / 1
Suaeda ifniensis	5 / 32	-	-	2 / 8	7 / 40
Suaeda mollis	5 / 48	-	3 / 14	-	8 / 62
Suaeda vera	5 / 38	-	3 / 15	4 / 9	12 / 62
TOTAL	30 / 287	4 / 75	9 / 34	19 / 177	62 / 573

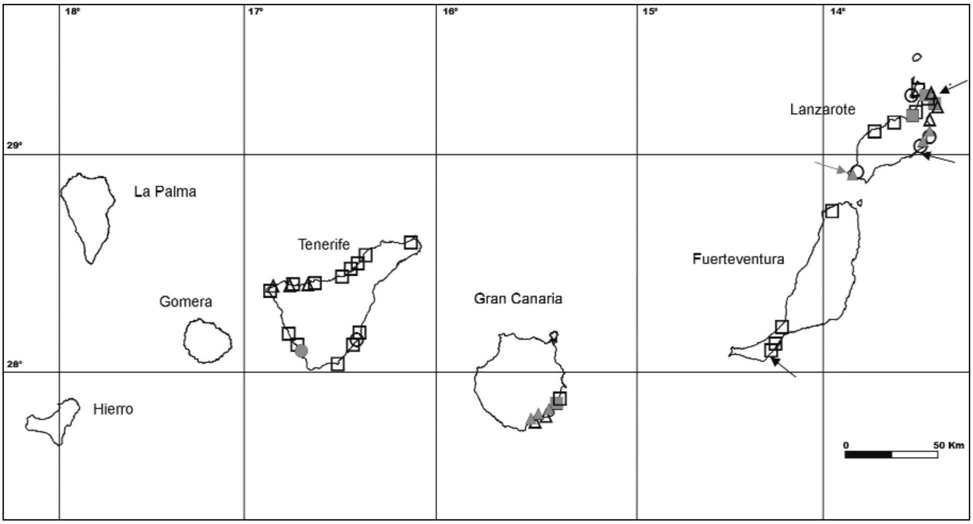

Fig.1. Location of collections. *Atriplex halimus* (grey square); *Salsola divaricata* (empty square); *Salsola tetrandra* (grey arrow); *Salsola vermiculata* (black arrow); *Suaeda vera* (triangle); *Suaeda fruticosa* (grey circle); *Suaeda ifniensis* (empty circle); *Suaeda mollis* (grey triangle).

Taxonomic account

1. ***Atriplex halimus*** L., *Sp. Pl.*: 1052 (1753).
Local name: mato salado, matogota
Flowering between (June) July and October. In fruit between (September) October and January (February).
It grows in sandy or stone-clayed moderate salty soils. Characteristic species of *Pegano-Salsoletea* communities. Also cultivated as ornamental in coastal gardens. It is a optional forage resource in arid and semiarid habitats.
World distribution: Mediterranean Region and S Africa (Castroviejo 1990).
Regional distribution: Lanzarote, Fuerteventura, Gran Canaria, and Tenerife (introduced).
Comments: Further investigations are needed to confirm the relation between Canary plants with the N Mediterranean race *A. halimus* subsp. *halimus* as it is suggested by Ortiz-Dorta & al. (2005).

2. ***Salsola divaricata*** Masson *ex* Link *in* Buch, *Phys. Beschr. Canar. Ins.*: 141 (1825).
[= *Seidlitzia orotavensis* Iljin, *Not. Syst. Herb. Inst. Bot. Acad. Sci. URSS* 15: 88 (1954). = *S. lowei* Iljin, *Not. Syst. Herb. Inst. Bot. Acad. Sci. URSS* 15: 90 (1954). = *Salsola marujae* Castrov. & Luceño, *Anales Jard. Bot. Madrid* 50 (2): 259-260 (1992).]
Local name: brusca (Kunkel 1982), mato, salado
Flowering between (June) July and November (February). In fruit between (July) October to January (March).

It grows in sandy or stone-clayed soils near the coast (rare inland) none or moderate salty. Characteristic species of *Pegano-Salsoletea.*
World distribution: Endemic of Canary Islands.
Regional distribution: Lanzarote, Fuerteventura, Gran Canaria, Tenerife, La Gomera, and La Palma?.
Comments: This species belongs to the *Salsola longifolia* group. Further studies are needed to know (i) the variability of this species into the Archipelago where two taxa have been recognized by Iljin (1954) and (ii) its affinities with the continental species *S. verticillata* Schousb. and *S. gymnosmaschala* Maire.

3. *Salsola tetrandra* Forssk., *Fl. Aegypt.-Arab.*: 58 (1775).
[= *S. vermiculata* L. var. *graciosae* Ktze., *Rev. Gen. Pl.* 2: 550 (1891).]
Local name: mato
Flowering between February and June (July). In fruit between May and August.
Frequent in dry plains and slopes, disturbed areas, abandoned crop fields, etc. It grows in sandy or clayed salty soils. Characteristic species of *Chenoleoidion tomentosae.*
World distribution: N of Africa, Egypt, Palestine, Arabie (Maire 1962).
Regional distribution: Lanzarote and Fuerteventura.

4. *Salsola vermiculata* L., *Sp. Pl.*: 223 (1753).
Local name: carambillo, rama (Kunkel 1982), mato, mato pardo, sogal
Flowering between June and September. In fruit between August and October.
Frequent along the roadsides, slopes and watercourses, disturbed areas, abandoned crop fields, etc. Characteristic species of *Pegano-Salsoletea.*
World distribution: S Europe, N Africa, Mediterranean, E to W and western C Persia, northwards to Nakhichevan, southwards to Saudi Arabia (Freitag 1997).
Regional distribution: Lanzarote and Fuerteventura. Tenerife?.
Comments: A very polymorphic species divided by Botschantzev (1975) in different microspecies depended of style size, indument and morphology of the tepals, etc. In spite of this, four species are mentioned for the Canary Islands (*Salsola vermiculata* L., *Salsola brevifolia* Desf., *Salsola frankeniodes* (Caball.) Botsch. and *Salsola portilloi* Caball.). Nevertheless, a detailed study is necessary to know better the variability of this group of microspecies and the taxonomic status of them. According to Freitag (1997) perhaps they are only different responses to ecological variations. Further studies are being carried out to clarify this subject.

5. *Suaeda fruticosa* Forssk. *ex* J. F. Gmelin, *Onomat. Bot. Compl.* 8: 798 (1776).
[= *S. fruticosa* Forssk., *Fl. Aegypt.-Arab.*: 70 (1775).]
Local name: mato moro
Flowering between February and June (July). In fruit between May and August.
It grows in sandy or clayed soils in littoral or inland saltmarshes. Characteristic species of *Suaedenion verae*; also growing in *Pegano-Salsoletea* and *Crithmo-Staticetea* communities, but always in hydromorphic soils.

World distribution: Not well known because some authors included *S. mollis* in the specific concept of *S. fruticosa*. Saharo-Sindian element extending into the southern Irano-Turanian (Freitag 2001).
Regional distribution: Tenerife.
Comments: a species threatened with extinction in the Canary Islands by tourist facilities.

6. *Suaeda ifniensis* Caball. *in* Maire, *Bull. Soc. Hist. Nat. Afrique N.* 29: 445, contr. 2560 (1938).
[= *Suaeda vera auct. canar. pro parte non* Forssk. *ex* J.F.Gmel.]
Local name: mato moro
Flowering between February and May. In fruit between April to July.
It grows in sandy or stone-clayed soils near the coast (rare inland), in dry slopes, plains and watercourses. Characteristic species of aerohalophilous communities of *Pegano-Salsoletea* and *Kleinio-Euphorbietea canariensis*.
World distribution: Ifni -Caballero-, from Cabo Juby to Dora, Spanish Sahara (Anouti) - Murat -, and Oued Noun near de d'Abouda and Ksiba (Maire 1962).
Regional distribution: Lanzarote, Fuerteventura and Tenerife.
Comments: A morphological detailed study of the canarian populations showed a particular combination of characters that distinguish them from continental populations. These differences are supported also by molecular data (Schütze & al. 2003). Seeds of various populations (insular versus continental) were cultivated under the same conditions to study the taxonomic value of these differences.

7. *Suaeda mollis* (Desf.) Delile, *Descr. Egypte, Hist. Nat.*: 57 (1813).
[= *Salsola mollis* Desf., *Fl. Atlant.* 1: 218 (1798). = *Suaeda vermiculata auct. non* Forssk. *ex* J.F.Gmel.]
Local name: brusquilla (Kunkel 1982), mato moro, uvilla
Flowering between (February) March and June (July). In fruit between April to July.
Frequent in salty dry plains, along the roadsides and disturbed areas, abandoned salt industries, etc. Characteristic species of halo-nitrophilous communities, in stone-clayed or loamy soils sometimes covered with sand. Characteristic species of *Chenoleoidion tomentosae.*
World distribution: Not well know because many authors consider this species co-specific with *S. fruticosa* (Freitag 1989, Boulos 1999). As far as we know *S. mollis* is presented from the Canary Islands to Libya.
Regional distribution: Lanzarote, Fuerteventura and Gran Canaria.
Comments: *Suaeda vermiculata* Forssk. *ex* J.F.Gmel. was the usual name for this plant, however after the typification work of Freitag (1989), who resolved that the type of *S. vermiculata* not corresponded with our plants but it was co-specific with the type of *Suaeda pruinosa* Lange, the use of the name *S. mollis* is more appropriate. In our opinion, to include *S. mollis* as synonym of *S. fruticosa* (Freitag 1989) is erroneous. *S. fruticosa* is a more robust plant (1 m high or more, 2 m wide), and it has different ecological require-

ments (it grows in habitats with water supplies). *S. mollis* is a slender plant (subshrub) (0.1-0.5 m high, 0.5-1 m wide) and it grows in dry salty soils.

8. *Suaeda vera* Forssk. *ex* J.F.Gmel., *Onomat. Bot. Compl.* 8: 797 (1776).
[= *Chenopodium fruticosum* L., *Sp. Pl.*: 221 (1753). = *Lerchea fruticosa sens.* Merino, *Fl. Galicia* 2: 571 (1905). = *Suaeda fruticosa auct. non* Forssk. *ex* J.F.Gmel.]
Local name: mato moro
Flowering between February and June (July). In fruit between May and August.
It grows in sandy or clayed soils in littoral or inland saltmarshes. Characteristic species of *Suaedenion verae,* also growing after impoverishment in *Sarcocornion fruticosae* and *Crithmo-Staticetea* communities but always in more or less hydromorphic soils. It is a companion species in halo-hydromorphic *Tamarix* stands.
World distribution: Mediterranean Region and Atlantic coast of Portugal, Spain, France and England (Pedrol & Castroviejo 1990).
Regional distribution: Lanzarote, Fuerteventura, Gran Canaria, Tenerife and La Gomera.

Key of the species of the genera Atriplex, Salsola and Suaeda included in this study

1. Leaves flat in cross-section. Flowers imperfect, the pistillate lacking a periant and enclosed by 2 accrescent or connate bracteoles . . . .*Atriplex halimus*
- Leaves terete or semiterete in cross-section. Flowers perfect, with tepals and not enclosed by the bracteoles 2
2. Leaves half-clasping at base, if not then opposite. Flowers with 2 well developed leaf-like (shorter) bracteoles 3
- Leaves not half-clasping at base, alternate. Flowers with 2 (3) small and scarious bracteoles 5
3. Leaves alternate . . . .*Salsola vermiculata*
- Leaves opposite 4
4. Leaves scale-like, sessile. Fruiting tepals without a dorsal wing (seldom with a small horizontal rib) . . . .*Salsola tetrandra*
- Leaves well developed, shortly petiolate (articulate at the base). Fruiting tepals with a conspicuous dorsal wing . . . .*Salsola divaricata*
5. Leaves shortly petiolate 6
- Leaves sessile 7
6. Shrub. Leaves terete and linear. Inflorescences very long, indefinites . .*Suaeda fruticosa*
- Dwarf shrub. Leaves semi-terete and globular. Short inflorescences . . . .*Suaeda mollis*
7. Bent branches. Leaves with shortly mucronate tips. Apical shoots hairy. Stigmas subulate, free . . . .*Suaeda ifniensis*
- Straight branches. Leaves without mucronate tips. Apical shoots glabrous. Stigmas flat, irregular lobed, fused at the base forming a peltate structure . . . .*Suaeda vera*

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Visitor diversity and pollinator specialization in Mediterranean Legumes

Abstract

Cristofolini, G. Galloni, M., Podda, L., Quaranta, M. & Vivarelli, D.: Visitor diversity and pollinator specialization in Mediterranean Legumes. — Bocconea 23: 261-266. 2009. — ISSN 1120-4060.

Papilionaceous flowers present functional traits commonly associated to the so-called "bee-syndrome". Despite this evolutionary specialization, many legume species are visited by a large number of insect species. In a sample of seven perennial Mediterranean legumes we focus on the ecological aspects of plant-pollinator interactions. Our aim is to compare the degree of specialization of pollination systems among species showing similar floral traits associated with bee pollination. In particular we ask the following questions: (1) Do all flower visitors act as pollinators? (2) Are pollinators equally important? and (3) Is there any relationship between the degree of specialization of plant-pollinator system and plant fitness?
We describe the spectrum of visitors and identify the potential pollinators by observing insects' behaviour on flowers. The diversity of each population's insect assemblage (flower visitors and potential pollinators) is calculated in order to estimate to which degree pollination systems are specialized. The importance value (PI) for main taxa of potential pollinators is computed considering both quality and quantity components of the pollination service: insect fidelity and relative abundance. Pollinator assemblages show different values of importance and dominance, revealing various degrees of plant-pollinator specificity. Visitors' and pollinators' diversity is negatively correlated with fruiting success, while there is a positive relation between maximum pollinator importance value and fruit set, suggesting the tendency towards a positive relationship between pollinator specificity and reproductive success.

Introduction

The flag flower characteristic of Faboideae is commonly considered a derived condition adapted for visits by bees (Faegri & Van der Pijl 1971). However, despite their specialized floral traits, many legume species are visited by a large number of insect species. As Fenster & al. (2004) pointed out, *evolutionary* specialization onto functional groups does not necessarily mean *ecological* specialization. The first has been defined by Olesen & Jordano (2002) as "the process of evolving in the direction of more specialization" whereas the latter refers to a state of a plant interacting with one to few insect species. Stebbins (1970) tried to solve the apparent paradox between evolutionary specialization and ecological generalization: "since selection is a quantitative process, the characteristic of a flower will be molded by those pollinators that visit it most frequently and effectively in the region where it is evolving". The terms "generalist" and "specialized" are used here in accordance with Fenster & al. (2004); Larsson (2005); Sargent & Otto (2006). Functional groups of pollinators may contain few or many species, varying in their effectiveness, thus plant species that appear to be generalists may prove to be much more specialized than a simple study of their pollinator spectrum would suggest (Moeller 2005). Also, to distinguish between pollen vectors and nonpollinating visitors, recording insect behaviour is highly advisable when studying plant-pollinators interactions (Potts 2005).

Pollinator effectiveness has been defined as any characteristic of a pollinator that contributes to its ability to affect plant fitness. Due to the ambiguity of this term, authors have estimated effectiveness in different ways, depending on the considered component (Ivey & al. 2003). The potential effectiveness of flower visitors can be investigated by analyzing their pollen load (Inouye & al. 1994; Schlindwein & Medeiros 2006), a procedure that gives an estimate of visitor's fidelity, and, combined with observation of their behaviour on the flowers, provides a first assessment of variation in their potential to act as pollinators (Tepedino & al. 1999). A further useful parameter is given by the "pollinator importance", defined as the product of a species' pollination effectiveness by its relative abundance (Moeller 2005).

In this paper we consider a sample of Mediterranean legumes and focus on the ecological aspect of plant-pollinator interactions. Our aim was to compare the degree of specialization of pollination systems among species showing similar floral traits associated with bee pollination. In particular we asked the following questions: (1) Do all flower visitors act as pollinators? (2) Are pollinators equally important? and (3) Is there any relationship between the degree of specialization of plant-pollinator system and plant fitness?

Materials and Methods

This study was conducted on seven legume species of *Leguminosae - Faboideae* (Table 1). To determine the spectrum of visitors in each population we observed and collected all insects approaching the flowers during the observation periods. Considering all flower visitors regardless of their pollination ability, we estimated the relative abundance of the principal taxa at the respective flowers. We calculated the taxonomic diversity of all visitors and potential pollinators assemblages in the studied populations using Shannon's diversity index, accounting for both richness and evenness of the taxa present. Correlations were computed: i) between diversity indexes and fruiting capacity in natural conditions; ii) between the proportion of insect visitors that did not touch reproductive structures and natural fruit set; iii) between the number of insect taxa observed visiting the flowers, and natural fruit set. Details of methodology in the field work are given in Galloni & al. (2007a, 2007b). For each taxon we calculated a value of pollinator importance (PI) by multiplying its relative abundance (percent of visits on total visits) by its fidelity (percent of carried self pollen grains); the maximum PI value of each taxon was recorded as PI_{max}.

Table 1. Insect diversity and pollinator importance indexes, fruit set, and correlations between them. *H vis* = floral visitors' Shannon diversity index; *H pol* = pollinating species Shannon diversity index; *No. vis* = number of visitor taxa; *No. pol* = number of pollinating species; *No. apo* = number of pollinating Apoidea species; *% nonpol* = percentage of non-pollinating visitors; *PI max* = maximum value of pollinator importance.
Lowest row: correlation between variables (columns 1 - 7) and fruit set (column 8). Significance levels: * = $p < 0.05$; n.s. = not significant.

Variables Species	1 *H vis*	2 *H pol*	3 *No. vis*	4 *No. pol*	5 *No. apo*	6 *% nonpol*	7 *PI* $_{max}$	8 *L/F (%)*
Coronilla emerus L.	1.524	1.3480	10	8	8	7.3	4598	35.64
Cytisus scoparius (L.) Link	0.506	0.4284	4	4	3	2.9	8117	47.66
Cytisophyllum sessilifolium (L.) Lang	2.190	1.8320	25	17	15	34.0	2694	6.46
Genista cilentina Valsecchi	1.306	0.9998	11	8	6	16.1	3143	35.21
Genista radiata (L.) Scop.	1.065	0.7626	12	11	4	10.3	5175	23.96
Hedysarum coronarium L.	0.244	0.2383	8	7	6	0.2	8849	37.89
Spartium junceum L.	1.356	1.4830	14	10	3	65.6	1818	6.03
Pearson's r correlation coefficient	n.s.	- 0.78 *	- 0.86 *	- 0.85 *	n.s.	- 0.86 *	0.77 *	-

Results

The most common insects observed visiting the flowers are hymenopterans belonging to superfamily Apoidea. *Cytisophyllum sessilifolium* exhibits the visitors' assemblage with highest taxonomic diversity, with 25 different taxa recorded, while *Cytisus scoparius,* by contrast, was visited by 4 taxa only. The spectrum of potential pollinators comprises only those visitors that accidentally or intentionally contacted the reproductive structures: taxonomic diversity ranges from 17 insect taxa in *Cytisophyllum sessilifolium* to 4 in *Cytisus scoparius.* Only on *Spartium junceum* the number of bee species (Apoidea) was not prevailing. The proportion of insects that did not contact anthers or stigma varies from 66% on *Spartium junceum* to 0.2% on *Hedysarum coronarium*. This percentage is negatively correlated with fruit set (Fig. 1a). The diversity of potential pollinators' assemblages (Shannon index), as well as visitors' and potential pollinators' taxonomic diversity, showed a significant negative correlation with fruit set (Fig. 1b, 1c).

In general, no or very few "host" pollen grains were found on insects recorded to visit flowers without touching anthers or stigma, while bees and bumblebees carried high amounts of host pollen. High importance values are associated to honeybees, bumblebees and solitary bees, while little or not important at all seem to be beetles, wasps and hoverflies. A significant positive correlation was found between the highest pollinator importance (PI_{max}) value of each pollinator assemblage and fruit set (Fig. 1d).

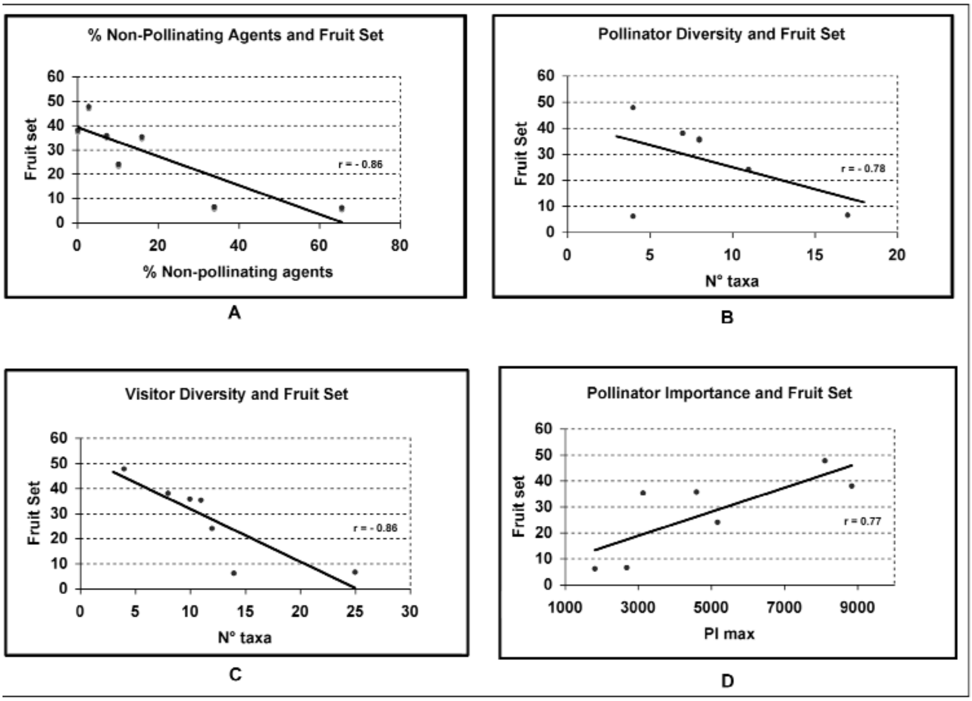

Fig. 1. Relationships between fruit set and visitors' and pollinators' diversity and importance.
X – axis : A – percent insects visiting the flower without touching the stigma ("non – pollinating insects"); B – number of insect species touching the stigma ("pollinating insects"); C – total number of insect species visiting the flower ("pollinating" and "non – pollinating insects"); D – maximum value of Pollinator Importance (Pi max) of all insect species visiting the flower.
Y – axis: percent ratio (number of fruits produced) / (number of flowers).

Conclusions

Despite the common evolutionary specialization of their papilionaceous flower, associated to the so-called "bee-syndrome", legume species show different degrees of ecological specialization of the pollinating system. As pollinator characteristics may influence floral traits over evolutionary time (Darwin 1862; Stebbins 1970), so plant characteristics may affect the foraging decision of animals in ecological time (Sargent & Otto 2006). The taxonomic diversity of pollinators alone cannot be a reliable indicator of the degree of specialization. As Johnson & Steiner (2000) pointed out, the dichotomy between generalization and specialization in pollination systems is a simplification of what is more likely a continuum and, furthermore, spatial and temporal factors strongly affect the degree of "ecological specialization" (Petanidou & Potts 2006).

Fruit production is negatively related to visitors' taxonomic diversity. In particular, our results show that the presence of non-pollen vectors is negatively related to fruit set, suggesting that non-pollinating visitors could exert a negative effect on successful pollination, possibly disturbing active vectors. By contrast, the taxonomic diversity of the main pollinators is not related to fruit production.

The positive correlation between PI_{max} and fruit production demonstrates that reproductive output is promoted by a greater pollinator importance. The negative correlations observed between pollinator and visitor diversity on one side, and fruiting success on the other, together with the positive correlation between maximum pollinator importance and fruit set, point to a positive relation between plant-pollinator specificity and plant reproductive success.

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M. L. Gargano, A. Lantieri, A. Saitta & G. Venturella

The current state of knowledge of fungal diversity in Sicily (southern Italy)

Abstract

Gargano, M. L., Lantieri, A., Saitta, A. & Venturella, G.: The current state of knowledge of fungal diversity in Sicily (southern Italy). — Bocconea 23: 267-271. 2009. — ISSN 1120-4060.

The paper deal with the status of fungal biodiversity in Sicily. 1500 taxa, growing in different types of vegetation, are distributed in the nine provinces of the region. In this contribution a preliminary list of rare and infrequent species is also provided.

Introduction

The evaluation of fungal biodiversity in Italy is still in progress. A remarkable step was the publication of the Check-list of Italian Fungi (*Basidiomycota*) by Onofri (2005). According to this recent report, Sicily is one of the most investigated regions.

A first attempt to assess fungal biodiversity of Sicily (southern Italy) was carried out on the basis of literature data reported from 1814 to 1991. The number of fungi (macromycetes and micromycetes), tallied with 1564 taxa belonging to 496 genera and 189 families, was contained in the "Check-list of Sicilian fungi" (Venturella 1991).

In 1989, a synthesis of the above-mentioned data, splitted per provinces and mountainous systems, was presented during the VI OPTIMA Meeting in Delphi (Greece) by Venturella & Mazzola 1991.

Afterwards a project of census and mapping of macromycetes in Sicily was based on intense exploration of forest ecosystems, natural parks, natural reserves, public and private gardens, botanical gardens, cultivated lands, etc. (Venturella 1992).

On the basis of fifteen years of investigation an up-to-date assessment of fungal biodiversity of Sicily is reported in this paper.

Materials and methods

The census of fungi in Sicily was carried out by the Laboratory of Mycology of the Department of Botany, University of Palermo, through field investigations in different ecosystems.

The survey consisted, every fifteen days, in the collection of all ascomata and basidiomata and their identification in laboratory through traditional techniques such as the use of optical microscopy and chemical reagents. The exsiccata were kept in the Herbarium Mediterraneum Panormitanum (PAL). All collections were stored in a database reporting the localities of picking, the ecological and distributive data.

Discussion

The number of macrofungi from Sicily (Fig. 1), corresponding to 650 taxa in 1991, is nowadays more than doubled (1500 taxa, data referred to December 2006).

As reported in Fig. 2 the more investigated provinces are Palermo (1068 taxa), Catania (675 taxa) and Messina (467 taxa) followed by the provinces of Trapani (232 taxa), Agrigento (214 taxa), Siracusa (212 taxa), Enna (143 taxa), Caltanissetta (102 taxa) and Ragusa (81 taxa).

The assessment of fungal diversity also permitted to increase the knowledge on the ecology of each investigated taxon and to prepare distribution maps.

A considerable number of fungi was recorded in woods with prevalence of *Quercus ilex* L. (WQi) and within the woods with prevalence of deciduous termophilous oaks (Wdo). As shown in Fig. 3 more than 500 taxa are growing in these types of vegetation. The woods of *Fagus sylvatica* L. (Fsw) also reach a high level of diversity and more than 300 taxa were recorded.

The number of fungi in reforested areas (R), woods with prevalence of *Quercus suber* L. (WQs) and woods with prevalence of Castanea sativa Miller (Wch), exceed 200 taxa.

The lowest amount of taxa was recorded in sown land and open air agricultural cultivation (Sc), vineyards (V) and vegetation of quarries and dumps (Vq).

The diversity of fungi in Sicily is strongly influenced by fire events which are very frequent in the Mediterranean area. The fungal mycocoenoses appearing in post-fire dynamics weigh on the total number of fungi recorded by 40 taxa.

A second factor which contribute to rise up the number of taxa is grazing. Nineteen saprobes specialized on degradation of dungs of bovine, equine, ovine and other wild animals such as boars, hares and rabbits were recorded.

The total number of fungi also include fungi growing on particular types of substrata such as cupoles of *Fagaceae* [*Ciboria batschiana* (Zopf) N.F. Buchw., *Hymenoscyphus fructigenus* (Bull.) Gray and *Rutstroemia echinophila* (Bull.) Höhn.], catkins [*Ciboria amentacea* (Balb.) Fuckel] and larvae of insects [*Cordyceps militaris* (L.) Link], parasite species on basidiomycetes [*Nyctalis parasitica* (Bull.) Fr. and *Syzygospora tumefaciens* (Ginns & Sunhede) Ginns] and saprobe species on residues of *Pleurotus* cultivation (*Peziza vesiculosa* Bull.).

Owing to the difficulties to have dogs trained in the search of hypogeous the list of fungi published in Europe are usually lacking of such fundamental component of diversity. Starting from 2000, a research team handled on the Sicilian territory to characterize the biodiversity of hypogeous component and 65 taxa belonging to 20 genera were recorded (Venturella & al. 2006).

The up-to-date check-list of macrofungi is also a useful base for a prevision of the status of rarity and infrequency of recorded species. *Entoloma plebeioides* (Schulzer) Noordel., *Gymnopus ocior* (Pers.) Antonín & Noordel. and *Symocybe sumptuosa* (P.D.

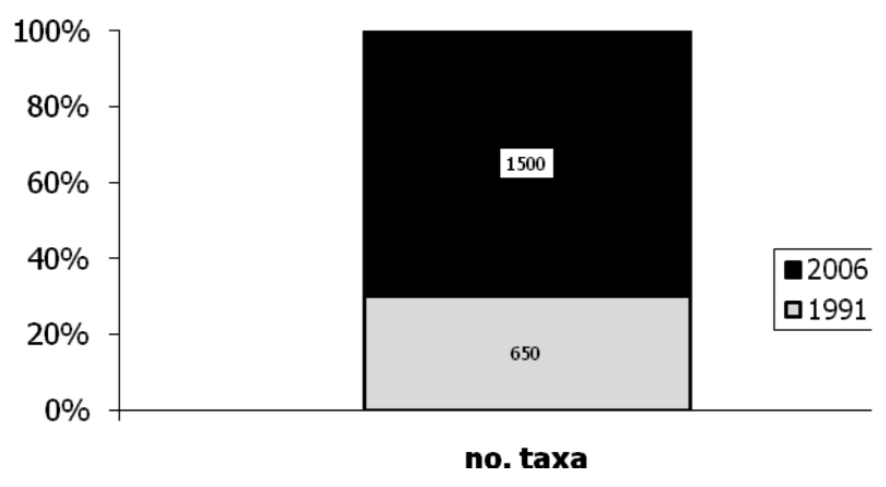


Fig. 1. The number of taxa reported from Sicily in 1991 and 2006.

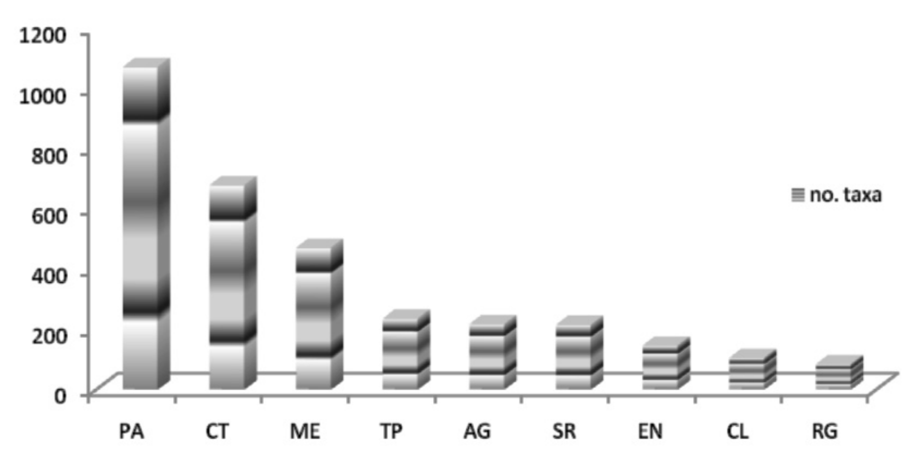
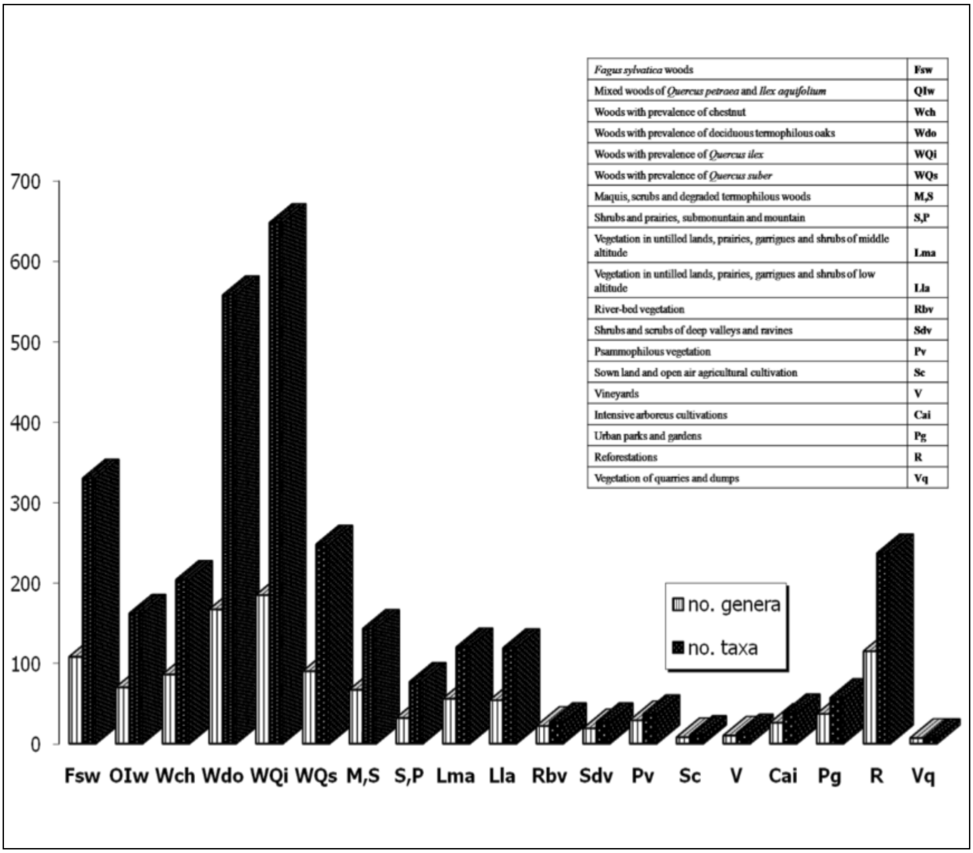


Fig. 2. Number of *taxa* per provinces. **PA**= Palermo**, CT** = Catania**, ME** = Messina**, TP** = Trapani**, AG** = Agrigento**, SR** = Siracusa**, EN** = Enna**, CL** = Caltanissetta**, RG** = Ragusa.



Fagus sylvatica woods	**Fsw**
Mixed woods of *Quercus petraea* and *Ilex aquifolium*	**QIw**
Woods with prevalence of chestnut	**Wch**
Woods with prevalence of deciduous termophilous oaks	**Wdo**
Woods with prevalence of *Quercus ilex*	**WQi**
Woods with prevalence of *Quercus suber*	**WQs**
Maquis, scrubs and degraded termophilous woods	**M,S**
Shrubs and prairies, submonuntain and mountain	**S,P**
Vegetation in untilled lands, prairies, garrigues and shrubs of middle altitude	**Lma**
Vegetation in untilled lands, prairies, garrigues and shrubs of low altitude	**Lla**
River-bed vegetation	**Rbv**
Shrubs and scrubs of deep valleys and ravines	**Sdv**
Psammophilous vegetation	**Pv**
Sown land and open air agricultural cultivation	**Sc**
Vineyards	**V**
Intensive arboreus cultivations	**Cai**
Urban parks and gardens	**Pg**
Reforestations	**R**
Vegetation of quarries and dumps	**Vq**

Fig. 3. Number of genera and taxa per vegetation type.

Orton) Singer, never collected before in Italy, together with *Agaricus luteomaculatus* (F.H. Møller) F.H. Møller, *Amanita pseudolactea* Contu, *Boletopsis leucomelaena* (Pers.) Fayod, *Buckwaldoboletus lignicola* (Kallenb.) Pilát, *Colus hirudinosus* Cavalier & Séchier, *Discina ancilis* (Pers.) Sacc., *Entoloma bloxamii* (Berk. & Broome) Sacc., *Gyromitra esculenta* (Pers.) Fr., *Gyroporus cyanescens* (Bull.) Quél., *Hericium cirrhatum* (Pers.) Nikol., *H. coralloides* (Scop.) Pers., *Hydnocristella himantia* (Schwein.) R.H. Petrsen, *Lactarius subumbonatus* Lindgr., *Phaeolus schweinitzii* (Fr.) Pat., *Pleurotus nebrodensis* (Inzenga) Quélet, *Rubinoboletus roseoalbidus* (Alessio & Littini) De Kesel, *Schenella pityophilus* (Malençon &Riousset) Estrada & Lado, *Strobilomyces strobilaceus* (Scop.) Berk, *Urnula pouchetii* Berthet & Riousset, *Xerocomus ichnusanus* Alessio, Galli & Littini, and are eligible for inclusion in a preliminar red-list of fungi from Sicily.

Recently Pleurotus nebrodensis has been reported by IUCN in the “Red List of Threatened Species” (www.iucnredlist.org) as Critically Endangered (CR) and included in the Top 50 Mediterranean Island Plants (Venturella 2005).

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Alessandro Saitta & Giuseppe Venturella

On the presence of *Diplomitoporus lindbladii* and *Phellinus pseudopunctatus* in Sicily (southern Italy)

Abstract

Saitta, A. & Venturella, G.: On the presence of *Diplomitoporus lindbladii* and *Phellinus pseudopunctatus* in Sicily (southern Italy). — Bocconea 23: 273-276. 2009. — ISSN 1120-4060.

Diplomitoporus lindbladii and *Phellinus pseudopunctatus* are reported for the first time from Sicily (southern Italy). The ecological and distributive features of these two interesting species are here provided.

Introduction

The increase of mycological investigation in Sicily allowed to select a huge number of fungi, to publish lists and maps of distribution, to collect many ecological data and to evaluate the rareness of some taxa (Onofri 2005; Venturella & al. 2005).

Within the framework of the project of assessment of fungal diversity in the Sicilian territory particular attention was devoted to the group of lignicolous fungi. They are widely distributed in Sicily on different plants of agronomic, forestry and ornamental interest and they play a fundamental role in decomposition of wood residues and large amount of lignocellulosic materials.

A list of lignicolous species, host plants and substrata, referred to 209 taxa (181 *Basidiomycetes* and 28 *Ascomycetes*), was published by Saitta & al. (2004). Besides distributive and ecological data on fourteen Aphyllophorales were reported by Venturella & al. (2006, 2007). Recently some additional findings allowed to increase the number of known species to 290 (250 *Basidiomycetes* and 40 *Ascomycetes*). The family of Polyporaceae s.l. (85 taxa) is overriding within the considerable number of taxa reported from Sicily.

Two new interesting species, *Diplomitoporus lindbladii* (Berk.) Gilb. & Ryvarden and *Phellinus pseudopunctatus* A. David, Dequatre & Fiasson were recently collected for the first time in Sicily.

Materials and methods

The basidiomata of lignicolous fungi were collected in broadleaved and conifer forest ecosystems of the Sicilian territory. The specimens were preserved in a paper bag, and identified in laboratory, after rehydratation in KOH, using a Leica optical microscopy

DMLB and chemical reagents (Melzer and KOH 5%). The macroscopic and microscopic features of *Diplomitoporus lindbladii* and *Phellinus pseudopunctatus*, such as the structure of basidiocarps, the pore surface, the subiculum, the hymenial layer coloration, the hyphal system, the basidiospores, the cystidioles, the basidia, the basal clamp of basidia and the reaction of gelatinizing hyphae in KOH were pointed out. The scientific binomials were obtained from Bernicchia (2005). The herbarium samples are kept in the *Herbarium Mediterraneum Panormitanum* (PAL).

Discussion

The annual and resupinate basidiomata of *Diplomitoporus lindbladii* (Berk.) Gilb. & Ryvarden (*Steccherinaceae*) (Fig. 1) are usually observed on stumps and trunks of conifers fallen to the ground. *D. lindbladii* is a white rot basidiomycetes conferring a fibrous aspect to the wood of *Pinus pinea* L., *P. nigra* Arnold, *P. sylvestris* L., *Abies alba* Miller, *Picea excelsa* (Lam.) Link and *Larix decidua* Miller (Bernicchia 2005). The distribution of *D. lindbladii* is restricted to temperate regions of northern hemisphere and this species is widely distributed in Europe but rare in the Mediterranean area.

D. lindbladii was frequently recorded in few Italian regions such as Emilia Romagna, Friuli Venezia Giulia, Lombardia, Trentino Alto Adige and Veneto. The new record from Sicily extend southwards the distribution area of *D. lindbladii* (Fig. 2).

The localities of finding of *D. lindbladii* are localized in reforested areas of central-western sector of Sicily. In the locality placed at 1350 m a.s.l., named Monte Rose, included in the territory of Bivona, a small town of the province of Agrigento, *D. lindbladii* was collected in spring (May) on fallen trunks of Pinus halepensis Miller while in Serra dell'Occhio (Monreale, province of Palermo), 970 m a.s.l., the basidiomata were observed in December, on fallen burnt trunks of *Pinus pinea* L. The type of soil is different in the two localities of finding, i.e. Typic xerochrepts associated with Calcixerollic xerochrepts and Lythic xerorthents in Monte Rose and Lithic xerorthents associated with Rock outcrop and Typic and/or Lythic rhodoxeralfs in Serra dell'Occhio.

In Italy the white rot *Phellinus pseudopunctatus* A. David, Dequatre & Fiasson (*Hymenochaetaceae*) (Fig. 3) is reported on plants of the genera Cistus L. and Juniperus L. (Bernicchia 2005). The basidiomata are macroscopically similar to *P. punctatus* (Fr.) Pilát while pronounced differences are pointed out with respect to microscopic features. In fact *P. pseudopunctatus* is characterized by hymenial setae, cystidiole with thick walls at the base, longer cylindrical neck and shorter basidiospores.

The distribution of *P. pseudopunctatus* is usually restricted to central and southern Europe. It is also considered a very rare species in Italy since it is reported only from Tuscany (Barluzzi & al. 1996; Bernicchia 2005) and Sardinia (Bernicchia, Herb. HUBO) (Fig. 4).

In Sicily the basidiomata were observed, during November, on a branch of cultivated *Corylus avellana* L. in the neighbourhood of Militello Rosmarino (province of Messina), 350 m a.s.l., on Typic xerochrepts associated with Typic haploxeralfs and Typic and/or Lithic xerorthents.

P. halepensis and *C. avellana* should be considered as host plants and substrata never reported before in literature for *D. lindbladii* and *P. pseudopunctatus* respectively.

Fig. 1. Basidioma of *D. lindbladii*.

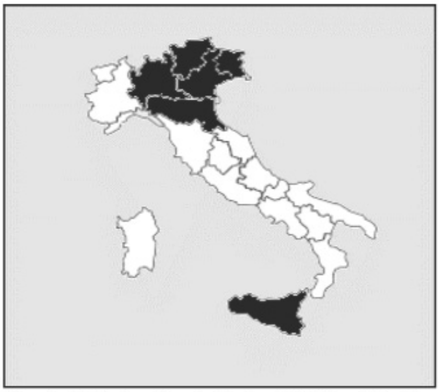

Fig. 2. Distribution in Italy of *D. lindbladii*.

Fig. 3. Basidioma of *P. pseudopunctatus*.

Fig. 4. Distribution in Italy of *P. pseudopunctatus*.

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Giuseppe Venturella & Alessandro Saitta

Poronia punctata, a rare ascomycetes from Italy

Abstract

Venturella, G. & Saitta, A.: *Poronia punctata*, a rare ascomycetes from Italy. — Bocconea 23: 277-279. 2009. — ISSN 1120-4060

Poronia punctata is reported from Sicily as a rare species. Ecological observations in comparison with literature data from Italy and other European countries demonstrated that the rarity of *P. punctata* should be attributed to environmental factors different from the presence or absence of suitable substrata.

Introduction

Until the end of 1800, *Poronia punctata* (L. : Fr.) Fr. (*Xylariaceae*, *Ascomycota*), usually named the "nail fungus", was considered in all Europe as a common and abundant species (Whalley & Dickson 1986). On the contrary, *P. punctata* (Fig. 1) is nowadays considered as extinct in numerous countries and it is included into the group of the most threatened species of macromycetes in Europe.

The "nail fungus" is listed in the UK Biodiversity Action Plan (UK BAP, http://www.ukbap.org.uk/) and reported in English Nature's Species Recovery Programme (Whalley & Dickson 1986). In Croatia it occurs only on the dung of ponies and horses which have fed on unimproved acidic grassland and healthy vegetation (Matocec 2000) while in other European countries it was collected on dung of cattle, donkeys and cows.

In Italy the distribution and the ecology of *P. punctata* is not well investigated and literature data are only available from Latium and Sicily. A new record from Sicily is reported in this paper together with some ecological remarks.

Materials and methods

Periodical observations on the occurrence of macromycetes in Sicily were carried out by the Laboratory of Mycology of the Department of Botany (University of Palermo). Basidiomata and ascomata were collected in broadleaved and conifer forest ecosystems of the Sicilian territory. The identification of fungi has been carried out in laboratory on fresh and dried material through traditional techniques such as the use of optical microscopy and chemical reagents (KOH 5%, Melzer, iodine). The herbarium samples were kept in the *Herbarium Mediterraneum Panormitanum* (PAL).

Results

The locality of collection, belonging to the territory of Aliminusa (province of Palermo), is located in the Natural Reserve "Bosco della Favara e Bosco Granza", a very interesting naturalistic area rich of endemisms and rare taxa, extended ca. 2977.5 hectares. The climate is typically xerothermic with a mean annual rainfall of 788.2 mm and a mean annual temperature corresponding to 16.9 °C. The forestry vegetation, partially modified by the introduction of exotic plants, is still well represented. The *Quercus suber* woods are widely distributed (289 hectares) followed by *Q. pubescens* woods (270 hectares).

P. punctata was collected by one of the authors (A.S.), on horses dung, in a mixed wood of *Quercus suber* L. and *Q. pubescens* Willd. s.l. in an area of the natural reserve named "Passo Scacciavalloni" (650 m a.s.l.).

Discussion

The dung of different hand-reared and wild animals is a suitable substratum for a considerable number of fungi species. There are many coprophilous fungi belonging to diverse taxonomic groups such as *Mucorales, Pezizales, Sordariales, Coprinaceae* and certain other *Basidiomycota* (Kirk & al. 2001). Among them the widespread genus *Poronia* Willd. includes 32 taxa (http://www.indexfungorum.org/Names/Names.asp). *P. punctata* (Fig. 1) is morphologically similar to *P. erici* Lohmeyer & Benkert but easily separated by spores observation. The spores of *P. punctata* are sub-ellipsoid, usually with two oil drops, often asymmetrical with longitudinal germinative pore. Ecological remarks on *P. punctata* were pointed out by Cox &

Fig. 1. Ascomata of *Poronia punctata.*

Pickess (1999) which underlined that it occurs on dung on predominantly short vegetation and that its fructification is not only dependent on the presence of pony dung. In Italy, *P. punctata* was previously collected by Granito & Lunghini (2006) in Latium on Monti Simbruini grasslands, in altitudinal range of 1400-1450 m, from April to June. These authors highlighted the power of inhibition versus other competitors and the cellulosolitic activity of *P. punctata. P. punctata* was also recorded from Sicily (southern Italy) by Signorello (1995) but no ecological and accurate distributive data could be gained from this publication. The locality here reported is the third record from Italy enriching literature with new ecological data such as the period of fructification that is autumnal (November), the infrequent type of substratum, the different environment of growth as the vegetation type and the altitudinal range are concerned. Therefore the rarity of *P. punctata* is confirmed also in Italy in agreement with considerations carried out by Ing (1992) which included the “nail fungus” on the provisional Red Data List of endangered British fungi. Besides the observations on the field in the Sicilian territory confirmed that grazing increases the abundance and diversity of fungi through vegetation removal and soil compaction as reported by Baars & Kuyper (1993). On the contrary the considerations of British authors which ascribed the rarity of *P. punctata* to changes in agricultural practices, decline in the use of horses, the loss of unimproved grasslands, major changes of stockbreeding (Cox & Pickess 1999) could not be applied to the Sicilian environment. In fact in many rural districts of Sicily the wild and semi-wild system of breeding horses still persist and grazing is widespread in many forest ecosystems. Nevertheless the “nail fungus” is very rare in Sicily so the opinion of British authors that the fungus is rare because it was left without its suitable substrate is not applicable in all environments. Besides other mycologists reported that ascospores dispersal of *P. punctata* could be probably ascribed to ponies which have eaten spore-bearing vegetation (Whalley & Dickson 1986).

In our opinion the rarity of *P. punctata* should be attributed to environmental factors different from the presence or absence of suitable substrata.

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I. Bazos, Y. Kokkoris, A. Zikos, P. Andriopoulos, P. Delipetrou, K. Georghiou, A. Yannitsaros & M. Arianoutsou

The alien vascular flora of Greece: Floristic analysis and chorology

Abstract

Bazos, I., Kokkoris, Y., Zikos, A., Andriopoulos, P., Delipetrou, P., Georghiou, K., Yannitsaros, A. & Arianoutsou, M.:The alien vascular flora of Greece: Floristic analysis and chorology. — Bocconea 23: 281-284. 2009. — ISSN 1120-4060.

Within the framework of the EC funded project DAISIE literature data regarding the alien flora of Greece were compiled in a database. The data collected concern taxonomy, distribution, origin, introduction pathway, status, life and growth form, flowering period, fruit type, habitat etc. Data on 326 taxa reported for Greece have been compiled in this database. Approximately 40% of these taxa are naturalized. The richest families in number of taxa, comprising approximately 30% of the total, are *Gramineae*, *Compositae* and *Leguminosae*, while *Amaranthus* is by far the richest genus consisted of 18 taxa. As far as their life form is concerned, the majority are therophytes followed by phanerophytes and hemicryptophytes. Chorological analysis showed that most of the taxa are of American origin (38%) As it was expected, most of the alien taxa grow in disturbed and man-made habitats.

Introduction

Alien plants, also known as exotic, introduced, non-native, non-indigenous, are those taxa whose presence in a given area is due to intentional or unintentional human involvement, or which have arrived there without the help of people from an area in which they are native (Pyšek & al. 2004; Pyšek & Richardson 2006). According to Webb (1985) alien species are those who reached an area as a consequence of the activities of neolithic or post-neolithic man or of his domestic animals. Pyšek & Richardson (2006) distinguished three categories of alien plants according to their ‘invasion status’: a) casual aliens, that are those plants which may flourish and reproduce occasionally away from cultivation, but that eventually die out because they do not form self-replacing populations, b) naturalized plants, which sustain self-replacing populations without direct human intervention and c) invasive plants, which are naturalized plants that produce reproductive offspring, often in large numbers, at considerable distances from the parent plants and thus have the potential to spread far over a large area. Yannitsaros (1982) uses the term adventive in its strict sense to define both naturalized and casual alien plant taxa, while in the wide sense subspontaneous are also included.

Invasion ecology is one of the most rapidly developing branches of ecology (Williamson 1996). This is due to the significant losses of the biological diversity and function of the ecosystems invaded as well as to their impact on the economy (Mooney & Hobbs 2000; Mack & al. 2000). The European Commission funded the project DAISIE (www.europe-aliens.org) with a view to deliver an alien invasive species inventory for Europe. The project aimed at producing a database on the alien species in Europe and the outcome is a web portal from which all interested scientists will have access to its data. The current work, mostly carried out under this project, is the first attempt to gather scattered information and provide the best possible overview of the Greek alien flora. The study of the alien vascular flora of Greece started in early 1970's (Yannitsaros 1982). It became more intense and systematic during the last two decades and many new records were added. Among the Greek regions with a sufficient knowledge of the alien flora are Attica, the island of Crete, the urban areas of Thessaloniki and Patras and some Aegean Islands (e.g. Lesvos, Chios, Kalymnos).

Material and methods

The data collected are based on an extensive survey of the existing literature and concern taxonomy, distribution, chorology, habitat, introduction pathway, as well as several life history traits of the alien plant taxa (e.g. life and growth form, fruit type, reproduction and dispersal mode etc.). A relational database has been created with fields corresponding to the above mentioned topics of information. Nomenclature is according to Tutin & al. (1968-1980, 1993). Life forms are identified according to the system proposed by Raunkiaer (1934, 1937) and modified by Ellenberg (1956) and Ellenberg & Müller-Dombois (1967). Chorology of the taxa is mainly after Pignatti (1982), Strid & Tan (1997, 2002) and Tutin & al. (1968-1980, 1993) while in many cases several additional sources were used.

Results and Discussion

The number of alien taxa (species, subspecies and hybrids) reported so far for Greece is 326. A high percentage of these (approximately 40%) are naturalized (Fig. 1). The majority of the taxa recorded belong to the families of *Gramineae* (45 taxa), *Compositae* (29 taxa), *Leguminosae* (25 taxa), *Amaranthaceae* (19 taxa), *Solanaceae* (18 taxa) and *Cruciferae* (14 taxa). *Amaranthus* is by far the richest genus consisted of 18 taxa. Therophytes (46.9%) are the majority in overall alien taxa followed by phanerophytes (19.6%), hemicryptophytes (13.4%) and geophytes (11.8%) as demonstrated in Fig. 2. The percentage of therophytes is increasing significantly within the casual alien plant taxa (54.5%). The majority of the alien plant taxa in Greece are of American origin (38%), followed by those of Asiatic (18%), Mediterranean (9%) and Tropical-Subtropical (8%) origin (Fig. 3). Notably, the majority of the alien taxa occur in disturbed or man-made habitats such as cultivations, road sides, fallow lands and waste deposits and only a limited number intrude natural habitats such as coastal habitats.

The alien flora of Greece is not yet fully studied, since several regions and habitats likely to host such species are under-investigated. However, it is expected that even if new data will be available, the trends presented above will not change significantly.

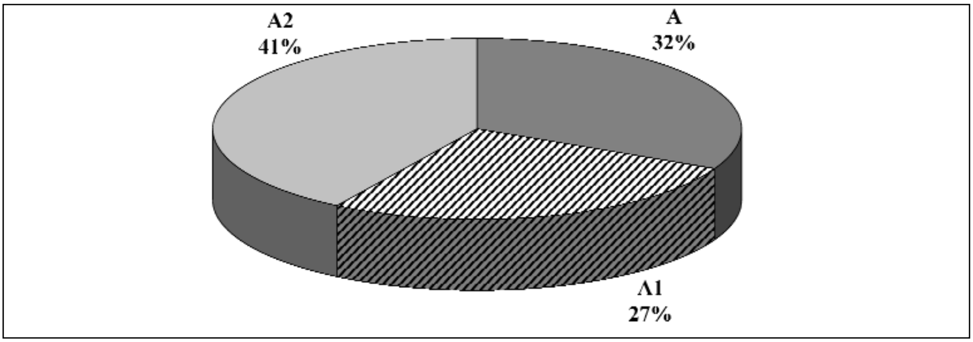

Fig. 1. Status of the alien plant taxa of Greece: Uncertain (A), Casual (A1), Naturalized (A2).

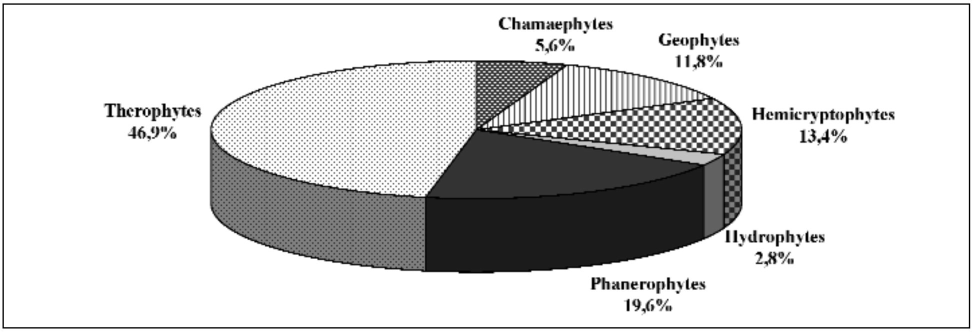

Fig. 2. Life form spectrum of the alien plant taxa of Greece.

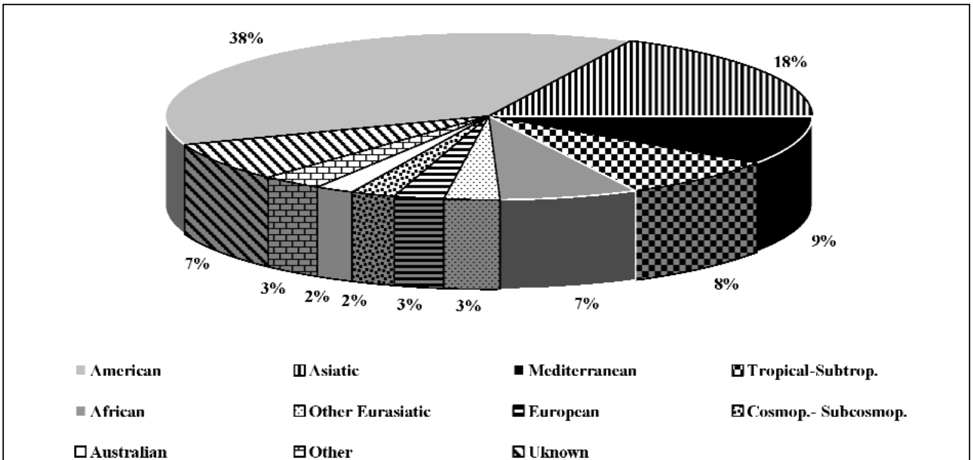

Fig. 3. Chorological spectrum of the alien plant taxa of Greece.

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G. Bosi, A. M. Mercuri & M. Bandini Mazzanti

Plants and Man in urban environment: the history of the city of Ferrara (10th - 16th cent. A.D.) through its archaeobotanical records

Abstract

Bosi, G., Mercuri, A. M. & Bandini Mazzanti, M.: Plants and Man in urban environment: the history of the city of Ferrara (10th - 16th cent. A.D.) through its archaeobotanical records. — Bocconea 23: 285-300. 2009. — ISSN 1120-4060.

An overview of the archaeobotanical analyses carried out on material from archaeological sites of the city of Ferrara (Emilia-Romagna; 10th – 16th cent. A.D.), made by the Laboratory of Palynology and Palaeobotany of the University of Modena and Reggio Emilia during over 15 years of research, is presented. The floristic list from seed/fruit analyses is reported, and interesting subject matters are tackled concerning both cultivated/cultivable plants (fruits and nuts, vegetables/aromatics/spices/medicinals plants, fibre and oil plants, cereals and pulses, flower and other ornamental plants), and wild plants not obviously used, together with plants of wet grounds, which represent rare and endangered species in the Emilia-Romagna region today.

Introduction

Ferrara is a renowned city of the Emilia-Romagna region, in Northern Italy, which offers one of the best examples of the bulk of information that can be inferred from archaeobotanical analyses from Mediaeval/Renaissance contexts. The city (10 m a. s. l.) grew up around a ford on the Po river at about the 7th cent. A.D., and is one of the rare Italian cities whose original layout was not based on the Roman tradition. The Este family ruled Ferrara from the second half of the 13th cent. A.D., and under its power the city reached a significant rank within the Italian states. Therefore, it played a key role in the political life inside as well as outside the peninsula. In the 15th and 16th cent. A.D., Ferrara became an intellectual and artistic centre which attracted the greatest minds of the Italian Renaissance. Currently, Ferrara is renowned for its historical centre, which is extraordinarily well-preserved, featuring small orchards and gardens, and was declared a World Heritage Site by UNESCO in 1995.

The archaeobotanical records from its deposits dated to between the 10th and 16th cent. A.D. (Bandini Mazzanti & al. 2005, 2006; Bosi 2000; Bosi & Bandini Mazzanti 2006; Bosi & al. 2006, and unpublished data). They were collected from facilities which included: pits, latrines (Bandini Mazzanti & al. 1992; Mercuri & al. 1999), a desiccated ditch with a man-made fill (Bandini Mazzanti & al. 1999), a fill from pharmaceutical bottles thrown into the rubbish (Bandini Mazzanti & al. 2006), rubbish pits and heaps, latrines, sewers, trenches, and containers – troughs and small barrels – used as rubbish bins (Bosi 2000). Other European cities with reports on archaeocarpological remains of the Mediaeval period are, for example, Prague (Beneš & al. 2002), Gdańsk, Elbląg and Kołobrzeg in Poland and other North European cities (Karg 2007).

This work presents a synthesis of the archaeocarpological investigations which have been carried out in the city of Ferrara since the beginning of 1990, mainly to underline: 1) the key differences between the Early and Late Mediaeval plant assemblages and their importance for outlining the urban plant environment; 2) the past presence of species which are currently very rare or absent in this region, or even in the Po Plain (Pignatti 1982; Alessandrini & Bonafede 1996; Pirola 1975, and the more recent *Check list of the Italian Vascular Flora* - Conti & al. 2005); 3) the cultural heritage of the Ferrara area studied by the evolution of some crops typical of the area, and by the history of their cultivations which are part of the cultural landscape even today.

Sites and methods

Samples for macroremains were collected from different layers belonging to the 5 sites (with 14 contexts, 25 typologies, 42 layers) located within the city (Tab. 1). A total 180 litres of sediment were sieved. Samples were soaked in water and then washed through a bank of three sieves with 10, 5 and 1 mm meshes. Seeds and fruits from each fraction were sorted and counted under a stereomicroscope, and identified at Wild M10 stereomicroscope (up to 80x magnification) with the reference collection, atlases and keys (Anderberg 1994; Beijerinck 1947; Berggren 1969, 1981; Cappers & al. 2006; Davis 1993; Delorit 1970; Frank & Stika 1988; Häfliger & Brun-Hool 1981; Hubbard 1992; Jacomet & al. 1991; Jacquat 1988; Kiffmann 1958; Montegut 1972; Nesbitt 2006; Pignotti 1998; Renfrew 1973; Schoch & al. 1988; Scurti 1948; Spjut 1994; Viggiani & Angelini 1991, 2005; Young & Young 1992). SEM was used for problematic determinations such as, for example, *Cucumis melo* and *C. sativus* discrimination. Unless otherwise specified, concentration (seeds/fruits per litre) and percentage data refer to a sum which excluded *Ficus* and *Vitis*. More than one million seed/fruit records were studied, most of which were well-preserved in a waterlogged condition. Flora d'Italia (Pignatti 1982) and European Flora (Tutin & al. 1964 - 93) were used for scientific plant names.

Results and discussion

The identified seeds and fruits belong to about 300 species/carpological types (Annex 1 and Fig. 1). Below, the main data will be reported by grouping them into categories, as it is the most useful method for their interpretation (Annex 1).

Fruits and nuts -Various taxa, including native species (cultivated/ possibly cultivated or not cultivated), species of uncertain indigenousness or exotics (Pignatti 1982; Saccardo 1909; Tutin & al. 1964-1993). Among the native species, ubiquitarian and abundant records belong to *Vitis vinifera* subsp. *vinifera*, *Prunus avium* (endocarps of cultivated form), *Rubus fruticosus* s.l., *R. caesius*, *R. idaeus*, *Fragaria* cf. *vesca*, *Prunus spinosa*, *Cornus mas*, *Corylus avellana*, … Among the others, many species have been already found in archaeological sites of the Roman Period in Emilia-Romagna region: *Citrullus lanatus*, *Ficus carica*, *Morus nigra, Pinus pinea*, *Punica granatum*, *Prunus cerasifera*, *P. domestica* subsp. *domestica*, *P. domestica* subsp. *insititia*, *P. persica* (Bandini Mazzanti & al. 2001a, 2001b and unpublished data). Six non-native species were added to the previous list of Mediaeval Ages (the date of the most ancient record is reported in brackets): *Cucumis melo* and *Prunus cerasus* (second half 10th – first half 11th cent. A.D.) and *Cydonia oblonga* (second half 11th – first half 12th cent. A.D.) in the early Middle Ages; *Ziziphus jujuba* (13th – 14th cent. A.D.), *Mespilus germanica* (14th cent. A.D.) and *Prunus armeniaca* (second half 15th cent. A.D.) in the late Middle Ages. A floristic diversity increase was observed, and other interesting events may be observed:

Tab. 1. List of the sites of Ferrara quoted in the text.

Site	chronology (cent. A.D.)	archaeological / archaeobotanical interpretation	deposit type	outdoor/indoor context (out/in)	users (only indoor context)	n° of layers	litres of sediment sieved	references (see text)
FERRARA corso Porta Reno via Vaspergolo	second half 10th	uncultivated land with anthropic frequentation	layer (outdoor?)	out (?)	\	1	2	Bosi, 2000; Bosi & al., unpublished data
	first half 11th	suburban farmhouse with vegetable garden	garbage heap filling	out	\	1	7	
			layer-beaten sandy silt layer inside a building	in	peasants-artisans	1	6	
			waste pit	out	\	1	9	
			garbage heap filling (cesspit)	out	\	1	6	
			layer of garbage heap filling	out	\	1	6	
			probable garbage heap filling	out	\	1	6	
			waste pit	out	\	1	7	
	second half 11th - first half 12th	reduction of cultivations (urbanization effect)	waste pit	out	\	1	2	
			latrine filling (vat)	out	\	1	2	
			waste pit	out	\	1	2	
	13th		frequentation level (?)	in/out?	\	1	2	
	end 14th - beginning 15th	urban gardens/vegetable gardens	garbage heap filling (trough)	out	\	1	2	
			sewer filling (canal)	out	\	1	2	
	middle 14th - end 15th	domestic rubbish pit	the Mirror Pit (brickwork rubbish pit)	in	high class families	6	12	Bandini Mazzanti & al., 2005
FERRARA Piazza Castello	end 13th - beginn 15th	village	waste pit	out	\	1	1	Bandini Mazzanti & al., 1992
	1300 - 1385		stone latrine	in	middle class families	1	1	
	1350 - 1385		waste pit	out	\	4	1 (and naked eye)	
	1385 - 1390		waste pit	out	\	2	2	
			waste pit	out	\	2	2	
			waste pit	out	\	5	3 (and naked aye)	
FERRARA Giardino delle Duchesse	15th	Este Court's Garden	test layer	out	\	1	0.2	Bosi & al., 2006
FERRARA Piazza Municipale	second half 15th	Este Court's rubbish pit	the Ducal Pit (brickwork rubbish pit)	in	Este family	1	90	Bosi & al., unpublished data
FERRARA Monastero Sant'Antonio	1425-1475	convent's rubbish pit	brickwork rubbish pit	in	Benedictine nuns	3	13.5	Bosi & Bandini Mazzanti, 2006
	15th - 16th	jugs for therapeutical preparations	jugs (in brickwork rubbish pit)			2	1.3	Bandini Mazzanti & al., 2006

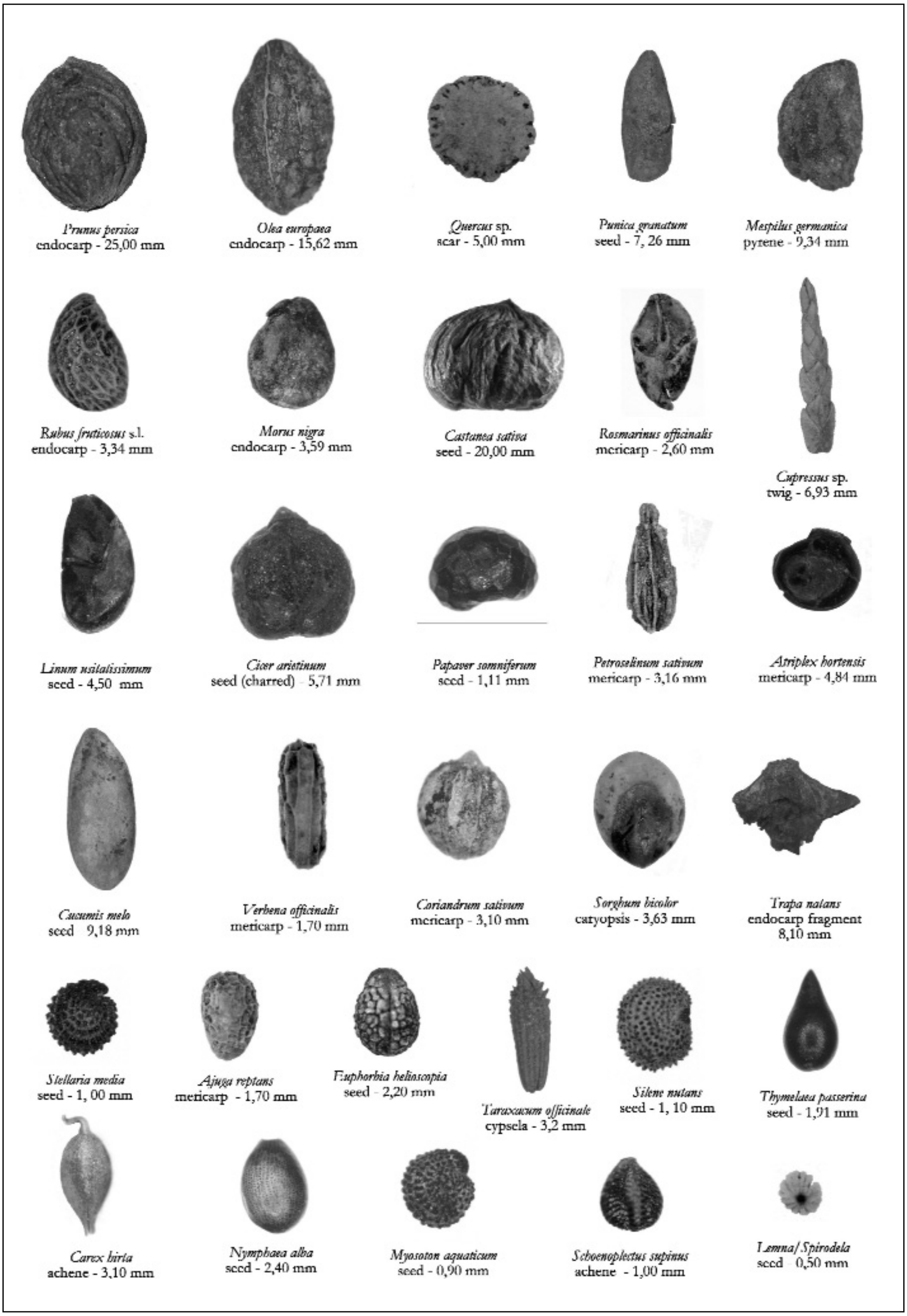

Fig. 1. Archaeocarpological records from Ferrara's sites (measure: length - photos by G. Bosi).

a. Anthropic care or cultivation of wild species: interestingly, the records of wild blackberries and common sloe, scarcely recovered from Roman sites (Bandini Mazzanti & al. 2001a, 2001b), became fairly more frequent in the Mediaeval sites of Emilia-Romagna, especially from layers dated to the late Middle Ages. Possibly in Ferrara wild blackberries and common sloe were first protected in their natural/seminatural habitats, and then planted in little orchards and gardens. Accordingly, Ruas (1992) observed that "*Rubus fruticosus*, *Prunus spinosa* and *Fragaria vesca* were firstly maintained in their natural habitats and gradually taken into cultivation in the 12th - 13th cent." in France.

b. Morphobiometrical variations of records: some species, owing to their frequent and abundant records, were selected to perform detailed analyses useful for investigating the history of crops which presently are very important in the culinary and cultural traditions of the Ferrara area: a) **melon:** it is frequent in the Mediaeval deposits of the region, and ubiquitarian in the sites of Ferrara (Bandini Mazzanti & Bosi 2007). It is a customary, popular crop, with a long agricultural and gastronomic tradition in this area. Earlier records dated back to the 10th cent., i.e. a shortly after the city's foundation (Bosi 2000). The study of the seeds of *Cucumis melo* showed that their size had a significant increase, in accordance with the chronology of the deposits (11 seeds from Corso Porta Reno - via Vaspergolo; 330 from Piazza Castello; 42 from Piazza Municipale). In fact, the smallest seeds were found in Porta Reno (first half of the 11th cent. A.D.), seeds with a bigger size in Piazza Castello (second half of the 14th cent. A.D.) and the biggest seeds in Piazza Municipale (second half of the 15th cent. A.D.; Bosi & al. 2006). This trend strongly suggests that the observed size increase is related to the amelioration of the agricultural practices (for example, Gremillon 1993; Lepofsky & al. 1998; Mangafa & Kotsakis 1996; Renfrew 1973; Smith 1987; Zohary & Hopf 1994). Moreover, the seed size increase observed in the Ducal Pit of the Este Family would be an index of the luxury food on the table of the noble house; b) **sour cherry** and **cherry** are species with a high importance for the culinary and cultural traditions of Ferrara. They left early traces in the archaeobotanical deposits of the city. The endocarps of *P. avium* showed a size increase passing from Roman to Mediaeval fruits (medium length × width × thickness: 102 Roman endocarps 7.13 × 5.93 x 4.80 mm; 266 early Mediaeval endocarps 8.15 × 6.72 × 5.27 mm - Bandini Mazzanti & Taroni 1988; Bandini Mazzanti & al. 2001a, 2001b; Santoro 2004/2005). Moreover, the records of the two species were more abundant passing from the early to the late Middle Ages. Interestingly, the endocarps of the Mirror Pit and the Ducal Pit, which came from two fairly coeval deposits, are very similar. The low variability could have been the result of the stabilization of the main characters of the cultivated forms, or the tendency to cultivate a more limited number of cultivars selected on the basis of the local environment (Piazza Castello – 14th cent. A.D.; corso Porta Reno – via Vaspergolo: Mirror Pit – second half of the 15th cent. A.D. – beginning of the 16th cent. A.D.; Piazza Municipale: Ducal Pit – second half of the 15th cent. A.D.; respectively *P. cerasus*: 153, 30, 62 endocarps; *P. avium*: 208, 18, 40 endocarps).

Flowers and other ornamental plants - These records are rare and fairly problematic since their interpretation as ornamentals often depends on the general context. In fact, some wild plants can have a decorative role outside of the natural habitat. In the early Mediaeval layers, *Viola* sp.pl. and *Platanus orientalis* were found. Records of this tree were in layers dated to the first half of the 11th cent. A.D., in the trampling floor of a sub-urban house named *"casale"* with gardens and courtyards most probably at the shadow of the plane. *Platanus orientalis,* native of southeastern Europe and western Asia, grows wild in wet woods of Sicily, Calabria and Campania (Pignatti 1982). Pliny the Older and Pliny the Younger described it as ornamental tree in Roman times. Most of the plane trees currently living in European cities are hybrids among *P. orientalis* and the north-American *P. occidentalis*, and are important ornamental or lining trees.

In the late Medieval Ages, ornamental plants were more frequent and diversified. The Ducal Pit was the richest in ornamentals. Seeds of beautiful flowers, i.e. pansy (*Viola* sp.pl.), superb pink (*Dianthus* cf. *superbus*) and crimson clover (*Trifolium incarnatum*), and achenes of rose (*Rosa* sp.) were found. *Dianthus superbus* is currently a rare and protected species, which grows wild on the

Apennines near Parma, in Emilia-Romagna. Some ornamental trees were also present: european yew (*Taxus baccata* - leave), italian cypress (*Cupressus sempervirens* - twig) and bigleaf linden (*Tilia* cf. *platyphyllos* - pseudosamara). *Taxus baccata* is a native evergreen Gymnosperm tree, and its natural distribution does not occur in the Po plain but in mountainous/sub-mountainous areas of the central-southern Italy. It grows wild as imposing individuals in the Foreste Casentinesi of the Tusco-Emilian Apennines (Alessandrini & Bonafede 1996). In the Po plain, yew trees have been commonly planted for ornamental purposes, especially in urban and church gardens. This most probably also occurred in Mediaeval times, as was suggested by the increase in the pollen frequency of *Taxus* passing from the Subboreal to Subatlantic period in Emilia-Romagna (Accorsi & al. 1997). *Cupressus sempervirens* is a tree which would not be native to Italy, and is more widespread in central-southern Italy than in the Po plain. It is known to have been grown as an ornamental plant since Roman times (Pignatti 1982). *Tilia* cf. *platyphyllos* is a native tree which also lives in plain woods, and is commonly cultivated in urban green areas even today. Other ornamental plants in the Ducal Pit might have included white water-lily (*Nymphaea alba*) and yellow pond lily (*Nuphar luteum*). It must be noted that *Nuphar* had never been recorded before, and *Nymphaea* was very rare and never found in closed pits as the Ducal Pit was. Though these two species were part of the wild flora widespread in wet environments, in this context they were possibly grown for decoration in garden lakes and fountains, probably in the gardens of the Ducal Palace together with the above mentioned flowers and trees. One of these gardens, the Duchesses' Garden (dated to the second half 15th cent. A.D.) was present in the area where the Ducal Pit was excavated. The pollen analysis from this garden, carried out on archaeological layers coeval to the Ducal Pit deposit, showed that ornamental plants were fairly frequent and sometimes abundant in the vicinity of the site, releasing pollen of *Taxus*, *Juniperus* type, *Tilia* cf. *platyphyllos*, *Dianthus superbus* type and *Nymphaea alba* (Bosi & al. 2006). The latter would have decorated the 'Fontana d'Oro', the golden fountain located in the centre of the Garden mentioned above.

Vegetables/aromatics/spices/medicinal plants - Vegetables are represented by *Portulaca oleracea*, *Daucus carota*, *Lagenaria siceraria*, *Pastinaca sativa*, *Beta vulgaris*, *Atriplex hortensis*, *Cichorium intybus, Lactuca sativa*, … Bottle gourd (*Lagenaria siceraria*) is practically ubiquitarian in the Ferrara archaeological layers. The records suggest that the bottle gourd was already used in local gastronomy in late Middle Ages. The bottle gourd will be substituted in the local gastronomy by the pumpkin of the *Cucurbita* genus; the first seeds in Italy *(C. pepo/moschata*), dated to the first part of the XVI cent. A.D., were discovered in the Ferrara area in the latrine of the Monastery of Santa Caterina ad Argenta (FE) (Mercuri & al. 1999).

Purslane (*Portulaca oleracea*), was appreciated in salads, employed as medicine, and the seeds were used as an aromatic spice. Moreover, in the Ferrara area, they were found from the 10th century onwards (Bosi & Bandini Mazzanti 2007). In the Ducal Pit of late Middle Ages, the maximum diameter of purslane seeds (*sensu* Danin & al. 1978) increased up to 1.2 mm on average, suggesting that in the Ducal Pit there was the commonly cultivated *P. oleracea* subsp. *sativa* (Bosi & Bandini Mazzanti 2007).

Aromatics/spices/medicinal plants include *Anethum graveolens*, *Eruca sativa*, *Ocimum basilicum*, *Origanum vulgare, Papaver somniferum*, *Petroselinum sativum*, *Pimpinella anisum*, *Rumex acetosella*, *Satureja hortensis*, *Thymus vulgaris* in the early Middle Ages. Then, in the late Middle Ages, *Foeniculum vulgare, Origanum* cf. *majorana*, *Rosmarinus officinalis*, *Cuminum cyminum*, and *Coriandrum sativum* were added to the previous species. Also a berry-like cone of *Juniperus communis* was found.

According to documentary evidences (Badiali 1999; Ballerini & Parzen 2001; Bandini 1992; Ehlert 2002; Flandrin & Montanari 2003; Redon & al. 1994; Sabban & Serventi 1996; Scully 1998), these plants were cultivated for their aromatic seeds/fruits, leaves, stems, and flowers (e.g. *Rosmarinus*). *Papaver somniferum* seeds were common and very abundant, especially in early

Middle Ages. Seeds coming from two samples of Porta Reno-Via Vaspergolo (second half 10th – first half 11th cent. A.D.) were compared with those of a modern commercial sample (condimentary seeds). Based on morphobiometrical analyses no significant differences were found among them. Interestingly, one Mediaeval sample resulted more similar to the modern than to the coeval sample (Bosi & al. 2006, unpublished data). Though it is difficult to discriminate *P. somniferum* subsp. *setigerum* from *P. somniferum* subsp. *somniferum* (Fritsch 1979), this suggested that those seeds came from cultivated forms. *Coriandrum sativum* is present only in late Middle Ages. It is noteworthy that, at that time, coriander would have been a luxury food because it was the prevalent aromatic plant in the Ducal Pit, and it was scarce or absent from the other pits of the city. Moreover, many common weeds on disturbed ground are known to have been largely used for medicinal and ornamental purposes, but their cultivation is difficult to establish (i.e. *Matricaria chamomilla*, *Hyosciamus niger*, *Hyssopus officinalis*, *Conium maculatum*, …).

Fibre and oil plants - *Cannabis sativa* and *Linum usitatissimum*, which supplied fibres and oil, were recorded together with few seeds of *Camelina sativa*. Hemp has been commonly cultivated for fibre in the lowlands of the region, mainly in the Bologna and Ferrara provinces, up to recent times. The neighbourhood of Ferrara matched this cultivation well, due to the presence of widespread wet environments suitable for hemp retting (Bandini Mazzanti & al. 1999; Bosi 2000; Marchesini 1997). In late Middle Ages the most interesting records of oil plants were the seeds of *Brassica rapa* subsp. *rapa*/subsp. *sylvestris* found in the Mirror Pit (second half of 15th – beginning 16th cent. A.D.). They were particularly abundant (> 30,000 seeds/12 l), and in a state of preservation which testified they were pressed to obtain oil: in fact, the remains were prevalently concave-convex as after a press action. Olive stones (*Olea europaea*) were found only in the Ducal Pit (78 stones/90 l), and as they were whole it was suggested that olive fruits were eaten raw. They had two fairly different morphologies: one has a rugose, elongated stone with a rostrum, and the other, which is more abundant, has a smoother and rounded stone.

Cereals and pulses – They were scarce, and this could be due taphonomical reasons as, for example, the absence of storages for food among the deposits studied. Among cereals, *Sorghum bicolor* and *Panicum miliaceum* were the most frequent, while *Hordeum vulgare* and *Triticum aestivum*/*durum* s.l. were fewer. Pulses included four species: *Pisum sativum*, *Vicia faba*, *Lens culinaris*, and *Cicer arietinum*, the latter only present in the Ducal Pit, i.e. in the late Middle Ages. Pulses and many cereals were found charred, they probably arrived in the layers from the fireside of the cooking room. Only *Sorghum* was prevalently uncharred thus suggesting that the plant would have been differently used, probably as part of brooms as currently occurs in the Ferrara area (Revedin 1909).

Wild plants not obviously used - This group includes a number of wild synanthropic plants which grew next to the sites, or in the surrounding area, in various habitats such as disturbed ground (e.g., refuse areas, kitchen and house gardens), trampled areas (e.g., streets, courts, waysides), waste and cultivated suburban land (e.g., fields, orchards, vineyards). Species which are presently rare or absent in the region or in the Po Plain are particularly interesting (Alessandrini & Bonafede 1996; Conti & al. 2005; Pignatti 1982; Pirola 1975): *Aethusa cynapyum*, *Anthemis* cf. *cotula*, *Arctium lappa*, *Euphorbia cyparissias*, *E. exigua*, *Chenopodium ficiifolium*, *Galium* cf. *mollugo*, *G.* cf. *tricornutum*, *Hyssopus officinalis*, *Lithospermum officinale*, *Sambucus ebulus*, *Silene* cf. *italica*, *Stachys* cf. *arvensis*, *Thymelaea passerina*, *Valerianella* cf. *microcarpa*, *V.* cf. *tetrasperma*… Few plants of *Chenopodium ficiifolium* live today on and near the walls of Ferrara (Piccoli 1989). Moreover, the commonest and more abundant records belong to, in order: *Myagrum perfoliatum*, *Agrostemma githago*, *Conium maculatum*, *Hyosciamus niger* and *Sonchus arvensis*. Between the early and late Middle Ages an increase in spontaneous plants is shown (i.e. Porta Reno, outdoor context, medium concentration values: early Middle Ages: 176 sf / litre; late Middle Ages: 528 sf / litre – Bosi 2000; Bosi & al. *in litteris*). The ancient maps showing this city as a patchwork of open and covered areas (Bonasera 1965; Farinelli Toselli & al. 1993) gives reason of the spreading of weeds in streets, squares, houses, mansions, sacred or governmental buildings, courtyards and house garden. Today, the well preserved Mediaeval centre of Ferrara, which has retained its urban fabric virtually intact, preserves many open places and contains many house and kitchen gardens and even small orchards.

Wet grounds plants - Plants of wet grounds were more abundant in open area deposits (i.e., outdoor layers of early and late Middle Ages: Porta Reno from 12 to 313 sf / litre – Bosi, 2000; Bosi & al., unpublished data) than in the late Mediaeval house pits which were found sealed (latrine of Piazza Castello: < 1 sf / litre; Porta Reno Mirror Cistern: < 1 sf / litre; Ducal Tank of Piazza Municipale: 2 sf / litre – Bandini Mazzanti & al. 1992; Bandini Mazzanti & al. 2005; Bosi & al. unpublished data). In pits these remains were certainly included by casual transport of trampling in open areas, or mud and silt used to make floors, or to connect the flooring elements. In open area deposits, records were present also as part of the natural "seed rain". It should be remembered that Ferrara greatly depended on the Po river and its variations had a huge impact on the evolution of the city. The antique maps of Ferrara and the archival documentation are full of references to the presence of damp environments tied to the watercourse.

This group includes hydrophytes, helophytes, and river bank plants, and, finally, many damp meadow plants (Tab. 2). Within this group there are numerous plants which today are rare or absent from the region and/or in the Padania area, owing to the reclamation works especially in the last two centuries, for example *Carex* cf. *appropinquata*, *C. oederi, C.* cf. *stellulata*, *Fimbrystilis dichotoma*, *Nuphar luteum*, *Ranunculus flammula*, *R.* cf. *ophyoglossifolius*, *Rhynchospora* cf. *alba*, *Schoenoplectus supinus*, … Particularly *Nymphaea alba* and *Nymphoides peltata*, which live in ponds, lakes, canals and slow-flowing streams, are rare and endangered wild species in the Emilia-Romagna region (Alessandrini & Bonafede 1996; Corbetta 1990; Ferrari 1980; Piccoli 1998, 2000; Piccoli & Gerdol 1983a, 1983b; Piva & Scortegnana 1993).

Conclusion

The well-preserved waterlogged seeds and fruits studied provided much palaeoethnobotanical information concerning diet, cultivation, uses and household tasks (i.e., for example, winemaking, oil-making, mustard-making). The results allowed the reconstruction of the main features of the plant/green environment of Ferrara which, from the 9th to the 13th century, passed from suburban gardens to a full urban condition. Resuming the principal evidences resulting from this study are:

Key differences between the early and late Mediaeval plant assemblages:

An important trait is the ornamental species' diversification which is particularly evident in the 15th cent. A.D. Though this group is more significant in the Ducal Pit where it might be amplified by the high wealth of the users, the increase in ornamentals is in accordance with the full urbanization.

From early to late Middle Ages, the floristic variety of cultivated or possibly cultivated plants, especially of fruits and vegetables *sensu lato*, increases. Thus, both early and late Mediaeval remains should be crop cultivation markers of the Ferrara area. A doubt remains for *Olea europaea*, whose fruits, found exclusively in the Ducal Pit, most probably represent an imported product.

Regarding wetland indicators, a qualitative and quantitative decrease is noted passing from outdoor to indoor contexts (where the assemblage is prevalently of anthropic origin), therefore depending more on the taphonomy of the deposits than on the evolution of the urban environment.

The high incidence and diversification of the ruderals *sensu lato* is constant, or slightly increases in the passage from the early Mediaeval suburban condition to the late Mediaeval urban condition. The gardens and orchards, still present in the city today, had favoured the spreading of ruderals.

The cultural heritage of the Ferrara area from the evolution of crops typical of the area, and from the history of their cultivations which are part of the cultural landscape even today:

It should be underlined that the vocation for cultivation in the territory of Ferrara seems to have its origin at least from the middle of the 11th cent. A.D. when the records testify a solid base of diversified crops present in the area. As mentioned above this base will show a further increase during the late Middle Ages.

Documents referring to species that are still part of traditional agriculture and gastronomy of the Ferrara area, as melon, bottle gourd, cherry, and sour cherry appear early, in the early Middle Ages, and are then documented continuously, in some cases abundantly. The biometrical analyses applied to the melon, sour cherry, and cherry remains gave interesting results. With respect to the early Medieval, the size increase of the late Medieval melon seeds is significant. It suggests the relevant increase in fruit size. Regarding cherry and sour cherry, the lower morphobiometric variability of the 15th cent. A.D. endocarps, respect to the ca. one century older ones, suggests the selection of a certain cultivar well-adapted to the Ferrara environment.

Papaver somniferum and *Portulaca oleracea* are other two species abundantly and continuously found in the record which must have been of great interest to the people of Ferrara in the Middle Ages. Therefore, they should be rediscovered and newly placed among the agriculture and gastronomy traditions of the area. *Papaver*, with seeds morphobiometrically identical to those sold today for condimentary purposes, was widely cultivated from the early Middle Ages onwards. Regarding purslane, starting from the 10th cent. A.D. the progressive increase in seed size hints to the cultivation of *P. oleracea* subsp. *sativa* in the late Middle Ages vegetable gardens.

The past presence of species which are currently very rare or absent in the studied region, or even in the Po Plain, is testifies by many records of ruderals s.l. and plants of wetlands found in early and late Middle Ages layers.

The information coming from the archaeobotanical research can be of interest for the assessment of the variations in local biodiversity.

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Annex 1. List of taxa from the archaeocarpological analyses in Ferrara, 10th - 16th cent. A.D.

Fruits and nuts

Castanea sativa Miller
Citrullus lanatus (Thun.) Matsum and Nakai.
Cornus mas L.
Cornus sanguinea L.
Corylus avellana L.
Crataegus cfr. *monogyna* Jacq.
Cucumis melo L.
Cydonia oblonga Miller
Ficus carica L.
Fragaria cfr. *vesca* L.
Juglans regia L.
Malus domestica Borkh.
Mespilus germanica L.
Morus nigra L.
Physalis alkekengi L.
Pinus pinea L.
Prunoideae indet.
Prunus armeniaca L.
Prunus avium L.
Prunus avium/cerasus
Prunus cerasifera Ehrh.
Prunus cerasus L.
Prunus domestica L. subsp. *domestica*
Prunus domestica L. subsp. *insititia*
Prunus mahaleb L.
Prunus persica (L.) Batsch
Prunus spinosa L.
Punica granatum L.
Pyrus communis L.
Pyrus/Malus
Rubus caesius L.
Rubus fruticosus s.l.
Rubus idaeus L.
Sambucus nigra L.
Sorbus cfr. *torminalis* (L.) Crantz
Sorbus domestica L.
Sorbus sp. (wild)
Trapa natans L.
Vitis vinifera L. subsp. *vinifera*
Ziziphus jujuba Miller

Flower and other ornamental plants

Cupressus sempervirens L.
Dianthus cfr. *superbus* L.
Dianthus sp.
Nuphar luteum (L.) S. et S.
Nymphaea alba L.
Platanus orientalis L.
Rosa sp.
Taxus baccata L.
Tilia cfr. *platyphyllos* Scop.
Trifolium incarnatum L.
Viola cfr. *canina* L.
Viola cfr. *riviniana* Rchb.
Viola sp.

Vegetables/aromatics/spices/ medicinal plants

Anethum graveolens L.
Atriplex hortensis L.
Beta vulgaris L.
Brassica nigra (L.) Koch
Cichorium intybus L.
Coriandrum sativum L.
Cuminum cyminum L.
Daucus carota L.
Eruca sativa Miller
Foeniculum vulgare Miller
Juniperus communis L.
Lactuca sativa L.
Lagenaria siceraria (Molina) Standley
Mentha arvensis L.
Mentha suavolens Ehrh.
Mentha suavolens/longifolia
Ocimum basilicum L. cfr.
Origanum cfr. *majorana* L.
Origanum vulgare L.
Papaver somniferum L.
Pastinaca sativa L.
Petroselinum sativum Hoffm.
Pimpinella anisum L.
Portulaca oleracea L.
Rosmarinus officinalis L.
Rumex acetosella L.
Satureja hortensis L.
Thymus vulgaris L.
Valerianella locusta L.
Verbena officinalis L.

Fibre and oil plants

Brassica rapa L. subsp. *rapa* / subsp. *sylvestris* (L.) Janchen
Camelina sativa (L.) Crantz
Cannabis sativa L.

Linum usitatissimum L.
Olea europaea L.

Cereals and Pulses
Hordeum vulgare L.
Panicum miliaceum L.
Secale cereale L.
Setaria cfr. *italica* (L.) Beauv.
Sorghum bicolor (L.) Moench
Triticum aestivum/durum s.l.
Triticum dicoccum Schubl.
Cereals indet.
Cicer arietinum L.
Lens culinaris Medicus
Pisum sativum L.
Vicia cfr. *faba* L.

Wild plants not obviously used (*weeds)
Aethusa cynapyum L.*
Agrimonia cfr. *eupatoria* L.*
Agropyron sp.
Agrostemma githago L.*
Ajuga reptans L.
Ammi visnaga (L.) Lam.*
Anagallis cfr. *arvensis* L.*
Anagallis sp.
Anthemis cfr. *cotula* L.*
Anthemis sp.
Aphanes arvensis L.*
Apium sp.
Arctium lappa L.*
Arum italicum Miller
Asteraceae indet.
Atriplex sp.*
Avena sp.*
Ballota nigra L.*
Boraginaceae indet.
Brassica/Sinapis
*Bromus secalinus/hordeaceus**
Bromus sp.
Buglossoides arvensis (L.) Johnston*
Bupleurum lancifolium Hornem.*
Calystegia sepium (L.) R. Br.
Capsella bursa-pastoris (L.) Medicus*
Carduus sp.
Carex caryophyllea La Tourr.
Carex contigua Hoppe
Carex sp.
*Caryophyllacea*e indet.
Centaurea cfr. *cyanus* L.*
Cerastium arvense L.
Cerastium sp.
Chaenorinum minus (L.) Lange*
Chelidonium majus L.*
Chenopodiaceae indet.
Chenopodium album L.*
Chenopodium cfr. *rubrum* L.*
Chenopodium ficifolium Sm.*
Chenopodium polyspermum L.*
Chenopodium sp.*
Cirsium arvense (L.) Scop.*
Cirsium cfr. *vulgare* (Savi) Ten.*
Cirsium sp.
Compositae indet.
Conium maculatum L.*
Convolvulus sp.
Coronilla emerus L.
Coronopus squamatus (Forsskal) Asch.*
Cruciferae indet.
Cuscuta cfr. *europaea* L.*
Cyperaceae indet.
Cyperus sp.
Digitaria sanguinalis (L.) Scop.*
Echinochloa crus-galli (L.) Beauv.*
Epilobium sp.
Erica sp.
Erodium sp. cfr.
Euphorbia cyparissias L.*
Euphorbia exigua L.*
Euphorbia helioscopia L.*
Euphorbia peplus L.*
Euphorbia sp.
Fallopia convolvolus (L.) Holub*
Fumaria officinalis L.*
*Galeopsis tetrahit/speciosa**
Galium aparine L. *
Galium cfr. *mollugo* L.
Galium cfr. *tricornutum* Dandy*
Galium cfr. *verum* L.
Galium sp.
Genista sp.
Geranium cfr. *molle* L.*
Geranium cfr. *pusillum* L.*
Geum urbanum L. cfr.*
Gramineae indet. (wild)
Hyosciamus niger L.*
Hyssopus officinalis L.
Juncus sp.

Labiatae indet.
Lactuca serriola L.*
Lamium cfr. *purpureum* L.*
Lamium sp.
Lapsana communis L.*
Lepidium sp.
Leucanthemum vulgare group
Liliaceae indet.
Lotus corniculatus group
Lotus sp.
Luzula sp.
Malva cfr. *sylvestris* L.*
Malva sp.
Matricaria chamomilla L.*
Medicago cfr. *lupulina* L.
Mercurialis annua L.*
Muscari/*Leopoldia*
Myagrum perfoliatum L.*
Myosotis arvensis (L.) Hill*
Nepeta cataria L.*
Onobrychis viciifolia Scop.
Oxalys corniculata L.*
Panicoideae indet.
Papaver rhoeas/*dubium**
Parietaria cfr. *officinalis* L.*
Peucedanum sp.
Picris eichioides L.*
Picris hieracioides L.*
Poa sp.
Polygala vulgaris L.
Polygonum aviculare group*
Polygonum lapathifolium L.*
Polygonum persicaria L.*
Polygonum sp.
Potentilla argentea L.*
Potentilla cfr. *anserina* L.*
Potentilla cfr. *recta* L.
Potentilla cfr. *supina* L.
Potentilla reptans L.*
Potentilla sp.
Prunella vulgaris L.
Quercus sp.
Ranunculus acris L.*
Ranunculus arvensis L.*
Ranunculus bulbosus/*lanuginosus*
Ranunculus sp.
Raphanus raphanistrum L.*
Raphistrum rugosum (L.) All.*
Rorippa sp.
Rumex crispus/*obtusifolius*
Rumex sanguineus/*conglomeratus*
Rumex sp.
Salvia pratensis L.
Sambucus ebulus L.*
Sambucus sp.
Sanguisorba cfr. *minor* Scop.*
Scabiosa cfr. *columbaria* L.
Scabiosa sp.
Scorzonera sp. cfr.
Senecio sp.
Setaria glauca/*ambigua**
Setaria sp.
Setaria viridis/*verticillata**
Silene alba (Miller) Krause*
Silene cfr. *nutans* L.
Silene sp.
Sisymbrium sp.
Solanum dulcamara L.
Solanum nigrum L.*
Solanum sp.
Sonchus arvensis L. s.s.*
Sonchus asper (L.) Hill*
Sonchus oleraceus L.*
Sonchus sp.
Stachys cfr. *arvensis* (L.) L.*
Stachys sp.
Stellaria media (L.) Vill.*
Tanacetum vulgare L.*
Taraxacum officinale Weber*
Thalictrum sp.
Thymelaea passerina (L.) Cosson et Germ.*
Trifolium cfr. *arvense* L.*
Trifolium cfr. *campestre* Schreber*
Trifolium pratense L.*
Trifolum sp.
Umbelliferae indet.
Urtica dioica L.*
Urtica urens L.*
Valerianella cfr. *microcarpa* Loisel.*
Valerianella dentata (L.) Pollich*
Valerianella rimosa Bastard*
Verbascum sp.
Vicia cfr. *tetrasperma* (L.) Schreber*
Vicia ervilia (L.) Willd.*
Vicia sp.
Vicia villosa Roth*

Wet ground plants

Alisma plantago-aquatica L.
Berula erecta (Hudson) Coville cfr.
Bolboschoenus maritimus (L.) Palla
Callitriche sp.
Caltha palustris L.
Carex cfr. *appropinquata* Schum.
Carex cfr. *elata* All.
Carex cfr. *elongata* L.
Carex cfr. *panicea* L.
Carex cfr. *pseudocyperus* L.
Carex cfr. *remota* L.
Carex cfr. *stellulata* Good.
Carex flacca Schreber
Carex hirta L.
Carex oederi Retz.
Carex otrubae Podp.
Carex riparia Curtis
Carex rostrata Stokes
Carex vesicaria L.
Cicuta virosa L. cfr.
Cyperus cfr. *longus* L.
Cyperus flavescens L.
Cyperus fuscus L.
Eleocharis palustris/uniglumis
Euphorbia palustris L.
Fimbrystilis dichotoma (L.) Vahl.
Galium palustre/elongatum
Hypericum cfr. *humifusum* L.
Isolepis setacea (L.) R. Br.
Lemna/Spirodela
Lithospermum officinale L.
Lycopus europaeus L.
Mentha aquatica L.
Mentha cfr. *pulegium* L.
Montia fontana L.
Myosoton aquaticum (L.) Moench
Nymphoides peltata (Gmelin) O. Kuntze
Polygonum amphibium L.
Polygonum hydropiper L.
Polygonum minus Hudson
Potamogeton cfr. *natans* L.
Ranunculus cfr. *ophyoglossifolius* Vill.
Ranunculus flammula L.
Ranunculus repens L.
Ranunculus sardous Crantz
Ranunculus sceleratus L.
Ranunculus subgen. *Batrachium*
Rhynchospora cfr. *alba* (L.)Vahl
Rumex cfr. *hydrolaphatum* Hudson
Rumex cfr. *palustris* Sm.
Saponaria officinalis L.
Schoenoplectus lacustris (L.) Palla
Schoenoplectus supinus (L.) Palla
Schoenoplectus tabernemontani (Gmelin) Palla
Scirpus sp.
Scirpus sylvaticus L.
Teucrium scordium L. cfr.
Typha latifolia/angustifolia

C. Dal Cin D'Agata, M. Skoula & G. Brundu

A preliminary inventory of the alien flora of Crete (Greece)

Abstract

Dal Cin D'Agata, C., Skoula, M. & Brundu, G.: A preliminary inventory of the alien flora of Crete (Greece). — Bocconea 23 : 301-315. 2009. — ISSN 1120-4060.

The island of Crete, with the close islet of Gavdos, lying between Greece and Libya, is the most southern region of Europe. Along with other islands of the Mediterranean basin it is highly vulnerable to biological invasions, due to its dependence on external trade, high rate of urban development in coastal areas and relatively large communication network. Despite the relevance of the processes, the actual documentation on the alien flora of Crete is incomplete and fragmentary.
The aims of this study are therefore to carry out the first comprehensive inventory of the alien flora of Crete and distribution mapping of the main widespread alien species. Data from literature and field observations were used to develope a preliminary information database for the inventory that includes, so far, 245 alien taxa. Mapping data has been stored in a geodatabase using GIS software, and preliminary analysis of the main features of the Cretan alien flora is herewith presented. The most abundant and invasive alien species in Crete are *Oxalis pes-caprae, Ailanthus altissima, Robinia pseudoacacia, Carpobrotus edulis, Nicotiana glauca* and *Ricinus communis.*

Introduction

The importance of studies on local alien floras, collecting detailed taxonomic information, distribution records and editing species lists, has been repeatedly stressed in literature and awareness of this has been rising (Pyšek & al., 2002). The availability of data on alien floras in Europe and in the Mediterranean basin has rapidly increased in the last decade. So far information on alien flora is available for many European countries, although the quality of such data is highly variable (Pyšek & al. 2002; Lambdon & al. 2008). Many projects are in progress both for producing national lists and for providing a general framework, such as the European Union funded project DAISIE (http://www.europe-aliens.org). Yet complete catalogues of alien species are still rather rare for many Mediterranean islands, and this represents a serious hindrance for management and control. The Mediterranean hosts one of the largest groups of islands in the world. The region is of high value to global biodiversity due to its diversity of plant species, relatively high rate of endemism, long history, and tolerances to many kinds of disruptions. The continuous environmental pressure maintained by humans in the Mediterranean throughout history is now an inescapable component of the Mediterranean ecosystems and landscapes. The islands of the Mediterranean basin are highly vulnerable to the entrance of alien plant species due to their dependence on external trade, the high rate of urban development and tourism pressure in coastal areas, and the relative widespread and dense communication network (Hulme & al. 2008).

Crete has been permanently inhabitated by settled peoples for the last 8,000 years. The landscape has undergone dramatical changes, partly due to an increasingly arid climate but mainly through human activities and grazing. The vascular flora of the island consists approximately of 1,742 native taxa (Chilton & Turland 2007). Its special interest lies in the high number of endemic taxa with eastern Mediterranean or Anatolian distribution.

Despite the relevance of the process, the available documentation on the alien flora of Greek islands, and in particular of Crete, is incomplete and fragmentary. Therefore, the aims of this study, started in 2005 and presently in progress, are (1) to provide an original updated list of alien plants that have been recorded in unmanaged habitats on the island of Crete; (2) to assess the taxonomic composition of the alien flora; (3) to assess and map the distribution of the main widespread alien species, (4) to evaluate the main driving forces of the process and set priorities for control of aliens and conservation on native habitats.

Material and Methods

Sampling methodology, database structure and data analysis. Data from literature (Turland & al. 1993; Chilton & Turland 1997, 2005, 2007; Fielding & Turland 2005; Strid & Tan 1997, 2002) and dedicated field surveys through the years 2005-2007, which have been implemented by handy GPS for recording site/species locations, are being stored in a geographical database dedicated to the inventory of the alien flora of Crete. A species was included if there was a record (bibliographic and /or field survey) stating at least one wild locality in which it was found on Crete, but also when it is very commonly cultivated in open fields, road-sides, public gardens, parks, re-forestation stands etc., i.e. with relative high propagule pressure or potential or documented repeated introductions, close to transport networks, and therefore with the potential to escape and establish in the wild. We believe that this contingent of broadly or systematically cultivated plants has to be both included in the inventory and carefully monitored because, similar to the set of casual alien plants, it may be a source for future naturalization (and invasion) processes.

For each species the following fields of the database have been compiled: (1) Taxonomical data (species name, main synonyms, common names or local names, family); (2) Geographical origin (America, Asia, Africa, Europe, Mediterranean region, Tropics and uncertain origin); (3) Residence status (Archaeophyte, Neophyte); (4) Status (planted-only, casual, naturalized, status uncertain or not assessed), according to Pyšek & al. 2004 and Richardson & al. 2000; (5) Distribution in Crete (according to the qualitative scale: rare, occasional, locally common, common, very common – assessed during regional field surveys); (6) Life form (following the Raunkiaer 1934 classification); (7) Flowering time (start / end); (8) Invaded habitats (and land-use types) in Crete according to EUNIS categories; (9) Altitudinal range (10 classes, from 0 m a.s.l. to 1,000 m a.s.l..); (10) Introduction pathways and uses related to introduction [crop or forestry species, horticultural, ornamental, multipurpose, agricultural weed, medicinal uses, accidental introduction (pathway unknown)].

During the field surveys voucher specimens have been collected and stored at the Herbarium of Park for the preservation of Flora and Fauna, Technical University of Crete (TUCCG) at Chania. Nomenclature follows *Flora Europaea* (Tutin & al. 1964-80). The invasive status (*sensu* Richardson & al. 2000) has not yet been assessed for the naturalized species, therefore in this first stage of our analysis we consider only three main categories (planted-only, casual, naturalized). In a second stage of the research, as soon as more detailed ecological information becomes available, invasive species will be carefully assessed among the naturalized species.

Altitudinal range distribution of the casual and naturalized species only has been analyzed using quantile regression analysis (Fig. 4). In fact, one problem arising from relating vegetation field data to explanatory variables is that only a small subset of all possible influencing factors can be measured and analyzed in principle. Hence the results may depend strongly on multiple unknown or unmeasured factors. This may be one reason why between-site comparisons often fail even if within-site species-environment relationships are quite clear (Ellenberg & al. 1992; Schröder & al. 2005). Quantile regression estimates multiple rates of change from the minimum to the maximum response, providing a more complete picture of the relationships between variables missed by other regression methods (Cade & Noon 2003). Qreg package of R was used to perform statistical analysis.

Results and Discussion

The alien flora of Crete comprises 245 taxa (Table 1) belonging to 76 families, with 61 Dicotyledoneae, 13 Monocotyledoneae and 2 Gymnospermae.

Ninety-one (37%) are naturalized, 49 (20%) are casual species and 95 (39%) are present as planted-only (Fig. 1). There is a significant presence (28%) of archaeophytes (introduced before the 1500's) e.g. *Punica granatum* and *Arundo donax*, while the majority (72%) of the alien taxa are neophytes such as *Robinia pseudoacacia* and *Ailanthus altissima*.

Some families, like Rosaceae, Cucurbitaceae, and Rutaceae are represented only by cultivated plants: fruit trees such as *Malus domestica* or *Prunus* spp. and vegetables like *Cucumis* spp. or *Cucurbita* spp. Others families, like Amaranthaceae and Brassicaceae, have higher numbers of naturalized species and weeds such as *Amaranthus* spp., *Atriplex* spp. and *Chenopodium* spp. Many of the most widespread alien species in Crete belong to families otherwise not represented in the Mediterranean Basin e.g. Agavaceae, Cactaceae, Phytolaccaceae, Simarubaceae.

The most common geographical origin of the naturalized taxa is American, while the planted-only and casual taxa are mainly Asian. This high percentage of Asian species could be related to the long period of Turkish occupation, till the last decades of the XIX century, when the island of Crete was particularly dependent on the Middle East markets with intensive trade activities between the two countries (Fig. 2).

The observation of the flowering times reveals a peak in the summer months of July, August and September, an increase in spring from March to June and a decrease in autumn from October to December. There are also some species that flower for the first time in spring and have a second flowering period in autumn, therefore with a very long potential reproductive period.

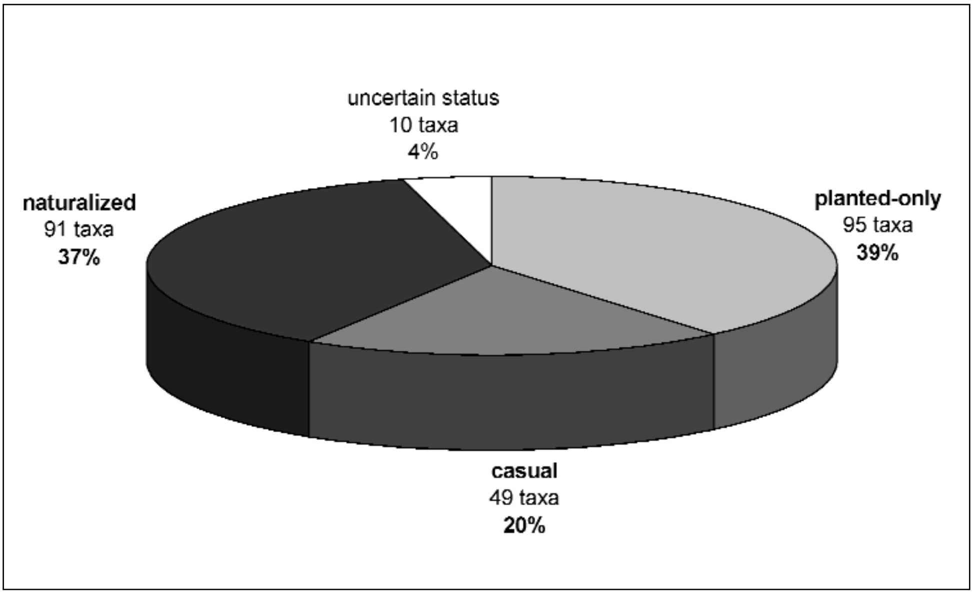


Fig.1. Alien flora of Crete. Percentages of casual, naturalized, planted-only and uncertain status species. The total number of species is 245

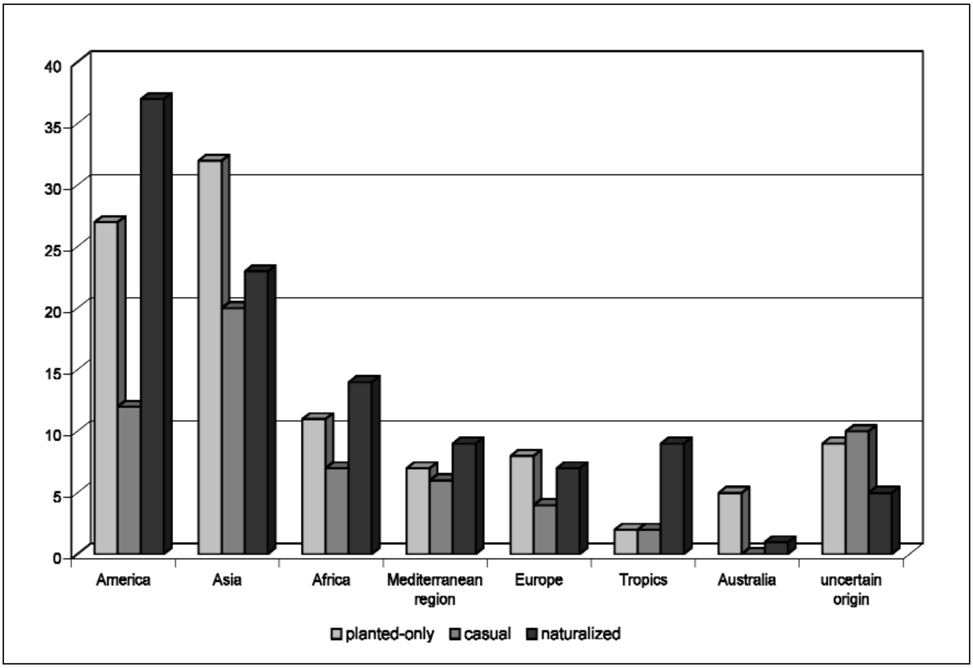


Fig 2. Alien flora of Crete. Geographical origin of planted-only, casual and naturalized taxa.

Habitats s.l. (i.e. including land-use types) disturbed or originated by high human pressure such as urban areas, transport networks and harbour surroundings are usually invasion hotspots with *Ailanthus altissima*, *Nicotiana glauca*, *Ricinus communis* and *Amaranthus* spp. In the agricultural areas such as in olive groves, orchards or abandoned fields *Oxalis pes-caprae*, *Phytolacca americana*, *Agave americana* and *Opuntia ficus-indica* are commonly present. The natural coastal habitats are usually less invaded, but where tourism pressure starts to be higher, species like *Carpobrotus edulis* are commonly found as its introduction is deliberately caused by men, and afterward naturalisation and spread easily occur.

If we consider abundance on the island as a proxy for potential impacts and for further spread, then the above indicated species are potential candidates to be indicated as IAS.

As recently remarked by Richardson and Pyšek (2007) the role of plant traits in the invasion process is to a very large extent stage and habitat-specific. Traits that confer an advantage at a given stage of the process, and in a particular habitat may be neutral or even detrimental at another phase and/or for a different habitat. Nevertheless, it might be worth remarking that naturalized aliens are mostly annuals while the cultivated-only aliens are mainly woody species (Fig.3). Many other widespread naturalized species recorded in Crete tend to have thorns e.g. *Robinia pseudoacacia*, *Agave americana*, *Opuntia ficus-indica*, and/or to be toxic to human or to livestock e.g. *Phytolacca americana*, *Ricinus communis*, *Nicotiana glauca*, and therefore are naturally defended from grazing. Their spread on the island may be promoted by land abandonment, and the reclamation of invaded land may be costly or seen as unnecessary. For some species there is quite well docu-

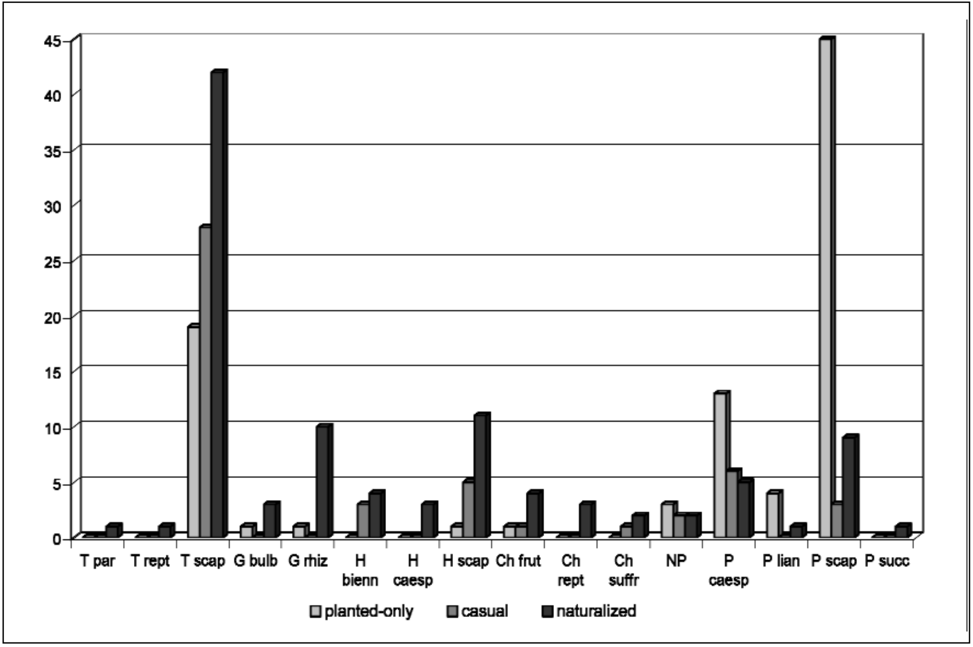
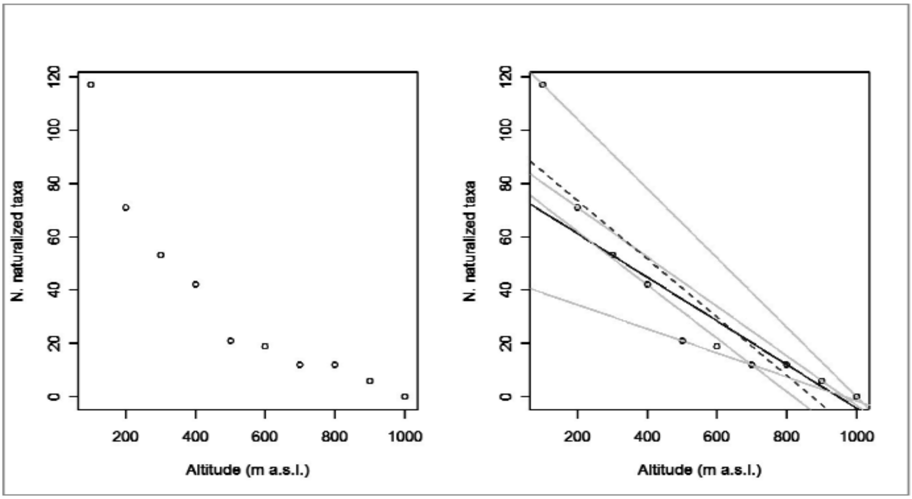


Fig. 3. Alien flora of Crete. Life forms of planted-only, casual and naturalized taxa.



	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	95.46667	11.05557	8.635	$2.51\ e^{-05}$ ***
x	-0.10939	0.01782	-6.140	0.000277 ***

Fig.4. Distribution of naturalized taxa (including casual aliens) along altitudinal classes in the island of Crete. Scatterplot and quantile regression fit of the data. Superimposed on the plot are the 0.05, 0.1, 0.25, 0.75, 0.9, 0.95 quantile regression lines (solid lines, in grey), the median fit in solid grey, and least squares estimate of the conditional mean function (as dashed line)

mented literature demonstrating a clear impact such as changes in soil properties (pH, nutrients, water balances) and reduction of the local native diversity as in the case of *Carpobrotus edulis* and *Oxalis pes-caprae*; production of phytotoxins that might prevent the establishment of other plants, as in the case of the invasive *Ailanthus altissima* (e.g.Vilà & al. 2006).

As observed in other Mediterranean islands (e.g., Brundu & al. 2003), the occurrence and abundance of casual and naturalized alien species decreases with increase of altitude (Fig. 4). Furthermore, on Crete, their abundance increases from east to west and from south to north. The northern coast is indeed more sensitive to invasion, and this seems to be related to higher levels of urbanization and anthropic pressure.

The spread of non-native taxa and even their simple presence as cultivated-only, may promote hybridization both between alien species and between alien and native species. For example hybridization may occur between *Phoenix canariensis*, an alien palm from the Canary Islands (introduced as ornamental), and the Cretan endemic palm *Phoenix theophrasti* (listed by IUCN in the Red List of Threatened Species. IUCN 2006) jeopardising the conservation of the endemic one.

The results of this inventory highlight that for Crete, similar to most of the other islands of the Mediterranean, the presence of alien species is rather high and their number is expected to increase. Deliberate introduction of alien species through forestry, agriculture and the ornamental nursery trade represents one of the major sources of casuals and naturalized exotic species. A wide range of semi-natural habitats is vulnerable to invasion and the future trends in drivers of invasion, especially pathways and land-use change, might accelerate the establishment or spread of alien species. Consequences for native biodiversity, traditional and cultural landscapes and ecosystem functions are complex and potentially severe if no action is taken to mitigate and control the process.

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Appendix, Table 1. Alien Flora of Crete, list of taxa.

N.	Family	Species	Geographical Origin	Residence Status	Invasive Status	Distribution	Introduction Pathway
1	Malvaceae	*Abelmoschus esculentus*	Africa	neophyte	planted-only	occasional	Multi-purpose
2	Malvaceae	*Abutilon theophrasti*	Asia	archaeophyte	Naturalized	occasional	Accidental
3	Fabaceae	*Acacia farnesiana*	C. America	neophyte	planted-only	occasional	Ornamental
4	Fabaceae	*Acacia karroo*	S. Africa	neophyte	planted-only	occasional	Ornamental
5	Fabaceae	*Acacia retinodes*	Australia	neophyte	planted-only	occasional	Ornamental
6	Fabaceae	*Acacia saligna*	Australia	neophyte	planted-only	common	Multi-purpose
7	Crassulaceae	*Aeonium arboreum*	N. Africa	neophyte	casual	occasional	Horticultural
8	Hippocastanaceae	*Aesculus hippocastanum*	Asia	neophyte	planted-only	rare	Ornamental
9	Agavaceae	*Agave americana*	C. America	neophyte	naturalized	locally common	Multi-purpose
10	Asteraceae	*Ageratina adenophorum*	C. America	neophyte	naturallized	occasional	Ornamental
11	Simarubaceae	*Ailanthus altissima*	Asia	neophyte	naturalized	very common	Ornamental
12	Fabaceae	*Albizzia julibrissin*	Tropics	neophyte	planted-only	locally common	Ornamental
13	Asphodelaceae	*Aloe ciliaris*	S. Africa	neophyte	planted-only	occasional	Ornamental
14	Asphodelaceae	*Aloe vera*	Africa / Asia	neophyte	casual	rare	Ornamental
15	Amaranthaceae	*Amaranthus albus*	N. America	neophyte	naturalized	locally common	Agricultural weed
16	Amaranthaceae	*Amaranthus blitoides*	N. America	neophyte	naturalized	locally common	Agricultural weed
17	Amaranthaceae	*Amaranthus bouchonii*	uncertain origin	neophyte	uncertain status	rare	Agricultural weed
18	Amaranthaceae	*Amaranthus caudatus*	Tropics	neophyte	casual	occasional	Ornamental
19	Amaranthaceae	*Amaranthus cruentus*	America	neophyte	naturalized	occasional	Ornamental
20	Amaranthaceae	*Amaranthus deflexus*	S. America	neophyte	naturalized	locally common	Agricultural weed
21	Amaranthaceae	*Amaranthus hybridus*	N. & S. America	neophyte	naturalized	locally common	Agricultural weed
22	Amaranthaceae	*Amaranthus hypochondriacus*	America	neophyte	naturalized	occasional	Ornamental
23	Amaranthaceae	*Amaranthus powelii*	America	neophyte	naturalized	occasional	Agricultural weed
24	Amaranthaceae	*Amaranthus quitensis*	S. America	neophyte	naturalized	occasional	Agricultural weed
25	Amaranthaceae	*Amaranthus retroflexus*	N. America	neophyte	naturalized	common	Agricultural weed
26	Amaranthaceae	*Amaranthus viridis*	S. America	neophyte	naturalized	occasional	Multi-purpose
27	Apiaceae	*Anethum graveolens*	Asia	archaeophyte	naturalized	occasional	Horticultural
28	Basellaceae	*Anredera cordifolia*	S. America	neophyte	naturalized	occasional	Ornamental
29	Plantaginaceae	*Anthirrhinum majus* subsp. *majus*	Mediterranean region	archaeophyte	casual	occasional	Ornamental
30	Plantaginaceae	*Anthirrhinum majus* subsp. *tortuosum*	Mediterranean region	archaeophyte	naturalized	occasional	Ornamental
31	Aizoaceae	*Aptenia cordifolia*	S. Africa	neophyte	naturalized	occasional	Ornamental
32	Araucariaceae	*Araucaria heterphylla*	Australia	neophyte	planted-only	locally common	Ornamental
33	Apocynaceae	*Araujia sericofera*	uncertain origin	neophyte	casual	rare	Ornamental

Table 1. Continued.

34	Asteraceae	*Argyranthemum frutescens*	Canary Islands/Madeira	neophyte	planted-only	occasional	Ornamental
35	Poaceae	*Arundo donax*	Asia	archaeophyte	naturalized	locally common	Multi-purpose
36	Apocynaceae	*Asclepias curassavica*	America	neophyte	casual	rare	Ornamental
37	Apocynaceae	*Asclepias fruticosa*	S. Africa	neophyte	naturalized	occasional	Multi-purpose
38	Apocynaceae	*Asclepias physocarpa*	S. Africa	neophyte	naturalized	occasional	Ornamental
39	Asteraceae	*Aster squamatus*	C.& S. America	neophyte	naturalized	occasional	Ornamental
40	Amaranthaceae	*Atriplex hortensis*	Asia	neophyte	casual	occasional	Horticultural
41	Amaranthaceae	*Atriplex sagittata*	Europe	neophyte	casual	rare	Accidental
42	Poaceae	*Avena sativa*	Europe	archaeophyte	planted-only	occasional	Crop
43	Amaranthaceae	*Bassia hyssopifolia*	Asia	neophyte	casual	occasional	Accidental
44	Amaranthaceae	*Bassia scoparia*	Asia	neophyte	naturalized	occasional	Ornamental
45	Fabaceae	*Bauhinia variegata*	Asia	neophyte	planted-only	locally common	Ornamental
46	Amaranthaceae	*Beta vulgaris* subsp. *vulgaris*	Mediterranean region	archaeophyte	naturalized	rare	Horticultural
47	Nyctaginaceae	*Bougainvillea glabra*	S. America	neophyte	planted-only	locally common	Ornamental
48	Nyctaginaceae	*Bougainvillea spectabilis*	S. America	neophyte	planted-only	locally common	Ornamental
49	Poaceae	*Bouteloua dactyloides*	N. America	neophyte	planted-only	rare	Ornamental
50	Poaceae	*Bromus catharticus*	N. & S. America	neophyte	naturalized	occasional	Agricultural weed
51	Solanaceae	*Brugmansia arborea*	S. America	neophyte	planted-only	occasional	Ornamental
52	Loganiaceae	*Buddleja madagascariensis*	uncertain origin	neophyte	planted-only	occasional	Ornamental
53	Asteraceae	*Calendula officinalis*	uncertain origin	archaeophyte	casual	rare	Multi-purpose
54	Myrtaceae	*Callistemom viminalis*	Australia	neophyte	planted-only	locally common	Ornamental
55	Cannabaceae	*Cannabis sativa*	Asia	archaeophyte	casual	rare	Multi-purpose
56	Solanaceae	*Capsicum annum*	S. America	neophyte	planted-only	occasional	Crop
57	Sapindaceae	*Cardiospermum halicacabum*	America	neophyte	casual	occasional	Accidental
58	Aizoaceae	*Carpobrotus edulis*	S. Africa	neophyte	naturalized	common	Ornamental
59	Fagaceae	*Castanea sativa*	Europe	archaeophyte	naturalized	locally common	Multi-purpose
60	Casuarinaceae	*Casuarina cunninghamia*	uncertain origin	neophyte	planted-only	occasional	Ornamental
61	Bignoniaceae	*Catalpa bignonioides*	N. America	neophyte	planted-only	rare	Ornamental
62	Apocynaceae	*Catharanthus roseus*	Africa	neophyte	casual	occasional	Ornamental
63	Ulmaceae	*Celtis australis*	Mediterranean region / Asia	archaeophyte	planted-only	occasional	Ornamental
64	Valerianaceae	*Centranthus ruber* subsp. *ruber*	Mediterranean region	archaeophyte	casual	occasional	Ornamental
65	Fabaceae	*Cercis siliquastrum*	Asia	archaeophyte	planted-only	locally common	Ornamental
66	Fabaceae	*Cesalpinia gilliesii*	S. America	neophyte	planted-only	occasional	Ornamental
67	Amaranthaceae	*Chenopodium ambrosoides*	America	neophyte	naturalized	occasional	Multi-purpose
68	Amaranthaceae	*Chenopodium giganteum*	Asia	neophyte	naturalized	rare	Horticultural
69	Fabaceae	*Cicer arietinum*	Asia	archaeophyte	casual	rare	Crop

Table 1. Continued.

70	Cucurbitaceae	*Citrullus lanatus*	Africa	archaeophyte	planted-only	occasional	Crop
71	Rutaceae	*Citrus deliciosa*	Asia	neophyte	planted-only	occasional	Crop
72	Rutaceae	*Citrus limetta*	Asia	neophyte	planted-only	rare	Crop
73	Rutaceae	*Citrus limon*	Asia	archaeophyte	planted-only	locally common	Crop
74	Rutaceae	*Citrus medica*	Asia	neophyte	planted-only	occasional	Crop
75	Rutaceae	*Citrus paradisi*	Asia	neophyte	planted-only	rare	Crop
76	Rutaceae	*Citrus sinensis*	Asia	neophyte	planted-only	locally common	Crop
77	Poaceae	*Coix lacrima - jobi*	Tropics	neophyte	naturalized	occasional	Horticultural
78	Araceae	*Colocasia esculenta*	Asia	neophyte	planted-only	occasional	Horticultural
79	Apiaceae	*Coriandrum sativum*	Africa / Asia	archaeophyte	naturalized	rare	Horticultural
80	Poaceae	*Cortaderia selloana*	S. America	neophyte	only-planted	occasional	Ornamental
81	Betulaceae	*Corylus maxima*	uncertain origin	neophyte	casual	rare	Horticultural
82	Cucurbitaceae	*Cucumis melo*	Tropics	archaeophyte	planted-only	occasional	Crop
83	Cucurbitaceae	*Cucumis sativus*	Asia	archaeophyte	planted-only	occasional	Crop
84	Cucurbitaceae	*Cucurbita maxima*	C. America	neophyte	planted-only	occasional	Crop
85	Cucurbitaceae	*Cucurbita pepo*	C. America	neophyte	planted-only	occasional	Crop
86	Convolvulaceae	*Cuscuta campestris*	N. America	neophyte	naturalized	occasional	Accidental
87	Rosaceae	*Cydonia oblonga*	Asia	archaeophyte	planted-only	rare	Crop
88	Plantaginaceae	*Cymbalaria muralis* subsp. *muralis*	Europe	archaeophyte	naturalized	locally common	Accidental
89	Cyperaceae	*Cyperus aesculentum*	America	neophyte	naturalized	occasional	Multi-purpose
90	Cyperaceae	*Cyperus involucratus*	America	neophyte	uncertain status	occasional	Ornamental
91	Solanaceae	*Cyphomandra betacea*	S. America	neophyte	planted-only	rare	Ornamental
92	Poaceae	*Dactyloctaenium aegiptium*	Tropics	neophyte	naturalized	rare	Accidental
93	Solanaceae	*Datura ferox*	Asia	neophyte	casual	occasional	Accidental
94	Solanaceae	*Datura innoxia*	C. America	neophyte	casual	occasional	Accidental
95	Solanaceae	*Datura stramonium*	America	neophyte	naturalized	locally common	Accidental
96	Poaceae	*Dichanthium annulatum*	Africa / Asia	neophyte	uncertain status	rare	Unknown
97	Poaceae	*Digitaria ciliaris*	Tropics	neophyte	naturalized	occasional	Agricultural weed
98	Ebenaceae	*Diospyros kaki*	Asia	neophyte	planted-only	occasional	Multi-purpose
99	Poaceae	*Echinochloa colona*	Tropics	neophyte	naturalized	occasional	Accidental
100	Eleagnaceae	*Eleagnus angustifolia*	Asia	neophyte	naturalized	occasional	Ornamental
101	Cyperaceae	*Eleocharis caduca*	Africa	neophyte	uncertain status	rare	Unknown
102	Poaceae	*Eleusine indica*	Tropics	neophyte	naturalized	occasional	Agricultural weed
103	Asteraceae	*Erigeron bonariensis*	N. America	neophyte	naturalized	locally common	Accidental
104	Asteraceae	*Erigeron canadensis*	N. America	neophyte	naturalized	locally common	Accidental
105	Asteraceae	*Erigeron sumatrensis*	America	neophyte	naturalized	locally common	Accidental

Table 1. Continued.

106	Rosaceae	*Eriobotrya japonica*	Asia	neophyte	planted-only	occasional	Crop
107	Papaveraceae	*Eschscholzia californica*	N. America	neophyte	casual	occasional	Ornamental
108	Myrtaceae	*Eucalyptus camaldulensis*	Australia	neophyte	naturalized	common	Ornamental
109	Euphorbiaceae	*Euphorbia maculata*	N. America	neophyte	uncertain status	rare	Accidental
110	Euphorbiaceae	*Euphorbia marginata*	N. America	neophyte	casual	rare	Ornamental
111	Euphorbiaceae	*Euphorbia milii* var. *splendens*	Africa	neophyte	planted-only	occasional	Ornamental
112	Euphorbiaceae	*Euphorbia prostrata*	N. America	neophyte	uncertain status	occasional	Accidental
113	Euphorbiaceae	*Euphorbia pulcherrima*	C. America	neophyte	planted-only	occasional	Ornamental
114	Moraceae	*Ficus* sp.pl.	uncertain origin	neophyte	planted-only	occasional	Ornamental
115	Fabaceae	*Gleditsia triacanthos*	N. America	neophyte	casual	occasional	Ornamental
116	Fabaceae	*Glycyrrhiza glabra*	Asia / Mediterranean region	neophyte	naturalized	occasional	Multi-purpose
117	Malvaceae	*Gossypium herbaceum*	Africa	archeophyte	naturalized	rare	Horticultural
118	Proteaceae	*Grevillea robusta*	Australia	neophyte	planted-only	occasional	Ornamental
119	Hydrocharitaceae	*Halophila stilpulacea*	Asia	neophyte	naturalized	occasional	Accidental
120	Asteraceae	*Helianthus annuus*	S. America	neophyte	casual	occasional	Multi-purpose
121	Malvaceae	*Hibiscus rosa-sinensis*	Asia	neophyte	planted-only	locally common	Ornamental
122	Amaryllidaceae	*Hippeastrum x johnsonii*	S. America	neophyte	planted-only	occasional	Ornamental
123	Poaceae	*Hordeum vulgare* subsp. *agricanthon*	Africa / Asia	archeophyte	naturalized	occasional	Accidental
124	Solanaceae	*Hyoscyamus aureus*	Africa / Asia	neophyte	naturalized	occasional	Accidental
125	Convolvulaceae	*Ipomoea indica*	Tropics	neophyte	naturalized	locally common	Ornamental
126	Convolvulaceae	*Ipomoea purpurea*	S. America	neophyte	casual	occasional	Ornamental
127	Iridaceae	*Iris albicans*	Asia	neophyte	naturalized	occasional	Ornamental
128	Iridaceae	*Iris germanica*	uncertain origin	archaeophyte	naturalized	occasional	Ornamental
129	Bignoniaceae	*Jacaranda mimosifolia*	S. America	neophyte	planted-only	locally common	Ornamental
130	Oleaceae	*Jasminum mesnyi*	Asia	neophyte	planted-only	occasional	Ornamental
131	Oleaceae	*Jasminum officinale*	Asia	neophyte	casual	locally common	Ornamental
132	Juglandaceae	*Juglans regia*	Asia	archaeophyte	naturalized	locally common	Multi-purpose
133	Acanthaceae	*Justicia brandegeeana*	C. America	neophyte	planted-only	occasional	Ornamental
134	Fabaceae	*Lablab purpureus*	Africa / Asia	neophyte	casual	rare	Ornamental
135	Asteraceae	*Lactuca sativa*	N. Africa	archaeophyte	casual	rare	Horticultural
136	Cucurbitaceae	*Lagenaria siceraria*	uncertain origin	archeophyte	planted-only	occasional	Ornamental
137	Aizoaceae	*Lampranthus purpureus*	S. Africa	neophyte	planted-only	occasional	Ornamental
138	Verbenaceae	*Lantana camara*	Tropics	neophyte	casual	locally common	Ornamental
139	Fabaceae	*Lathyrus ochrus*	Mediterranean region	archeophyte	planted-only	rare	Crop
140	Fabaceae	*Lathyrus sativus*	uncertain origin	archeophyte	casual	rare	Horticultural
141	Fabaceae	*Lens culinaris*	uncertain origin	archeophyte	casual	rare	Crop

Table 1. Continued.

142	Brassicaceae	*Lepidium didymus*	S. America	neophyte	naturalized	rare	Accidental
143	Brassicaceae	*Lepidium latifolium*	Asia	neophyte	naturalized	rare	Accidental
144	Brassicaceae	*Lepidium sativum*	Africa / Asia	neophyte	casual	rare	Horticultural
145	Brassicaceae	*Lepidum virginicum*	N. America	neophyte	casual	rare	Accidental
146	Oleaceae	*Ligustrum lucidum*	Asia	neophyte	planted-only	locally common	Ornamental
147	Liliaceae	*Lilium longiflorum*	Asia	neophyte	planted-only	occasional	Ornamental
148	Linaceae	*Linum usitatissimum*	Asia	archaeophyte	naturalized	rare	Horticultural
149	Solanaceae	*Lycium barbatum*	Asia	neophyte	naturalized	occasional	Accidental
150	Solanaceae	*Lycopersicon aesculentum*	C. & S. America	neophyte	casual	rare	Crop
151	Magnoliaceae	*Magnolia grandiflora*	N. America	neophyte	planted-only	locally common	Ornamental
152	Aizoaceae	*Malephora purpurocrocea*	S. Africa	neophyte	naturalized	rare	Ornamental
153	Rosaceae	*Malus domestica*	Europe / Asia	archaeophyte	planted-only	occasional	Crop
154	Fabaceae	*Medicago falcata*	Europe / Asia	archaeophyte	casual	rare	Crop
155	Fabaceae	*Medicago sativa*	Asia	archaeophyte	naturalized	rare	Crop
156	Meliaceae	*Melia azedarach*	Asia	neophyte	casual	common	Ornamental
157	Fabaceae	*Melilotus albus*	Europe / Asia	archaeophyte	uncertain status	rare	Horticultural
158	Fabaceae	*Melilotus officinalis*	Europe / Asia	archaeophyte	casual	rare	Horticultural
159	Nyctaginaceae	*Mirabilis jalapa*	S. America	neophyte	naturalized	locally common	Ornamental
160	Moraceae	*Morus alba*	Asia	archaeophyte	planted-only	locally common	Multi-purpose
161	Moraceae	*Morus nigra*	Asia	archaeophyte	planted-only	common	Multi-purpose
162	Musaceae	*Musa cavendishii*	Asia	neophyte	planted-only	rare	Horticultural
163	Solanaceae	*Nicandra physalodes*	S. America	neophyte	casual	occasional	Accidental
164	Solanaceae	*Nicotiana glauca*	S. America	neophyte	naturalized	very common	Accidental
165	Solanaceae	*Nicotiana tabacum*	N. America	neophyte	planted-only	rare	Crop
166	Lamiaceae	*Ocinum basilicum*	Asia	archaeophyte	casual	occasional	Horticultural
167	Cactaceae	*Opuntia ficus-indica*	America	neophyte	naturalized	common	Multi-purpose
168	Asteraceae	*Osteospermum* cultivar	S. Africa	neophyte	planted-only	occasional	Ornamental
169	Oxalidaceae	*Oxalis debilis*	S. America	neophyte	naturalized	rare	Accidental
170	Oxalidaceae	*Oxalis pes-caprae*	S. Africa	neophyte	naturalized	very common	Accidental
171	Poaceae	*Panicum capillare*	N. America	neophyte	naturalized	occasional	Accidental
172	Poaceae	*Panicum miliaceum*	C. Asia	archaeophyte	casual	occasional	Accidental
173	Poaceae	*Panicum repentellum*	E. Africa	neophyte	casual	rare	Multi-purpose
174	Papaveraceae	*Papaver sonniferum* subsp. *sonniferum*	Mediterranean region / Asia	archaeophyte	casual	occasional	Horticultural
175	Poaceae	*Paspalum dilatatum*	S. America	neophyte	naturalized	occasional	Accidental
176	Poaceae	*Paspalum distichum*	Tropics	neophyte	naturalized	occasional	Accidental
177	Geraniaceae	*Pelargonium x hortorum*	S. Africa	neophyte	planted-only	occasional	Multi-purpose

Table 1. Continued.

178	Poaceae	*Pennisetum clandestinum*	Africa	neophyte	naturalized	rare	horticultural
179	Asteraceae	*Pericallis x hybrida*	Canary Islands/Madeira	neophyte	planted-only	occasional	Ornamental
180	Lauraceae	*Persea americana*	C. America	neophyte	planted-only	occasional	Multi-purpose
181	Polygonaceae	*Persicaria senegalensis*	Tropics	neophyte	uncertain status	rare	Horticultural
182	Hydrophyllaceae	*Phacelia tanacetifolia*	N. America	neophyte	planted-only	rare	Horticultural
183	Arecaceae	*Phoenix canariensis*	Canary Islands	neophyte	planted-only	occasional	Ornamental
184	Arecaceae	*Phoenix dactylifera*	uncertain origin	neophyte	planted-only	occasional	Ornamental
185	Phytolaccaceae	*Phytolacca americana*	N. America	neophyte	naturalized	locally common	Multi-purpose
186	Pinaceae	*Pinus pinea*	Mediterranean region	archaeophyte	planted-only	rare	Multi-purpose
187	Anacardiaceae	*Pistacia vera*	Mediterranean region	archaeophyte	planted-only	rare	Crop
188	Fabaceae	*Pisum sativum*	Europe	archaeophyte	planted-only	occasional	Crop
189	Pittosporaceae	*Pittosporum tobira*	Asia	neophyte	planted-only	occasional	Ornamental
190	Poaceae	*Pleuraphis jamesii*	N. America	neophyte	uncertain status	rare	
191	Plumbaginaceae	*Plumbago auriculata*	S. Africa	neophyte	naturalized	rare	Ornamental
192	Polygalaceae	*Polygala myrtifolia*	S. Africa	neophyte	planted-only	occasional	Ornamental
193	Salicaceae	*Populus alba*	Europe / Asia	archaeophyte	naturalized	locally common	Ornamental
194	Salicaceae	*Populus nigra*	Europe / Asia	archaeophyte	planted-only	occasional	Ornamental
195	Rosaceae	*Prunus armeniaca*	Asia	archaeophyte	planted-only	rare	Crop
196	Rosaceae	*Prunus avium*	W. Asia	archaeophyte	planted-only	rare	Crop
197	Rosaceae	*Prunus cerasifera*	W. Asia	archaeophyte	planted-only	rare	Crop
198	Rosaceae	*Prunus cerasus*	W. Asia	archaeophyte	planted-only	rare	Crop
199	Rosaceae	*Prunus domestica*	uncertain origin	archaeophyte	planted-only	rare	Crop
200	Rosaceae	*Prunus dulcis*	Mediterranean region	archaeophyte	planted-only	locally common	Crop
201	Rosaceae	*Prunus persica*	Asia	archaeophyte	planted-only	occasional	Crop
202	Punicaceae	*Punica granatum*	W. Asia	archaeophyte	naturalized	locally common	Horticultural
203	Rosaceae	*Pyrus communis*	uncertain origin	archaeophyte	planted-only	occasional	Crop
204	Brassicaceae	*Raphanus sativum*	uncertain origin	archaeophyte	casual	rare	Crop
205	Euphorbiaceae	*Ricinus communis*	Tropics	archaeophyte	naturalized	common	Ornamental
206	Fabaceae	*Robinia pseudoacacia*	N. America	neophyte	naturalized	common	Ornamental
207	Rubiaceae	*Rubia tinctorum*	Asia	neophyte	naturalized	occasional	Horticultural
208	Scrophulariaceae	*Russelia equisetiformis*	C. America	neophyte	planted-only	occasional	Ornamental
209	Poaceae	*Saccharum spontaneum*	Tropics	neophyte	naturalized	occasional	Accidental
210	Salicaceae	*Salix babylonica*	Asia	neophyte	planted-only	rare	Ornamental
211	Adoxaceae	*Sambucus nigra*	Europe	archaeophyte	casual	occasional	Multi-purpose
212	Anacardiaceae	*Schinus molle*	America	neophyte	planted-only	occasional	Ornamental
213	Fabaceae	*Senna corymbosa*	S. America	neophyte	planted-only	occasional	Ornamental

Table 1. Continued.

214	Fabaceae	*Senna didymobotrya*	C. Africa	neophyte	planted-only	occasional	Ornamental
215	Poaceae	*Setaria pumila*	uncertain origin	neophyte	naturalized	occasional	Accidental
216	Brassicaceae	*Sinapis alba* subsp. *alba*	Mediterraneae region	archaeophyte	casual	occasional	Horticultural
217	Solanaceae	*Solanum elaeagnifolium*	S. America	neophyte	naturalized	occasional	Accidental
218	Solanaceae	*Solanum physalifolium*	America	neophyte	naturalized	rare	Agricultural weed
219	Solanaceae	*Solanum pseudocapsicum*	S. America	neophyte	casual	rare	Ornamental
220	Solanaceae	*Solanum tuberosum*	S. America	neophyte	planted-only	occasional	Crop
221	Amaranthaceae	*Spinacia oleracea*	Asia	archaeophyte	casual	rare	Crop
222	Amaryllidaceae	*Sternbergia fischeriana*	Asia	neophyte	uncertain status	rare	
223	Asteraceae	*Tagetes minuta*	S. America	neophyte	naturalized	occasional	Accidental
224	Tamaricaceae	*Tamarix smyrnensis*	uncertain origin	neophyte	planted-only	common	Ornamental
225	Asteraceae	*Tanacetum parthenium*	Europe / Asia	neophyte	naturalized	occasional	Accidental
226	Bignoniaceae	*Tecoma capensis*	S. Africa	neophyte	planted-only	occasional	Ornamental
227	Commelinaceae	*Tradescantia fluminensis*	S. America	neophyte	naturalized	occasional	Accidental
228	Commelinaceae	*Tradescantia pallida*	C. America	neophyte	planted-only	occasional	Ornamental
229	Fabaceae	*Trigonella foenum graecum*	Asia	archaeophyte	casual	rare	Horticultural
230	Poaceae	*Triticum aestivum*	uncertain origin	archaeophyte	naturalized	rare	Agricultural weed
231	Tropaeolaceae	*Tropaeolum majus*	S. America	neophyte	naturalized	locally common	Ornamental
232	Plantaginaceae	*Veronica persica*	Asia	archaeophyte	naturalized	occasional	Accidental
233	Fabaceae	*Vicia ervilia*	Mediterranean region	archaeophyte	casual	rare	Horticultural
234	Fabaceae	*Vicia faba*	uncertain origin	archaeophyte	casual	rare	Crop
235	Fabaceae	*Vicia sativa* subsp. *macrocarpa*	Mediterranean region	archaeophyte	planted-only	rare	Horticultural
236	Fabaceae	*Vicia sativa* subsp. *sativa*	Mediterranean region	archaeophyte	naturalized	rare	Horticultural
237	Vitaceae	*Vitis vinifera* subsp. *vinifera*	uncertain origin	archaeophyte	naturalized	occasional	Crop
238	Arecaceae	*Whashingtonia filifera*	N. America	neophyte	planted-only	occasional	Ornamental
239	Fabaceae	*Wisteria sinensis*	Asia	neophyte	planted-only	occasional	Ornamental
240	Asteraceae	*Xanthium orientale* subsp. *italicum*	N. America	neophyte	naturalized	locally common	Accidental
241	Asteraceae	*Xanthium spinosum*	S. America	neophyte	naturalized	locally common	Accidental
242	Asteraceae	*Xanthium strumarium* subsp. *brasilicum*	uncertain origin	neophyte	naturalized	occasional	Accidental
243	Araceae	*Zantedeschia aetiopica*	S. Africa	neophyte	naturalized	occasional	Ornamental
244	Poaceae	*Zea mays*	C. America	neophyte	planted-only	occasional	Crop
245	Rhamnaceae	*Zizyphus zizyphus*	Asia	archaeophyte	casual	rare	Horticultural

João Domingues de Almeida

Flora of the Beira-Duriense mountains (Portugal)

Abstract

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An inventory of the vascular flora and vegetation of a group of Portuguese situated between the rivers Douro and Mondego is presented. The area (about 1900 km2) belongs to 4 different provinces: Beira Alta, Beira Litoral, Douro Litoral and Trás-os-Montes e Alto Douro. It comprises 5 major mountain groups: Montemuro/ Leomil/ Nave/ Lapa (culminating at 1381 m), Arada/Freita/Arestal/S. Macário (1119 m), Caramulo (1077 m), Penedono/ Meda/ Sernancelhe/ Trancoso (1000 m), and Chavães (985 m); and 2 minor sierras: Senhora do Viso (814 m) and Senhora do Monte (782 m). Based on herbarium material, field observations and bibliography, 1236 taxa (species, subspecies, and a few varieties and hybrids) are listed as present, belonging to 136 families and 552 genera of *Pteridophyta* (14 families, 17 genera, 30 taxa), *Gymnospermae* (3, 8, 10), *Magnoliopsida* (93, 406, 939) and *Liliopsida* (26, 121, 257).

Introduction

In the last ten years, within a Ph.D. project on Ecology of vascular plants, I have been studying the flora and vegetation of a group of Portuguese mountains and highlands (above 700 m), situated south of the river Douro and north of the river Mondego. This area (about 1900 km^2, and one fifth of the total Portuguese area above 700 m) is included in three districts: Viseu, Guarda and a small portion of the district of Aveiro (northeast). Four provinces are included in this area: Beira Alta (BA), Beira Litoral (BL), Douro Litoral (DL) and Trás-os-Montes e Alto Douro (TM). It can be divided into five major groups of mainly granitic mountains (Tab. 1).

Granites (mainly) and schists (belonging to the Schist-Greywacke Complex) are the dominant rocks, but there are also present some quartzitic and (very rare) calco-silicated rocks.

Material and Methods

This work is based on herbarium material, field observations and a large selection of literature, including among many others, the following sources: Almeida (2009), Costa (1955), Franco (1958), Henriques (1886, 1901), Marques (1958), Melo (1949), Mendonça & Vasconcellos (1954-1970), Moura (2001), Paiva (2000), Ribeiro (2006), Rozeira (1944), Sampaio (1936), Santos (2001), Teles (1970).

Table 1. The seven main groups of mountains isolated above 700 m.

No.	Groups of mountains	Symbol	Max. height	Area (km^2)	Nº of taxa
1	Montemuro/Leomil/Nave/Lapa	mo	1381 m	1024	975
2	Arada/Freita/Arestal/São Macário	fr	1119 m	183	595
3	Caramulo	ca	1077 m	107	684
4	Penedono/Meda/Sernancelhe/Trancoso	pe	1000 m	502	858
5	Chavães	ch	985 m	56	578
6	Senhora do Viso	sv	814 m	4	329
7	Senhora do Monte	sm	782 m	2	323

The numerous herbarium specimens collected (more than 8000) were identified with the help of the following floras and botanical guides: Aizpuru Oiharbide & al. (2003), Bolòs & Vigo (1984–2001), Castroviejo & al. (1986–2009), Coutinho (1939), Devesa & al. (1991), Franco (1971, 1984), Franco & Rocha Afonso (1994–2003), Jansen (2002), López González (2001), Pignatti (1982), Sampaio (1990), Valdés, Talavera & Fernández-Galiano (1987).

The following nine Portuguese herbaria were consulted: Universidade de Aveiro (AVE), Escola Superior Agrária de Bragança (BRESA), Universidade de Coimbra (COI), Estação Nacional de Melhoramento de Plantas (ELVE), Universidade de Vila Real (HVR), Estação Agronómica Nacional (LISE), Instituto Superior de Agronomia (LISI), Universidade de Lisboa (LISU) and Universidade do Porto (PO).

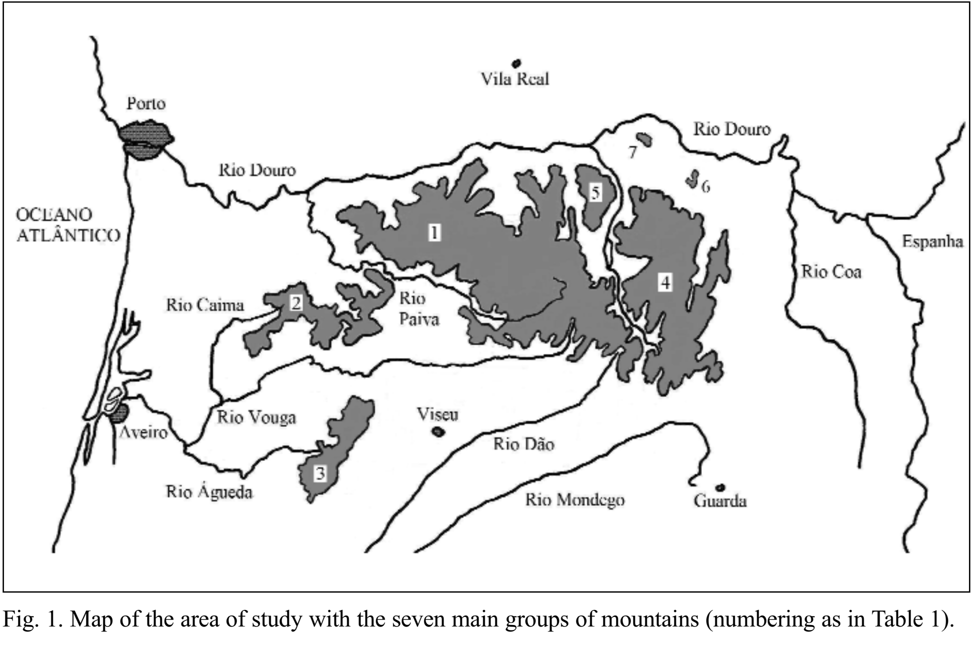

Fig. 1. Map of the area of study with the seven main groups of mountains (numbering as in Table 1).

Results

After ten years of intensive study, and based on herbarium material, field observations and bibliography, 1236 taxa have been selected (species, subspecies, and a few varieties and named interspecific hybrids), belonging to 136 families and 552 genera of *Pteridophyta* (14 families, 17 genera, 30 species and aditional subspecies), *Gymnospermae* (3 families, 8 genera, 10 species), *Magnoliopsida* or *Dicotyledones* (93 families, 406 genera, 939 taxa) and *Liliopsida* or *Monocotyledones* (26 families, 121 genera, 257 taxa). These 1236 taxa present in the Beira-Duriense Mountains are about 34 % of the total flora of Portugal (ca. 3640 taxa) and more than 15 % of the total flora of the Iberian Peninsula, which is probably more than 7700 species and aditional subspecies (Greuter 1991).

Conclusions

1236 taxa have been found in the area of the Beira-Duriense Mountains (ca. 1900 km^2), belonging to 136 families of Pteridophyta (14 families, 17 genera, 30 species and aditional subspecies), *Gymnospermae* (3 families, 8 genera, 10 species), *Magnoliopsida* (93 families, 406 genera, 939 taxa) and *Liliopsida* (26 families, 121 genera, 257 taxa).

The genera with eight or more taxa are *Ranunculus* (24 taxa), *Trifolium* (22), *Rubus* (18), *Carex* (17), *Galium* (15), *Sedum* and *Centaurea* (13), *Festuca* (12), *Juncus* and *Veronica* (11), *Polygonum* and *Silene* (10), *Geranium*, *Medicago*, *Myosotis* and *Rumex* (9), *Allium*, *Erica* and *Genista* (8).

There are about 171 Iberian endemic species living in the Beira-Duriense Mountains (almost 14 % of the total flora of these mountains and more or less 10 % of the total number of Iberian endemisms), including fifteen taxa which have been considered exclusively Portuguese endemisms: *Ceratocapnos claviculata* subsp. *picta*, *Murbeckiella sousae*, *Lamium coutinhoi*, *Teucrium salviastrum*, *Ranunculus henriquesii*, *Galium belizianum*, *Anarrhinum longipedicellatum*, *Digitalis amandiana*, *Centaurea herminii* subsp. *herminii*, *Centaurea herminii* subsp. *lusitana*, *Centaurea rothmalerana*, *Leucanthemum sylvaticum*, *Taraxacum duriense*, *Gagea lusitanica* and *Festuca summilusitana*, according to Franco (1971, 1984), Franco & Rocha Afonso (1994, 1998, 2003), Castroviejo & al. (1986–2009) and Álvarez Fernandez & al. (2001).

The exotic naturalized flora present in the Beira-Duriense Mountains is rich (158 species/1236, or about 13 %), but not particularly invasive. The more invasive species in the studied area are probably *Acacia dealbata*, *Acacia melanoxylon*, *Ailanthus altissima*, *Erigeron bonariensis*, *Erigeron canadensis*, *Erigeron sumatrensis* and *Symphyotrichum squamatum*. 158 species are about 28 % of the total exotic naturalized flora of continental Portugal, 564 taxa according to Almeida & Freitas (2006).

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Floristic list: The flora of the seven major Beira-Duriense groups of mountains.

Iberian endemics appear in **bold characters**, naturalised exotics in *italic type*.; mountains abbreviations according to table 1.

ASPLENIACEAE
Asplenium adiantum-nigrum L.; mo; fr; ca; pe;
Asplenium ceterach L.; mo; pe;
Asplenium obovatum subsp. lanceolatum P. Silva; mo; fr; ca; pe;
Asplenium onopteris L.; mo; fr; ca; pe; ch;
Asplenium scolopendrium L.; mo;
Asplenium trichomanes subsp. quadrivalens D.E. Meyer; mo; fr; ca; pe; ch;

ATHYRIACEAE
Athyrium filix-femina (L.) Roth; mo; fr; ca; pe; ch;
Cystopteris dickieana R. Sim; mo; pe;
Cystopteris fragilis (L.) Bernh.; mo; fr;
Cystopteris viridula (Desv.) Desv.; mo; fr; ca; pe; ch;

AZOLLACEAE
Azolla filiculoides Lam.; pe;

BLECHNACEAE
Blechnum spicant (L.) Roth; mo; fr; ca; pe;
Woodwardia radicans (L.) Sm.; fr;

DRYOPTERIDACEAE
Dryopteris affinis (Lowe) Fraser-Jenkins subsp. affinis; fr; ca; pe;
Dryopteris affinis subsp. borreri (Newman) Fraser-Jenkins; mo; fr; ca; pe; ch;
Dryopteris dilatata (Hoffm.) A. Gray; fr;
Dryopteris filix-mas (L.) Schott; mo; fr; pe;
Polystichum setiferum (Forsskal) Woynar; mo; fr; ca; pe; ch;

EQUISETACEAE
Equisetum telmateia Ehrh.; pe;

HEMIONITIDACEAE
Anogramma leptophylla (L.) Link; mo; fr; ca; pe; ch;

HYPOLEPIDACEAE
Pteridium aquilinum (L.) Kuhn; mo; fr; ca; pe; ch; sv; sm;

ISOETACEAE
Isoetes histrix Bory; pe;

OPHIOGLOSSACEAE
Ophioglossum azoricum K. Presl; ch;

OSMUNDACEAE
Osmunda regalis L.; mo; fr; ca; pe; ch;

POLYPODIACEAE
Polypodium cambricum L.; mo; fr; ca;
Polypodium interjectum Shivas; mo; ca; pe;
Polypodium vulgare L.; mo; fr; ca;

SELAGINELLACEAE
Selaginella denticulata (L.) Spring;; mo;

SINOPTERIDACEAE
Cheilanthes hispanica Mett.; pe;
Cheilanthes tinaei Tod.; mo;

CUPRESSACEAE
Chamaecyparis lawsoniana (A. Murray) Parl.; mo; fr; ca; pe; ch;
Cupressus lusitanica Mill.; mo; ca;
Juniperus oxycedrus L. subsp. oxycedrus; pe;

PINACEAE
Cedrus deodara (Roxb. ex D. Don) G. Don; mo; pe; ch;
Picea abies (L.) Karsten; ca;
Pinus pinaster Aiton; mo; fr; ca; pe; ch; sv; sm
Pinus pinea L.; mo; fr; ca; pe; ch;
Pinus sylvestris L.; mo; fr; ca;
Pseudotsuga menziesii (Mirb.) Franco; mo; fr;

TAXACEAE
Taxus baccata L.; ca;

ACANTHACEAE
Acanthus mollis L.; mo;

ACERACEAE
Acer monspessulanum L.; pe;
Acer pseudoplatanus L.; mo; fr; ca; pe; ch; sv;

AIZOACEAE
Carpobrotus edulis (L.) N.E. Br.; mo; ca;

AMARANTHACEAE
Amaranthus albus L.; mo; pe; ch; sv; sm
Amaranthus blitum L. subsp. blitum; pe;
Amaranthus caudatus L.; mo; fr; ca; pe; ch;
Amaranthus deflexus L.; mo; fr; ca; pe; ch;
Amaranthus hybridus L.; ca;
Amaranthus powelii S. Watson; mo; ca; pe;
Amaranthus retroflexus L.; Amaranthaceae; pe;

ANACARDIACEAE
Pistacia terebinthus L.; ch;
Rhus coriaria L.; mo;

APIACEAE
Ammi majus L.; pe;
Angelica sylvestris L.; mo; fr; ca; pe;
Anthriscus caucalis M. Bieb.; mo; ca; pe;
Anthriscus sylvestris (L.) Hoffm.; mo; ca; pe; ch;
Apium inundatum (L.) Reichenb. fil.; pe;
Apium nodiflorum (L.) Lag.; mo; pe;
Bupleurum gerardi All.; mo; pe;
Carum verticillatum (L.) Koch; mo; fr; ca; pe; ch;
Chaerophyllum temulum L.; mo; fr; ca; pe; ch; sv; sm;
Conium maculatum L.; pe;
Conopodium majus subsp. **marizianum** (Samp.) López Udias & G. Mateo; mo; fr; ca; pe; ch; sv; sm;
Conopodium marianum Lange; mo; pe;
Conopodium pyrenaeum (Loisel.) Miégev.; mo;
Conopodium subcarneum (Boiss. & Reut.) Boiss. & Reut.; mo; fr; ca; pe;
Daucus carota L. subsp. carota; mo; fr; ca; pe; ch; sv; sm;
Daucus crinitus Desf.; mo;
Daucus durieua Lange; mo; pe; ch;
Daucus muricatus (L.) L.; ch;
Eryngium campestre L.; mo; fr; ca; pe; ch; sv; sm;
Eryngium duriaei subsp. **juresianum** (M. Laínz) M. Laínz; fr;
Eryngium tenue Lam.; pe; ch;
Ferula communis subsp. **catalaunica** (C. Vicioso) Sánchez Cuxart & Bernal; pe;
Ferulago capillaris (Sprengel) Cout.; pe;
Foeniculum vulgare Miller; mo; fr; ca; pe; ch; sv; sm;
Heracleum sphondylium L.; mo; fr; ca; pe; ch;
Hydrocotyle vulgaris L.; fr;
Laserpitium eliasii subsp. **thalictrifolium** (Samp.) P. Monts.; mo;
Magydaris panacifolia (Vahl) Lange; pe;
Margotia gummifera (Desf.) Lange; mo; fr; pe;
Oenanthe crocata L.; mo; fr; ca; pe; ch;
Petroselinum crispum (Miller) Fuss; mo; fr; ca; pe; ch;
Peucedanum lancifolium Lange; mo; fr; ca; pe; ch;
Physospermum cornubiense (L.) DC.; mo; fr; ca; pe;
Pimpinella villosa Schousboe; mo; pe; ch; sv; sm;
Scandix pecten-veneris L.; mo; pe; sv; sm;
Selinum broteri Hoffmanns. & Link; mo;
Smyrnium olusatrum L.; pe;
Thapsia minor Hoffmanns. & Link; mo; ca; pe;
Thapsia villosa L.; mo; fr; ca; pe; ch; sv; sm
Tordylium maximum L.; mo; pe;
Torilis arvensis subsp. neglecta (Sprengel) Thell.; mo; fr; ca; pe; ch;
Torilis arvensis subsp. purpurea (Ten.) Hayek; mo; fr; ca; pe; ch; sv; sm;
Torilis elongata (Hoffmanns. & Link) Samp.; ca;
Torilis japonica (Houtt.) DC.; fr;
Torilis nodosa (L.) Gaertner; pe; sv; sm;

APOCYNACEAE
Vinca difformis Pourr.; mo; fr; ca;
Vinca major L.; mo; fr; ca; pe; ch;

AQUIFOLIACEAE
Ilex aquifolium L.; mo; fr; ca; pe;

ARALIACEAE
Hedera helix L. subsp. helix; ca;
Hedera hibernica (G. Kirchn.) Bean; mo; fr; ca; pe; ch;
Hedera maderensis subsp. iberica McAllister; mo; pe; ch;

ARISTOLOCHIACEAE
Aristolochia paucinervis Pomel; mo; fr; ca; pe; ch;

ASCLEPIADACEAE
Vincetoxicum nigrum (L.) Moench; pe;

ASTERACEAE
Achillea ageratum L.; ch;
Achillea millefolium L. subsp. millefolium; mo; fr; ca; pe; ch; sv; sm;
Achillea millefolium subsp. ceretanica (Sennen) Sennen; mo; fr; ca; pe; ch;
Andryala integrifolia L.; mo; fr; ca; pe; ch; sv; sm;
Andryala laxiflora DC.; pe;
Anthemis arvensis L.; mo; fr; ca; pe; ch; sv; sm;
Anthemis cotula L.; mo; pe;
Arctium minus Bernh.; mo; fr; pe;
Arnica montana subsp. atlantica A. Bolòs; mo;
Arnoseris minima (L.) Schweigger & Koerte; mo; fr; ca; pe; ch; sv; sm;
Artemisia vulgaris L.; mo; pe;
Bellis annua L.; mo;
Bellis perennis L.; mo; fr; ca; pe; ch; sv; sm;
Bellis sylvestris Cyrillo; mo;
Bidens frondosa L.; ca;
Calendula arvensis (Vaill.) L.; mo; fr; ca; pe; ch; sv; sm;
Calendula officinalis L.; mo; ca; pe; ch;
Carduus carpetanus Boiss. & Reut.; mo; fr; ca; pe; ch; sv;
Carduus nutans subsp. **platypus** (Lange) Greuter; mo; pe; ch;
Carduus pycnocephalus L.; mo; fr; ca; pe; ch; sv; sm;
Carduus tenuiflorus Curtis; mo; fr; ca; pe; ch; sv; sm;
Carlina corymbosa L.; mo; fr; ca; pe; ch; sv; sm;
Carlina racemosa L.; pe;
Carthamus lanatus L.; ch; sm;

Centaurea amblensis Graells; ch;
Centaurea aristata subsp. **langeana** (Willk.) Dostál; mo;
Centaurea benedicta (L.) L.; mo; pe; ch; sv; sm;
Centaurea calcitrapa L.; pe;
Centaurea herminii Rouy subsp. **herminii;** mo; pe; ch; sv; sm
Centaurea herminii subsp. **lusitana** (J. Arènes) Franco; mo; fr; ca;
Centaurea limbata Hoffmanns. & Link subsp. **limbata;** fr; ca;
Centaurea melanosticta (Lange) Franco; mo; ca; pe;
Centaurea melitensis L.; mo; ca; pe;
Centaurea micrantha Hoffmanns. & Link; mo; pe; ch; sv; sm;
Centaurea nigra subsp. **rivularis** (Brot.) Cout.; mo; fr; ca; pe; ch;
Centaurea ornata Willd. subsp. **ornata**; pe; sv;
Centaurea rothmaleriana (Arènes) Dostál; ca;
Chamaemelum fuscatum (Brot.) Vasc.; mo; pe; ch; sv; sm;
Chamaemelum nobile (L.) All.; mo; fr; ca; pe; ch; sv; sm;
Chondrilla juncea L.; mo; ca; pe; ch; sv; sm;
Cirsium arvense (L.) Scop.; mo;
Cirsium filipendulum Lange; mo; fr; ca;
Cirsium palustre (L.) Scop.; mo; fr; ca; pe; ch;
Cirsium vulgare (Savi) Ten.; mo; fr; ca; pe; ch; sv; sm;
Cladanthus mixtus (L.) Chevall.; mo; fr; ca; pe;
Coleostephus myconis (L.) Reichenb.; mo; fr; ca; pe; ch; sv; sm;
Cosmos bipinnatus Cav.; ca;
Crepis capillaris (L.) Wallr.; mo; fr; ca; pe; ch; sv; sm;
Crepis lampsanoides (Gouan) Tausch; mo; fr; ca; pe; ch;
Crepis vesicaria subsp. taraxacifolia (Thuill.) Thell.; mo; pe; ch; sv; sm;
Cyanus segetum Hill; mo;
Cynara cardunculus L.; mo; ca; pe;
Dittrichia graveolens (L.) Greuter; mo; ca; pe; ch; sv; sm;
Dittrichia viscosa (L.) Greuter; mo; ca; pe; ch; sv; sm;
Doronicum plantagineum L.; mo; pe;
Erigeron bonariensis L.; mo; fr; ca; pe; ch; sv; sm;
Erigeron canadensis L.; mo; fr; ca; pe; ch; sv; sm;
Erigeron karwinskianus DC.; mo; fr; ca;
Erigeron sumatrensis Retz.; mo; fr; ca; pe; ch; sv; sm;
Eupatorium cannabinum L.; mo; fr; ca;
Filago carpetana (Lange) Chrtek & Holub; mo; pe;
Filago gallica L.; mo; fr; ca; pe; ch; sv; sm;
Filago germanica (L.) Huds.; mo; pe; ch;
Filago lutescens subsp. atlantica Wagenitz; ca;
Filago lutescens Jord. subsp. lutescens; pe;
Filago minima (Sm.) Pers.; mo; fr; ca; pe; ch; sv; sm;
Filago pygmaea subsp. ramosissima (Mariz) R. Fern. & Nogueira; pe;
Gaillardia aristata Pursh; ch;
Galactites tomentosus Moench; mo; fr; ca; pe; ch; sv; sm;
Galinsoga parviflora Cav.; mo; fr; ca; pe; ch;
Galinsoga quadriradiata Ruiz & Pavón; mo; fr; ca; pe;
Glebionis segetum (L.) Fourr.; mo; fr; ca; pe; ch;
Gnaphalium americanum Mill.; ca;
Gnaphalium falcatum Lam.; mo; pe; ch;
Gnaphalium purpureum L.; mo;
Gnaphalium uliginosum L.; mo; fr; ca; pe; ch;
Hedypnois rhagadioloides (L.) F.W. Schmidt; mo; pe; sv;
Helianthus annuus L.; mo;
Helichrysum stoechas (L.) Moench; mo; pe; ch; sv; sm;
Helminthotheca echioides (L.) Holub; mo; ca;
Hieracium brevifolium Tausch; fr; ca;
Hieracium lachenalii Gmel.; pe; ch;
Hieracium sabaudum L.; fr;
Hieracium schmidtii Tausch; mo;
Hispidella hispanica Lam.; mo; fr; ca; pe; ch; sv; sm;
Hypochaeris glabra L.; mo; fr; ca; pe; ch; sv; sm;
Hypochaeris radicata L.; mo; fr; ca; pe; ch; sv; sm;
Inula conyzae (Griess) Meikle; ca;
Jacobaea vulgaris Gaertn.; mo; fr; ca; pe; ch; sv; sm;
Lactuca saligna L.; mo; pe; ch;
Lactuca serriola L.; mo; fr; ca; pe; ch; sv; sm;
Lactuca viminea subsp. chondrilliflora (Bor.) St.-Lag.; mo; pe; ch;
Lactuca viminea (L.) F.W. Schmidt subsp. viminea; mo; fr; ca; pe; ch; sv; sm;
Lactuca virosa L.; mo; fr; ca; pe; ch;
Laphangium luteoalbum (L.) Tzvelev; mo; fr; ca; pe; ch; sv; sm;
Lapsana communis L. subsp. communis; mo; fr; ca; pe; ch;
Leontodon saxatilis subsp. rothii Maire; mo; fr; pe;
Leontodon saxatilis Lam. subsp. saxatilis; mo; fr; ca; pe; ch; sv; sm;
Leontodon tuberosus L.; mo; ca;
Lepidophorum repandum (L.) DC.; mo; fr; ca;
Leucanthemopsis pulverulenta (Lag.) Heywood; fr; pe;
Leucanthemum ircutianum subsp. **pseudosylvaticum** Vogt; mo; pe; ch;
Leucanthemum sylvaticum (Brot.) Nyman; mo; fr; ca; pe; ch;
Leucanthemum vulgare (Vaill.) Lam.; fr;
Mantisalca salmantica (L.) Briq. & Cavillier; pe;
Matricaria discoidea DC.; mo; fr; ca; pe; ch; sv; sm;
Onopordum acanthium L.; mo; pe; ch;
Pallenis spinosa (L.) Cass.; pe;
Phagnalon saxatile (L.) Cass.; mo;
Phalacrocarpum oppositifolium (Brot.) Willk. subsp. **oppositifolium**; mo; fr; ca;
Picris hieracioides subsp. **longifolia** (Boiss. & Reut.) P.D. Sell; mo; fr; ca;
Pilosella castellana (Boiss. & Reut.) F.W. Schultz & Sch. Bip.; mo; fr; ca; pe; ch; sv; sm;

Pilosella officinarum Vaill.; mo; pe;
Pilosella pseudopilosella (Ten.) Soják; pe;
Pilosella vansoesti (de Retz) Mateo; mo; pe; sm;
Pulicaria arabica subsp. hispanica (Boiss.) Murb.; pe; ch;
Pulicaria odora (L.) Reichenb.; mo;
Reichardia intermedia (Sch. Bip.) Samp.; pe;
Scolymus hispanicus L.; pe; sv; sm;
Scorzonera angustifolia L.; mo; pe; ch; sv; sm;
Scorzoneroides autumnalis (L.) Moench; mo; fr;
Scorzoneroides cantabrica (Widder) Holub; mo; ca;
Senecio gallicus Vill.; mo; pe; ch;
Senecio lividus L.; mo; pe; ch; sv; sm;
Senecio sylvaticus L.; mo; fr; ca; pe; ch; sv; sm;
Senecio vulgaris L.; mo; fr; ca; pe; ch; sv; sm;
Serratula tinctoria subsp. seoanei (Willk.) M. Laínz; mo; fr; ca;
Silybum marianum (L.) Gaertn.; mo; pe; ch; sv; sm;
Solidago virgaurea L. subsp. virgaurea; mo; fr; ca; pe; ch;
Sonchus asper (L.) Hill subsp. asper; mo; fr; ca; pe; ch;
Sonchus asper subsp. glaucescens (Jordan) Ball; mo;
Sonchus oleraceus L.; mo; fr; ca; pe; ch; sv; sm;
Sonchus tenerrimus L.; mo; pe;
Symphyotrichum lanceolatum (Willd.) G.L. Nesom; ca;
Symphyotrichum squamatum (Spreng.) G.L. Nesom; mo; fr;
Tagetes patula L.; pe;
Tanacetum corymbosum (L.) Sch. Bip.; mo; fr; ca;
Tanacetum parthenium (L.) Sch. Bip.; mo; ca;
Tanacetum vulgare L.; mo; fr; ca;
Taraxacum adamii Claire; ca; pe;
Taraxacum duriense Soest; sm;
Taraxacum lacistophyllum (Dahlst.) Raunk.; mo; pe; ch; sv; sm;
Taraxacum nordstedtii Dahlst.; mo;
Taraxacum obovatum subsp. ochrocarpum Soest; mo; pe; sv;
Taraxacum sundbergii Dahlst.; mo; fr; ca; pe; ch; sv; sm;
Tolpis barbata (L.) Gaertner; mo; fr; ca; pe; ch; sv; sm;
Tolpis umbellata Bertol.; mo; fr; ca; pe; ch;
Tragopogon dubius Scop.; pe;
Urospermum picroides (L.) F.W. Schmidt; pe;
Xanthium orientale subsp. *italicum* (Moretti) Greuter; ca;
Xanthium spinosum L.; ch;
Zinnia elegans Jacq.; pe;

BALSAMINACEAE
Impatiens balfourii Hooker fil.; ca; pe;

BETULACEAE
Alnus glutinosa (L.) Gaertner; mo; fr; ca;
Betula celtiberica Rothm. & Vasc.; mo; fr; ca; pe; ch;
Betula pendula Roth subsp. pendula; ca;
Corylus avellana L.; mo; fr; ca; pe; ch;

BIGNONIACEAE
Catalpa bignonioides Walter; ca;

BORAGINACEAE
Anchusa arvensis (L.) M. Bieb.; mo; pe;
Anchusa undulata L.; mo; pe; ch;
Borago officinalis L.; ca;
Echium lusitanicum L.; mo; fr; ca; pe; ch; sv; sm;
Echium plantagineum L.; mo; fr; ca; pe; ch; sv; sm;
Echium rosulatum Lange; mo; fr; ca; pe; ch; sv; sm;
Echium vulgare L.; mo; pe; ch;
Heliotropium europaeum L.; mo; pe; ch; sv; sm;
Lithodora prostrata (Loisel.) Griseb.; mo; fr; ca;
Myosotis balbisiana Jordan; mo;
Myosotis debilis Pomel; ca;
Myosotis discolor Pers. subsp. discolor; mo; fr; ca; pe; ch;
Myosotis discolor subsp. dubia (Arrondeau) Blaise; mo; fr; ca; pe; ch; sv; sm;
Myosotis laxa subsp. caespitosa (C.F. Schultz) Nordh.; ca; pe;
Myosotis ramosissima Rochel; mo; ca;
Myosotis secunda A. Murray; mo; fr; ca; pe; ch; sv; sm;
Myosotis stolonifera subsp. hirsuta Schuster; mo; fr; ca; pe; ch;
Myosotis stolonifera (DC.) Leresche & Levier subsp. stolonifera; mo;
Myosotis welwitschii Boiss. & Reut.; mo; ca;
Omphalodes nitida Hoffmanns. & Link; mo; fr; ca; pe; ch;
Pentaglottis sempervirens (L.) L.H. Bailey; mo; fr; ca;

BRASSICACEAE
Alyssum granatense Boiss. & Reut.; mo; pe; ; sv; sm;
Alyssum minutum DC.; mo;
Alyssum simplex Rudolphi; mo; pe;
Arabidopsis thaliana (L.) Heynhold; mo; fr; ca; pe; ch; sv; sm;
Arabis juressi Rothm.; mo; fr;
Arabis stenocarpa Boiss. & Reut.; mo; fr; sm;
Barbarea vulgaris R. Br.; pe;
Biscutella valentina (L.) Heywood subsp. valentina; mo; pe; sv; sm;
Brassica barrelieri (L.) Janka; mo; fr; ca; pe; ch; sv; sm;
Brassica napus L.; mo; fr; ca; pe; ch;
Brassica oleracea L.; mo; fr; ca; pe; ch;
Bunias erucago L.; mo; pe; ch; sv; sm;
Camelina alyssum (Mill.) Thell.; mo;
Capsella bursa-pastoris (L.) Med.; mo; fr; ca; pe; ch; sv; sm;
Cardamine flexuosa With.; mo; ca;
Cardamine hirsuta L.; mo; fr; ca; pe; ch; sv; sm;
Coincya monensis subsp. cheiranthos (Vill.) Aedo & al.; mo; fr; ca; pe; ch; sv; sm;

Coincya monensis subsp. orophila (Franco) Aedo, Leadlay & Muñoz Garm.; mo; fr; ca;
Diplotaxis catholica (L.) DC.; mo;
Draba muralis L.; mo; pe; ch; sv; sm;
Draba verna L. subsp. verna ; mo; fr; ca; pe; ch; sv; sm;
Erysimum cheiri (L.) Crantz; pe;
Erysimum linifolium (Pers.) Gay; mo; pe; ch; sv; sm;
Hirschfeldia incana (L.) Lagr.-Foss.; mo; pe; ch; sv; sm;
Lepidium didymum L.; mo; pe;
Lepidium heterophyllum Benth.; mo; fr; ca; pe; ch; sv; sm;
Lepidium sativum L.; mo; pe; ch;
Lobularia maritima (L.) Desv.; pe;
Lunaria annua L.; mo; fr; ca; pe; ch;
Matthiola incana (L.) R. Br.; pe;
Murbeckiella sousae Rothm.; fr; ca;
Nasturtium officinale R. Br.; mo; fr; ca; pe; ch;
Raphanus raphanistrum subsp. microcarpus (Lange) Thell.; mo; fr; ca; pe; ch;
Raphanus raphanistrum L. subsp. raphanistrum; mo; fr; ca; pe; ch; sv; sm;
Raphanus sativus L.; mo; pe;
Sinapis alba L. subsp. alba; mo; pe;
Sisymbrella aspera (L.) Spach; pe;
Sisymbrium officinale (L.) Scop.; mo; fr; ca; pe; ch; sv; sm;
Teesdalia nudicaulis (L.) R. Br.; mo; fr; ca; pe; ch; sv; sm;

BUDDLEJACEAE
Buddleja davidii Franchet; ca;

BUXACEAE
Buxus sempervirens L.; mo;

CACTACEAE
Opuntia maxima Mill.; ca; sv;

CALLITRICHACEAE
Callitriche stagnalis Scop.; mo; fr; ca; pe; ch;

CAMPANULACEAE
Campanula erinus L.; pe;
Campanula lusitanica L.; mo; fr; ca; pe; ch; sv; sm;
Campanula rapunculus L.; mo; fr; ca; pe; ch; sv; sm
Jasione montana L.; mo; fr; ca; pe; ch; sv; sm;
Jasione sessiliflora Boiss. & Reut. subsp. **sessiliflora**; pe;
Lobelia urens L.; mo; fr; ca;
Legousia scabra (Lowe) Gamisans; mo;
Wahlenbergia hederacea (L.) Reichenb.; mo; fr; ca; pe; ch;

CANNABACEAE
Cannabis sativa L.; fr;
Humulus lupulus L.; Cannabaceae; ch;

CAPRIFOLIACEAE
Lonicera etrusca G. Santi; mo;
Lonicera periclymenum subsp. hispanica (Boiss. & Reut.) Nyman; mo;
Lonicera periclymenum L. subsp. periclymenum; mo; fr; ca; pe; ch;
Sambucus nigra L.; mo; fr; ca; pe; ch; sv; sm;
Viburnum tinus L.; fr; ca;

CARYOPHYLLACEAE
Agrostemma githago L.; mo; fr; pe;
Arenaria montana L.; mo; fr; ca; pe; ch; sv; sm;
Arenaria leptoclados (Reichenb.) Guss.; pe;
Arenaria querioides Willk. subsp. **querioides**; mo;
Arenaria serpyllifolia L.; pe;
Cerastium brachypetalum Pers.; mo; pe;
Cerastium diffusum Pers.; mo; fr; ca; pe; ch; sv; sm;
Cerastium fontanum subsp. vulgare (Hartman) Greuter & Burdet; mo; fr; ca; pe; ch;
Cerastium glomeratum Thuill.; mo; fr; ca; pe; ch; sv; sm;
Cerastium ramosissimum Boiss.; mo; pe; ch;
Chaetonychia cymosa (L.) Willk.; mo; fr; pe;
Corrigiola littoralis L.; mo; fr; ca; pe; ch; sv; sm;
Corrigiola telephiifolia Pourr.; mo; pe;
Cucubalus baccifer L.; pe;
Dianthus hyssopifolius L.; fr;
Dianthus langeanus Willk.; fr;
Dianthus laricifolius Boiss. & Reut. subsp. **laricifolius**; mo; fr; ca;
Dianthus lusitanus Brot.; mo; fr; ca; pe; ch; sv; sm;
Herniaria hirsuta L.; mo; pe;
Herniaria lusitanica Chaudhri subsp. **lusitanica**; mo; fr; ca; pe; ch;
Herniaria scabrida Boiss.; mo; fr; ca; pe; ch; sv; sm;
Holosteum umbellatum L.; pe;
Illecebrum verticillatum L.; mo; fr; ca; pe; ch; sv; sm;
Lychnis coronaria (L.) Desr.; mo; ; ca; pe; ch;
Minuartia hybrida (Vill.) Schischkin; pe;
Moehringia pentandra Gay; mo; pe; ch; sm;
Moenchia erecta (L.) P. Gaertner, B. Meyer & Scherb.; mo; fr; ca; pe; ch; sv; sm;
Ortega hispanica L.; mo; pe; ch; sv; sm;
Paronychia argentea Lam.; mo; pe; ch;
Petrorhagia dubia (Rafin.) G. López & Romo; pe;
Petrorhagia nanteuilii (Burnat) Heywood & P.W. Ball; mo; fr; ca; pe; ch; sv; sm;
Polycarpon tetraphyllum L.; mo; fr; ca; pe; ch; sv; sm;
Sagina apetala Ard.; mo; fr; ca; pe; ch; sv; sm;
Sagina procumbens L.; mo; fr; ca; pe; ch;
Sagina subulata (Swartz) K. Presl; mo; ca;
Saponaria officinalis L.; mo; fr; ca; pe; ch;
Scleranthus annuus L.; mo; fr; ca; pe; ch; sv; sm;
Scleranthus polycarpos L.; mo; fr; ca; pe; ch; sv; sm;
Silene acutifolia Rohrb.; mo; fr; ca;

Silene armeria L.; mo; ca;
Silene coutinhoi Rothm. & P. Silva; fr; ch;
Silene gallica L.; mo; fr; ca; pe; ch; sv; sm;
Silene laeta (Aiton) Godron; mo; ; ca; pe; ch;
Silene latifolia Poiret; mo; fr; ca; pe; ch;
Silene marizii Samp.; mo; fr; ca; pe; ch;
Silene nutans L.; mo; fr; ca; pe; ch;
Silene portensis L.; mo; pe; ch;
Silene psammitis Sprengel; mo;
Silene scabriflora Brot.; mo; ca; pe; ch;
Silene vulgaris (Moench.) Garcke; mo; pe; ch; sv; sm;
Spergula arvensis L.; mo; fr; ca; pe; ch; sv; sm;
Spergula morisonii Boreau; mo; fr; ca; pe; ch; sv; sm;
Spergularia capillacea (Kindb.) Willk.; mo; fr; ca; pe; ch;
Spergularia purpurea (Pers.) G. Don fil.; mo; fr; ca; pe; ch; sv; sm;
Stellaria alsine Grimm; mo; fr; ca; pe; ch;
Stellaria graminea L.; mo; fr; ca; pe; ch;
Stellaria holostea L.; mo; fr; ca; pe; ch;
Stellaria media (L.) Vill.; mo; fr; ca; pe; ch; sv; sm;

CHENOPODIACEAE
Atriplex rosea L.; mo; pe; ch;
Bassia scoparia (L.) Voss.; pe;
Chenopodium album L.; mo; fr; ca; pe; ch; sv; sm;
Chenopodium ambrosioides L.; mo; pe; ch;
Chenopodium botrys L.; pe; ch; sv;
Chenopodium glaucum L.; mo;
Chenopodium murale L.; mo; pe; ch;

CISTACEAE
Cistus ×candidus nothosubsp. tomentosus Demoly; mo;
Cistus crispus L.; mo; pe; ch; sv; sm;
Cistus ladanifer L.; mo; pe; ch; sv; sm;
Cistus populifolius L.; mo; pe; ch;
Cistus psilosepalus Sweet; mo; fr; ca; pe; ch;
Cistus salviifolius L.; mo; pe; ch; sv; sm;
Halimium lasianthum subsp. alyssoides (Lam.) Greuter; mo; fr; ca; pe; ch; sv; sm;
Halimium ocymoides (Lam.) Willk.; mo; fr; ca; pe; ch;
Halimium umbellatum (L.) Spach subsp. umbellatum; mo; fr; ca;
Halimium umbellatum subsp. viscosum (Willk.) O Bolòs & Vigo; mo; pe; sv; sm;
Helianthemum aegyptiacum (L.) Mill.; pe; sv; sm;
Helianthemum nummularium (L.) Mill.; mo; fr; ca; pe; ch;
Helianthemum salicifolium (L.) Mill.; pe;
Tuberaria globulariifolia (Lam.) Willk.; mo; fr; ca;
Tuberaria guttata (L.) Fourr.; mo; fr; ca; pe; ch; sv; sm;
Tuberaria lignosa (Sweet) Samp.; mo; pe;

CONVOLVULACEAE
Calystegia sepium (L.) R. Br.; mo; ca;
Calystegia silvatica (Kit.) Griseb.; ca;
Convolvulus arvensis L.; mo; fr; ca; pe; ch; sv; sm;
Cuscuta approximata Bab.; ca;
Cuscuta epithymum (L.) L.; mo; fr; ca; pe; ch; sv; sm;
Ipomoea indica (Burm.) Merrill; ca;

CRASSULACEAE
Sedum acre L.; pe;
Sedum album L.; mo;
Sedum amplexicaule DC.; ch;
Sedum andegavense (DC.) Desv.; mo;
Sedum anglicum subsp. pyrenaicum (Lange) M. Laínz; mo; fr; ca;
Sedum arenarium Brot.; mo; fr; ca; pe; ch; sv; sm;
Sedum brevifolium DC.; mo; fr; ca; pe; ch; sv; sm;
Sedum dendroideum Mociño & Sessé; mo;
Sedum forsterianum Sm.; mo; fr; ca; pe; ch;
Sedum hirsutum All.; mo; fr; ca; pe; ch; sv; sm;
Sedum pedicellatum subsp. lusitanicum (Mariz) M. Laínz; mo;
Sedum pruinatum Brot.; fr;
Sedum villosum subsp. **aristatum** (Emb. & Maire) M. Laínz; mo; ca;
Tillaea muscosa L.; mo; fr; ca; pe; ch; sv; sm;
Tillaea vaillantii Willd.; mo;
Umbilicus heylandianus Webb & Berthel.; pe;
Umbilicus rupestris (Salisb.) Dandy; mo; fr; ca; pe; ch; sv; sm;

CUCURBITACEAE
Bryonia dioica Jacq.; mo; fr; ca; pe; ch;
Cucurbita ficifolia Bouché; ch;
Cucurbita pepo L.; ca;
Ecballium elaterium (L.) A. Rich; pe;

DIPSACACEAE
Knautia nevadensis (Szabó) Szabó; mo;
Pterocephalidium diandrum (Lag.) G. López; mo; pe; ch; sv; sm;
Scabiosa columbaria L.; mo;
Succisa pratensis Moench; mo;

DROSERACEAE
Drosera intermedia Hayne; fr;
Drosera rotundifolia L.; Droseraceae; mo; fr;

ELATINACEAE
Elatine macropoda Guss.; pe;

ERICACEAE
Arbutus unedo L.; mo; fr; ca; pe; ch;
Calluna vulgaris (L.) Hull; mo; fr; ca; pe; ch;
Erica arborea L.; mo; fr; ca; pe; ch; sv; sm

Erica australis subsp. **aragonensis** (Willk.) Cout.; mo; fr; ca;
Erica ciliaris L.; mo; fr; ca;
Erica cinerea L.; mo; fr; ca;
Erica erigena R. Ross; fr;
Erica scoparia L.; mo; fr;
Erica tetralix L.; mo; fr;
Erica umbellata L.; mo; fr; ca; pe; ch;
Rhododendron ponticum L.; fr; ca;
Vaccinium myrtillus L.; fr;

EUPHORBIACEAE
Chamaesyce canescens (L.) Prokh.; sv;
Chamaesyce maculata (L.) Small; mo;
Euphorbia amygdaloides L.; mo; fr; ca; pe;
Euphorbia dulcis L.; mo; fr; ca; pe; ch;
Euphorbia helioscopia L.; mo; fr; pe; ch; sv; sm;
Euphorbia oxyphylla Boiss.; mo; pe; ch;
Euphorbia peplus L.; mo; fr; ca; pe; ch; sv; sm;
Euphorbia segetalis L.; mo; pe; ch; sv; sm;
Mercurialis ambigua L. fil.; mo; fr; ca; pe; ch; sv; sm;

FABACEAE
Acacia dealbata Link;; mo; fr; ca; pe; ch;
Acacia melanoxylon Link; mo; ca; pe; ch;
Adenocarpus complicatus (L.) J. Gay; mo; fr; ca; pe; ch;
Adenocarpus lainzii (Castrov.) Castrov.; mo; ca;
Anthyllis cornicina L.; pe;
Anthyllis lotoides L.; mo; fr; ca; pe; ch; sv; sm;
Anthyllis vulneraria subsp. gandogeri (Sagorski) Maire; pe;
Astragalus cymbaecarpos Brot.; mo; pe;
Astragalus glycyphyllos L.; pe;
Biserrula pelecinus L.; mo; pe; ch; sv; sm;
Bituminaria bituminosa (L.) C.H. Stirton; mo; pe; ch;
Cicer arietinum L.; mo;
Coronilla repanda subsp. dura (Cav.) Cout.; mo; pe;
Coronilla scorpioides (L.) W.D.J. Koch; mo; pe; sv; sm;
Cytisus grandiflorus (Brot.) DC.; mo; pe; ch;
Cytisus multiflorus (L'Hér.) Sweet; mo; fr; ca; pe; ch; sv; sm;
Cytisus scoparius (L.) Link subsp. scoparius; mo; fr; ca; pe; ch;
Cytisus striatus (Hill) Rothm.; mo; fr; ca; pe; ch; sv; sm;
Dorycnopsis gerardi (L.) Boiss.; mo;
Echinospartum ibericum Rivas Mart., Sánchez-Mata & Sancho; mo; pe; ch;
Genista anglica L.; mo; pe;
Genista berberidea Lange; ca;
Genista cinerascens Lange; mo; pe;
Genista falcata Brot.; mo; fr; ca; pe; ch;
Genista florida subsp. **polygalaephylla** (Brot.) Cout.; mo; fr; ca; pe; ch;
Genista micrantha Gómez Ortega; mo; pe;
Genista obtusiramea Spach; mo;
Genista triacanthos Brot.; mo; fr; ca; pe; ch;
Lathyrus angulatus L.; mo; fr; ca; pe; ch; sv; sm;
Lathyrus cicera L.; mo; pe;
Lathyrus clymenum L.; pe;
Lathyrus linifolius (Reichard) Bässler; fr;
Lathyrus niger (L.) Bernh.; mo;
Lathyrus odoratus L.; pe;
Lathyrus setifolius L.; pe;
Lathyrus sphaericus Retz.; mo; pe; ch; sv; sm;
Lathyrus sylvestris L.; mo; fr; ca; pe; ch; sv; sm;
Lotus castellanus Boiss. & Reut.; sm;
Lotus conimbricensis Brot.; mo; pe; sv;
Lotus corniculatus subsp. **carpetanus** (Lacaita) Rivas Mart.; mo; fr; ca; pe; ch; sv; sm;
Lotus pedunculatus Cav.; mo; fr; ca; pe; ch;
Lupinus albus L.; mo; ca;
Lupinus angustifolius L.; mo; pe; ch; sv; sm;
Lupinus gredensis Gand.; mo; ca; pe; ch;
Lupinus luteus L.; mo; fr; ca; pe; ch; sv; sm;
Medicago arabica (L.) Huds.; mo; pe; ch;
Medicago italica (Miller) Fiori; sm;
Medicago littoralis Loisel.; sm;
Medicago lupulina L.; mo; fr; ca; pe; ch; sv; sm;
Medicago minima var. brevispina Benth.; pe;
Medicago minima (L.) L. var. minima; mo; pe; ch; sv; sm;
Medicago polymorpha L.; mo; fr; ca; pe; ch; sv; sm;
Medicago rigidula (L.) All.; sv;
Medicago truncatula Gaertner; pe; sm;
Melilotus officinalis (L.) Pall.; mo;
Ononis spinosa subsp. australis (Širj.) Greuter & Burdet; mo; pe; ch; sv; sm;
Ononis spinosa L. subsp. spinosa; mo; pe; ch;
Ornithopus compressus L.; mo; fr; ca; pe; ch; sv; sm;
Ornithopus perpusillus L.; mo; fr; ca; pe; ch; sv; sm;
Ornithopus pinnatus (Mill.) Druce; mo; fr; ca; pe; ch; sv; sm;
Ornithopus sativus Brot. subsp. sativus; mo; fr; ca; pe; ch;
Pterospartum cantabricum (Spach) Willk.; mo; fr; ca;
Pterospartum lasianthum (Spach) Willk.; mo;
Pterospartum tridentatum (L.) Willk.; ca;
Retama sphaerocarpa (L.) Boiss.; sv;
Robinia pseudacacia L.; mo; ca; sm;
Trifolium angustifolium L.; mo; fr; ca; pe; ch; sv; sm;
Trifolium arvense L.; mo; fr; ca; pe; ch; sv; sm;
Trifolium campestre Schreber; mo; fr; ca; pe; ch; sv; sm;
Trifolium cernuum Brot.; mo; fr; ca; pe; ch;
Trifolium cherleri L. ; mo; pe; ch; sv; sm;
Trifolium diffusum Ehrh.; mo;
Trifolium dubium Sibth.; mo; fr; ca; pe; ch; sv; sm;

Trifolium gemellum Willd.; mo;
Trifolium glomeratum L.; mo; fr; ca; pe; ch; sv; sm;
Trifolium hirtum All.; mo; pe; sv; sm;
Trifolium incarnatum L.; mo; ca; pe; ch;
Trifolium ochroleucon Hudson; mo; pe;
Trifolium pratense L.; mo; fr; ca; pe; ch; sv; sm;
Trifolium repens L.; mo; fr; ca; pe; ch;
Trifolium scabrum L.; mo; pe; ch; sv; sm;
Trifolium stellatum L.; mo; pe; sv; sm;
Trifolium striatum L.; mo; pe;
Trifolium strictum L.; pe;
Trifolium subterraneum L.; mo; fr; ca; pe; ch;
Trifolium suffocatum L.; mo; pe;
Trifolium sylvaticum Loisel.; mo; pe; sv; sm;
Trifolium tomentosum L.; mo; ca; pe; ch; sv; sm;
Trigonella monspeliaca L.; pe;
Ulex europaeus subsp. **latebracteatus** (Mariz) Rothm.; mo; fr; ca; pe; ch;
Ulex micranthus Lange; mo; fr; ca;
Ulex minor Roth; mo; fr; ca; pe; ch;
Vicia angustifolia L.; mo; fr; ca; pe; ch;
Vicia benghalensis L.; mo; ; ca; pe; ch;
Vicia disperma DC.; mo; fr; ca; pe; ch; sv; sm;
Vicia hirsuta (L.) Gray; mo; fr; ca; pe;
Vicia lathyroides L.; pe; sv;
Vicia lutea L.; mo; pe; ch; sv; sm;
Vicia sativa L.; mo; fr; ca; pe; ch; sv; sm;
Vicia tenuifolia Roth; fr;
Wisteria sinensis (Sims) Sweet; ca;

FAGACEAE
Castanea crenata Siebold & Zucc.; ca;
Castanea sativa Miller; mo; fr; ca; pe; ch; sv; sm;
Fagus sylvatica L.; ca;
Quercus × andegavensis Hy (Q. robur × Q. pyrenaica); mo; fr; ca; pe;
Quercus × coutinhoi Samp. (Q. faginea × Q. robur); mo;
Quercus faginea Lam. subsp. **faginea**; mo; pe;
Quercus pyrenaica Willd.; mo; fr; ca; pe; ch;
Quercus robur L.; mo; fr; ca; pe;
Quercus rotundifolia Lam.; mo; fr; ca; pe; ch; sv; sm;
Quercus rubra L.; mo; fr; ca;
Quercus suber L.; mo; fr; ca; pe; ch;

FUMARIACEAE
Ceratocapnos claviculata (L.) Lidén subsp. claviculata; mo; fr; ca; pe;
Ceratocapnos claviculata subsp. **picta** (Samp.) Lidén; mo;
Fumaria bastardii Boreau; mo; ca; pe; ch;
Fumaria capreolata L.; mo; pe; ch;
Fumaria densiflora DC.; mo; pe; ch; sv; sm;
Fumaria muralis Koch; mo; fr; ca; pe; ch; sv; sm;
Fumaria officinalis L.; mo; pe;
Fumaria parviflora Lam.; mo; ca; pe; ch; sv; sm;
Fumaria reuteri Boiss.; mo; pe;
Hypecoum imberbe L.; pe;
Platycapnos spicata (L.) Bernh.; pe;

GENTIANACEAE
Centaurium erythraea Rafn; mo; pe; sv;
Cicendia filiformis (L.) Delarbre; ca;
Gentiana pneumonanthe L.; mo; fr; ca;

GERANIACEAE
Erodium botrys (Cav.) Bertol.; mo; fr; ca; pe; ch;
Erodium cicutarium (L.) L'Hér.; mo; fr; ca; pe; ch; sv; sm;
Erodium malacoides (L.) L'Hér.; mo; pe;
Erodium moschatum (L.) L'Hér.; mo; pe; ch; sm;
Geranium columbinum L.; mo; ca;
Geranium dissectum L.; mo; fr; ca; pe; ch;
Geranium lucidum L.; mo; fr; ca; pe; ch;
Geranium molle L.; mo; fr; ca; pe; ch; sv; sm;
Geranium purpureum Vill.; mo; fr; ca; pe; ch; sv; sm;
Geranium pusillum L.; pe;
Geranium pyrenaicum subsp. **lusitanicum** (Samp.) S. Ortiz; mo; fr; ca; pe; ch;
Geranium robertianum L.; mo; fr; ca; pe; ch;
Geranium rotundifolium L.; mo; fr; ca; pe; ch;

HALORAGACEAE
Myriophyllum alterniflorum DC.; mo;

HIPPOCASTANEACEAE
Aesculus hippocastanum L.; mo; ca; pe; sv;

HYDRANGEACEAE
Philadelphus coronarius L.; ca; pe;

HYPERICACEAE
Hypericum androsaemum L.; mo; fr; ca;
Hypericum calycinum L.; ca;
Hypericum elodes L.; mo;
Hypericum humifusum L.; mo; fr; ca; pe; ch; sv; sm;
Hypericum linariifolium var. **parviflorum** Lange; mo; fr; ca; pe; ch; sv; sm;
Hypericum perforatum L.; mo; fr; ca; pe; ch; sv; sm;
Hypericum pulchrum L.; mo; fr;
Hypericum undulatum Willd.; mo; fr; ca; pe; ch;

JUGLANDACEAE
Juglans nigra L.; fr;

LAMIACEAE
Ajuga pyramidalis subsp. **meonantha** (Hoffmanns. & Link) R. Fern.; mo; fr; ca; pe; ch;

Ballota nigra subsp. foetida Hayek; mo; fr; ca; pe; ch;
Calamintha nepeta (L.) Savi subsp. nepeta; mo; fr; ca; pe; ch; sv; sm;
Clinopodium vulgare L. subsp. vulgare; mo; fr; ca; pe; ch; sv; sm;
Glechoma hederacea L.; mo; ca; pe;
Lamium amplexicaule L.; mo; fr; ca; pe; ch; sv; sm;
Lamium coutinhoi Garcia; mo; pe;
Lamium maculatum L.; mo; fr; ca; pe; ch;
Lamium purpureum L.; mo; fr; ca; pe; ch; sv; sm;
Lavandula stoechas subsp. **sampaioana** Rozeira; mo; pe; ch; sv; sm;
Marrubium vulgare L.; mo; pe; ch; sv; sm;
Melittis melissophyllum L.; mo; fr; ca; pe; ch;
Mentha pulegium L.; mo; fr; ca; pe; ch;
Mentha suaveolens Ehrh.; mo; fr; ca; pe; ch; sv; sm;
Origanum virens Hoffmanns. & Link; mo; fr; ca; pe; ch; sv; sm;
Prunella hastifolia Brot.; mo;
Prunella vulgaris L.; mo; fr; ca; pe; ch; sv; sm;
Rosmarinus officinalis L.; mo; ca;
Salvia microphylla Kunth; mo; pe; ch;
Salvia verbenaca L.; mo; pe; ch; sv; sm;
Scutellaria minor L.; mo; fr; ca; pe;
Stachys arvensis (L.) L.; mo; fr; ca; pe; ch; sv; sm;
Stachys officinalis (L.) Trevisan; mo; fr;
Teucrium salviastrum Schreber; mo; fr; ca;
Teucrium scorodonia L.; mo; fr; ca; pe; ch;
Thymus caespititius Brot.; mo; fr; ca;
Thymus mastichina (L.) L.; mo; pe;

LAURACEAE
Laurus nobilis L.; mo; fr; ca; pe; ch;

LENTIBULARIACEAE
Pinguicula lusitanica L.; fr; ca;

LINACEAE
Linum bienne Miller; mo; fr; ca; pe; ch; sv; sm;
Linum trigynum L.; mo;
Radiola linoides Roth; mo; fr; pe;

LYTHRACEAE
Lythrum hyssopifolia L.; ca;
Lythrum junceum Banks & Solander; mo;
Lythrum portula (L.) D.A. Webb; mo; ca; pe;
Lythrum salicaria L.; mo; pe;

MALVACEAE
Alcea rosea L.; mo; fr; ca; pe; sv;
Malva neglecta Wallr.; mo; fr; ca; pe; ch; sv; sm
Malva nicaeensis All.; ca;
Malva pseudolavatera Webb & Berth.; mo; ; ca; pe; ch;
Malva sylvestris L.; pe;
Malva tournefortiana L.; mo; fr; ca; pe; ch; sv; sm

MENYANTHACEAE
Menyanthes trifoliata L.; mo; pe;

MONOTROPACEAE
Monotropa hypopitys L.; mo; ca;

MORACEAE
Ficus carica L.; mo; fr; ca; pe; ch; sv; sm;

MYRTACEAE
Eucalyptus camaldulensis Dehnh.; mo; sv;
Eucalyptus globulus Labill. subsp. *globulus*; mo; fr; ca;
Eucalyptus robusta Sm.; mo;
Myrtus communis L.; mo; pe;

NYCTAGINACEAE
Mirabilis jalapa L.; mo; pe; ch;

OLEACEAE
Fraxinus angustifolia Vahl; mo; fr; ca; pe; ch;
Fraxinus excelsior L.; pe;
Jasminum fruticans L.; mo; pe;
Ligustrum vulgare L.; fr;
Olea europaea L. var. *europaea*; mo; pe; ch; sv; sm;
Olea europaea var. sylvestris (Mill.) Lehr.; mo; pe;
Phillyrea angustifolia L.; mo; pe;
Syringa vulgaris L.; pe;

ONAGRACEAE
Circaea lutetiana L.; fr;
Epilobium hirsutum L.; ca;
Epilobium lanceolatum Sebast. & Mauri; mo; fr; ca;
Epilobium obscurum Schreb.; mo; fr; ca;
Epilobium tetragonum L.; ca;
Oenothera biennis L.; mo; ca; pe; ch;
Oenothera glazioviana Micheli; Onagraceae; ca;
Oenothera stricta Link; ca;

OROBANCHACEAE
Orobanche gracilis Sm.; mo; fr; ca; pe; ch;
Orobanche minor Sm.; mo; fr; ca; pe; ch;
Orobanche ramosa subsp. nana (Reut.) Cout.; mo; pe;
Orobanche rapum-genistae Thuill.; mo; fr; ca; pe; ch; sv; sm;

OXALIDACEAE
Oxalis articulata Savigny; mo;
Oxalis corniculata L.; mo; fr; ca; pe; ch;
Oxalis debilis Kunth; ca;
Oxalis pes-caprae L.; ca;
Oxalis purpurea L.; pe;

PAEONIACEAE
Paeonia broteroi Boiss. & Reut.; pe;

PAPAVERACEAE
Chelidonium majus L.; mo; fr; ca; pe; ch; sv; sm;
Eschscholzia californica Cham.; mo; fr; ca; pe; ch;
Papaver argemone L.; mo; pe; ch; sv; sm;
Papaver dubium L.; mo; pe; ch; sv; sm;
Papaver hybridum L.; sm;
Papaver rhoeas L.; mo; fr; ca; pe; ch; sv; sm;
Papaver somniferum L. subsp. somniferum; mo; fr; ca; pe; ch;

PHYTOLACCACEAE
Phytolacca americana L.; mo; fr; ca; pe; ch;

PLANTAGINACEAE
Plantago afra L.; mo; pe;
Plantago bellardii All.; mo; pe; ch; sv; sm;
Plantago coronopus L. subsp. coronopus; mo; fr; ca; pe; ch; sv; sm
Plantago holosteum Scop.; mo;
Plantago lagopus L.; mo; pe;
Plantago lanceolata L.; mo; fr; ca; pe; ch; sv; sm;
Plantago loeflingii L.; pe;
Plantago major L.; mo; fr; ca; pe; ch; sv; sm;

PLATANACEAE
Platanus orientalis var. *acerifolia* Aiton; mo; fr; ca; pe; ch; sv;

PLUMBAGINACEAE
Armeria beirana Franco; mo; fr; ca; pe; ch; sv; sm;
Armeria x francoi Costa & Capelo; mo; pe;
Armeria transmontana (Samp.) Lawrence; mo; ca; pe; ch;

POLYGALACEAE
Polygala microphylla L.; mo; fr; ca;
Polygala monspeliaca L.; ca;
Polygala serpyllifolia J.A.C. Hose; mo; fr; ca;
Polygala vulgaris L.; mo; fr; ca; pe; ch; sv; sm;

POLYGONACEAE
Fallopia convolvulus (L.) Á. Löve; mo; fr; ca; pe; ch; sv; sm;
Persicaria capitata (D. Don) H. Gross; mo; ca;
Persicaria hydropiper (L.) Spach; mo; pe;
Persicaria lapathifolia (L.) S.F. Gray; mo; pe;
Persicaria maculosa S.F. Gray; mo; fr; ca; pe; ch; sv; sm
Persicaria orientalis (L.) Spach; pe;
Polygonum arenarium subsp. pulchellum (Loisel.) Thell.; pe;
Polygonum arenastrum Boreau var. arenastrum; mo; fr; ca; pe; ch; sv; sm;
Polygonum arenastrum var. microspermum (Boreau) Franco & Rocha Afonso; mo; fr; ca; pe; ch;
Polygonum aviculare L.; mo; fr; ca; pe; ch; sv; sm;
Polygonum rurivagum Boreau; mo; ca;
Rumex acetosa L. subsp. acetosa; mo; ca; pe;
Rumex acetosella subsp. angiocarpus (Murb.) Murb.; mo; fr; ca; pe; ch; sv; sm;
Rumex bucephalophorus subsp. gallicus (Steinh.) Rech. f.; mo; fr; ca; pe; ch; sv; sm;
Rumex conglomeratus Murray; mo; ca;
Rumex crispus L.; mo; fr; ca; pe;
Rumex induratus Boiss. & Reut.; mo; fr; ca; pe; ch; sv; sm;
Rumex obtusifolius L.; mo; fr; ca; pe; ch;
Rumex papillaris Boiss. & Reut.; mo; pe; ch;
Rumex pulcher subsp. woodsii (De Not.) Arcangeli; mo; pe; ch; sv; sm;

PORTULACACEAE
Claytonia perfoliata Willd.; pe;
Montia fontana subsp. amporitana Sennen; mo; fr; ca; pe; sm;
Montia fontana subsp. chondrosperma (Fenzl) Walters; mo; fr; ca; pe; ch;
Portulaca oleracea L. subsp. oleracea; ca; pe;

PRIMULACEAE
Anagallis arvensis L.; mo; ca; pe;
Anagallis tenella (L.) L.; mo; fr; ca; pe;
Asterolinon linum-stellatum (L.) Duby; mo; fr; ca; pe; ch; sv; sm;
Lysimachia vulgaris L.; mo; fr;
Primula acaulis (L.) L.; mo; fr; ca; pe;

RAFFLESIACEAE
Cytinus hypocistis subsp. macranthus Wettst.; mo; fr; ca; pe; ch;

RANUNCULACEAE
Anemone trifolia subsp. **albida** (Mariz) Ulbr.; mo; fr; ca;
Aquilegia vulgaris subsp. **dichroa** (Freyn) T.E. Díaz; mo; fr; ca;
Aquilegia vulgaris L. subsp. vulgaris; ca;
Caltha palustris var. minor (Mill.) DC.; mo; fr; ca;
Clematis campaniflora Brot.; pe;
Clematis vitalba L.; mo; fr; pe;
Consolida ajacis (L.) Schur; mo; fr; ca; pe; ch;
Consolida hispanica (Costa) Greuter & Burdet; pe;
Delphinium gracile DC.; pe;
Delphinium halteratum subsp. verdunense (Balbis) Graebner & Graebner fil.; pe;

Delphinium staphisagria L.; pe;
Helleborus foetidus L.; mo; fr;
Ranunculus aquatilis L.; mo;
Ranunculus arvensis L.; mo; ca;
Ranunculus baudotii Godron; mo; ca;
Ranunculus bulbosus var. adscendens (Brot.) P. Silva; mo; fr; ca; pe; ch;
Ranunculus bulbosus var. gallaecicus (Willk.) G. López; mo; fr;
Ranunculus bulbosus var. hispanicus Freyn; mo;
Ranunculus bupleuroides Brot.; mo; fr; ca;
Ranunculus ficaria L.; mo; fr; ca; pe; ch;
Ranunculus flammula L.; mo; fr; ca; pe; ch;
Ranunculus gregarius Brot.; mo; pe; ch;
Ranunculus hederaceus L.; mo; fr; ca; pe; ch;
Ranunculus henriquesii Freyn; mo; pe; sm;
Ranunculus muricatus L.; mo; fr; ca; pe;
Ranunculus nigrescens Freyn; mo; fr; ca;
Ranunculus olissiponensis Pers.; mo; fr; ca; pe; ch; sv; sm;
Ranunculus ololeucos Lloyd; mo; fr; ca; pe; ch;
Ranunculus omiophyllus Ten.; mo; ca; pe;
Ranunculus paludosus Poiret; mo; ; ca; pe;
Ranunculus parviflorus L.; pe;
Ranunculus peltatus Schrank; mo; ca; pe;
Ranunculus repens var. **petiolatus** Merino; mo; fr; ca; pe; ch;
Ranunculus saniculifolius Viv.; mo;
Ranunculus trilobus Desf.; pe;
Ranunculus tripartitus DC.; mo;
Thalictrum speciosissimum L.; mo; fr; ca; pe; ch;

RESEDACEAE
Reseda luteola L.; mo; pe; ch; sv; sm;
Reseda media Lag.; mo; fr; ca; pe;
Sesamoides purpurascens (L.) G. López; mo; fr; ca; pe; ch; sv; sm;
Sesamoides suffruticosa (Lange) Kuntze; mo; fr; ca; pe; ch;

RHAMNACEAE
Frangula alnus Miller;; mo; fr; ca; pe; ch;

ROSACEAE
Aphanes australis Rydb.; mo; fr; ca; pe; ch; sv; sm;
Aphanes cornucopioides Lag.; sv;
Cotoneaster horizontalis Decne; ca;
Crataegus monogyna Jacq.; mo; fr; ca; pe; ch; sv; sm;
Fragaria vesca L.; mo; fr; ca; pe; ch;
Geum sylvaticum Pourr.; mo; sm;
Geum urbanum L.; mo; ca;
Malus domestica (Borkh.) Borkh.; mo; fr; ca; pe; ch;
Potentilla erecta (L.) Raeuschel var. erecta; mo; fr; ca; pe; ch; sv; sm;
Potentilla erecta var. **herminii** (Ficalho) Cout. ; mo; fr; ca; pe; ch;
Prunus avium L.; mo; fr;
Prunus domestica L.; mo; pe; ch; sv; sm;
Prunus dulcis (Mill.) D.A. Webb; mo; pe; ch;
Prunus insititia L.; mo; pe; ch;
Prunus laurocerasus L.; ca;
Prunus lusitanica L.; fr;
Prunus spinosa L.; mo; pe;
Pyracantha angustifolia (Franch.) C.K. Schneid.; mo; ca;
Pyracantha coccinea M. Roem.; mo; ca;
Pyrus bourgaeana Decne; mo; pe;
Pyrus communis L.; mo;
Pyrus cordata Desv.; mo; fr; ca; pe;
Rosa agrestis Savi; mo;
Rosa canina L.; mo; pe; ch; sm;
Rosa corymbifera Borkh.; mo; pe;
Rosa dumalis Bechst.; pe;
Rosa micrantha Sm.; mo; fr; ca; pe; ch; sv; sm;
Rosa pouzinii Tratt.; mo; fr; pe;
Rosa squarrosa (A. Rau) Boreau; mo;
Rubus beirensis Samp.; mo; ca; pe; ch;
Rubus brigantinus Samp.; mo; ca; pe;
Rubus canescens DC.; ca; pe;
Rubus castellarnaui Pau; mo; fr; ca; pe; ch;
Rubus castroviejoi Monasterio-Huelin; ca;
Rubus galloecicus Pau; mo;
Rubus gerezianus (Samp.) Samp.; pe;
Rubus idaeus L.; mo; ca;
Rubus henriquesii Samp.; mo; fr; ca; pe; ch;
Rubus lainzii H.E. Weber; mo; pe; ch;
Rubus peratticus Samp.; mo; fr; ; pe; ch;
Rubus praecox Bertol.; mo; fr;
Rubus radula Weihe; mo; fr; ca; pe; ch;
Rubus sampaioanus Samp.; mo; fr; ca; pe;
Rubus ulmifolius Schott ; mo; fr; ca; pe; ch; sv; sm;
Rubus vagabundus Samp.; mo; fr; ch;
Rubus vigoi R. Roselló, Peres & Stübing; mo; ca;
Sanguisorba minor Scop.; mo;
Sanguisorba verrucosa (G. Don) Ces.; mo; fr; ca; pe; ch; sv; sm;
Sorbus aria (L.) Crantz; mo; ca; pe;
Sorbus aucuparia L.; mo; ca;
Sorbus latifolia (Lam.) Pers.; pe;

RUBIACEAE
Crucianella angustifolia L.; mo; pe;
Cruciata glabra subsp. hirticaulis (Beck) Natali & Jeanm.; mo; fr; ca; pe;
Cruciata laevipes var. chersonensis (Willd.) Devesa & al.; mo;
Cruciata pedemontana (All.) Ehrend.; mo; pe; ch; sv; sm;

Galium aparine L. subsp. aparine; mo; ca; pe;
Galium aparine subsp. aparinella (Lange) Jauzein; ch;
Galium aparine subsp. spurium (L.) Hartm.; mo; pe; ch;
Galium belizianum Ort. Oliv. & al.; mo; fr; ca;
Galium broterianum Boiss. & Reut.; mo; fr; ca; pe; ch;
Galium debile Desv.; pe;
Galium mollugo subsp. erectum Syme; mo; ; ca; pe; ch;
Galium mollugo L. subsp. mollugo; mo; fr; ca; pe; ch; sv; sm;
Galium palustre L. subsp. palustre var. elongatum (C. Presl.) Rchb. fil.; ca;
Galium palustre L. subsp. palustre var. palustre; mo; fr; pe;
Galium papillosum subsp. helodes (Hoffmanns. & Link) Ortega Oliv & Devesa; mo; fr; ca; pe;
Galium parisiense subsp. divaricatum (Lam.) Rouy & Camus; mo; fr; pe;
Galium parisiense L. subsp. parisiense; mo; fr; ca; pe; ch; sv; sm;
Galium rotundifolium L.; mo;
Galium saxatile L. subsp. saxatile; mo; ca;
Galium saxatile subsp. **vivianum** (Kliphius) Ehrend.; mo; fr; ca; pe; ch;
Galium verum L. subsp. verum; pe;
Rubia peregrina L.; mo; fr; ca; pe; ch; sv; sm;
Sherardia arvensis L.; mo; fr; ca; pe; ch; sv; sm;

RUTACEAE
Ruta chalepensis L.; ca; ch;
Ruta montana (L.) L.; mo; pe; ch; sv;

SALICACEAE
Populus alba L.; mo;
Populus nigra L.; pe;
Salix atrocinerea Brot.; mo; fr; ca; pe; ch; sv; sm;
Salix babylonica L.; pe; ch;
Salix salviifolia Brot.; mo; ca; pe; ch;

SANTALACEAE
Osyris alba L.; mo; pe; ch; sv; sm;
Thesium humifusum DC.; mo; fr; pe; ch;
Thesium pyrenaicum Pourr.; mo;

SAXIFRAGACEAE
Bergenia crassifolia (L.) Fritsch; mo; ca;
Chrysosplenium oppositifolium L.; mo;
Saxifraga fragosoi Sennen; mo; pe; ch; sv;
Saxifraga granulata L.; mo; fr; ca; pe; ch; sv; sm;
Saxifraga lepismigena Planellas; mo; fr; ca;
Saxifraga spathularis Brot.; mo; fr; ca;
Saxifraga stolonifera Meerb.; pe;

SCROPHULARIACEAE
Anarrhinum bellidifolium (L.) Willd.; mo; fr; ca; pe; ch; sv; sm;
Anarrhinum duriminium (Brot.) Pers.; mo; fr; pe;
Anarrhinum longipedicellatum R. Fernandes; mo; fr;
Antirrhinum graniticum Rothm.; mo; pe; ch;
Antirrhinum majus L.; mo;
Antirrhinum meonanthum Hoffmanns. & Link; pe;
Bartsia trixago L.; mo; fr; ; pe; ch; sv; sm;
Cymbalaria muralis G. Gaertner, B. Meyer & Scherb.; mo; ca; pe; ch;
Digitalis amandiana Samp.; mo; pe; ch;
Digitalis purpurea L. subsp. purpurea; mo; fr; ca; pe; ch; sv; sm;
Digitalis thapsi L.; mo; ; ca; pe; ch;
Linaria aeruginea (Gouan) Cav.; mo; pe; ch;
Linaria amethystea (Vent.) Hoffmanns. & Link; mo; pe;
Linaria elegans Cav.; mo; fr; ca; pe; ch; sv; sm;
Linaria incarnata (Vent.) Sprengel; pe;
Linaria saxatilis (L.) Chaz.; mo; fr; ca; pe; ch; sv; sm;
Linaria spartea (L.) Chaz.; mo; fr; ca; pe; ch; sv; sm;
Linaria triornithophora (L.) Cav.; mo; fr; ca; pe; ch;
Melampyrum pratense subsp. latifolium Schübl. & G. Martens; mo; ca; pe;
Misopates orontium (L.) Rafin.; mo; fr; ca; pe; ch; sv; sm;
Odontitella virgata (Link) Rothm.; mo; pe; sm;
Odontites vernus (Bellardi) Dumort.; mo;
Parentucellia latifolia (L.) Caruel; mo; fr; ca; pe; ch; sv; sm;
Parentucellia viscosa (L.) Caruel; mo; fr; ca; pe; ch; sv; sm;
Pedicularis sylvatica subsp. **lusitanica** (Hoffmanns. & Link) Cout.; mo; fr; ca; pe; ch;
Rhinanthus minor L.; mo; pe;
Scrophularia auriculata L.; mo; fr;
Scrophularia canina L.; pe;
Scrophularia herminii Hoffmanns. & Link; mo;
Scrophularia scorodonia L.; mo; fr; ca; pe; ch;
Scrophularia sublyrata Brot.; mo; fr; ca; pe;
Sibthorpia europaea L.; mo; fr; ca; pe; ch;
Verbascum pulverulentum Villars; mo; ca; pe; ch; sm;
Verbascum simplex Hoffmanns. & Link; mo; fr; ca; pe; ch; sv; sm;
Verbascum virgatum Stokes; mo; fr; ca; pe; ch; sm;
Veronica anagallis-aquatica L.; mo; fr; ca; pe; ch;
Veronica arvensis L.; mo; fr; ca; pe; ch; sv; sm;
Veronica cymbalaria Bodard; pe;
Veronica hederifolia L.; mo; ca; pe; ch;
Veronica linkiana Franco; pe;
Veronica micrantha Hoffmanns. & Link; mo; ca; ch;
Veronica montana L.; mo;
Veronica officinalis L.; mo; fr; ca; pe; ch;
Veronica persica Poiret; mo; ca; pe; ch;
Veronica scutellata L.; mo;
Veronica serpyllifolia L.; mo; ca; pe;

SIMAROUBACEAE
Ailanthus altissima (Miller) Swingle; mo; fr; ca; pe; ch; sv; sm;

SOLANACEAE
Datura stramonium L.; mo; fr; ca; pe; ch; sv; sm;
Hyoscyamus niger L.; mo; sm;
Petunia x hybrida (Hook.) Vilm.; mo; pe; ch;
Solanum chenopodioides Lam.; mo; ca;
Solanum dulcamara L.; mo; fr; ca; pe; ch;
Solanum laciniatum Aiton; fr;
Solanum nigrum L.; mo; fr; ca; pe; ch; sv; sm;
Solanum pseudocapsicum L.; mo; ca; pe; ch;
Solanum tuberosum L.; mo; fr; ca; pe; ch; sv; sm;

THYMELAEACEAE
Daphne gnidium L.; mo; fr; ca; pe; ch; sv; sm;

TILIACEAE
Tilia x vulgaris Hayne; mo;

TROPAEOLACEAE
Tropaeolum majus L.; pe;

ULMACEAE
Celtis australis L.; mo; pe;
Ulmus glabra Huds.; mo; ca;
Ulmus minor Miller; pe; ch;

URTICACEAE
Parietaria judaica L.; mo; ca; pe;
Parietaria lusitanica L.; mo; pe; ch; sv;
Soleirolia soleirolii (Req.) Dandy; pe;
Urtica dioica L.; mo; ca; pe;
Urtica membranacea Poir.; mo; fr; ca; pe; ch;
Urtica pilulifera L.; pe;
Urtica urens L.; mo; fr; ca; pe; ch;

VALERIANACEAE
Centranthus calcitrapae (L.) Dufresne; mo; fr; ca; pe; ch; sv; sm;
Centranthus ruber (L.) DC.; mo; fr; ca; pe; ch;
Valerianella carinata Loisel.; mo; pe; ch; sv; sm;
Valerianella coronata (L.) DC.; pe; sv;
Valerianella microcarpa Loisel.; mo;
Valerianella locusta (L.) Laterrade; pe;

VERBENACEAE
Verbena bonariensis L.; ca;
Verbena officinalis L.; mo; ca; pe; sm;

VIOLACEAE
Viola arvensis Murray; mo; pe; ch;
Viola canina L.; mo; ca; pe; sm;
Viola kitaibeliana Schultes; mo; ca; pe; ch; sv; sm;
Viola lactea Sm.; fr; ca;
Viola palustris L.; mo; fr; ca; pe; sv; sm;
Viola riviniana Reichenb.; mo; fr; ca; pe; ch; sv; sm;
Viola x wittrockiana Gams; ca;

VITACEAE
Vitis vinifera L.; mo; ca;

ZYGOPHYLLACEAE
Tribulus terrestris L.; mo; pe;

AGAVACEAE
Agave americana L.; sv;

ALISMATACEAE
Alisma lanceolatum With.; pe;
Baldellia alpestris (Cosson) M. Laínz; mo;
Baldellia repens subsp. cavanillesii (Molina Abril & al.) Talavera; mo;

ALLIACEAE
Allium massaessylum Batt. & Trabut; mo; fr; ca;
Allium neapolitanum Cyr.; pe;
Allium oleraceum L.; pe; ch;
Allium pallens L.; mo; pe; ch; sv;
Allium sativum L.; mo;
Allium scorzonerifolium DC.; fr;
Allium sphaerocephalon L.; mo; fr; ca; pe; ch; sv; sm;
Allium triquetrum L.; mo; fr; ca; pe; ch;

AMARYLLIDACEAE
Acis autumnalis (L.) Herb.; mo; ca;
Amaryllis belladona L.; mo; ca;
Narcissus bulbocodium L. subsp. bulbocodium; mo; fr; ca; pe; ch; sv; sm
Narcissus × caramulensis Ribeiro & al. (N. bulbocodium × N. cyclamineus); fr; ca;
Narcissus cyclamineus DC.; fr;
Narcissus minor subsp. **asturiensis** (Jordan) Barra & G. López; mo;
Narcissus pseudonarcissus subsp. **confusus** (Pugsley) A. Fernandes; ca;
Narcissus rupicola Dufour; pe;
Narcissus triandrus subsp. **pallidulus** (Graells) Rivas Goday; pe;
Narcissus triandrus L. subsp. **triandrus;** mo; fr; ca; pe; ch; sv; sm;

ANTHERICACEAE
Anthericum liliago L.; mo;

ARACEAE
Arisarum simorrhinum var. subexertum (Webb & Berthel.) Talavera; mo; sv;
Arum italicum Miller; mo; pe;
Zantedeschia aethiopica (L.) Sprengel; ca;

ASPARAGACEAE
Asparagus acutifolius L.; ch;

ASPHODELACEAE
Asphodelus lusitanicus var. **ovoideus** (Merino) Z. Díaz & Valdés;; mo; fr; ca; pe; ch; sv; sm;
Asphodelus macrocarpus var. arrondeaui (Lloyd) Z. Díaz & Valdés; mo; fr; ca; pe; ch; sv; sm;
Asphodelus macrocarpus Parl. var. macrocarpus; mo; pe; ch;
Asphodelus serotinus Wolley-Dod; mo; pe; ch;
Paradisea lusitanica (Cout.) Samp.; mo; fr; ca;
Simethis mattiazzii (Vandelli) Saccardo; mo; fr; ca; pe; ch; sv; sm;

CANNACEAE
Canna indica L.; ca;

COLCHICACEAE
Merendera filifolia Camb.; Colchicaceae; ca; sm;
Merendera montana (L.) Lange; mo; fr; ca; pe; ch; sv; sm;

COMMELINACEAE
Tradescantia fluminensis Velloso; mo; fr; ca; pe;

CONVALLARIACEAE
Polygonatum odoratum (Mill.) Druce; mo; fr; ca;

CYPERACEAE
Carex asturica Boiss.; mo; fr;
Carex binervis Sm.; mo; fr; ca;
Carex caryophyllea Latourr.; mo;
Carex demissa Hornem.; mo;
Carex depressa Link; ca;
Carex distachya Desf.; mo; fr; pe;
Carex distans L.; mo; ca;
Carex divisa Huds.; pe;
Carex divulsa Stokes; fr;
Carex echinata Murray; mo; fr; ca;
Carex elata subsp. **reuteriana** (Boiss.) Luceño & Aedo; mo; fr; ca;
Carex hirta L.; mo;
Carex laevigata Sm.; mo; fr; ca; pe; ch;
Carex leporina L.; mo; fr; ca; pe;
Carex muricata subsp. pairae (F.W. Schultz) Čelak.; mo; fr; ca; pe; ch;
Carex paniculata subsp. lusitanica (Willd.) Maire; mo;
Carex pilulifera L.; mo; fr; ca;
Carex spicata Huds.; mo;
Cyperus eragrostis Lam.; ca;
Cyperus longus L.; mo; fr; ca; pe; ch;
Eleocharis multicaulis (Sm.) Desv.; mo; ca; pe;
Eleocharis palustris (L.) Roemer & Schultes; mo; ca; pe;
Isolepis fluitans (L.) R. Br.; mo;
Isolepis setacea (L.) R. Br.; mo; pe;
Rhynchospora alba (L.) Vahl; mo;
Scirpoides holoschoenus (L.) Soják; mo; fr; ca; pe; ch; sm;

DIOSCOREACEAE
Dioscorea communis (L.) Caddick & Wilkin; mo; fr; ca; pe; ch;

DRACAENACEAE
Cordyline australis (Forster f.) Endl.; ca;

HYACINTHACEAE
Cathissa broteroi (M. Laínz) Speta; mo; fr; ca;
Cathissa concinna (Salisb.) Salisb.; mo; fr; ca; pe; ch; sv; sm;
Charybdis maritima (L.) Speta; ca; pe; sv;
Dipcadi serotinum (L.) Med.; mo;
Hyacinthoides hispanica (Mill.) Rothm.; mo; fr; ca; pe; ch; sv; sm
Hyacinthoides non-scripta (L.) Rothm.; mo;
Muscari comosum (L.) Mill.; mo; pe; ch; sv; sm;
Muscari neglectum Ten.; pe; sv;
Ornithogalum baeticum Boiss.; mo; pe; ch;
Loncomelos pyrenaicus (L.) Holub; mo; fr; ca; pe; ch; sv; sm;
Prospero autumnale (L.) Speta; mo; fr; ca; pe; ch; sv; sm;
Scilla monophyllos Link; mo; fr; ca; pe; ch;
Scilla ramburii Boiss.; mo; fr; ca; pe; ch;
Scilla verna Huds.; mo; ca;

IRIDACEAE
Crocus carpetanus Boiss. & Reut.; mo; fr; ca;
Crocus serotinus Salisb.; mo; fr; ca; pe; ch; sv; sm;
Gladiolus illyricus Koch; mo; fr; ca; pe; ch;
Iris germanica L.; mo; pe;
Iris pseudacorus L.; mo; ca; pe;
Romulea bulbocodium (L.) Seb. & Mauri; mo; fr; ca; pe; ch;

JUNCACEAE
Juncus acutiflorus Hoffm.; mo; fr; ca; pe;
Juncus articulatus L.; mo; fr; ca;
Juncus bufonius L.; mo; fr; ca; pe; ch; sv; sm;
Juncus bulbosus L.; mo; fr; ca; pe; ch;
Juncus capitatus Weigel; mo; fr; ca; pe; ch;
Juncus effusus L.; mo; fr; ca; pe; ch; sv; sm;
Juncus foliosus Desf.; ca;
Juncus heterophyllus Dufour; mo; ca;
Juncus pygmaeus L.C.M. Richard; mo; fr; ca; pe;
Juncus squarrosus L.; mo; fr; ca;
Juncus tenageia L. fil.; mo; fr; ca; pe;
Luzula campestris (L.) DC.; mo;

Luzula forsteri (Sm.) DC.; mo;
Luzula lactea (Link) E.H.F. Meyer; mo; fr; ca; pe;
Luzula multiflora (Retz.) Lej.; mo; fr; ca; pe; ch; sv; sm;
Luzula sylvatica subsp. **henriquesii** (Degen) P. Silva; mo; fr; ca;

LEMNACEAE
Lemna minor L.; mo; fr; pe; ch;

LILIACEAE
Erythronium dens-canis L.; fr;
Fritillaria nervosa Willd.; fr;
Gagea lusitanica A. Terracc.; sv; sm;
Gagea soleirolii F.W. Schultz; mo; fr; ca; pe; ch;
Lilium martagon L.; mo; pe;
Tulipa sylvestris subsp. australis (Link) Pamp.; mo; fr;

ORCHIDACEAE
Cephalanthera longifolia (L.) Fritsch; mo;
Dactylorhiza caramulensis (Verm.) Tyteca; mo; fr; ca; pe; ch;
Dactylorhiza elata (Poiret) Soó; mo; pe;
Dactylorhiza sulphurea (Link) Franco; mo; pe; ch;
Epipactis helleborine (L.) Crantz; pe;
Neotinea maculata (Desf.) Stearn; mo; ca; pe;
Orchis champagneuxii Barn.; mo; pe;
Orchis coriophora L.; ch;
Orchis mascula L.; sv;
Orchis picta Loisel.; sm;
Platanthera bifolia (L.) L.C.M. Richard; mo;
Serapias cordigera L.; mo; fr; ca; pe; ch; sm;
Serapias lingua L.; mo; ca; pe; ch; sm;
Serapias parviflora Parl.; pe;
Spiranthes aestivalis (L.) L.C.M. Richard; mo;

POACEAE
Aegilops geniculata Roth; pe; sv;
Aegilops triuncialis L.; pe;
Agrostis capillaris L.; mo;
Agrostis castellana Boiss. & Reut.; mo; fr; ca; pe; ch; sv; sm;
Agrostis curtisii Kerguélen; mo; fr; ca; pe; ch; sv; sm;
Agrostis ×fouilladei P. Fourn.; mo; fr; ca; pe; ch; sv; sm;
Agrostis hesperica Romero García, Blanca & Morales Torres; mo; fr; ca;
Agrostis × murbeckii P. Fourn.; mo;
Agrostis stolonifera L.; mo; ca; pe; ch;
Aira caryophyllea L.; mo; fr; ca; pe; ch; sv; sm;
Aira cupaniana Guss.; pe; ch; sv;
Aira praecox L.; mo; fr; ca; pe; ch;
Airopsis tenella (Cav.) Aschers. & Graebn.; mo;
Alopecurus arundinaceus Poiret; pe;
Anisantha diandra (Roth) Tzvelev; mo; fr; ca; pe; ch; sv; sm;
Anisantha madritensis (L.) Nevski; mo; pe; ch;
Anisantha rigida (Roth) Hyl.; mo;
Anisantha rubens (L.) Nevski ; mo; pe; ch; sv; sm;
Anisantha sterilis (L.) Nevski; mo; fr; ca; pe; ch;
Anisantha tectorum (L.) Nevski; mo; pe; ch; sv; sm;
Anthoxanthum amarum Brot.; mo; fr; ca;
Anthoxanthum aristatum Boiss.; mo; fr; ca; pe; ch; sv; sm;
Anthoxanthum odoratum L.; mo;
Antinoria agrostidea subsp. **natans** (Hackel) Rivas Mart.; mo; fr; pe;
Arrhenatherum elatius subsp. baeticum Romero Zarco; mo; fr; ca; pe; ch; sv; sm;
Arrhenatherum elatius subsp. bulbosum (Willd.) Schübler & Martens; mo; fr; ca; pe; ch;
Arrhenatherum elatius (L.) J. & C. Presl subsp. elatius; pe;
Arundo donax L.; mo;
Avena barbata Link subsp. barbata; mo; fr; ca; pe; ch; sv; sm;
Avena barbata subsp. lusitanica (Tab. Mor.) Romero Zarco; pe;
Avena sativa subsp. macrantha (Hackel) Rocha Afonso; pe;
Avena strigosa Schreber; mo;
Avenella flexuosa (L.) Drejer; mo; fr; ca;
Avenula lodunensis (Delastre) Kerguélen subsp. lodunensis; mo; fr; ca; pe; ch; sv; sm;
Brachypodium phoenicoides (L.) Roemer & Schultes; mo; fr; ca; pe; ch;
Brachypodium rupestre (Host) Roemer & Schultes; mo;
Brachypodium sylvaticum (Huds.) P. Beauv.; mo; fr;
Briza maxima L.; mo; fr; ca; pe; ch; sv; sm;
Briza minor L.; mo; fr; ca; pe; ch;
Bromus hordeaceus L.; mo; fr; ca; pe; ch; sv; sm;
Bromus scoparius var. villiglumis Maire & Weiller; pe;
Catapodium rigidum (L.) C.E. Hubbard; mo; ca; sv;
Celtica gigantea (Link) F.M. Vázquez & E.M. Barkworth; mo; fr; ca; pe; ch;
Cortaderia selloana (Schultes & Schultes fil.) Ascherson & Graebner; mo; fr; ca; pe; ch;
Corynephorus canescens (L.) Beauv.; mo; pe; ch;
Cynodon dactylon (L.) Pers.; mo; fr; ca; pe; ch; sv; sm;
Cynosurus cristatus L.; mo; fr; ca; pe; ch;
Cynosurus echinatus L.; mo; fr; ca; pe; ch; sv;
Cynosurus effusus Link; mo; pe;
Dactylis glomerata subsp. hispanica (Roth) Nyman; mo; fr; ca; pe; ch; sv; sm;
Dactylis glomerata subsp. lusitanica Stebbins & Zohary; mo; fr; ca; pe; ch;
Danthonia decumbens (L.) DC.; mo; fr; ca; pe; ch;
Deschampsia cespitosa (L.) P. Beauv.; mo; fr;
Digitaria debilis (Desf.) Willd.; mo; ca;

Digitaria sanguinalis (L.) Scop.; mo; fr; ca; pe; ch; sv; sm;
Echinochloa crus-galli (L.) P. Beauv.; mo; fr; ca; pe; ch;
Eragrostis cilianensis (All.) F.T. Hubbard; mo; pe;
Eragrostis curvula (Schrader) Nees; mo; pe;
Eragrostis minor Host; mo; pe;
Festuca ampla Hackel; mo;
Festuca durandoi subsp. **livida** (Hackel) Rivas Ponce & Cebolla; mo; fr;
Festuca elegans Boiss.; mo;
Festuca indigesta Boiss.; mo; fr; ca;
Festuca nigrescens subsp. microphylla (St. Yves) Markgr.-Dannenb.; mo; fr;
Festuca paniculata subsp. multispiculata Rivas Ponce & Cebolla; mo; fr; ca; pe; ch;
Festuca pseudotrichophylla Patzke; mo;
Festuca rivularis Boiss.; mo; fr; ca; pe; ch;
Festuca rothmaleri (Litard.) Markgr.-Dannenb.; mo;
Festuca rubra L.; mo;
Festuca summilusitana Franco & Rocha Afonso; mo; fr; ca; pe; ch;
Festuca trichophylla (Gaudin) K. Richter; fr;
Gastridium ventricosum (Gouan) Schinz & Thell.; pe;
Gaudinia fragilis (L.) Beauv.; ca; pe;
Glyceria declinata Bréb.; mo; fr; ca; pe; ch;
Glyceria fluitans (L.) R. Br.; fr; pe;
Hainardia cylindrica (Willd.) Greuter; pe;
Holcus annuus subsp. duriensis (P. Silva) Franco & Rocha Afonso; mo; ch;
Holcus gayanus Boiss.; mo; ch;
Holcus lanatus L.; mo; fr; ca; pe; ch; sv; sm;
Holcus mollis L.; mo; fr; ca; pe; ch; sv; sm;
Hordeum murinum L. subsp. murinum; mo; fr; ca; pe; ch; sv; sm;
Hordeum murinum subsp. leporinum (Link) Arcangeli; mo; ca; pe;
Hordeum secalinum Schreber; pe;
Koeleria caudata (Link) Steudel subsp. **caudata**; mo; pe; ch;
Koeleria crassipes Lange subsp. **crassipes**; mo; fr; ca; pe; ch;
Lamarckia aurea (L.) Moench; mo; pe; ch; sv; sm;
Lolium aristatum (Willd.) Lag.; mo; fr; ca; pe; ch;
Lolium multiflorum Lam.; mo; fr; ca; pe; ch;
Lolium perenne L.; mo; fr; ca; pe; ch;
Lolium rigidum Gaudin; mo; fr; ca; pe; ch; sv; sm;
Melica ciliata subsp. magnolii (Gren. & Godron) Husnot; mo; pe; ch;
Melica uniflora Retz.; mo;
Mibora minima (L.) Desv.; mo; fr; ca; pe; ch; sv; sm
Micropyrum patens (Brot.) Pilger; mo; ca; pe;
Micropyrum tenellum (L.) Link; mo; fr; ca; pe; ch; sv; sm;
Milium vernale Bieb.; pe;
Molineriella laevis (Brot.) Rouy; mo; fr; ca; pe; ch; sv; sm;
Molinia coerulea (L.) Moench; mo; fr; ca; pe; ch;
Nardus stricta L.; mo; fr; ca; pe; ch;
Neoschischkinia pourretii (Willd.) Valdés & H. Scholz; mo; ca; pe; ch;
Neoschischkinia truncatula subsp. durieui (Willk.) Valdés & H. Scholz ; mo; fr; ca; pe; ch; sv; sm
Neoschischkinia truncatula (Parl.) Valdés & H. Scholz subsp. truncatula; mo; fr; ca; pe;
Ochlopoa annua (L.) H. Scholz; mo; fr; ca; pe; ch; sv; sm;
Panicum repens L.; mo;
Periballia involucrata (Cav.) Janka; mo; pe; ch;
Poa bulbosa L. var. bulbosa; mo; fr; ca; pe; ch; sv; sm;
Poa bulbosa L. var. vivipara Borkh.; mo; fr; ca; pe; ch; sv; sm;
Poa nemoralis L.; mo;
Poa trivialis subsp. sylvicola (Guss.) H. Lindb. fil.; mo;
Poa trivialis L. subsp. trivialis; mo; fr; ca; pe; ch;
Polypogon viridis (Gouan) Breistr.; ca;
Pseudarrhenatherum longifolium (Thore) Rouy; mo; fr; ca;
Psilurus incurvus (Gouan) Schinz & Thell.; pe;
Secale cereale L.; mo; fr; ca; pe; ch;
Setaria pumila (Poiret) Roemer & Schultes; mo;
Setaria verticillata (L.) Beauv.; ca;
Stipa lagascae Roemer & Schultes; mo; pe;
Taeniatherum caput-medusae (L.) Nevski; mo; pe;
Trachynia distachya (L.) Link; mo; pe; sv; sm;
Trisetaria hispida (Lange) Paunero; pe;
Trisetaria ovata (Cav.) Paunero; mo; fr; ca; pe; ch; sv;
Triticum aestivum L.; mo; pe;
Vulpia bromoides (L.) S.F. Gray; mo; fr; ca; pe; ch; sv; sm;
Vulpia ciliata Dumort.; pe;
Vulpia muralis (Kunth) Nees; mo; fr; ca; pe; ch; sv; sm;
Vulpia myuros (L.) C.C. Gmelin; mo; fr; ca; pe; ch;
Zea mays L.; mo; fr; ca; pe; ch;

POTAMOGETONACEAE
Potamogeton natans L.; fr; pe;
Potamogeton nodosus Poir.; mo; pe;
Potamogeton polygonifolius Pourr.; mo;

RUSCACEAE
Ruscus aculeatus L.; mo; fr; ca; pe; ch;

SPARGANIACEAE
Sparganium erectum subsp. neglectum (Beeby) Schinz & Thell.; mo;

TYPHACEAE
Typha latifolia L.; mo; ca; pe;

Christian Eichberger

The vegetation of the Lousi valley (Peloponnesos, Greece): a geobotanical survey

Abstract

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Lousi (ca. 1000 msm) is a high-lying valley in north-western Peloponnesos (Nomos Achaia, Greece) southwest of the Chelmos Mountains. A city called Lousoi and a sanctuary of Artemis was even known in classical literature. As a contribution to a recent archaeological field survey a geobotanical outline was worked out including a vegetation map. In the Lousi valley 15 different vegetation types appear, among them *Abies cephalonica* and *Quercus aegilops* forests as well as *Q. coccifera* macchia. Finally the vegetation types were intersected with the geology units of the area.

Introduction

The high-lying valley of Lousi in north-western Peloponnesos (Nomos Achaia, Greece) is situated approximately 5 km south of the city of Kalavrita (see fig. 1 and fig. 2). In the northeast the Chelmos Mountains reach 2338 msm. Along the margins of the valley floor, which is situated between 950 msm and 1000 msm, four little hamlets are located: Ano Lousi and Kato Lousi in the north, as well as Sigouni, Levki in the south (cf. fig. 3).

A city called "Lousoi" and its sanctuary of Artemis was even known in classical times and mentioned in classical literature (cf. Pausanias VIII, 18, 7-8 vide Eckstein & Bol 1989). Since more than hundred years (Mitsopoulos-Leon 2001) excavations are carried out by the Austrian Archaeological Institute (leader of the recent excavations: Dr. Georg Ladstätter). Today one can visit the ruins of the temple of Artemis, in the last years the agora and other parts of the city were investigated (see Ladstätter 2001, Mitsopoulos-Leon 2001, Schauer 2001).

Plants like *Laurus nobilis* connected with the goddess Artemis (and with her brother Apollon too) can not be found in the Lousi valley (cf. Eichberger & al. 2007).

Material and methods

An archaeological field survey is a process by which archaeologists collect information about the location, distribution and organisation of past human cultures across a larger

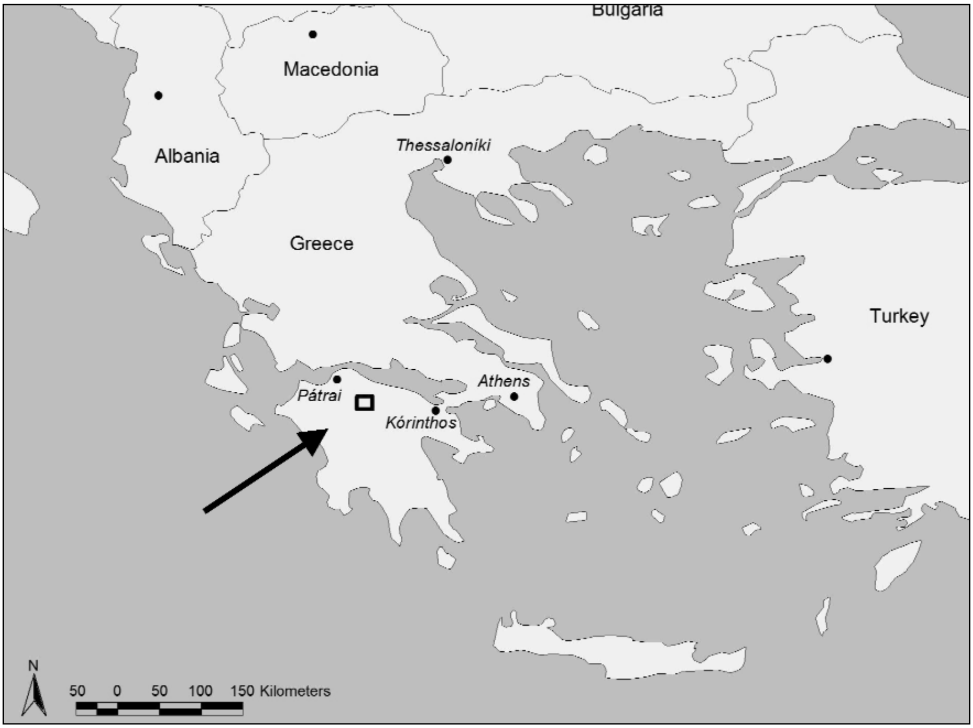

Fig. 1. Map of Greece and surrounding countries (data source by ESRI® 1998). The area of investigation is marked by a black rectangle.

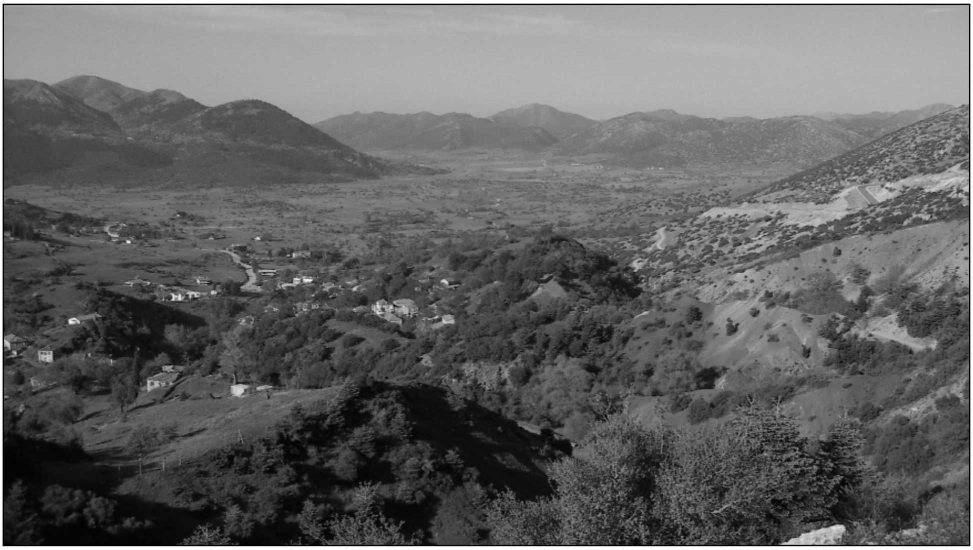

Fig. 2. View on the Lousi valley from NE southwards (15.5.2006).

area. Surveys can be a practical way to decide whether or not to carry out an excavation (e.g. “The Kythera Island Project” http://www.ucl.ac.uk/kip).

Often the botanical research involves primarily the compilation of a species list, accompanied by an analysis of the local ecology of particular species, both intended for comparative purposes. A further aim of the botanical field work, however, is tot map the vegetation units as done in the recent project for ecological information and to assess the impact of human processes as land-clearance and abandonment.

Within the scope of recent archaeological activities the present geobotanical field survey was worked out including a vegetation map of the Lousi valley. The digital map contains 15 different vegetation types. It was created by means of ESRI® ArcMapTM 9.2 (data source by GoogleEarthTM 4.0, 2007, see fig. 3).

In order to gain the geological information, the Geological Map of Greece (Dhafni Sheet, cf. Meilliez & al. 1978) was used and intersected with the vegetation map of Lousi (see above). By this, all the vegetation areas got additionally spatial information which could be summarized per vegetation unit. Per unit the total area (that is 100 %) can therefore be divided into the following geological units: fo: flysch (Eocene), H1.br: ancient alluvium (Holocene), H2: recent alluvium (Holocene), J-Ki: radiolarian rock (Upper Jurassic), Q.cs: ancient and recent debris cones of lime deposit (Quaternary), Q.h: ancient and recent debris cones of lime and silicate deposit (Quaternary), K 1: thick-bedded limestone and dolomite (Maastrichtian to Senonian), K 2: thin-bedded limestone of the Plattenkalk group (Maastrichtian to Upper Palaeocene), T: pelite, sandstone and limestone (Upper Triassic to Liassic).

Results and discussion

In the Lousi valley 15 different vegetation types appear (see fig. 2 and 3, as well as tab. 1). Among these pastures, fields and a macchia of *Quercus coccifera* cover about 20 % of the total area particularly (see tab. 1). The community seems to be included into the association *Phillyreo latifoliae-Quercetum cocciferae* Knapp 1965 em. Bolòs & al. 1996, alliance *Andrachno-Quercion cocciferae* Barbéro & Quézel 1979 (cf. Barbéro & Quézel 1979, 1983, Bolòs & al. 1996, Eichberger 2001 a.o.). A more detailed vegetation analysis including phytosociological relevés of the particular communities is planned for the future.

The valley floor with its fertile loamy soil (recent Alluvia of the Holocene) is traditionally used for cereal cultivation (1016 ha; see tab. 1) while the slopes, dominated by *Quercus coccifera* L. and therophytes, are grazed by sheep and goats. In the north-eastern part of the valley coniferous communities with *Abies cephalonica* J.W. Loudon cover especially north-exposed slopes (433 ha) and can be integrated into the Abietion cephalonicae (cf. Bergmeier 2002).

In the south of the valley, on the old path to Kleitoría deciduous forests of *Quercus frainetto* Ten., an important timber tree, can be found (162 ha; see fig. 4 and tab. 1).

By intersecting the vegetation units with the geology layer (cf. Meilliez & al. 1978) some correlations are obvious: *Abies cephalonica* forests occur on limestones and dolomites of the Upper Cretaceous (K 1) in 65.8 % of its covered area whereas open and rocky erosion areas with *Abies cephalonica* and *Quercus coccifera* appear on ancient allu-

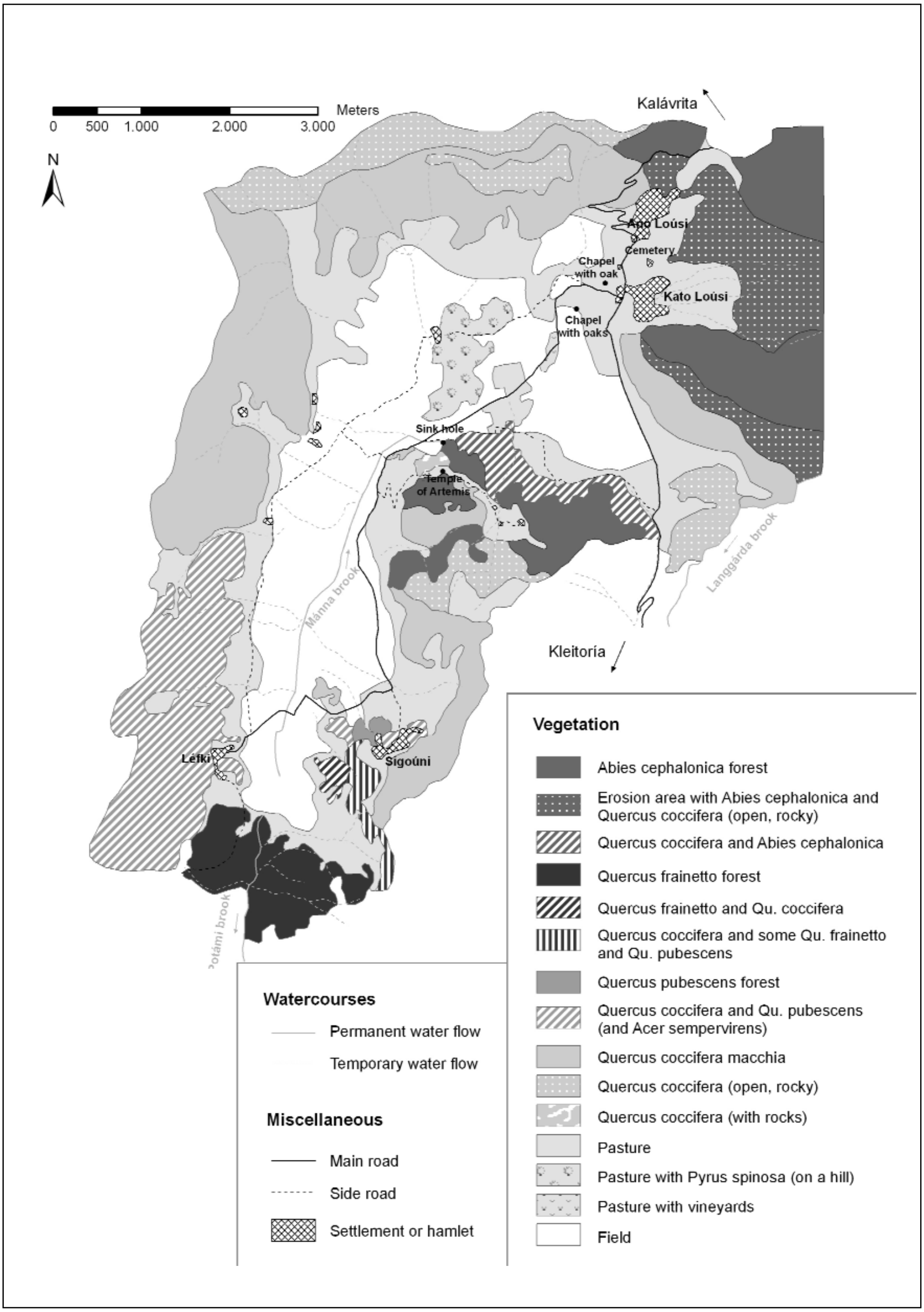

Fig. 3. Vegetation map of the Lousi valley (map scale 1:22.500); data source by GoogleEarthTM 4.0, 2007; data collection 2006-2007; cartography: I. Kurtz.

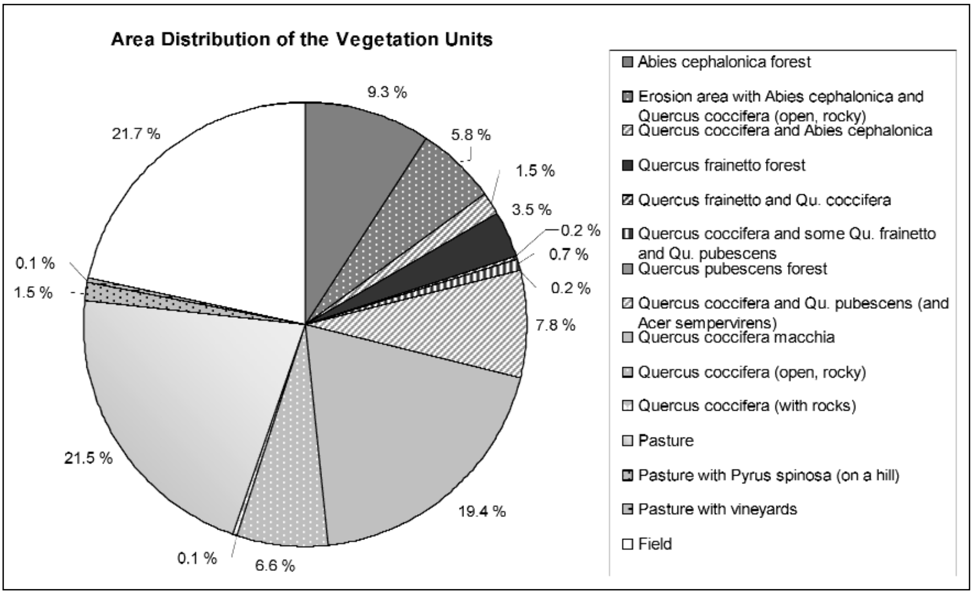

Fig. 4. Area distribution of the mapped vegetation units: The total area amounts 4674.4 ha; in the diagram the settlement area (50.6 ha) is not included. The order of the vegetation units is to be read clockwise, starting at the top.

Table 1. Area distribution of the vegetation units of the Lousi valley in total hectare [ha].

Vegetation unit	**Area [ha]**	**Percentage [%]**
Abies cephalonica forest	433.1	9.3
Erosion area with *Abies cephalonica* and *Quercus coccifera* (open, rocky)	271.3	5.8
Quercus coccifera and *Abies cephalonica*	72.1	1.5
Quercus frainetto forest	162.3	3.5
Quercus frainetto and *Qu. coccifera*	11.5	0.2
Quercus coccifera and some *Qu. frainetto* and *Qu. pubescens*	31.2	0.7
Quercus pubescens forest	8.8	0.2
Quercus coccifera and *Qu. pubescens* (and *Acer sempervirens*)	366.0	7.8
Quercus coccifera macchia	905.7	19.4
Quercus coccifera community (open, rocky)	310.7	6.6
Quercus coccifera community with rocks	6.2	0.1
Pasture	1006.0	21.5
Pasture with *Pyrus spinosa* (on a hill)	68.4	1.5
Pasture with vineyards	5.0	0.1
Field	1016.3	21.7
	4674.4	100.0

Table 2. Distribution of the vegetation units (percentage [%]) among the geological units on which they occur (abbreviations of the geological units compare chapter "Material and methods").

	fo	H1.br	H2	J-Ki	Q.cs	Q.h	K 1	K 2	T
Abies cephalonica forest	7.7	5.5	0.9	12.2	0.6	–	**65.8**	7.4	–
Erosion area with *Abies cephalonica* and *Quercus coccifera* (open, rocky)	–	**64.8**	–	–	1.8	–	33.4	–	–
Quercus coccifera and *Abies cephalonica*	1.2	–	43.7	–	–	–	55.1	–	–
Quercus frainetto forest	33.8	–	2.4	19.2	–	23.0	–	3.5	18.1
Quercus frainetto and *Qu. Coccifera*	**99.95**	–	0.05	–	–	–	–	–	–
Quercus coccifera and some *Qu. frainetto* and *Qu. pubescens*	12.5	–	0.4	31.1	7.5	–	–	18.7	29.8
Quercus pubescens forest	**84.5**	–	–	15.5	–	–	–	–	–
Quercus coccifera and *Qu. pubescens* and *Acer sempervirens*)	13.4	–	1.5	3.3	8.6	–	–	73.2	–
Quercus coccifera macchia	7.0	7.8	0.5	12.8	10.6	–	2.5	**58.8**	–
Quercus coccifera (open, rocky)	–	13.7	5.4	5.8	24.6	–	–	**50.4**	–
Quercus coccifera (with rocks)	3.2	–	5.5	–	–	–	23.2	**68.1**	–
Pasture	7.4	13.0	32.2	2.4	29.8	1.3	0.4	12.5	1.1
Pasture with *Pyrus spinosa* (on a hill)	–	–	**78.4**	–	21.6	–	–	–	–
Pasture with vineyards	–	–	**100.0**	–	–	–	–	–	–
Field	0.03	–	**79.2**	0.3	20.0	–	0.001	0.5	–

A macchia dominated by *Quercus coccifera*, widely spread in the Lousi area, prefers limestone of the Plattenkalk group (Upper Cretaceous; K 2) in 58.8 %. Other varieties of *Quercus coccifera* communities occurring on more rocky habitats also favour the Plattenkalk group (50.4 % resp. 68.1 %).

In the southern part of the investigation area vegetation units with local distribution patterns like combinations of *Quercus coccifera* and *Qu. frainetto* (11.5 ha) as well as *Quercus pubescens* forests (8.8 ha) are nearly restricted to the geological unit flysch (Eocene; fo) in 99.5 % resp. 84.5 % (cf. tab. 4).

Most of the fields are concentrated on the bottom of the high valley where recent alluvium of the Quaternary prevails (79.2 %). Many pastures in this altitude show the same preference (78.4 % resp. 100 %, see tab. 4). However, pastures in general which also include those of higher altitudes can be found on all geological units with different weightings.

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Kurtz (Salzburg) for the digital cartography and the help to prepare the manuscript.

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L. Guglielmone, L. Gallo & A. Guiggi

The Italian "Succulent Flora": a taxonomical, chorological and historical approach

Abstract

Guglielmone, L., Gallo, L., Guiggi, A.: The Italian "Succulent Flora": a taxonomical, chorological and historical approach. — Bocconea 23: 345-351. 2009. — ISSN 1120-4060.

A first account of the italian "succulent flora" is given with special evidence for countries origines, status (indigen or alien) following the current models and historical aspects, especially for introduction data and first naturalization, when known.

Editing a list of the "Italian succulent flora" is a very difficult task. At first, the concept of succulence shall be defined. A rigorous study of morphological, physiological and ecological traits, may allow to establish the boundaries of this taxonomically heterogeneous group of plants, nowadays not yet defined in a satisfactory way (Eggli 2001). In the table 1 the families of succulent plants present in Italy, with the number of species and their origin, are listed. It is possible to notice the high number of alien species, nearly the 50% of the total.

The study of this component of the succulent flora, according to (Richardson & al. 2000; Pysek & al. 2004), arouses lively interest (Camarda & al. 2005; Acosta & al. 2007) and represents one of the most important aspects of this project. Special care will be given to verify the distributional aspects and the conservation *status* of the endemic species (Scoppola & al. 2005). Finally, a last aim of this project focuses on historical, horticultural (in private or institutional Botanical Gardens) and iconographic aspects, especially regarding the alien species. For the latter, moreover, information about the dates of first introduction in cultivation and of naturalization, according to Saccardo (1909) and Maniero (2000) (if avalaible), is given.

When the distinction between succulent and non succulent species was uncertain the checklist was based on the "Illustrated Handbook of Succulent Plants" (Eggli 2001, 2002, 2003; Hartmann 2001a, 2001b; Albers & Meve 2002). The taxonomical arrangement pursued the same reference with the exception of *Crassulaceae* and *Cactaceae* for which others reviews are followed (Gallo 2005; Gallo 2007; Guiggi 2008).

Nevertheless, still some problems persist, as in the case of *Pelargonium zonale* L'Hérit. This species, occasionally naturalized in Italy, was excluded from the checklist because

Tab. 1. Number and origin of the species of the italian succulent flora by families and Continents.

Families	**Continents**							
	Africa	America	Asia	Europe	Oceania	Doubtful	Cult.	**Total**
Agavaceae	0	7	0	0	0	0	1	**8 (5.97%)**
Aizoaceae	6	0	0	3	1	0	0	**10 (7.46%)**
Apocynaceae	0	0	0	1	0	0	0	**1 (0.75%)**
Asphodelaceae	2	0	1	0	0	0	0	**3 (2.23%)**
Cactaceae	0	23	0	0	0	0	0	**23 (17.16%)**
Commelinaceae	0	1	0	0	0	0	0	**1 (0.75%)**
Crassulaceae	11	3	2	59	0	0	1	**76 (56.71%)**
Cucurbitaceae	1	0	0	0	0	0	0	**1 (0.75%)**
Euphorbiaceae	0	0	0	1	0	0	0	**1 (0.75%)**
Geraniaceae	1	0	0	0	0	0	0	**1 (0.75%)**
Phytolaccaceae	0	1	0	0	0	0	0	**1 (0.75%)**
Portulacaceae	1	1	0	0	0	5	1	**8 (5.97%)**
Total	**22 (16.42%)**	**36 (26.86%)**	**3 (2.24%)**	**64 (47.76%)**	**1 (0,75%)**	**5 (3.73%)**	**3 (2.24%)**	**134 (100%)**

Albers (2002) does not consider it as a succulent but other authors list it as a semi-succulent (Walt van der 1979; Clifton 1999). The alien species *Senecio talinoides* subsp. *mandraliscae* (Tin.) G.D. Rowley (= *Kleinia mandraliscae* Tin.), today only cultivated in Italy (Domina 2005; Pasta 2003), is also included in this checklist to document its wild past occurrence.

A first account of this study is reported in Table 2.

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Table 2. Provisional checklist of the italian succulent flora. Column 3 (Status): indigenous (I), alien (A) or doubtful status (?) of the species. Column 4 (Origin): country of origin. Column 5 (Ref./Doc.): literature or other documents (photo; living collection) about their presence/absence (+/-). Column 6 (Introd.) and 7 (Naturaliz.): respectively, date of the first introduction and date of naturalization of the alien species according to Saccardo (1909) (S) and Maniero (2000) (M).

Taxon	**Family**	**Status**	**Origin**	**Ref./Doc.**	**Introd.**	**Naturaliz.**
Aeonium arboreum (L.) Webb & Berthel.	Crassulaceae	A	Canary Is. (Gran Canaria)	Conti & al. (2005)	1561 (S)	1827 (S)
Aeonium decorum Webb ex Bolle	Crassulaceae	A	Canary Is. (Gomera)	Conti & al. (2005)	-	-
Aeonium haworthii Salm-Dyck ex Webb & Berthel.	Crassulaceae	A	Canary Is. (Tenerife)	Conti & al. (2005)	-	-
Aeonium simsii (Sweet) Stearn	Crassulaceae	A	Canary Is. (Gran Canaria)	Conti & al. (2005)	-	-
Agave americana L. subsp. *americana*	Agavaceae	A	USA, Mexico	Conti & al. (2005)	1561 (S, M)	-
Agave salmiana Otto *ex* Salm-Dyck	Agavaceae	A	Mexico	Conti & al. (2005)	-	-
Agave sisalana Perrine	Agavaceae	A	Cultivated	Conti & al. (2007)	-	-
Agave vivipara L.	Agavaceae	A	Mexico, Costa Rica, Honduras, Belize, Nicaragua, Panama, El Salvador	Gallo (photo)	-	-
Aizoanthemum hispanicum (L.) H.E.K. Hartmann	Aizoaceae	I	Mediterranean region	Conti & al. (2005)[1]		
Aloe cfr. *ciliaris* Haw.	Asphodelaceae	A	South Africa	Gallo (photo)	1845 (M)	-
Aloe maculata All.	Asphodelaceae	A	South Africa	Gallo (living collection)	1805 (M)	-
Aloe vera (L.) Burman *fil.*	Asphodelaceae	A	Arabian penin. (?)	Pignatti (1982)[2]	1772 (M)[3]	-
Aptenia cordifolia (L.f.) Schwantes	Aizoaceae	A	South Africa, Namibia	Conti & al. (2005)	-	-
Aptenia lancifolia L.Bolus	Aizoaceae	A	South Africa	Romano & al. (2006)	-	-
Austrocylindropuntia subulata (Muehlenpf.) Backeb.	Cactaceae	A	Bolivia, Peru	Conti & al. (2007)[4]	1883 (M)	-
Bulliarda vaillantii (Willd.) DC.	Crassulaceae	I		Conti & al. (2005)		
Caralluma europaea (Guss.) N.E.Br.	Apocynaceae	I		Conti & al. (2005)		
Carpobrotus edulis (L.) L. Bolus	Aizoaceae	A	South Africa	Conti & al. (2005)	-	-
Citrullus colocynthis (L.) Schrader	Cucurbitaceae	A	saharian and sub-saharian Africa , East Africa	Conti & al. (2005)	1415 (S)	1844 (S)
Cotyledon orbiculata L.	Crassulaceae	A	South Africa	Conti & al. (2005)	1793 (S) 1772 (M)	1850 (S)
Crassula muscosa L.	Crassulaceae	A	South Africa	Conti & al. (2005)	-	-
Crassula ovata (Miller) Druce	Crassulaceae	A	South Africa	Conti & al. (2005)	1793 (M)	-
Crassula tetragona L.	Crassulaceae	A	South Africa	Conti & al. (2005)	1772 (M)	-
Cylindropuntia kleiniae (DC.) F.M.Knuth	Cactaceae	A	USA, Mexico	Guiggi (2008)	-	-
Cylindropuntia tunicata (Lehm.) F.M.Knuth	Cactaceae	A	USA, Mexico	Guiggi (2008)	-	-
Delosperma cooperii (Hook. f.) L.Bolus	Aizoaceae	A	South Africa	Gallo (coll. viv.)	-	
Drosanthemum hispidum (L.) Schwantes	Aizoaceae	A	South Africa	Conti & al. (2005)	-	-
Euphorbia dendroides L.	Euphorbiaceae	I	Mediterranean region	Conti & al. (2005)	1532 (S)	1714? (S)
Graptopetalum paraguayense (N.E.Br.) E.Walther subsp. *paraguayense*	Crassulaceae	A		Conti & al. (2005)	-	-
Hylotelephium anacampseros (L.) H.Ohba	Crassulaceae	I		Conti & al. (2005)		
Hylotelephium maximum (L.) Holub subsp. *maximum*	Crassulaceae	I		Conti & al. (2005)		
Jovibarba allionii (Jord. & Fourr.) D.A.Webb	Crassulaceae	I		Conti & al. (2005)		
Jovibarba arenaria (W.D.J.Koch) Opiz	Crassulaceae	I		Conti & al. (2005)		
Jovibarba globifera (L.) J.Parn. subsp. *hirta* (L.) J.Parn.	Crassulaceae	I		Conti & al. (2005)		
Kalanchoe daigremontiana Raym.-Hamet & H.Perrier	Crassulaceae	A	Madagascar	Conti & al. (2005)	-	-

Table 2. Contnued.

Taxon	**Family**	**Status**	**Origin**	**Ref./Doc.**	**Introd.**	**Naturaliz.**
Kalanchoe delagoensis Ecklon & Zeyher	Crassulaceae	A	Madagascar	Turrisi (2005)	-	-
Lobivia silvestrii (Speg.) G.D.Rowley	Cactaceae	A	Argentina	Guiggi (2006)	-	-
Malephora crocea (Jacq.) Schwantes	Aizoaceae	A	South Africa	Romano & al. (2006)	-	-
Mesembryanthemum crystallinum L.	Aizoaceae	I	Mediterranean region	Conti & al. (2005)	1789 (S) 1772 (M)	-
Mesembryanthemum nodiflorum L.	Aizoaceae	I	Mediterranean region	Conti & al. (2005)	1606 (S,M)	1826 (S)
Opuntia amyclaea Ten.	Cactaceae	A	Mexico	Conti & al. (2005)	1789 (S)	-
Opuntia chlorotica Engelm. & J.M. Bigelow	Cactaceae	A	USA, Mexico	Guiggi (2007)	-	-
Opuntia dillenii (Ker-Gawler) Haw.	Cactaceae	A	Caribbean Is.	Conti & al. (2005)	1894 (S)	1894 (S)
Opuntia elatior Miller	Cactaceae	A	Caribbean Is., Colombia, Costa Rica, Venezuela	Conti & al. (2005)	-	-
Opuntia engelmannii Salm-Dyck ex Engelm. subsp. *engelmannii*	Cactaceae	A	USA, Mexico	Guiggi & al. (2007)	-	-
Opuntia engelmannii subsp. *lindheimeri* (Engelm.) Guzman & Mandujano	Cactaceae	A	USA, Mexico	Guiggi & al. (2007)	-	-
Opuntia ficus-indica (L.) Miller	Cactaceae	A	Mexico	Conti & al. (2005)	1565 (SM)	1565 ? (S)
Opuntia humifusa (Raf.) Raf.	Cactaceae	A	Canada, Mexico, USA	Conti & al. (2005)	1702 (S,M)	1785 (S)
Opuntia jamaicensis Britton & Harris	Cactaceae	A	Jamaica	Guiggi (2008)	-	-
Opuntia leucotricha DC.	Cactaceae	A	Mexico	Guiggi (2008)	1835 (M)	-
Opuntia macrorhiza Engelm.	Cactaceae	A	USA, Mexico	Guiggi (2008)	-	-
Opuntia microdasys (Lehm.) Pfeiff.	Cactaceae	A	Mexico	Guiggi (2008)	-	-
Opuntia monacantha (Willd.) Haw.	Cactaceae	A	Argentina, Brazil, Paraguay, Uruguay	Conti & al. (2005)	1899 (S)	1899 (S)
Opuntia phaeacantha Engelm.	Cactaceae	A	Mexico, USA	Guiggi (2007)	-	-
Opuntia robusta H.L.Wendl.	Cactaceae	A	Mexico	Conti & al. (2005)	-	-
Opuntia scheeri F.A.C.Weber	Cactaceae	A	Mexico	Conti & al. (2005)	-	-
Opuntia spinulifera Salm-Dyck	Cactaceae	A	Mexico	Guiggi (2008)	-	-
Opuntia stricta (Haw.) Haw.	Cactaceae	A	Cuba, Mexico, USA	Conti & al. (2005)	-	-
Opuntia tomentosa Salm-Dyck	Cactaceae	A	Mexico	Guiggi (2008)	-	-
Pelargonium peltatum (L.) L'Hér.	Geraniaceae	A	South Africa	Conti & al. (2005) [+] Conti & al. (2007) [-]	-	-
Phedimus spurius (M.Bieb.) 't Hart	Crassulaceae	A	Caucasus	Conti & al. (2005)	-	-
Phedimus stellatus (L.) Raf.	Crassulaceae	I		Conti & al. (2005)		
Phytolacca dioica L.	Phytolaccaceae	A	Argentina, Brazil, Ecuador	Conti & al. (2005)	1803 (M), 1840 (S)	1878 (S)
Portulaca grandiflora Hook.	Portulacaceae	A	Argentina, Uruguay	Conti & al. (2005)	1836 (S,M)	≤ 1909 (S)
Portulaca granulato-stellata (Poelln.) Ricceri & Arrigoni	Portulacaceae	?		Conti & al. (2005)	-	-
Portulaca macrantha (Maire) Ricceri & Arrigoni	Portulacaceae	?		Conti & al. (2005)	-	-
Portulaca nitida (Danin & H. & G. Baker) Ricceri & Arrigoni	Portulacaceae	?		Conti & al. (2005)	-	-
Portulaca oleracea L. subsp. *oleracea*	Portulacaceae	?		Conti & al. (2005)	1415 (S)	-
Portulaca oleracea L. subsp. *sativa* (Haw.) Celak	Portulacaceae	A		Conti & al. (2005)	1562 (S)	-
Portulaca stellata (Danin & H. & G. Baker) Ricceri & Arrigoni	Portulacaceae	?		Conti & al. (2005)	-	-
Rhodiola rosea L.	Crassulaceae	I		Conti & al. (2005)		
Sedum acre L.	Crassulaceae	I		Conti & al. (2005)		

Table 2. Contnued.

Taxon	Family	Status	Origin	Ref./Doc.	Introd.	Naturaliz.
Sedum aetnense Tin.	Crassulaceae	I		Conti & al. (2005)		
Sedum album L. subsp. *album*	Crassulaceae	I		Conti & al. (2005)		
Sedum album L. subsp. *micranthum*	Crassulaceae	I		Pignatti (1982)		
Sedum alpestre Vill.	Crassulaceae	I		Conti & al. (2005)		
Sedum alsinefolium All.	Crassulaceae	I		Conti & al. (2005)		
Sedum amplexicaule DC. *amplexicaule*	Crassulaceae	I		Conti & al. (2005)		
Sedum amplexicaule subsp *tenuifolium* (Sm.) Greuter	Crassulaceae	I		Conti & al. (2005)		
Sedum andegavense (DC.) Desv.	Crassulaceae	I		Conti & al. (2005)		
Sedum annuum L.	Crassulaceae	I		Conti & al. (2005)		
Sedum atratum L.	Crassulaceae	I		Conti & al. (2005)		
Sedum caeruleum L.	Crassulaceae	I		Conti & al. (2005)		
Sedum caespitosum (Cav.) DC.	Crassulaceae	I		Conti & al. (2005)		
Sedum cepaea L.	Crassulaceae	I		Conti & al. (2005)		
Sedum dasyphyllum L. subsp. *dasyphyllum*	Crassulaceae	I		Conti & al. (2005)		
Sedum dasyphyllum subsp. *glanduliferum* (Guss.) Nyman	Crassulaceae	I		Conti & al. (2005)		
Sedum fragrans 't Hart	Crassulaceae	I		Conti & al. (2005)		
Sedum glandulosum Moris	Crassulaceae	I		Conti & al. (2005)		
Sedum gypsicola Boiss. & Reut.	Crassulaceae	I		Conti & al. (2005)		
Sedum hirsutum All. subsp. *hirsutum*	Crassulaceae	I		Conti & al. (2005)		
Sedum hispanicum L.	Crassulaceae	I		Conti & al. (2005)		
Sedum litoreum Guss.	Crassulaceae	I		Conti & al. (2005)		
Sedum luteolum Chaboiss.	Crassulaceae	I		Pignatti (1982)		
Sedum magellense Ten. *magellense*	Crassulaceae	I		Conti & al. (2005)		
Sedum magellense Ten. *olympicum* (Boiss.) Grande	Crassulaceae	I		Conti & al. (2005)		
Sedum monregalense Balb.	Crassulaceae	I		Conti & al. (2005)		
Sedum montanum Songeon & E.P.Perrier	Crassulaceae	I		Conti & al. (2005)		
Sedum nussbaumerianum Bitter	Crassulaceae	A	Mexico	Conti & al. (2005)	-	-
Sedum ochroleucum Chaix	Crassulaceae	I		Conti & al. (2005)		
Sedum palmeri S.Watson	Crassulaceae	A	Mexico	Conti & al. (2005)	-	-
Sedum praealtum DC.	Crassulaceae	A	Mexico	Conti & al. (2005)	-	-
Sedum rubens L.	Crassulaceae	I		Conti & al. (2005)		
Sedum rupestre L.	Crassulaceae	I		Conti & al. (2005)		
Sedum sarmentosum Bunge	Crassulaceae	A	China, Korea, Japan	Conti & al. (2005)	1880 (S, M)	-
Sedum sediforme (Jacq.) Pau	Crassulaceae	I		Conti & al. (2005)		
Sedum sexangulare L.	Crassulaceae	I		Conti & al. (2005)		
Sedum thartii L.P.Hebert	Crassulaceae	I		Conti & al. (2005)[5]		
Sedum villosum L.	Crassulaceae	I		Conti & al. (2005)		
Sempervivum alpinum Griseb. & Schenk	Crassulaceae	I		Conti & al. (2005)		
Sempervivum arachnoideum L.	Crassulaceae	I		Conti & al. (2005)		
Sempervivum calcareum Jord.	Crassulaceae	?		Conti & al. (2005)	-	-
Sempervivum dolomiticum Facchini	Crassulaceae	I		Conti & al. (2005)		
Sempervivum glaucum Ten.	Crassulaceae	I		Conti & al. (2005)		
Sempervivum grandiflorum Haw.	Crassulaceae	I		Conti & al. (2005)		
Sempervivum montanum subsp. *burnatii* Wettst. ex Hayek	Crassulaceae	I		Conti & al. (2005)		
Sempervivum montanum L. subsp. *montanum*	Crassulaceae	I		Conti & al. (2005)		

Table 2. Contnued.

Taxon	**Family**	**Status**	**Origin**	**Ref./Doc.**	**Introd.**	**Naturaliz.**
Sempervivum riccii Iberite & Anzal.	Crassulaceae	I		Conti & al. (2005)		
Sempervivum tectorum L. gruppo	Crassulaceae	I		Conti & al. (2005)		
Sempervivum wulfenii Hoppe ex Mert. & Koch subsp. *wulfenii*	Crassulaceae	I		Conti & al. (2005)		
Senecio talinoides subsp. *mandraliscae* (Tin.) G.D. Rowley	Asteraceae		South Africa	Domina (2005); Pasta (2003)[6]	1780 (S, M)	1856 (S)
Tetragonia tetragonoides (Pall.) Kuntze	Aizoaceae	A	New Zealand	Conti & al. (2005) [+]; Conti & al. (2007) [-]	-	-
Tillaea alata Viv.	Crassulaceae	A	Asia Minor, Mediterranean region	Conti & al. (2007)	-	-
Tillaea campestris (Eckl. & Zeyh.) Brullo, Giusso & Siracusa	Crassulaceae	A	South Africa	Conti & al. (2005)	-	-
Tillaea muscosa L.	Crassulaceae	I		Conti & al. (2005)		
Tradescantia fluminensis Velloso	Commelinaceae	A	Argentina, Brazil, Paraguay, Uruguay	Conti & al. (2005)	-	-
Umbilicus chloranthus Heldr. & Sartori *ex* Boiss.	Crassulaceae	?	Albania, Anatolia, Greece, Serbia	Conti & al. (2005)	-	-
Umbilicus horizontalis (Guss.) DC.	Crassulaceae	I		Conti & al. (2005)		
Umbilicus rupestris (Salisb.) Dandy	Crassulaceae	I		Conti & al. (2005)		
Yucca aloifolia L.	Agavaceae	A	Mexico	Conti & al. (2005)	1780 (S, M)	1860 (S)
Yucca filamentosa L.	Agavaceae	A	USA	Webb (1980); Viegi (1993)	-	-
Yucca gloriosa L.	Agavaceae	A	USA	Conti & al. (2005)	1635 (S, M)	1790 (S)

1 *sub Aizoon hispanicum* L.
2 *sub Aloe barbadensis* Miller
3 *sub Aloe succotrina* Lam.
4 *sub Opuntia subulata* (Muehlenpf.) Engelm.
5 *sub Sedum montanum* Song. & Perr. subsp. *orientale* ‘t Hart
6 *sub Kleinia mandraliscae* Tin.

Emanuele Bocchieri & Gianluca Iiriti

Contribution to knowledge of the endemic vascular flora of the capes and promontories of Sardinia (Italy)

Abstract

Bocchieri, E. & Iiriti, G.: Contribution to knowledge of the endemic vascular flora of the capes and promontories of Sardinia (Italy). — Bocconea 23: 353-369. 2009. — ISSN 1120-4060.

The Authors report on the presence on 24 capes and 2 promontories in Sardinia of 112 endemic *taxa*, 72 of which of specific rank, 36 sub-specific, 2 varietal and 2 hybrid. The best-represented families are: *Plumbaginaceae* (22), *Asteraceae* (15) and *Fabaceae* (11). Analysis of the biological spectrum denotes dominance of chamaephytes (46%) followed by geophytes (21%) and hemicryptophytes (18%). The chorological spectrum highlights greater presence of Sardinian (41%) and Sardinian-Corsican (28%) endemisms. Noteworthy is the presence in these areas of the *locus classicus* of 16 endemic taxa.

Introduction

In the framework of a research programme targeting study of the flora and vegetation landscape in the coastal territories of Sardinia, our attention was attracted to analysis of the endemic component present on capes and promontories.

Along the coasts of Sardinia, according to indications of the IGM (Italian Military Geographical Institute), there are 36 capes and numerous promontories which preserve eco-systems of significant naturalistic value and rich endemic flora (Bocchieri & Iiriti 2005). Preceding contributions addressing the endemic component of these territories covered exclusively Cape Caccia (Valsecchi, 1964) and Cape Teulada (Ballero & Bocchieri 1987). Our investigations, which for some years now have been concerned with the floristic aspects of these areas, aim at defining endemic flora present in these areas to highlight the importance of preserving the coastal eco-systems which all too often are subjected to the encroachment of human activity.

Material and methods

This paper contains definition of the endemic component and distribution of the *taxa* present on 24 capes and 2 promontories in Sardinia (Fig. 1) by means of bibliographical references and unpublished data collected during numerous herborizations.

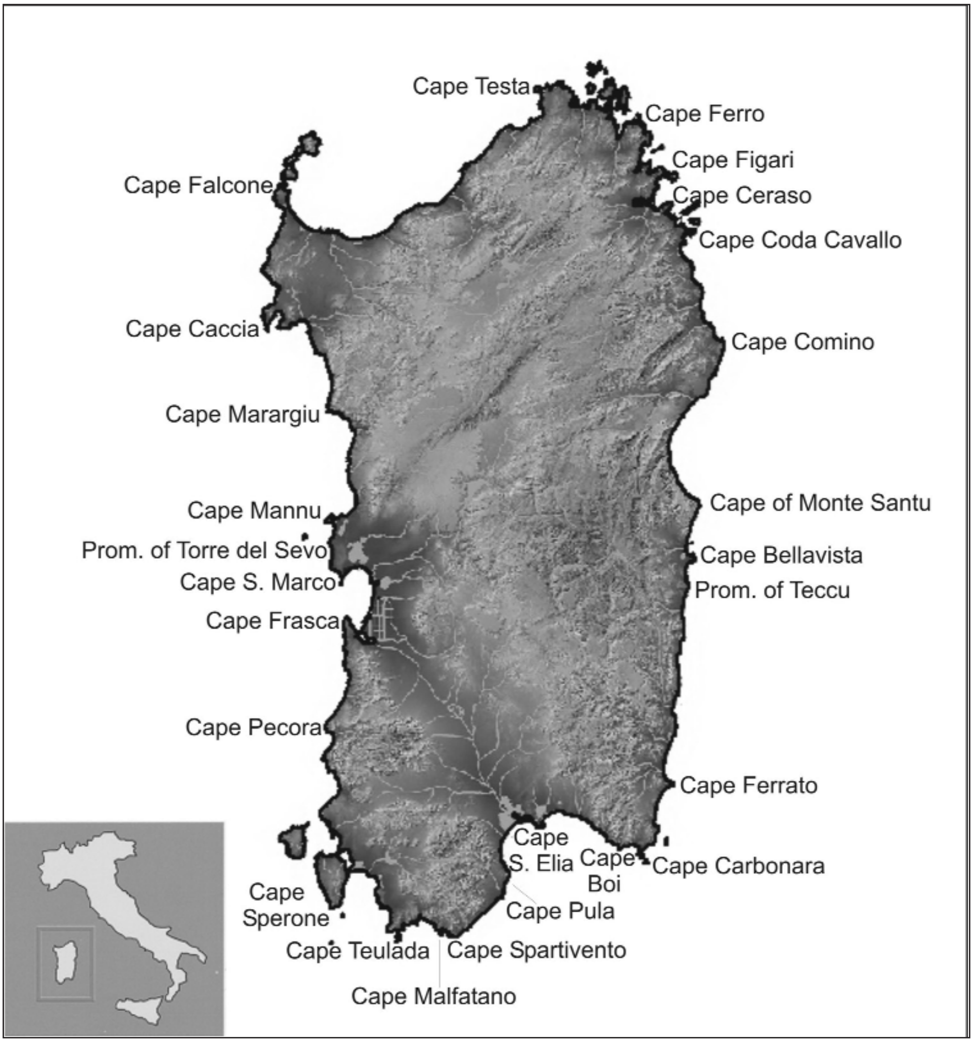

Fig. 1. Localization of the capes and promontories with distribution data referred to the endemic *taxa* present in the floristic listing.

Special attention was addressed to the *taxa* mentioned previously but not observed in recent times: in this respect, we performed a field survey to define their actual distribution and presence.

Apart from "Flora d'Italia" (Pignatti, 1982), "Flora Europaea" (Tutin & al. 1968-1980; 1993), "Med-Checklist" (Greuter & al. 1984; 1986; 1989), "La flore endèmique de la Corse" (Gamisans & Marzocchi 1996) and "Guide des orchidées d'Europe" (Delforge 2005), for nomenclature updating we also used "An Annotated Checklist of Italian Vascular Flora" (Conti & al. 2005) and, when available, reviews of specific taxonomic groups. Quotations from the authors are shown in standard form in accordance with Brummitt & Powell (1982).

In the floristic listing, *taxa* are shown in alphabetical order and for each entity we indicate the specific or lower rank binomial, family and biological form following the abbreviations proposed by Raunkiaer (1934), in square brackets the chorological form and, finally, distribution data. Chorology is expressed through use of the following codes: AG=Algerian punctiform localities (North Africa), AT=Tuscan Archipelago, BL=Balearic Islands, CAL=Calabria, CO=Corsica, H=Hyerès Islands, GA=punctiform localities of southern France, ITM=punctiform localities of the Italian peninsula, SA=Sardinia, SI=Sicily, TN=Tunisian punctiform localities (North Africa). For analysis of the endemic flora we utilised the chorological categories indicated by the abbreviations used by Arrigoni & Di Tommaso (1991), integrated by Bacchetta & Pontecorvo (2005).

We furthermore utilised the following apex symbols: † indicates a *taxon* previously mentioned but not observed; * indicates an unpublished datum referring to distribution of a *taxon*; ● indicates the *locus classicus* of a given *taxon*. Where necessary, we have added explanatory notes.

Floristic list

Allium parciflorum Viv. – *Liliaceae* - G – [SA-CO] – C. Caccia (Valsecchi 1964; 1966; 1974; 1982); C. Testa (Valsecchi 1974; 1982); C. Falcone (Valsecchi 1974; 1982); C. of Monte Santu (Bocchieri & al. 2008).

Allium roseum L. var. *insulare* Genn. – *Liliaceae* - G – [SA-CO] - C. S. Elia (Martinoli 1950 sub *A. roseum* L.); C. Caccia (Valsecchi 1966 sub *A. roseum* L.); C. Carbonara (Camarda & Ballero 1981 sub *A. roseum* L.); C. of Pula (Bocchieri 1984 sub *A. roseum* L.); C. Teulada (Ballero & Bocchieri 1987 sub *A. roseum* L.; Bacchetta 2006); C. Mannu (Bocchieri & al. 1988 sub *A. roseum* L.); C. Ferrato (Ballero 1988 sub *A. roseum* L.); C. Frasca (Bocchieri & Mulas 1992 sub *A. roseum* L.); Prom. of Torre del Sevo (Mulas 1993 sub *A. roseum* L.); C. S. Marco (Bocchieri & Mulas 1996 sub *A. roseum* L.); Prom. of Teccu (Bocchieri & Iiriti 2003 sub *A. roseum* L.); C. Malfatano (Bocchieri & Iiriti 2004a sub *A. roseum* L.; Bacchetta 2006); *C. Coda Cavallo; *C. Comino; *C. Marargiu.

†*Anchusa crispa* Viv. spp. *crispa* - *Boragineceae* - H – [SA-CO] - C. Falcone (Valsecchi 1980; Biondi & al. 2001).

Note: from recent research (Bacchetta & al. 2008) it would appear that the biological station of the beach of Pelosa (Stintino), sited at Cape Falcone, should be considered extinct. This datum is also confirmed by Farris (*in verbis*) who states that in 2000 this population consisted of some 30 exemplars, which gradually decreased in number over the past few years until their total extinction.

Anthemis arvensis L. ssp. *acrochordona* Briq. *et* Cavill. – *Asteraceae* - T – [SA-SI] - C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006).

Anthyllis hermanniae L. ssp. *ichnusae* Brullo & Giusto – *Fabaceae* - NP – [SA] - C. S. Elia (Martinoli 1950); C. of Monte Santu (Bocchieri & al. 2008).

Arenaria balearica L. – *Caryophyllaceae* – H - [SA–CO-AT-BL] - C. Testa (Diana Corrias 1981).

Aristolochia tyrrhena E. Nardi & Arrigoni – *Aristolochiaceae* - G - [SA] - C. Ferrato (Ballero 1988).

Arum pictum L. f. ssp. *pictum* – *Araceae* - G - [SA-CO] - C. Caccia (Valsecchi 1964; 1966; Diana Corrias 1982); C. Carbonara (Camarda & Ballero 1981); C. Testa (Diana Corrias 1982); C. of

Pula (Bocchieri 1984); C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006); C. Ferrato (Ballero 1988); C. Mannu (Bocchieri & al. 1988); C. Frasca (Bocchieri & Mulas 1992); Prom. of Torre del Sevo (Mulas 1993); C. Bellavista (Bocchieri 1998); C. S. Marco (Bocchieri & Mulas 1996); C. Malfatano (Bocchieri & Iiriti 2004a; Bacchetta 2006); C. Coda Cavallo (Bocchieri & Iiriti 2004b); C. of Monte Santu (Bocchieri & al. 2008); *C. Marargiu.

Astragalus terraccianoi Vals. – *Fabaceae* - NP - [SA-CO] - •C. Caccia (Valsecchi 1994); C. Falcone (Valsecchi 1994; Biondi & al. 2001); C. Teulada (Ballero & Bocchieri 1987 sub *A. massiliensis* (Miller.) Lam.; Valsecchi 1994; Bacchetta 2006).

Bellium bellidioides L. – *Asteraceae* - H - [SA-CO-BL] - C. Caccia (Valsecchi 1964; 1966; Arrigoni 1979); C. Falcone (Arrigoni 1979; Biondi & al. 2001); C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006); C. Ferrato (Ballero 1988); C. Mannu (Arrigoni 1979; Bocchieri & al. 1988); C. Frasca (Bocchieri & Mulas 1992); Prom. of Torre del Sevo (Mulas 1993); C. Bellavista (Arrigoni 1979; Bocchieri 1998); C. Coda Cavallo (Bocchieri & Iiriti 2004b); C. of Monte Santu (Bocchieri & al. 2008).

Bellium crassifolium Moris – *Asteraceae* - Ch - [SA] - •C. S. Elia (Martinoli 1950; Chiappini 1978a; Arrigoni 1979; Biondi & Mossa 1992); C. Spartivento (Arrigoni 1979); C. Pecora (Arrigoni 1979); C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006); C. Malfatano (Bocchieri & Iiriti 2004a; Bacchetta 2006).

Biscutella morisiana Raffaelli – *Brassicaceae* – T - [SA-CO] - C. S. Elia (Martinoli 1950 sub *B. didyma* L. var. *Columnae* (Ten.); C. Bellavista (Bocchieri 1998 sub *B. didyma* L.); C. of Monte Santu (Bocchieri & al. 2008).

Bituminaria morisiana (Pignatti & Metlesics) Greuter - *Fabaceae* - Ch – [SA-TN] - C. Bellavista (Bocchieri 1998 sub *Psoralea morisiana* Pignatti & Metlesics); C. of Monte Santu (Bocchieri & al. 2008).

Brassica insularis Moris – *Brassicaceae* – Ch – [SA-CO-SI-TN] - C. Caccia (Valsecchi 1964; 1966; Chiappini 1978b; Biondi & al. 2001); *C. Figari.

Note: recent research has highlighted the absence of the species for Cape Carbonara (Iiriti 2007) where it was reported by Camarda & Ballero (1981).

Brassica tyrrhena Giotta, Piccitto & Arrigoni - *Brassicaceae* - Ch – [SA] - C. of Monte Santu (Bocchieri & al. 2008).

Bryonia marmorata Petit – *Curcurbitaceae* - G – [SA-CO] - C. Pecora (Arrigoni 1982); C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006); C. Ferrato (Ballero 1988); C. Frasca (Bocchieri & Mulas 1992); C. of Monte Santu (Bocchieri & al. 2008).

†*Buglossoides minima* (Moris) R. Fernandes – *Boragineceae* - T – [SA-SI-CAL] - C. S. Elia (Martinoli 1950 sub *Lithospermum minimum* Moris).

Note: the report by Martinoli is not supported by any *exsiccata* and subsequent research (Biondi & Mossa 1992), together with recent field surveys by the authors themselves, did not lead to finding of this species. The absence of recent data concerning its distribution leads to its exclusion from the floristic and endemic component of Cape S. Elia.

Buphthalmum inuloides Moris - *Asteraceae* - Ch – [SA] - C. Testa (Valsecchi 1976a).

Carex microcarpa Bertol. *ex* Moris – *Cyperaceae* – H – [SA-CO-AT] - C. Spartivento (Arrigoni 1984; Bacchetta 2006); C. of Monte Santu (Bocchieri & al. 2008).

Centaurea filiformis Viv. ssp. *ferulacea* (Martelli) Arrigoni – *Asteraceae* - Ch - [SA] - C. of Monte Santu (Bocchieri & al. 2008).

Centaurea filiformis Viv. ssp. *filiformis* – *Asteraceae* - Ch - [SA] - C. Figari (Arrigoni 1981).

Centaurea horrida Badarò – *Asteraceae* - NP – [SA] – C. Caccia (Valsecchi 1976a); C. Falcone (Valsecchi 1976a; Biondi & al. 2001).

Cephalaria squamiflora (Sieber) Greuter ssp. *mediterranea* (Viv.) Pignatti – *Dipsacaceae* – Ch - [SA-CO-BL] - C. of Monte Santu (Bocchieri & al. 2008).

Colchicum actupii Fridlender – *Liliaceae* - G – [SA] - C. of Monte Santu (Bocchieri & al. 2008).

Crepis vesicaria L. ssp. *hyemalis* (Biv.) Babc. – *Asteraceae* - T – [SA-SI] - C. Carbonara (Camarda & Ballero 1981); C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006); C. Ferrato (Ballero 1988); C. Mannu (Bocchieri & al. 1988); Prom. of Torre del Sevo (Mulas 1993); C. S. Marco (Bocchieri & Mulas 1996); C. Malfatano (Bocchieri & Iiriti 2004a; Bacchetta 2006).

Crocus minimus DC. – *Iridaceae* - G – [SA-CO-AT] – C. Caccia (Valsecchi 1964; 1966; Camarda 1982); C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006); C. Ferrato (Ballero 1988); Prom. of Teccu (Bocchieri & Iiriti 2003); C. Coda Cavallo (Bocchieri & Iiriti 2004b); C. of Monte Santu (Bocchieri & al. 2008).

Cymbalaria aequitriloba (Viv.) A. Chev. ssp. *aequitriloba* - *Scrophulariaceae* – Ch – [SA-CO-AT-BL] – C. of Monte Santu (Bocchieri & al. 2008).

Delphinium longipes Moris – *Ranunculaceae* - H – [SA] – C. S. Elia (Martinoli 1950 sub *D. peregrinum* var. *longipes* Moris); C. Mannu (Bocchieri & al. 1988; Arrigoni 2006b); C. S. Marco (Bocchieri & Mulas 1996).

Delphinium pictum Willd. ssp. *pictum* - *Ranunculaceae* - H – [SA-CO-BL-H] – C. Frasca (Bocchieri & Mulas 1992); C. of Monte Santu (Bocchieri & al. 2008).

Dianthus cyathophorus Moris – *Caryophyllaceae* – Ch – [SA] – C. of Monte Santu (Bocchieri & al. 2008).

Dianthus sardous Bacch., Brullo, Casti & Giusto - *Caryophyllaceae* – Ch – [SA] – C. Caccia (Valsecchi 1964 sub *Dianthus arrostii* C. Presl.; 1966 sub *Dianthus arrostii* C. Presl.); C. of Monte Santu (Bocchieri & al. 2008); *C. Figari.

Dipsacus ferox Loisel. - *Dipsacaceae* - H – [SA-CO] – Prom. of Torre del Sevo (Mulas 1993).

Erodium corsicum Léman – *Geraniaceae* – Ch – [SA-CO] - C. Caccia (Valsecchi 1964; 1966; 1977; Chiappini 1978b; Biondi & al. 2001); C. Falcone (Valsecchi 1977; Biondi & al. 2001); C. Testa (Valsecchi 1977).

Euphorbia pithyusa L. ssp. *cupanii* (Guss. ex Bertol.) Radcl.-Sm. - *Euphorbiaceae* - G – [SA-CO-SI] - C. Figari (Valsecchi 1980 sub *E. pithyusa* L. ssp. *cupanii* Guss. ex Bertol.); C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006 sub *E. cupanii* Guss. ex Bertol.); C. Mannu (Bocchieri & al. 1988); C. S. Marco (Bocchieri & Mulas 1996); C. Comino (Arrigoni 1996 sub *E. pithyusa* L. ssp. *cupanii* Guss. ex Bertol.); Prom. of Torre del Sevo (Mulas 1993); Prom. of Teccu (Bocchieri & Iiriti 2003 sub *Euphorbia amygdaloides* L. ssp. *semiperfoliata* (Viv.) Radcl.-Sm.).

Ferula arrigonii Bocchieri - *Apiaceae* - H – [SA-CO] - C. Frasca (Bocchieri & Mulas 1992); C. S. Marco (Bocchieri & Mulas 1996); C. Caccia (Biondi & al. 2001); C. Teulada (Bacchetta 2006).

Filago tyrrhenica Chrtek & Holub *ex* Soldano & F. Conti – *Asteraceae* - H - [SA-CO] - C. Testa (Corrias 1977 sub *Evax rotundata* Moris); C. Falcone (Corrias 1977 sub *Evax rotundata* Moris; Biondi & al. 2001 sub *Evax rotundata* Moris).

Galium corsicum Spreng. – *Rubiaceae* - H - [SA-CO] - C. of Monte Santu (Bocchieri & al. 2008).

Galium schmidii Arrigoni - *Rubiaceae* - Ch – [SA] - C. Caccia (Arrigoni 1980).

Genista casadonensis Vals. – *Fabaceae* - NP – [SA] - C. of Monte Santu (Bocchieri & al. 2008).

Genista corsica (Loisel.) DC. – *Fabaceae* - NP – [SA-CO] - C. S. Elia (Martinoli 1950; Valsecchi 1977; Biondi & Mossa 1992); C. Caccia (Valsecchi 1964; 1966; 1977); C. Figari (Valsecchi 1977); C. Ceraso (Valsecchi 1977); C. Testa (Valsecchi 1977); C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006); C. Ferrato (Ballero 1988); C. Mannu (Valsecchi 1977; Bocchieri & al. 1988); C. Falcone (Biondi & al. 2001); Prom. of Teccu (Bocchieri & Iiriti 2003); C. of Monte Santu (Bocchieri & al. 2008).

Genista ephedroides DC. – *Fabaceae* - NP - [SA-CO] - C. Testa (Valsecchi 1986; Brullo & De Marco 1996).

Genista ferox Poir. – *Fabaceae* - NP – [SA-AG-TN] - C. Malfatano (Bacchetta 2006).

Genista morisii Colla – *Fabaceae* - NP - [SA] - C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006).

Genista sardoa Vals. – *Fabaceae* - NP - [SA] - •C. Caccia (Valsecchi 1964 sub *G. aspalatoides* Lam. v. *salzmanni* DC.; 1966 sub *G. aspalatoides* Lam. v. *salzmanni* DC.; 1984; Biondi & al. 2001).

Genista valsecchiae Brullo & De Marco – *Fabaceae* - NP – [SA] - C. Spartivento (Valsecchi 1986 sub *Genista ephedroides* DC.; Brullo & De Marco 1996; Bacchetta 2006); C. Pecora (Valsecchi 1986 sub *Genista ephedroides* DC.; Brullo & De Marco 1996; Bacchetta 2006); C. Malfatano (Bocchieri & Iiriti 2004a sub *Genista ephedroides* DC.; Bacchetta 2006).

Helichrysum microphyllum (Willd.) Camb. ssp. *tyrrhenicum* Bacch., Brullo & Giusto – *Asteraceae* - Ch – [SA-CO-BL] - C. S. Elia (Martinoli 1950 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman; Biondi & Mossa 1992 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); C. Caccia (Valsecchi 1964 sub *H. microphyllum* Cambess; 1966 sub *H. microphyllum* Cambess; Biondi & al. 2001 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); C. Carbonara (Camarda & Ballero 1981 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); C. of Pula (Bocchieri 1984 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); C. Teulada (Ballero & Bocchieri 1987 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman; Bacchetta 2006); C. Ferrato (Ballero 1988 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); C. Mannu (Bocchieri & al. 1988 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); C. Frasca (Bocchieri & Mulas 1992 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); Prom. of Torre del Sevo (Mulas 1993 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); C. Bellavista (Bocchieri 1998 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); C. S. Marco (Bocchieri & Mulas 1996 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); C. Comino (Arrigoni 1996 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); C. Falcone (Biondi & al. 2001 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); Prom. of Teccu (Bocchieri & Iiriti 2003 sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); C. Malfatano (Bocchieri & Iiriti 2004a sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman; Bacchetta 2006); C. Coda Cavallo (Bocchieri & Iiriti 2004b sub *H. italicum* (Roth) Don ssp. *microphyllum* (Wills.) Nyman); C. di Monte Santu (Bocchieri & al. 2008); *C. Boi; *C. Figari; *C Marargiu; *C. Pecora; *C. Spartivento; *C. Testa.

Helichrysum saxatile Moris ssp. *saxatile* – *Asteraceae* - Ch – [SA] - C. of Monte Santu (Bocchieri & al. 2008).

Note: the report by Martinoli is not supported by any *exsiccata* and subsequent research (Biondi & Mossa 1992), together with recent field surveys by the authors themselves, did not lead to finding of this species. The absence of recent data concerning its distribution leads to its exclusion from the floristic and endemic component of Capo S. Elia.

Hyoseris taurina (Pamp.) Martinoli - *Asteraceae* - Ch - [SA-SI-CAL-TN] - C. Spartivento (Arrigoni 1981; Bacchetta 2006); C. Teulada (Ballero & Bocchieri 1984; Bacchetta 2006).

Isoëtes tiguliana Genn. - *Isoëtaceae* - I – [SA-TN] - C. Frasca (Bocchieri & Mulas 1992; Arrigoni 2006b).

Lactuca longidentata Moris - *Asteraceae* - H - [SA] - C. of Monte Santu (Bocchieri & al. 2008).

Leucojum roseum Martin – *Amaryllidaceae* - G – [SA-CO] – C. Testa (Corrias 1977); C. Falcone (Corrias 1977).

Limonium acutifolium (Rchb.) Salmon ssp. *acutifolium* – *Plumbaginaceae* - Ch – [SA-CO] - C. Falcone (Diana Corrias 1977; Biondi & al. 2001); C. Mannu (Diana Corrias 1977); Prom. of Torre del Sevo (Diana Corrias 1977).

Limonium acutifolium (Rchb.) Salmon ssp. *nymphaeum* (Erben) Arrigoni – *Plumbaginaceae* - Ch – [SA] - C. Caccia (Valsecchi 1964 sub *L. acutifolium* (Rchb.) Salmon; 1966 sub *L. acutifolium* (Rchb.) Salmon; Diana Corrias 1977 sub *L. acutifolium* (Rchb) Salmon ssp. *obtusifolium* (Rouy) Diana-Corrias; Mayer 1995 sub *L. nymphaeum* Erben; Biondi & al. 2001 sub *L. acutifolium* (Rchb.) Salmon).

Limonium acutifolium (Rchb.) Salmon ssp. *tenuifolium* (Bertol. ex Moris) Arrigoni – *Plumbaginaceae* - Ch – [SA] - C. Mannu (Arrigoni & Diana 1985 sub *L. tenuifolium* (Bertol. ex Moris) Erben; Bocchieri & al. 1988 sub *L. tenuifolium* (Bertol. ex Moris) Erben); Prom. of Torre del Sevo (Arrigoni & Diana 1985 sub *L. tenuifolium* (Bertol. ex Moris) Erben; Mulas 1993 sub *L. tenuifolium* (Bertol. ex Moris) Erben).

Limonium acutifolium (Rchb.) Salmon ssp. *tharrosianum* (Arrigoni & Diana) Arrigoni – *Plumbaginaceae* - Ch – [SA] - •C. S. Marco (Arrigoni & Diana 1985 sub *L. tharrosianum* Arrigoni & Diana; Mayer 1995 sub *L. tharrosianum* Arrigoni & Diana; Bocchieri & Mulas 1996 sub *L. tharrosianum* Arrigoni & Diana).

Limonium capitis-eliae Erben – *Plumbaginaceae* - Ch – [SA] - •C. S. Elia (Erben 2001).

Limonium capitis-marci Arrigoni & Diana – *Plumbaginaceae* - Ch – [SA] - •C. S. Marco (Arrigoni & Diana 1990; Bocchieri & Mulas 1996).

Limonium contortirameum (Mab.) Erben – *Plumbaginaceae* - Ch – [SA-CO] - C. Testa (Diana Corrias 1977 sub *L. articulatum* (Loisel.) Kuntze; Pignatti 1982 sub *L. articulatum* (Loisel.) Kuntze); C. Comino (Arrigoni 1996); C. Coda Cavallo (Bocchieri & Iiriti 2004b); *C. Figari.

Limonium dubium (Guss.) Litard. – *Plumbaginaceae* - Ch – [SA-CO-SI] - C. of Pula (Arrigoni & Diana 1985); C. Comino (Arrigoni & Diana 1985); C. S. Elia (Arrigoni & Diana 1985); C. Ferrato (Ballero 1988); C. Mannu (Bocchieri & al. 1988).

Limonium gallurense Arrigoni & Diana – *Plumbaginaceae* - Ch – [SA] - •C. Testa (Arrigoni & Diana 1986; Mayer 1995).

Limonium glomeratum (Tausch) Erben – *Plumbaginaceae* - Ch – [SA-SI] - C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006); C. Falcone (Arrigoni & Diana 1985); C. Mannu (Bocchieri & al. 1988); C. Frasca (Bocchieri & Mulas 1992); C. S. Marco (Arrigoni & Diana 1985; Bocchieri & Mulas 1996); C. Falcone (Biondi & al. 2001).

Limonium hermaeum (Pignatti) Pignatti – *Plumbaginaceae* - Ch – [SA] - C. of Monte Santu (Bocchieri & al. 2008).

Limonium laetum (Nyman) Pignatti – *Plumbaginaceae* - Ch – [SA] - C. Caccia (Valsecchi 1964; 1966; Chiappini 1978b); C. Mannu (Bocchieri & al. 1988); C. Falcone (Diana Corrias 1977 sub *L. turritanum* Diana-Corrias; Biondi & al. 2001).

Limonium lausianum Pignatti – *Plumbaginaceae* - Ch – [SA] - •C. S. Marco (Diana Corrias 1976; Pignatti 1982; Mayer 1995; Bocchieri & Mulas 1996); C. Mannu (Diana Corrias 1976; Bocchieri & al. 1988).

Limonium malfatanicum Erben – *Plumbaginaceae* - Ch – [SA] - •C. Malfatano (Erben 2001; Bocchieri & Iiriti 2004a; Bacchetta 2006).

Limonium merxmuelleri Erben ssp. *oristanum* (Mayer) Arrigoni – *Plumbaginaceae* - Ch – [SA] - C. S. Marco (Bocchieri & Mulas 1996 sub *L. oristanense* Mayer; Mayer 1995 sub *L. oristanum* Mayer).

Limonium merxmuelleri Erben ssp. *sulcitanum* (Arrigoni) Arrigoni – *Plumbaginaceae* - Ch – [SA] - C. S. Marco (Arrigoni 1981 sub *L. sulcitanum* Arrigoni); C. Teulada (Ballero & Bocchieri 1984 sub *L. sulcitanum* Arrigoni; 1987 sub *L. sulcitanum* Arrigoni).

Limonium merxmuelleri Erben ssp. *tigulianum* (Arrigoni & Diana) Arrigoni – *Plumbaginaceae* - Ch – [SA] - C. Spartivento (Arrigoni 1981 *L. dictyocladum* (Boiss. in A. DC.) Kuntze; Arrigoni & Diana 1991 sub *L. tigulianum* Arrigoni & Diana; Bacchetta 2006 sub *L. tigulianum* Arrigoni & Diana); C. of Pula (Bocchieri 1984 *L. dictyocladum* (Boiss. in A. DC.) Kuntze; Arrigoni &

Diana 1991 sub *L. tigulianum* Arrigoni & Diana); C. Teulada (Ballero & Bocchieri 1984 *L. dictyocladum* (Boiss. in A. DC.) Kuntze; 1987 sub *L. dictyocladum* (Boiss. in A. DC.) Kuntze; Arrigoni & Diana 1991 sub *L. tigulianum* Arrigoni & Diana); C. Sperone (Arrigoni & Diana 1991 sub *L. tigulianum* Arrigoni & Diana); C. Malfatano (Bocchieri & Iriti 2004a sub *L. tigulianum* Arrigoni & Diana; Bacchetta 2006 sub *L. tigulianum* Arrigoni & Diana).

Limonium protohermaeum Arrigoni & Diana – *Plumbaginaceae* - Ch – [SA] - •C. Bellavista (Arrigoni & Diana 1985; Mayer 1995; Bocchieri 1998); Prom. of Teccu (Bocchieri e Iiriti 2003).

Limonium pseudolaetum Arrigoni & Diana – *Plumbaginaceae* - Ch – [SA] – •C. Mannu (Arrigoni & Diana 1990; Mayer 1995).

Limonium retirameum Greuter & Burdet ssp. *caralitanum* (Erben) Arrigoni – *Plumbaginaceae* - Ch – [SA] - •C. S. Elia (Arrigoni & Diana 1991 sub *L. retirameum* Arrigoni & Diana; Erben 2001 sub *L. caralitanum* Erben).

Limonium retirameum Greuter & Burdet ssp. *retirameum* – *Plumbaginaceae* - Ch – [SA] - C. S. Elia (Arrigoni 1981 *L. dictyocladum* (Boiss. in A. DC.) Kuntze; Biondi & Mossa 1992); C. Carbonara (Camarda & Ballero 1981 *L. dictyocladum* (Boiss. in A. DC.) Kuntze; Arrigoni 1981 *L. dictyocladum* (Boiss. in A. DC.) Kuntze; Arrigoni & Diana 1991); C. Ferrato (Ballero 1988 *L. dictyocladum* (Boiss. in A. DC.) Kuntze; Arrigoni & Diana 1991); *C. Boi.

Limonium tyrrhenicum Arrigoni & Diana – *Plumbaginaceae* - Ch – [SA] - C. Figari (Arrigoni & Diana 1985); Prom. of Teccu (Bocchieri & Iiriti 2003).

Lotus cytisoides L. ssp. *conradiae* Gamisans – *Fabaceae* - Ch - [SA-CO] - C. S. Elia (Martinoli 1950 sub *L. creticus* L.); C. Caccia (Valsecchi 1964; 1966 sub *L. cytisoides* L.; Biondi & al. 2001 sub *L. cytisoides* L.); C. Carbonara (Camarda & Ballero 1981 sub *L. cytisoides* L.); C. of Pula (Bocchieri 1984 sub *L. cytisoides* L.); C. Teulada (Ballero & Bocchieri 1987 sub *L. cytisoides* L.; Bacchetta 2006); C. Ferrato (Ballero 1988 sub *L. cytisoides* L.); C. Mannu (Bocchieri & al. 1988 sub *L. cytisoides* L.); C. Frasca (Bocchieri & Mulas 1992 sub *L. cytisoides* L.); Prom. of Torre del Sevo (Mulas 1993 sub *L. cytisoides* L.); C. Bellavista (Bocchieri 1998 sub *L. cytisoides* L.); C. S. Marco (Bocchieri e Mulas 1996 sub *L. cytisoides* L.); C. Comino (Arrigoni 1996 sub *L. cytisoides* L.); C. Falcone (Biondi & al. 2001 sub *L. cytisoides* L.); Prom. of Teccu (Bocchieri & Iiriti 2003 sub *L. cytisoides* L.); C. Malfatano (Bocchieri & Iiriti 2004a sub *L. cytisoides* L.; Bacchetta 2006); C. of Monte Santu (Bocchieri & al. 2008); *C. Boi; *C. Pecora; *C. Testa; *C. Coda Cavallo; *C. Figari.

Mentha suaveolens Ehrh. ssp. *insularis* (Req.) Greuter – *Lamiaceae* - H - [SA-CO-AT-BL] - C. S. Elia (Martinoli 1950 sub *M. rotundifolia* L. var. *insularis* (Req.); C. Testa (Valsecchi 1983).

Mercurialis corsica Coss. & Kralil – *Euphorbiaceae* - Ch – [SA-CO] - C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006); C. di Monte Santu (Bocchieri & al. 2008).

Micromeria filiformis (Aiton) Benth. ssp. *cordata* (Bertol.) Pignatti – *Lamiaceae* – Ch – [SA] - C. of Monte Santu (Bocchieri & al. 2008).

Micromeria filiformis (Aiton) Benth. ssp. *filiformis* – *Lamiaceae* – Ch – [SA-CO-BL] - Prom. of Torre del Sevo (Arrigoni 1986; Mulas 1993).

Nananthea perpusilla (Loisel.) DC. – *Asteraceae* - T – [SA-CO] - C. Falcone (Corrias 1981; Biondi & al. 2001).

Narcissus supramontanus Arrigoni ssp. *supramontanus* – *Amaryllidaceae* – G – [SA] - C. of Monte Santu (Bocchieri & al. 2008); *C. Figari.

Orchis brancifortii Biv. – *Orchidaceae* - G – [SA-SI] - C. Figari (Corrias 1980); C. of Monte Santu (Bocchieri & al. 2008).

Orchis mascula (L.) L. ssp. *ichnusae* Corrias – *Orchidaceae* - G – [SA-BL] - C. of Monte Santu (Bocchieri & al. 2008).

Orchis x *penzigiana* A. Camus nssp. *sardoa* Scrugli & Grasso – *Orchidaceae* - G – [SA] - C. of Monte Santu (Bocchieri & al. 2008).

Ophrys morisii (Martelli) Soò in Keller & al. – *Orchidaceae* - G – [SA-CO] - C. Teulada (Bocchieri & Ballero 1987 sub *O. arachnidiformis* Gren. *et* Phil.); Prom. of Torre del Sevo (Mulas 1993); C. of Monte Santu (Bocchieri & al. 2008).

Ophrys panattensis Scrugli, Cogoni & Pessei – *Orchidaceae* - G – [SA] - C. of Monte Santu (Bocchieri & al. 2008).

Ophrys x *laconiensis* Scrugli & Grasso nssp. *laconiensis* – *Orchidaceae* - G – [SA] - C. Ferrato (Ballero 1988).

Ornithogalum corsicum Jord. & Fourr. – *Liliaceae* - G – [SA-CO] - C. Caccia (Valsecchi 1964 sub *O. exscapum* Ten. ssp. *sandalioticum* Tornadore & Garbari; 1966 sub *O. exscapum* Ten. ssp. *sandalioticum* Tornadore & Garbari; Corrias 1984 sub *O. biflorum* Jord. & Fourr.; Biondi & al. 2001); C. Teulada (Ballero & Bocchieri 1984 sub *O. exscapum* Ten. ssp. *sandalioticum* Tornadore & Garbari; 1987 sub *O. exscapum* Ten. ssp. *sandalioticum* Tornadore & Garbari); C. Falcone (Corrias 1984 sub *O. biflorum* Jord. & Fourr.; Biondi & al. 2001); C. Mannu (Bocchieri & al. 1988); C. Frasca (Bocchieri & Mulas 1992); Prom. of Torre del Sevo (Mulas 1993); C. S. Marco (Bocchieri & Mulas 1996 sub *O. exscapum* Ten. ssp. *sandalioticum* Tornadore & Garbari); C. Malfatano (Bocchieri & Iiriti 2004a; Bacchetta 2006).

Orobanche denudata Moris – *Orobanchaceae* - G – [SA] - C. S. Elia (Martinoli 1950); C. Caccia (Valsecchi 1964; 1966).

Orobanche rigens Loisel. – *Orobanchaceae* - G – [SA-CO] - C. S. Elia (Domina & Arrigoni 2007); C. Falcone (Domina & Arrigoni 2007).

Pancratium illyricum L. - *Amaryllidaceae* – G – [SA-CO-AT] - C. Caccia (Valsecchi 1964; 1966; 1982; Biondi & al. 2001); C. S. Elia (Valsecchi 1982); C. Figari (Valsecchi 1982); C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006); C. Spartivento (Bacchetta 2006); C. of Monte Santu (Bocchieri & al. 2008).

Polygala sardoa Chodat – *Polygalaceae* – H – [SA] - C. of Monte Santu (Bocchieri & al. 2008).

Polygala sinisica Arrigoni – *Polygalaceae* – Ch – [SA] - •C. Mannu (Arrigoni 1983a; Bocchieri & al. 1988).

Polygonum scoparium Loisel. – *Polygonaceae* - Ch – [SA-CO] - C. Ferrato (Ballero 1988).

Potentilla caulescens L. ssp. *nebrodensis* (Strobl. ex Zimm.) Arrigoni – *Rosaceae* - Ch – [SA-SI-ITM] - C. of Monte Santu (Bocchieri & al. 2008).

Prospero autumnale (L.) Speta var. *corsicum* (Boullu) Briq. – *Liliaceae* - G - [SA-CO] - C. Carbonara (Camarda & Ballero 1981 sub *Scilla autumnalis* L.); C. of Pula (Bocchieri 1984 sub *Scilla autumnalis* L.); C. Teulada (Ballero & Bocchieri 1987 sub *Scilla autumnalis* L.; Bacchetta 2006); C. Mannu (Bocchieri & al. 1988 sub *Scilla autumnalis* L.); C. Ferrato (Ballero 1988 sub *Scilla autumnalis* L.); C. Frasca (Bocchieri & Mulas 1992 sub *Scilla autumnalis* L.); Prom. of Torre del Sevo (Mulas 1993 sub *Scilla autumnalis* L.); C. S. Marco (Bocchieri & Mulas 1996 sub *Scilla autumnalis* L.); C. Bellavista (Bocchieri 1998 sub *Scilla autumnalis* L.); C. Malfatano (Bocchieri & Iiriti 2004a sub *Scilla autumnalis* L.; Bacchetta 2006); C. Spartivento (Bacchetta 2006); *C. Boi; *C. Figari; *C Marargiu; *C. Spartivento.

Prospero obtusifolia (Poir.) Speta ssp. *obtusifolia* – *Liliaceae* - G - [SA-AG] - C. S. Elia (Martinoli 1950 sub *Scilla obtusifolia* Poir.); C. Caccia (Valsecchi 1964 sub *Scilla obtusifolia* Poir.; 1966 sub *Scilla obtusifolia* Poir.; Biondi & al. 2001 sub *Scilla obtusifolia* Poir.); C. of Pula (Bocchieri 1984 sub *Scilla obtusifolia* Poir.); C. Ferrato (Ballero 1988 sub *Scilla obtusifolia* Poir.); C. Frasca (Bocchieri & Mulas 1992 sub *Scilla obtusifolia* Poir.).

Ptilostemon casabonae (L.) Greuter – *Asteraceae* - Ch – [SA-CO-AT-H] - C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006); C. Ferrato (Ballero 1988); C. of Monte Santu (Bocchieri & al. 2008).

Ranunculus cordiger Viv. ssp. *diffusus* (Moris) Arrigoni – *Ranunculaceae* - H – [SA-CO] - •C. Carbonara (Arrigoni 1993); C. Falcone (Arrigoni 1983a); C. Spartivento (Arrigoni 1983a;

Bacchetta 2006); C. Frasca (Bocchieri & Mulas 1992; Arrigioni 2006).

Ranunculus revelieri Boreau – *Ranunculaceae* - T – [SA-CO-GA] - C. Frasca (Bocchieri & Mulas 1992).

Romulea requienii Parl. – *Iridaceae* - G - [SA-CO] - C. Caccia (Valsecchi 1964; 1966; Diana Corrias 1983; Biondi & al. 2001); C. Falcone (Diana Corrias 1983; Biondi & al. 2001); C. Carbonara (Diana Corrias 1983); C. of Pula (Bocchieri 1984); C. Teulada (Ballero & Bocchieri 1984; 1987; Bacchetta 2006); C. Ferrato (Ballero 1988); C. Mannu (Bocchieri & al. 1988); C. S. Marco (Bocchieri & Mulas 1996); C. Frasca (Bocchieri & Mulas 1992); Prom. of Torre del Sevo (Mulas 1993); Prom. of Teccu (Bocchieri & Iiriti 2003); C. Malfatano (Bocchieri & Iiriti 2004a; Bacchetta 2006); C. Coda Cavallo (Bocchieri & Iiriti 2004b); *C. Pecora.

Scrophularia canina L. ssp. *bicolor* (Sm.) Greuter – *Scrophulariaceae* - H - [SA-SI] - C. of Monte Santu (Bocchieri & al. 2008).

Scrophularia ramosissima Loisel. – *Scrophulariaceae* - Ch - [SA-CO-BL-GA] - C. Mannu (Bocchieri & al. 1988).

Scrophularia trifoliata L. – *Scrophulariaceae* - H - [SA-CO-AT] - C. S. Elia (Martinoli 1950; Valsecchi 1976b); C. Figari (Valsecchi 1976b); C. of Monte Santu (Bocchieri & al. 2008).

Seseli praecox (Gamisans) Gamisans – *Apiaceae* - Ch - [SA-CO] - C. Caccia (Diana Corrias 1980; Biondi & al. 2001 sub *S. bocconi* Guss. ssp *praecox* Gamisans); C. Figari (Diana Corrias 1980); C. of Monte Santu (Bocchieri & al. 2008).

Sesleria insularis Sommier ssp. *insularis* – *Poaceae* – H – [SA-CO-BL] - •C. Figari (Arrigoni 1983a; 2006a).

Silene nodulosa Viv. – *Caryophyllaceae* - H – [SA-CO] – C. Caccia (Valsecchi 1977).

Silene rosulata Soy.-Will. & Godr. ssp. *sanctae-theresiae* (Jeanm.) Jeanm. – *Caryophyllaceae* - G – [SA] – •C. Testa (Jeanmonod 1983; Corrias 1985).

Silene succulenta Forssk. ssp. *corsica* (DC.) Nyman – *Caryophyllaceae* - T – [SA-CO] – C. Caccia (Arrigoni 1984); C. Testa (Arrigoni 1984); C. Ferro (Arrigoni 1984); C. S. Marco (Arrigoni 1984); C. Teulada (Ballero & Bocchieri 1984; 1987; Arrigoni 1984; Bacchetta 2006); Prom. of Torre del Sevo (Mulas 1993); C. Comino (Arrigoni 1996 sub *S. corsica* DC.) C. Falcone (Biondi & al. 2001 sub *S. corsica* DC.).

Spergularia macrorhiza (Req. ex Loisel.) Heynh. – *Caryophyllaceae* - H – [SA-CO] – C. Testa (Diana Corrias 1984); C. Coda Cavallo (Bocchieri & Iiriti 2004b).

Stachys corsica Pers. – *Lamiaceae* – H – [SA-CO] - C. of Monte Santu (Bocchieri & al. 2008).

Stachys glutinosa L. – *Lamiaceae* - Ch – [SA-CO-AT] - C. S. Elia (Martinoli 1950; Camarda 1980); C. Caccia (Valsecchi 1964; 1966; Camarda 1980); C. Figari (Camarda 1980); C. Teulada (Ballero & Bocchieri 1984; 1987); C. Ferrato (Ballero 1988); C. Falcone (Biondi & al. 2001); Prom. of Teccu (Bocchieri & Iiriti 2003); C. of Monte Santu (Bocchieri & al. 2008).

Teucrium marum L. ssp. *marum* – *Lamiaceae* - Ch – [SA-CO-AT-BL-H] - C. S. Elia (Martinoli 1950; Biondi & Mossa 1992); C. Caccia (Valsecchi 1964; 1966); C. Ferrato (Ballero 1988); C. Mannu (Bocchieri & al. 1988); C. Frasca (Bocchieri & Mulas 1992); Prom. of Torre del Sevo (Mulas 1993); C. S. Marco (Bocchieri & Mulas 1996); C. Falcone (Biondi & al. 2001); Prom. of Teccu (Bocchieri & Iiriti 2003); C. of Monte Santu (Bocchieri & al. 2008); C. Carbonara*.

Teucrium subspinosum Pourr. ex Willd. – *Lamiaceae* - Ch – [SA-BL] - C. Mannu (Arrigoni 1986); C. Teulada (Ballero & Bocchieri 1984 sub *T. marum* L.; 1987 sub *T. marum* L.; Bacchetta 2006).

Urtica atrovirens Req. ex Loisel. ssp. *atrovirens* – *Urticaceae* – H - [SA-CO-AT] - C. Caccia (Valsecchi 1964; 1966); C. of Monte Santu (Bocchieri & al. 2008).

Results and discussion

The endemic flora found on 24 capes and 2 promontories in Sardinia includes 112 *taxa* (72 species, 32 sub-species, 2 varieties 2 hybrids) comprising 28 families and 63 genera. The most numerous families are *Plumbaginaceae* (22), *Asteraceae* (15), *Fabaceae* (11), *Caryophyllaceae* and *Lamiaceae* (7), *Liliaceae* and *Orchidaceae* (6). Comparison between the most numerous families found on the capes and promontories with those most widespread in Sardinia and which include endemisms, shows differences probably due to the coastal siting of the areas under study. Indeed, at regional level, families with the greatest number of endemic *taxa* are the *Asteraceae* with 49 *taxa* followed by the *Plumbaginaceae* with 43, *Caryophyllaceae* with 32 and *Fabaceae* with 23 (Bacchetta & al., 2005). This reveals an inversion between *Asteraceae* and *Plumbaginaceae*, this latter family consisting prevalently of steno-Mediterranean elements marking the rupicolous vegetation of the coasts, halophyte vegetation and at times perennial psammophyte vegetation. In relation with the most numerous family, we also find the largest genus, *Limonium*, which with 22 *taxa* is far ahead of the others. The latter is followed by genera *Genista* (7), *Centaurea*, *Orchis*, *Ophrys*, *Scrophularia* and *Silene* all represented by 3 *taxa*. The dominance of genera *Limonium* and *Genista* is in line with regional data insofar as in Sardinia they are the most widespread, respectively with 39 and 14 *taxa* (Bacchetta & al., 2005).

From the biological spectrum (Fig. 2) we can observe that the dominant forms, with 51 *taxa,* are the chamaephytes (46%), followed by geophytes with 24 (21%) hemicryptophytes with 20 (18%), nanophanerophytes with 10 (9%), therophytes with 6 (5%) and hydrophytes with 1 (1%). The biological spectrum, as regards the territories investigated, highlights a climate decidedly Mediterranean in character, expressed in particular by a high

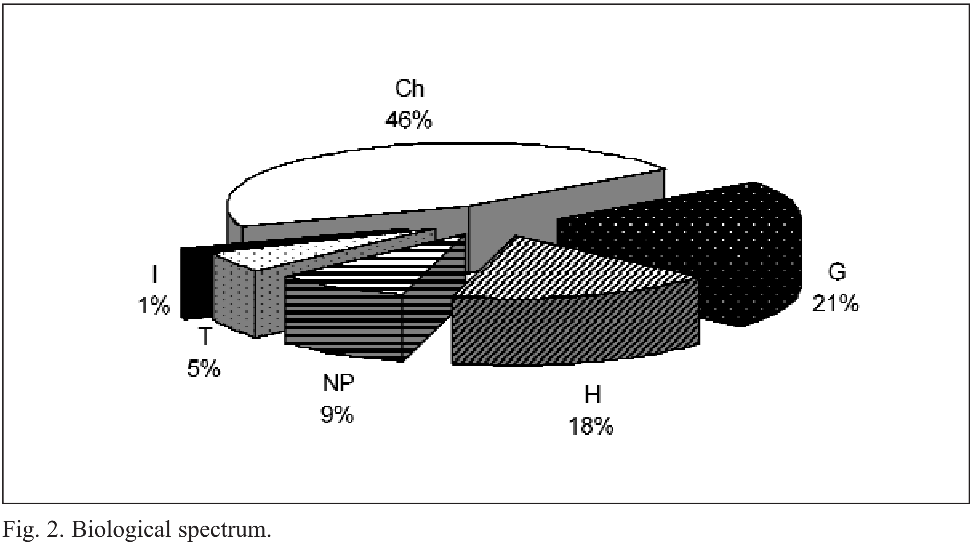

Fig. 2. Biological spectrum.

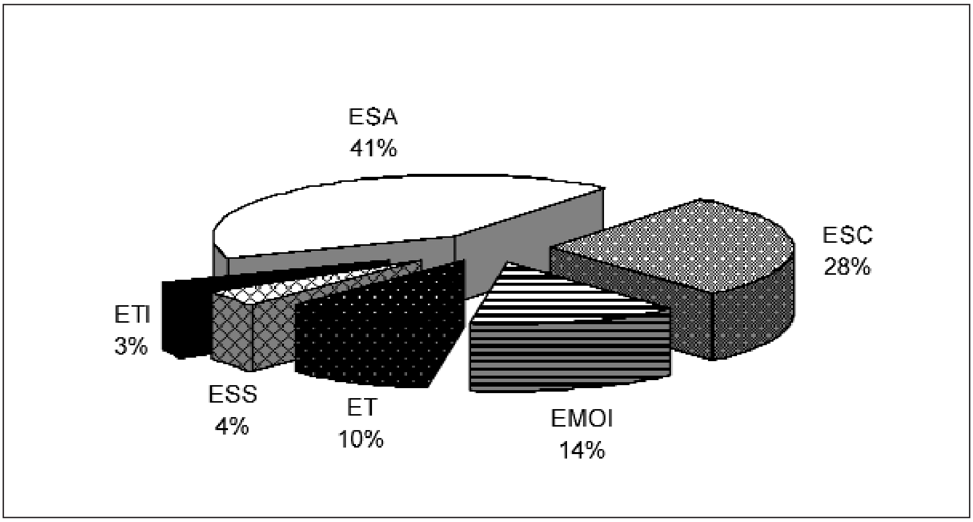

Fig. 3. Chorological spectrum. ESA = Sardinian; ESC = Sardinian-Corsican; EMOI= insular western Mediterranean; ETI = insular-Tyrrhenian; ESS = Sardinian-Sicilian; ET = Tyrrhenian.

percentage of geophytes, greater by some percentage points than the regional level which rests at 17.3%. The dominance of chamaephytes should be related to the high presence of natural habitats to be found on the capes and promontories, in particular the rupicolous ones. Indeed, the endemic chamaephytes on the island as a whole are 30%, whereas on the capes and promontories they are no less than 46%. Several authors (Martinoli 1950; Valsecchi 1964, 1966; Arrigoni 1983b; Gamisans & Marzocchi 1996; Bocchieri & al. 2006) previously highlighted the fact that the rocky stations are those hosting the most characteristic endemisms of Sardinia and Corsica and represent habitats where long floris-

Table 1. Total number of *taxa* and endemic entities of capes and promontories investigated in Sardinia (* includes unpublished data and taxonomic updates).

Locality	**Surface Kmq**	**Type of substratum**	**Nr. *taxa***	**Nr. of endemics ***
Cape of Monte Santu	19	Limestone	380	43
Cape Teulada	70	Metamorphic/Limestone	466	29
Cape Caccia	20	Limestone	231	29
Cape Mannu	5	Mesozoic limestone	446	23
Cape Ferrato	6,1	Granite/Basalt	367	20
Cape S. Marco	1	Sandstone/Limestone	400	19
Cape S. Elia	9	Miocenic limestone	547	19
Prom. Torre del Sevo	1,1	Sandstone/Limestone	335	17
Cape Frasca	16	Basalt	517	16
Cape Malfatano	1	Metamorphic	255	13
Prom. of Teccu	7	Basalt	401	11
Cape Carbonara	2,4	Granite	321	9
Cape di Pula	6	Andesit/Granite	537	9
Cape Bellavista	1,5	Granite/Porphyry	318	8

Table 2. Endemisms noted on the capes whose flora is not known. (* indicates areas in which field surveys are in progress).

Locality	**Nr. of endemics**
Cape Falcone	21
Cape Testa	17
Cape Figari *	17
Cape Spartivento *	10
Cape Coda Cavallo *	9
Cape Comino	7
Cape Pecora	6
Cape Boi	4
Cape Marargiu	2
Cape Ceraso	1
Cape Ferro	1
Cape Sperone	1

tic evolution processes favoured the origin of various chasmophytes adapted to rocky habitats, especially calcareous ones. A significant presence of chamaephytes is to be found in localities such as Cape of Monte Santu, Cape Caccia, Cape S. Elia, Cape Teulada, Cape Figari and Cape Testa, all territories marked by rupicolous environments, with steep rocky walls. As regards therophytes and nanophanerophytes, data are in line with figures for the region as a whole, as can also be said for hydrophytes, whose scarce presence is to be attributed to the limited existence on the capes and promontories of ecological niches suitable for the growth of these plants.

From the chorological spectrum (Fig. 3) we can note the dominance, with 46 *taxa,* of Sardinian endemic entities (41%) and, with 31 *taxa*, of Sardinian-Corsican (28%) followed by western Mediterranean insular entities with 16, (14%), Tyrrhenian with 11, (10%), Sardinian-Sicilian with 5 (4%) and Tyrrhenian-insular with 3 (3%). Exclusively Sardinian and Sardinian-Corsican endemic entities overall account for 69% of total endemisms present on the capes and promontories, a figure lower than the 72% registered for Sardinia as a whole (Bacchetta & al., 2005). Presumably, exclusion of the interior territories - prevalently mountainous - and limitation of our considerations to coastal areas, leads to the emergence of greater affinity with the other island systems localized in the western Mediterranean; this assumption is supported by the abundance of *taxa* widespread in the western Mediterranean which, with a percentage of 14%, are double with respect to the 6.9% calculated by Bacchetta & al. (2005) for Sardinia.

Focusing attention on the endemic elements exclusive to Sardinia, it can be seen that, as already noted by other authors (Arrigoni & Di Tomaso 1991; Mossa & Bacchetta 1998; Bacchetta & al. 2005), Sardinian endemisms are more closely linked to carbonate-type substrata, whereas the Sardinian-Corsican prefer crystalline, and secondarily metamorphic substrata. Indeed, the endemic calciphile *taxa* exclusive to Sardinia are to be found on Cape of Monte Santu, Cape Figari, Cape Caccia, Cape Mannu, Cape S. Marco, Cape Teulada, Cape S. Elia and the Promontory of Torre del Sevo, all territories with rocky out-crops and totally or partially carbonate soils. These pedological conditions also favour the abundance of endemisms, as is shown in Table 1 where we have grouped all the capes and promontories investigated from a botanical point of view and for which complete information on the flora is available. The territory with the highest number of endemic *taxa* is Cape of Monte Santu with 43 followed by Cape Teulada and Cape Caccia both with 29, Cape Mannu with 23, Cape Ferrato with 20, and Cape S. Marco and Cape S. Elia, both with 19. The number of endemisms decreases on the capes and promontories marked by granite, basalt and/or andesite substrata (Table 1).

As regards other capes of Sardinia, the composition of the endemic floristic component is only partially known and, to remedy this, on some of them field surveys are in progress (Table 2). From this initial analysis it can be seen that Cape Falcone, Cape Testa and Cape Figari have fairly rich endemic flora with several different *taxa* of significant phyto-geographical interest. They include *Centaurea filiformis* Viv. ssp. *filiformis* and *Sesleria insularis* Sommier ssp. *insularis* (Cape Figari), *Genista ephedroides* DC., *Leucojum roseum* Martin, *Silene rosulata* Soy.-Will. & Godr. ssp. *sanctae-theresiae* (Jeanm.) Jeanm. and *Limonium gallurense* Arrigoni & Diana (Cape Testa) and *Nananthea perpusilla* (Loisel.) DC. (Cape Falcone).

The capes and promontories, apart from being marked by an important endemic floristic component, often also are the habitats of rare species of considerable phytogeographical importance. Some examples are the populations of *Limonium sinuatum* (L.) Mill. and *Brimeura fastigiata* (Viv.) Chouard (Cape Coda Cavallo), *Sarcopoterium spinosum* (L.) Spach and *Globularia alypum* L. (Cape S. Elia), *Helianthemum caput-felis* Boiss., *Viola arborescens* L., *Coris monspeliensis* L. (Cape Mannu), *Apium crassipes* (W.D.J. Koch ex Rchb.) Rchb. f. (Cape Frasca and Cape Mannu), *Armeria pungens* (Link) Hoffmanns & Link (Cape Falcone and Cape Mannu), *Scolymus grandiflorus* Desf. (Cape Malfatano), *Erica multiflora* L. (Cape Figari and Cape Mannu), *Asplenium petrarchae* (Guérin) DC. ssp. *petrarchae* (Cape of Monte Santu and Cape Figari).

In conclusion, the authors wish to point out that 16 endemic *taxa* have their *locus classicus* on the capes: this would seem to indicate that, compared with other coastal areas, capes favour the conservation of ecosystems of naturalistic interest with a high degree of biodiversity. Because of their geo-morphological characteristics, these territories, open towards the sea and exposed to the winds, are usually unaffected by urban and/or tourist developments, which are commonly located in adjacent coastal areas or in the hinterland. And indeed, there is no lack of recent findings of vegetation species new to science and/or of naturalistic interest on capes and promontories, which exert particular fascination on the student of botany since they have maintained a high degree of naturality.

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D. Jeanmonod, J. Gamisans & A. Schlüssel

Flora Corsica: a New Field Guide to the Corsican Flora

Abstract

Jeanmonod, D., Gamisans J., Schlüssel, A.: *Flora Corsica*: a New Field Guide to the Corsican Flora. — Bocconea 23: 371-378. 2009. — ISSN 1120-4060.

Flora Corsica (Jeanmonod D. & J. Gamisans 2007), a new comprehensive, and pocket sized field guide to the flora of Corsica is presented. This book includs identification keys, and the description, biology, phenology, ecology, scarcity, and biogeographical type of all the 2858 taxa occuring on the island. About 1200 illustrations are also given at the end of the book. Results are presented in the form of datas dealing with diversity and specificity of the corsican flora.

Introduction

The first ever comprehensive field guide to the flora of Corsica is now available in French (Jeanmonod & Gamisans 2007, with the collaboration of 16 specialists). This book (Fig. 1) is the result of 20 years of intensive study, field work, the observation of thousands of living and herbarium specimens, and the compilation of all known published data on the island's plants. Much data dealing with the flora of Corsica has been published over the last 20 years (506 publications between 1987 and 2007) including on the discovery of many plants that are new for the island's flora, and the description of several species new to science (e.g. *Orobanche cyrnea* Jeanm. & al., *Stachys aymericii* Gamisans). An up-to-date working summary of the contemporey flora was needed and something long-awaited by nature conservationists and botanists.

This pocket sized work (18.5 × 11.5 × 3.5 cm, 1050 pages printed on Bible paper) treats all vascular plants occuring in the wild on Corsica, i.e. 870 genera including 2858 specific or infraspecific taxa. In the first part of the flora, the authors give an introduction to phytogeography of the island: geography, geology, climate, paleogeography, vegetation belts, but also some taxonomical analyses and informations on the threats affecting the plants as well as on the protection measures put in place for the benefit of the flora and vegetation of the island as a whole.

Presentation

Dichotomous keys (Fig. 2), supplemented with many line drawings of plant features (Fig. 3) permit the identification of all the vascular plants that have been found in the wild on Corsica. Keys are given at four levels:

- Family keys (158 families in a classical conception, but organized with the APGII system).
- Generic keys inside each family (870 genera, most of them are treated based on the modern concept issuing from molecular and phylogenetic studies).
- Species keys inside each genus.
- Infraspecific keys (at subspecific and sometimes variety level) inside each species.

Then, for each taxon, *Flora Corsica* provides additional information such as given in this example:

Castroviejoa frigida (Labill.) Galbany & al. (≡ *Helichrysum frigidum* (Labill.) Willd.). I. des frimas, murzella **— -v-** Cham. 5-10 cm. Pl. tomenteuse-grisâtre, cespiteuse, prostrée, à rameaux arqués-ascendants; flles de 2-5 mm, densémt imbriquées; capitule solitaire, de 12-18 mm de diamètre, à bractées d'un blanc pur, raremt rosées; akènes densémt pourvus de soies raides, longs de 1,2-1,6 mm, à pappus de soies sétulées, de 3,5-4 mm **— 6-8 —** MO OR SA AL **—** Fissures de rochers; silice; du Cintu à Cagna **— C —** End. Co-Sa d'orig. Méd-Mont.

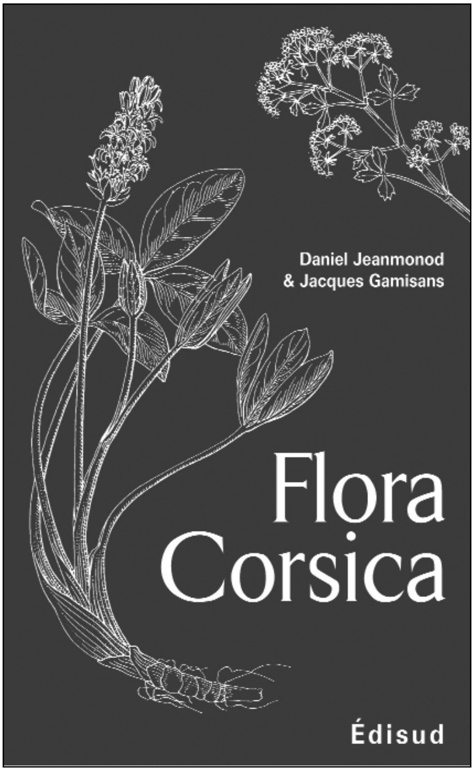
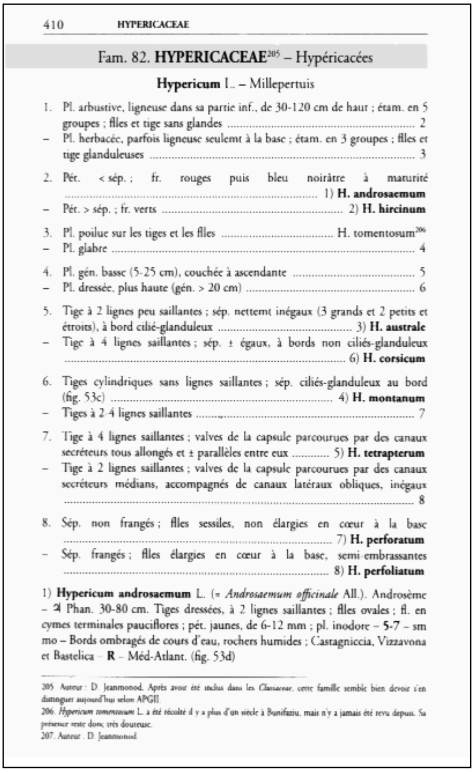


Fig. 1. *Flora Corsica.*



410 HYPERICACEAE

Fam. 82. **HYPERICACEAE**[205] – Hypéricacées

Hypericum L. – Millepertuis

1. Pl. arbustive, ligneuse dans sa partie inf., de 30-120 cm de haut ; étam. en 5 groupes ; flles et tige sans glandes ... 2
– Pl. herbacée, parfois ligneuse seulemt à la base ; étam. en 3 groupes ; flles et tige glanduleuses ... 3

2. Pét. < sép. ; fr. rouges puis bleu noirâtre à maturité ... 1) **H. androsaemum**
– Pét. > sép. ; fr. verts ... 2) **H. hircinum**

3. Pl. poilue sur les tiges et les flles ... H. tomentosum[206]
– Pl. glabre ... 4

4. Pl. gén. basse (5-25 cm), couchée à ascendante ... 5
– Pl. dressée, plus haute (gén. > 20 cm) ... 6

5. Tige à 2 lignes peu saillantes ; sép. nettemt inégaux (3 grands et 2 petits et étroits), à bord cilié-glanduleux ... 3) **H. australe**
– Tige à 4 lignes saillantes ; sép. ± égaux, à bords non ciliés-glanduleux ... 6) **H. corsicum**

6. Tiges cylindriques sans lignes saillantes ; sép. ciliés-glanduleux au bord (fig. 53c) ... 4) **H. montanum**
– Tiges à 2-4 lignes saillantes ... 7

7. Tige à 4 lignes saillantes ; valves de la capsule parcourues par des canaux secréteurs tous allongés et ± parallèles entre eux ... 5) **H. tetrapterum**
– Tige à 2 lignes saillantes ; valves de la capsule parcourues par des canaux secréteurs médians, accompagnés de canaux latéraux obliques, inégaux ... 8

8. Sép. non frangés ; flles sessiles, non élargies en cœur à la base ... 7) **H. perforatum**
– Sép. frangés ; flles élargies en cœur à la base, semi-embrassantes ... 8) **H. perfoliatum**

1) **Hypericum androsaemum** L. (= *Androsaemum officinale* All.). Androsème – ♃ Phan. 30-80 cm. Tiges dressées, à 2 lignes saillantes ; flles ovales ; fl. en cymes terminales pauciflores ; pét. jaunes, de 6-12 mm ; pl. inodore – **5-7** – sm mo – Bords ombragés de cours d'eau, rochers humides ; Castagniccia, Vizzavona et Bastelica – **R** – Méd-Atlant. (fig. 53d)

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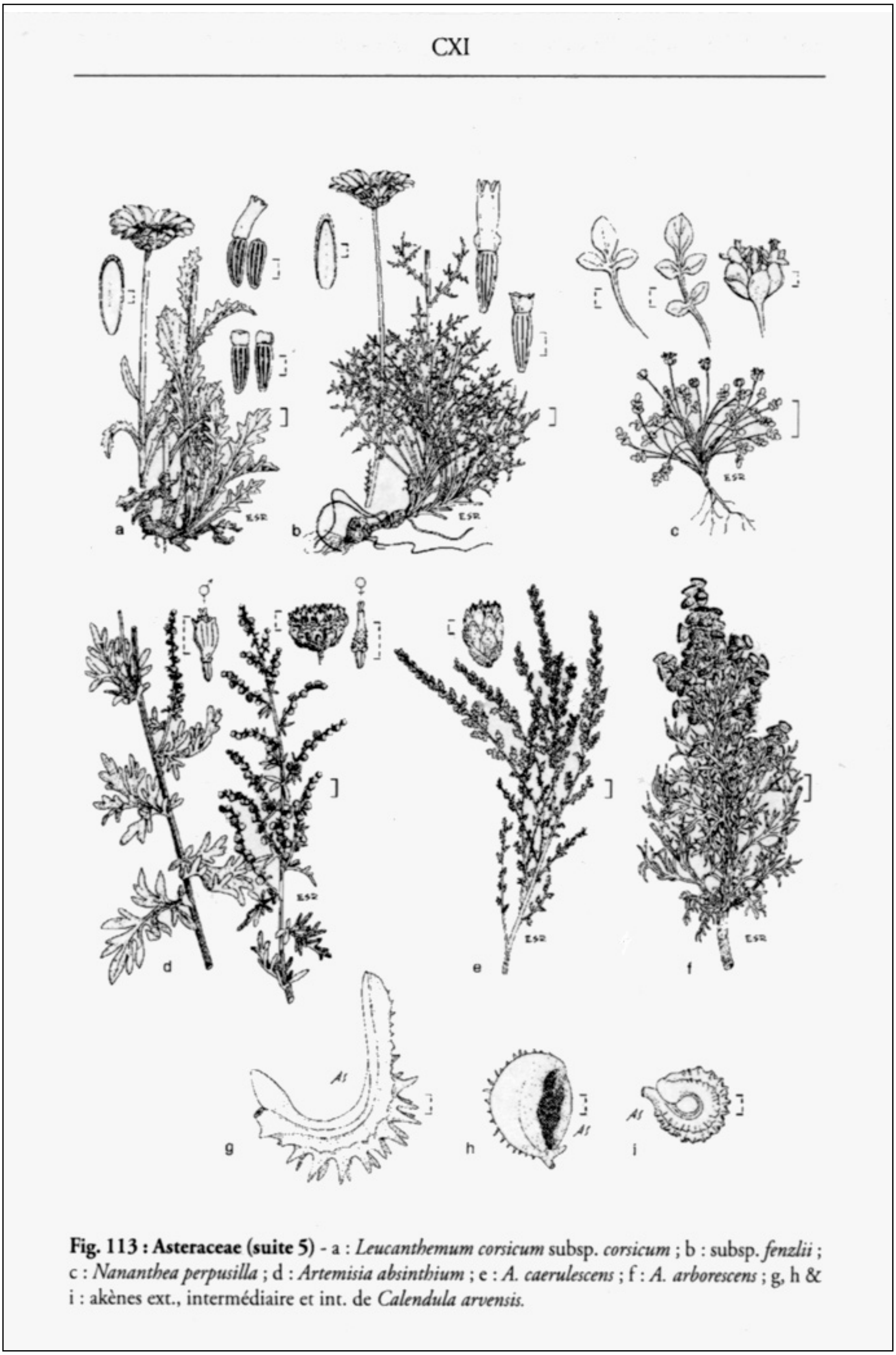
[205] Auteur : D. Jeanmonod. Après avoir été inclus dans les *Clusiaceae*, cette famille semble bien devoir s'en distinguer aujourd'hui selon APGII.
[206] *Hypericum tomentosum* L. a été récolté il y a plus d'un siècle à Bunifaziu, mais n'y a jamais été revu depuis. Sa présence reste donc très douteuse.
[207] Auteur : D. Jeanmonod.

Fig. 2. Example of a page.



CXI

Fig. 113 : Asteraceae (suite 5) - a : *Leucanthemum corsicum* subsp. *corsicum* ; b : subsp. *fenzlii* ; c : *Nananthea perpusilla* ; d : *Artemisia absinthium* ; e : *A. caerulescens* ; f : *A. arborescens* ; g, h & i : akènes ext., intermédiaire et int. de *Calendula arvensis.*

Fig. 3. Example of a plate.

This information includes:

- taxa names (Latin, French and Corsican if available): the taxonomy used is up-to-date, and takes into account the results of the most recent molecular studies, as in the above example;
- most frequently used synonyms (ca 5’000 names);
- biology (Raunkier biological types);
- description (briefly in 2-3 lines);
- phenology (months are indicated to show flowering period);
- ecology (vegetation belts (11 categories), habitat, substrate, and vegetation units);
- scarcity in 7 categories (very common (CC), common (C), localized (LOC), uncommon (PF), rare (less than 11 localities; R), very rare (less than 6 localities: RR), extinct (D);
- biogeographical type and protection status.

Entire plant and morphological details for many taxa are illustrated with line drawings (about 1200) (Fig. 3).

Results

This work demonstrates the high diversity and specificity of this insular flora:

13.6 % of the native taxa (11 % of the total flora) are endemic. This is the result of a long isolation (ca. 5 millions years) augmented by its strong topographic relief which creates a lot of different microclimates, as well as ecological and geological situations. Over the past twenty years, the number of non-native species found on the island has increased, likely due to the economic development of it. The presence of introduced species has become very significant (Fig. 4): 16 % of all species are non-native and 6 % of these are naturalized species. 31 of these species are considered to be invasive. These invasive alien species are also highlighted out because of the potential danger they may pose for the local flora and habitats. A chapter discusses the threats affecting this exceptional flora, and proposes mesures to ensure its protection.

46 % of the native flora has a strictly mediterranean origin, whereas 19 % show an European origin (Fig. 5). Unlike other mediterraean islands, Corsica consists of a high mountain chain (reaching at 2710 m a.s.l.) that rises from the sea. This explains the presence of a significant element of the temperate european mountain flora. The occurence of several boreal or arctico-alpine species (such as *Trichophorum alpinum* (L.) Pers., *Diphasiastrum alpinum* (L.) Holub, *Trientalis europaea* L. and *Corallorhiza trifida* Châtel.) is, however, rather surprising. These species often occur in only one locality sometimes only in the form of small populations, representing the last populations left after the past glaciations. This flora also highlights the scarcity of many taxa (Fig. 6): 34 % of the native flora are known only from 1 to 10 localities (RR + R), which means that they must be considered as threatened or even endangered. The intensive exploration of Corsica conducted over the past twenty years have resulted in the discovery of many new localities for plants that used to be considered as rare but which have finally proved to be more common or more widespread. On the other hand, the many species that are now classified as very rare (RR) or rare (R) in *Flora Corsica* should definitively be considered as such and are evidence of a past that we do not yet fully understand. Most

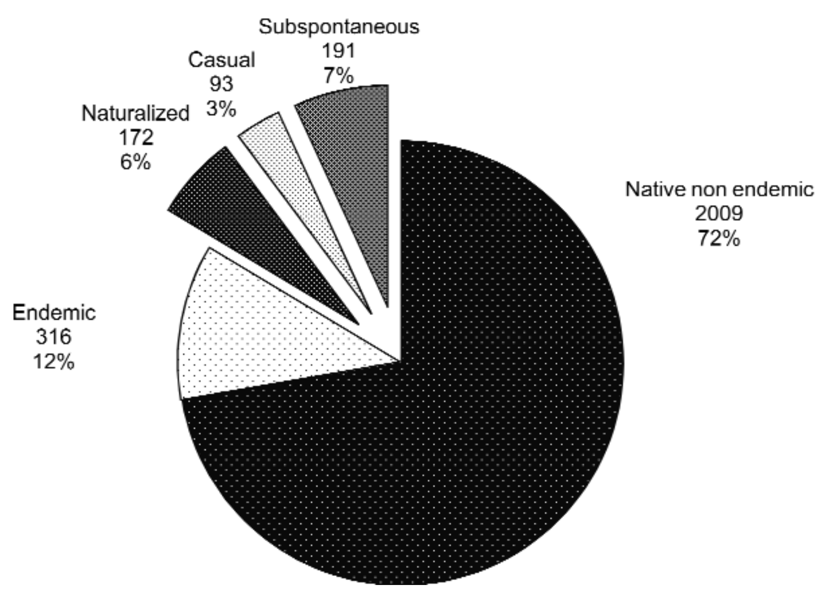


Fig. 4. Proportion of native and introduced species.

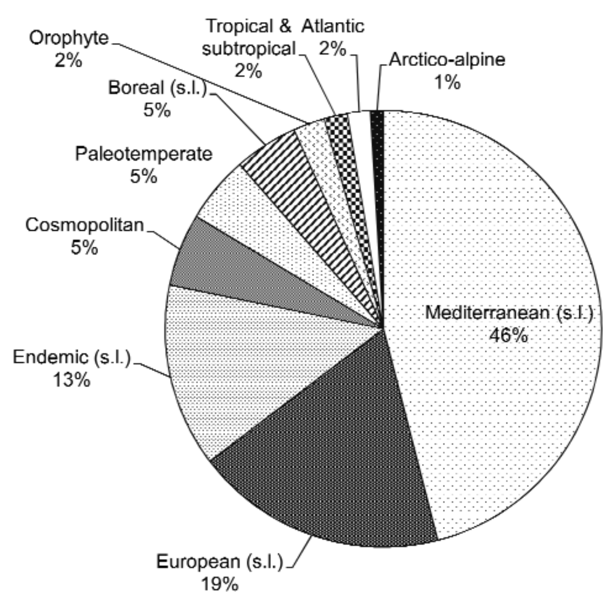


Fig. 5. Biogeographical origin of the native flora of Corsica.

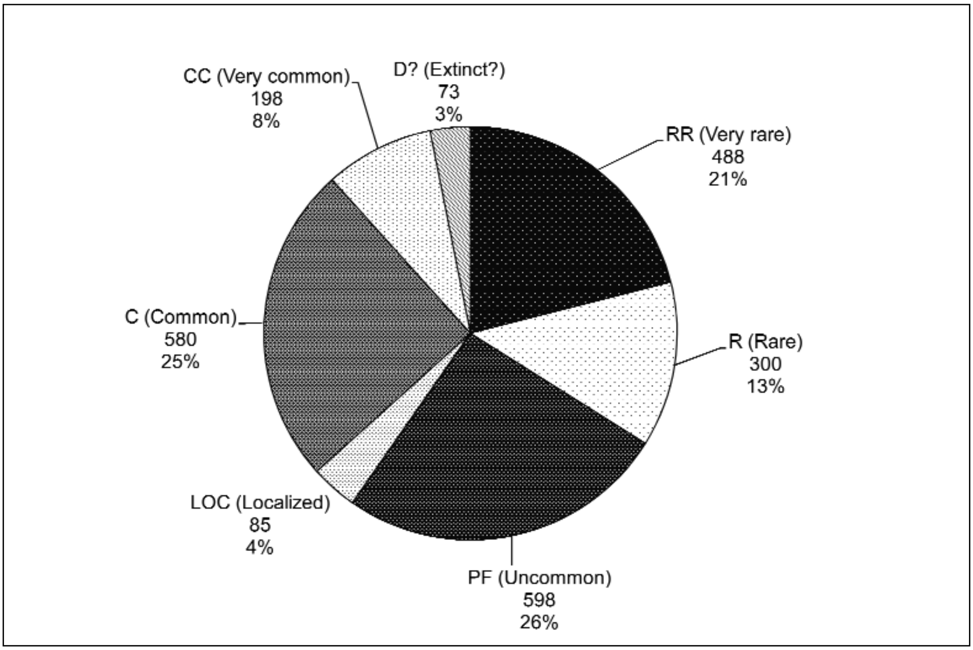
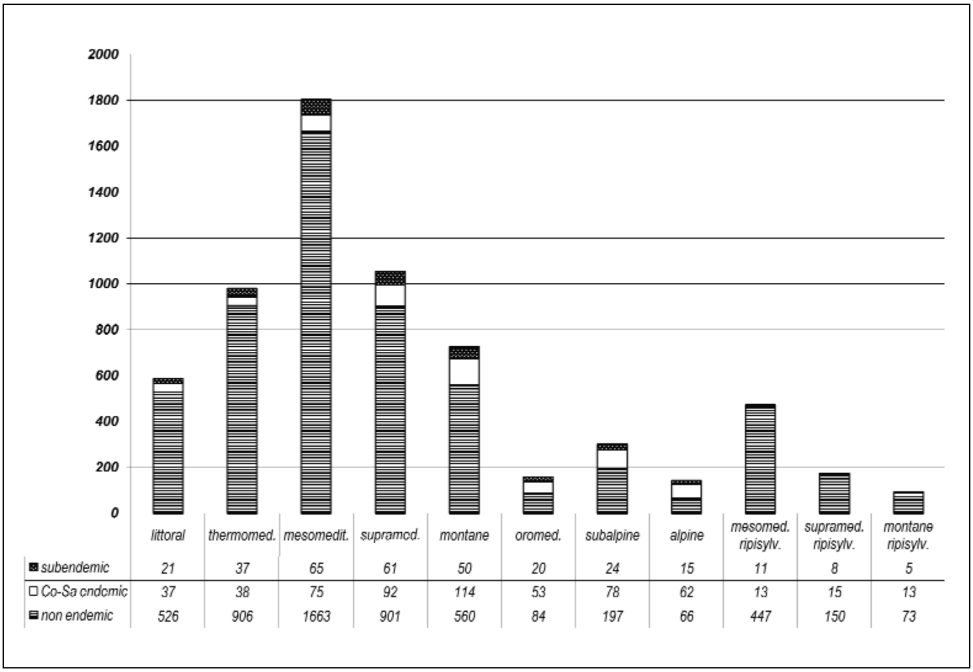


Fig. 6. Degree of scarcity of the native flora.



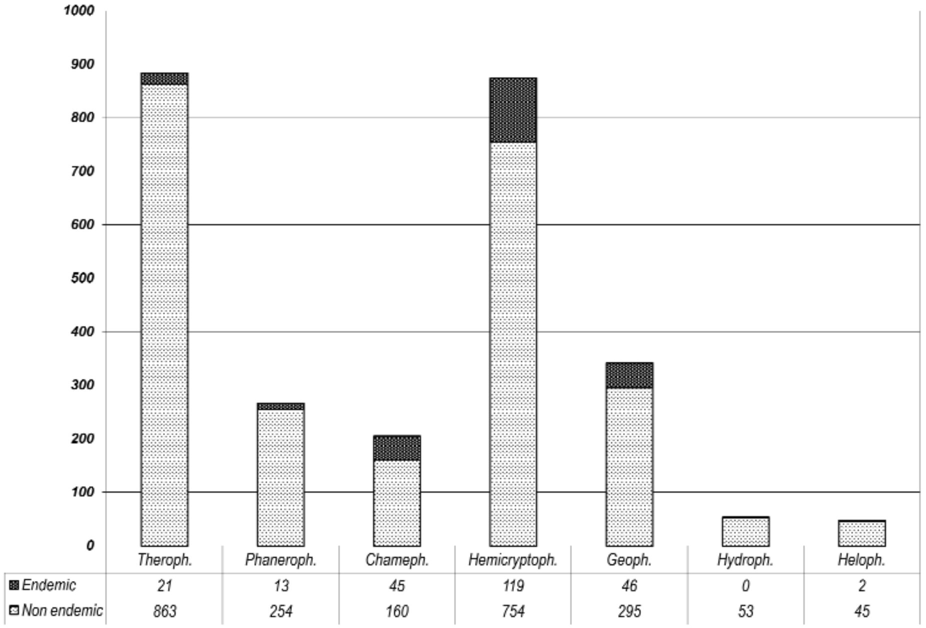
	littoral	thermomed.	mesomedit.	supramed.	montane	oromed.	subalpine	alpine	mesomed. ripisylv.	supramed. ripisylv.	montane ripisylv.
■ subendemic	21	37	65	61	50	20	24	15	11	8	5
□ Co-Sa endemic	37	38	75	92	114	53	78	62	13	15	13
▤ non endemic	526	906	1663	901	560	84	197	66	447	150	73

Fig. 7. Distribution of of the number of endemic and non endemic taxa within the different vegetation belts.

of them are included in the official Red List for the island and these taxa are labelled with a **P!** in the Flora (191 taxa).

Endemic and subendemic taxa represent 40.5 % of the highest vegetation belts (subalpine and alpine) flora, but the greatest number of them are located in the montane (164) and supramediterranean (153) vegetation belts (Fig. 7). This is very important in terms of protection management, especially since most corsican villages and their associated traditional economic activities, are located in these two lower belts.

The greatest proportion of the flora (33.11 %) consists of therophytes (Fig. 8), which are typical of a mediterranean type of flora. However, this result is lower than that obtained for other mediterranean islands such as for Cyprus where about 48 % of the flora consists of therophytes (Alziar, 1995), while hemicryptophytes (about 18 %) show a significantly lower proportion than in Corsica (32.7 %). It appears that it is not the geographical position of the island, but the strong topographic relief that is likely to play the biggest role (four mountain chains culminating beyond the height of 2000 m a.s.l. in Corsica versus one isolated mountain culminating at 1952 m in Cyprus). Sardinia, which is just adjacent to Corsica, has a less pronounced relief (1835 m a.s.l.) and shows a much greater proportion of mediterranean type vegetation. This is highlightes by the larger amount of therophytes (39,9 %) and a lower amount of hemicryptophytes (28.1 %) found on this Italian island (Bocchieri 1995).



	Theroph.	Phaneroph.	Chameph.	Hemicryptoph.	Geoph.	Hydroph.	Heloph.
▩ Endemic	21	13	45	119	46	0	2
▨ Non endemic	863	254	160	754	295	53	45

Fig. 8. Distribution of endemic and non-endemic biological types.

The endemic taxa show a rather different biological spectrum from the one obtained when looking at the flora of Corsica as a whole: most of them (48.37 %) are hemicryptophytes or chamaephytes (18.29 %) and geophytes (18.7 %) with a very small number of therophytes (8.54 %). On the island of Cyprus endemic taxa show a much higher proportion of therophytes (17.3 %) but only 22.9 % of hemicryptophytes. The endemism on Corsica seems more due to the ecological conditions linked to the presence of high mountains isolated from the continent (mesogean endemism) rather then a typical mediterranean endemism linked to the prevailing conditions in the mediterranean region.

The huge amount of data contained in *Flora Corsica* will permit, in the near future, a more detailed analysis of the flora.

Flora Corsica is not only a must for anyone interested in plants and wishing to visit the Island but it also represents a useful tool for biologists and professionals working in Nature conservation and management.

Acknowledgements

We are very grateful to the following specialists: Jacques Deleuze, Robert Deschâtres, Roger Engel, Matthias Erben, Michel Gruber, Christine Habashi, Philippe Jauzein, Jacques Lambinon, Michel Murracciole, Paul Piquemal, Jean-Pierre Reduron, Eric Schmitt, Marc-André Thiébaud and Jean-Marc Tison who have actively, and substantially contributed to the quality of *Flora Corsica*. We acknowledge Michele Price for the revision of the english version of this paper.

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A. M. Mercuri, G. Bosi, L. Olmi, L. Mori, E. Giannassi & A. Florenzano

Human-plant relationships in the Garamantian culture (Fezzan, Libya, Central Sahara)

Abstract

Mercuri, A. M., Bosi, G., Olmi, L., Mori, L., Giannassi E. & Florenzano, A.: Human-plant relationships in the Garamantian culture (Fezzan, Libya, Central Sahara). — Bocconea 23: 379-393. 2009. — ISSN 1120-4060.

This paper reports archaeobotanical data which can help understand the relationships between humans and plants in Garamantian times in Fezzan. This region of the Central Sahara was inhabited by a sedentary population, the Garamantes, who exploited wells in the oasis and developed a network of sites controlling the Saharan caravan routes, as attested by archaeological and epigraphic sources since halfway through the 1st millennium BC.

The research on pollen and plant macrofossils has been carried out from a multidisciplinary perspective on Garamantian settlements belonging to different occupational phases. *Phoenix dactilyfera* and *Hordeum vulgare* are the best represented plants in the archaeobotanical record, together with other fruits such as grapes and figs. Therefore, palms and cereals would have been the most characteristic crops cultivated by the Garamantes, and markers of the Fezzan landscape at that time. Plants were planted in the oasis, along channels and in gardens, or imported by trade and exchanges. It emerges that the Garamantes knew the limits and potentialities of the environment they inhabited, which was already in its current hyperarid climatic phase.

Introduction

The '*Garamantian Project*' (coordinated by Mario Liverani of the University of Rome 'La Sapienza') focuses on the civilization of the Garamantes, a sedentary population who exploited wells in the oasis of Fezzan and developed a network of sites controlling the Saharan caravan routes from halfway through the 1st millennium BC onwards. The research investigates a period spanning from the Final Pastoral – Early Garamantian transition (about 1000-600 BC) to the decline of the Garamantian kingdom (around 400 AD) and its subsequent collapse, analyzing the different phases of development of this culture in the Southern part of the Fezzan region (Castelli & al. 2005; Liverani 2000a).

The ancient kingdom of the Garamantes flourished along the Wadi el-Ajal and the nearby Wadis Tanezzuft, al-Shati and Barjuj, in Fezzan, south-western Libya (Liverani 2000b). Garama, known today as Old Jarma, was situated within 2 km of the modern-day Jarma oasis and was the Garamantian capital of the Wadi al-Ajal. Several settlements were located along this wide wadi, and approximately 400 km to the south, in the Wadi Tanezzuft, the Italian-Libyan archaeological Mission of University 'La Sapienza' of Rome, excavated several sites around the Ghat, Barkat and Fewet oases. Moreover, a network of fortified castles, controlling strategic locations on the caravan routes were found; two of these have survived and are located on the eastern side of the Akakus mountain, along the Wadi Awis and Wadi Adad (Fig. 1).

The Garamantes were first mentioned by Herodotus, in the fifth century BC, and later by Pliny the Elder, Lucano, Tacitus, Sallust, and other Classical authors. Epigraphic sources generally describe these inhabitants of the central Sahara and North Africa as nomads with a rough, cultureless lifestyle (intending by 'culture', the Mediterranean-centred variety). Recent archaeological research is now revealing how the reality of this ancient period has been greatly obscured by prejudice. In actual fact, as material and biological evidence is pieced together, the picture that emerges clearly demonstrates that the Garamantes had an advanced and complex society, which was extremely capable of adapting to particular environmental conditions (Liverani 2000a, 2000b, 2000c, 2005; Mattingly & al. 2000, 2003).

The understanding of the liaisons between people and the environment they inhabited is an important topic of investigation to understand the features of the Garamantian society. At the time considered, the Sahara desert was already a dry environment, in which particular adaptive strategies were required to survive (Cremaschi & di Lernia 1998; Brooks & al. 2005). In fact, the water crisis, which involved desiccation of lakes and springs, had been highly evident in Fezzan since around 3000 years BP (Cremaschi 1998), and in the Saharan region overall (Olago 2001). It opened the way to the current subtropical, hot and arid climate, typical of the Saharan regional Transitional Zone (White 1983). Presently, the mean annual rainfall is lower than 20 mm, and the mean summer isotherm of 32°, one of the world's highest, crosses the region (El-Tantawi 2005).

Archaeobotanical analyses have been carried out on several Garamantian settlements belonging to different occupational phases (Table 1). Research on pollen and plant macrofossils has been carried out from a multidisciplinary perspective (Mercuri & al. 2005; Pelling 2003, 2005; van der Veen 1992; Trevisan Grandi & al. 2006), which largely resulted in a 'more Saharan-centred view' of the Garamantes' history (Pelling 2005). Overall, plant records brought to light details of the human-plant relationships which characterised this culture.

This paper adds new archaeobotanical data from the fortified citadel Aghram Nadharif to those published previously (Mercuri & al. 2006), and reports some very preliminary results from the small settlement of Fewet. These two sites are located in the Wadi Tanezzuft, near the Barkat oasis and in the Fewet oasis, respectively. Moreover, the paper aims to provide an overview of the main archaeobotanical data obtained from all the sites, in order to reconstruct the main features of Garamantian plant exploitation and culture.

Material and methods

During the excavations in Aghram Nadharif in 1999-2002 and Fewet in 2002-2006, hundreds of botanical samples, including 'naked-eye' and volumetric samples, were systematically collected by the archaeologists from occupation levels, walls, floors, pits, boreholes and hearths of the two sites. Archaeological contexts and chronologies are described

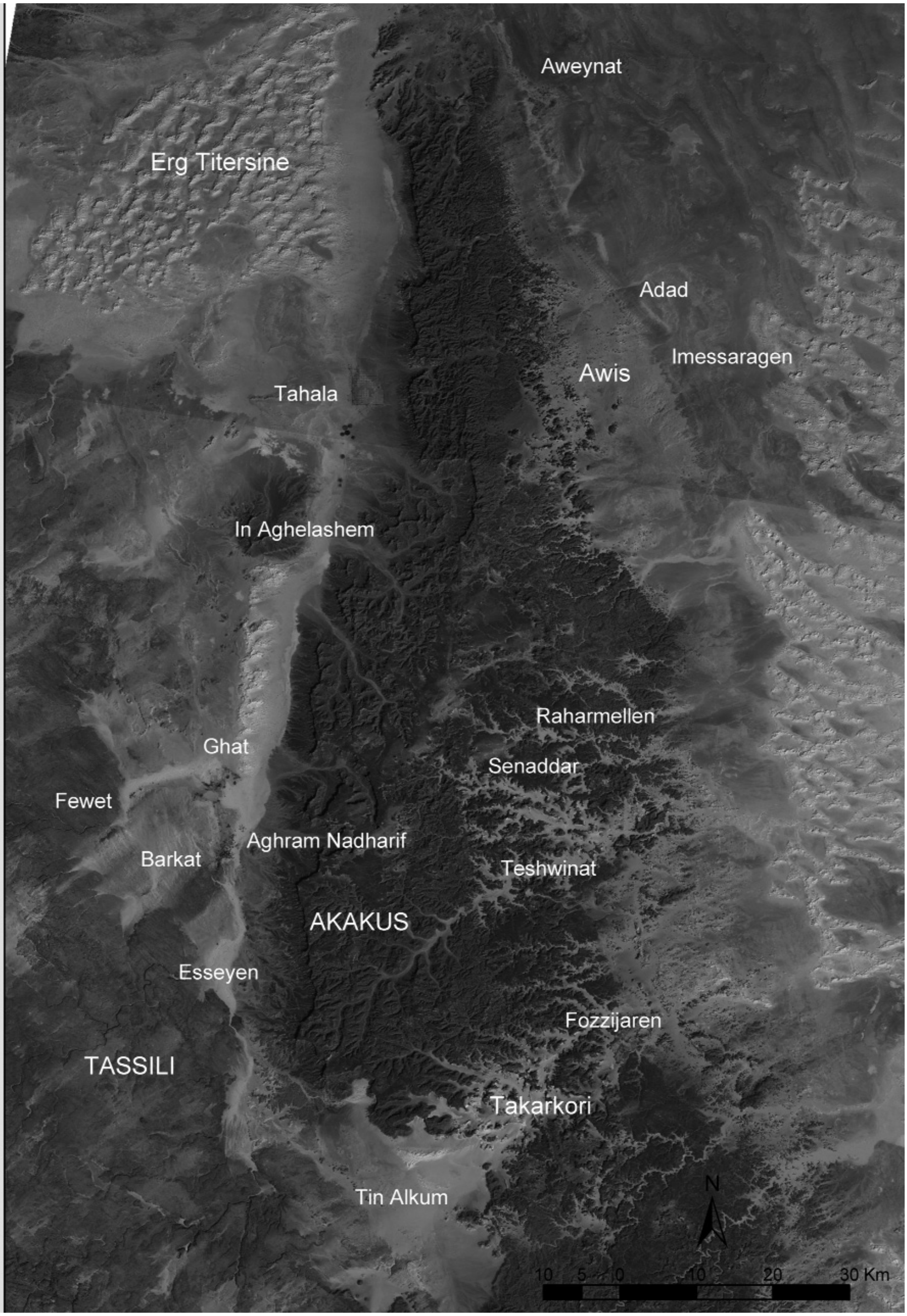

Fig. 1 – Location map of the Garamantian sites quoted in the text.

Table 1. Garamantian sites performing archaeobotanical data.

Wadi	**Wadi Al-Ajal**					**Wadi Tanezzuft**			
Site	**Zinkekra**	**Jarma**			**Tinda**	**Fewet**	**Aghram Nadharif**		
Chronology	900 – 400 BC	400 BC – 50 AD	50 – 200 AD	200 – 750 AD	370 – 110 BC	200 – 0 BC	50 BC - 200 AD	200 - 350 AD	350 - 1200 AD
Garamantian Phase	Formation phase	Mature phase	Classical phase	Late phase	Late phase	Mature phase	Classical phase	Late phase	Late phase
Archaeological context	hill-fort	town, capital of the Garamantian kingdom			promontory	little town	fortified citadel		
Archaeobotany	seeds/fruits	seeds/fruits			seeds/fruits	seeds/fruits-woods/charcoals	seeds/fruits-woods/charcoals-pollen		
References	van der Veen 1992; Pelling 2005	Pelling 2003, 2005			Pelling 2005	this paper	Mercuri & Trevisan Grandi 2005; Mercuri & al. 2005; Trevisan Grandi & al. 2006		

elsewhere (Castelli & al. 2005; Liverani 2005). Hand-picked plant records (mainly charcoal and dates) and botanical finds from coarse-sieving in the field contained a variable number of records. However, these only provide qualitative information, as the selective sampling introduces biases in the quantitative interpretation. Volumetric samples (from 1 to 6 litres each) were first sub-sampled for pollen analysis in laboratory, and then dry-sieved through 10, 2 and 0.5 mm sieves to recover macroremains. These samples also enabled concentration data to be obtained, together with information on the quantities of plant remains in a known volume of deposit.

The examined samples from Aghram Nadharif consisted of pollen and macroremains, and came from sixteen rooms and open areas of the citadel. The majority were attributed to the Late/Post-Garamantian phase, and a lower number to the Classical Garamantian phase and Medieval and modern times (Mercuri & al. 2005). In this paper a sediment sample from AN3 (99C27), relatively rich in remains from the Classical phase, has been added to previous data.

Preliminary archaeobotanical data from Fewet refer to macroremains collected from room FW5, which was buried after a fire, and the deposit in question belonged to the Classical phase (sediment sample: C154a; naked-eye samples: C120, C121, C128).

Seed/fruit– In Aghram Nadharif, sixteen samples from volumetric and two naked-eye samples were analysed for seeds/fruits. At Fewet, one volumetric sample and one naked-eye sample were studied from room FW5. These were then hand-sorted under a stereomicroscope at 25× magnification. Identification was made at 25-80× magnifications by means of, e.g. Wasylikowa 1992a - 1992b and the reference collection.

Charcoal - In Aghram Nadharif, thirty-two samples from volumetric and naked-eye samples were analysed. In Fewet, three naked-eye samples have been examined so far. Sediments were hand-sorted under a stereomicroscope as reported above. Identification was performed on cross, tangential and radial sections along fresh hand-made fractures of the records. The identification was made with, e.g., Fahn & al. 1986, Neumann & al. 2001 and the reference collection.

Pollen -Twenty-one sediment samples from Aghram Nadharif were treated with Na-pyrophosphate, HCl 10%, sieving (7 µm nylon meshes), acetolysis, heavy liquid separation (Na-metatungstate hydrate), HF 40%, ethanol 98%, glycerol, stove-drying, and permanent mounting on slides in glycerol jelly. *Lycopodium* tablets were added to establish the pollen concentration (pollen per gram = p/g). Microscopic analyses were carried out at 1000 magnifications using a light microscope. Identification was made with, e.g., Reille 1992, 1995, 1998, the reference collection, and Andersen 1979, Beug 1961 and Faegri & al., 1989 for Cerealia pollen. The Cerealia Type III of Bottema (1992) includes *Triticum* pollen with maximum diameter > 60-70 µm, porus + annulus 15-17 µm, and scabrate exine.

Results

Plant records were found in different preservation states in the sites. In general, Aghram Nadharif showed poorly preserved macroremains in prevalently sandy layers, while Fewet conserved a high amount of charred macroremains in the burnt rooms. Though a large range of analyses were performed on the Aghram Nadharif deposit, only a few have been completed at this stage on the Fewet samples. This prevents any comparison of quantitative and pollen data from the two sites. The next section outlines the main results obtained so far concerning pollen, seeds/fruits and charcoals.

The two sites showed **seeds/fruits** with very different states of preservation: while scarce and generally mummified in Aghram Nadharif, in Fewet they were abundant and mainly charred. At the Aghram Nadharif site, *Phoenix dactylifera* fruit stones with different morphologies were prevalent, sometimes crushed or with the dried flesh preserved, (Table 2). Other woody plants with edible fruits included *Vitis vinifera*, *Ziziphus* sp. and *Prunus persica*. Cereals were scarce, and consisted of charred caryopses and few uncharred chaffs of *Hordeum vulgare*, and few *Triticum* sp. Traces of minor cereals were also found, such as uncharred caryopses of *Pennisetum* sp. (showing morphological affinity with *P. glaucum*) and uncharred caryopses of *Panicum* sp. and *Setaria* sp. Legumes comprised *Vigna unguiculata* cf., *Vicia* sp. and a few other undifferentiated types. Aromatic herbs *Foeniculum vulgare* cf. and *Petroselinum* sp., the vegetable *Portulaca oleracea* and the medicinal *Citrullus* cf. *colocynthis* were present too. *S*ome new taxa in sample 99C77 were exclusive to the sample (*Carex* sp., *Medicago* sp., *Amaranthus* sp., *Anethum graveolens* cf., *Umbelliferae* indet.; Fontana 2006/2007), and were added to the previous carpological list (Mercuri & al. 2005). Interestingly, a rate of 7000 coprolites per 6 litres was also noted, which had not been observed in the samples previously examined. The coprolites probably belonged to ovicaprines, and were of variable size (Fontana 2006/2007).

In the Fewet sample (Torricelli 2006/2007), cereals consisting of charred *Hordeum vulgare* and Paniceae were prevalent. What is more, some legumes and dates were found in a charred state, while two seeds of *Punica granatum* were found uncharred (Table 3).

Charcoal was frequent, abundant and well-preserved, while desiccated wood remains were not recorded. In Aghram Nadharif, *Tamarix* and *Phoenix dactylifera* prevailed, of the same types as found at Fewet (Table 4).

Pollen was generally well preserved (24% of the samples; Table 5) in Aghram Nadharif. Concentrations were fairly high (from about $2x10^3$ to $4x10^4$). The pollen flora included woody plants such as *Phoenix* (13%, mean of the deposit) and *Tamarix* (7%), and herbs such as *Typha* (31%), *Gramineae* including Cerealia (21%) and *Chenopodiaceae* (5%). Cerealia pollen (20%) included: a) major cereals such as *Hordeum* group (barley = 3.3%), -*Avena/Triticum* group and Type III (oat/wheat - wheat = 2.6%); b) minor cereals such as *Panicum* type (millets = 0.5%).

Discussion

Phoenix dactilyfera and *Hordeum vulgare* are the best represented plants in the archaeobotanical record from the Garamantian sites (Table 6). In the different analyses, they were found as pollen, flowers, fruits, seeds, and wood of date palm, and grains, chaffs, and nodes of barley. Wheat and other cereals were also fairly frequent and significant. Therefore, palms and cereals would have been the most characteristic crops grown by the

Table 2. Seeds, fruits and other plant remains from the rooms of Aghram Nadharif. There are naked eye and volumetric samples (1-6 litres each). Samples with less than 10 records were omitted.

Chronological Phase		**Classic Garamantian**				**Late - Post Garamantian**			
Rooms (AN)		**AN 3**	**AN17**	**AN 18**	**AN 22**	**AN 3**		**AN 1**	**AN 7**
Archaeological layer		**4**	**3**	**3**	**7**	**2**		**2**	**2**
Archaeological sample		**99C27**	**01C516**	**01C522**	**00C515-E1**	**99C13+C1**	**99C16**	**97C16**	**99C39**
Carpological Sample (= CS; * = volumetric)		**CS16***	**CS13***	**CS14**	**CS15***	**CS3+CS4**	**CS5***	**CS1***	**CS11***
Hordeum vulgare	caryopsis (hulled, charred)	23		1	2		72	3	
	caryopsis (hulled, uncharred)		1						
	rachis fragment	7	3	1	1		6		
	lemna/palea/glume			2					80
Triticum sp.	caryopsis				1				
	rachis fragment						9		
	spikelet fork						6		
Triticum aestivum/ durum	caryopsis (charred)	2							
Triticum dicoccum	caryopsis (charred)	1							
Digitaria sp.	lemna/palea						40		
Panicum cf. *repens*	lemna/palea						6		
Panicum sp.	lemna/palea		270	8			3		
Pennisetum sp.	caryopsis						43		
Setaria cf. *italica*	lemna/palea		2						
Setaria sp.	lemna/palea (uncharred)	1463	240	6			4330		
	lemna/palea (charred)	147							
Paniceae	caryopsis	14	3				200		
	lemna/palea	21	300	28	1				
Cerealia	caryopsis	10							
Gramineae	culm fragments and nodes							870	5
Vigna unguiculata cf.	seed		1				30		
Vicia sp.	seed						3		
Leguminosae	seed	1					3	3	
Phoenix dactylifera	seed	5	82	3	11	13	105		2
	fruit	1			1	12			
	calix		15				27		
Vitis vinifera	pip	100	53	11	30		133	3	4
Ficus carica	achene			6			120		
Ziziphus sp.	endocarp	2		1	4		21		1
Prunus persica	endocarp					1			
Amelanchier sp.	seed						1		
Anethum graveolens cf.	mericarp	14							
Apium sp.	mericarp						1		
Foeniculum vulgare cf.	mericarp						3		
Petroselinum sp.	mericarp	14					1		
Umbelliferae	mericarp	7							
Portulaca oleracea	seed								2
Citrullus cf. *colocynthis*	seed		1	2			9	3	
Asphodelus sp.	seed						6		
Atriplex sp.	seed						43		
Amaranthus sp.	seed	42							
Chenopodium sp.	seed						40		
Chenopodiaceae	seed	14							
Fagonia sp. cf.	spiny		1				3		
Polygonum sp.	achene	1							
Polygonaceae	achene		2		1		166		1
Labiatae	mericarp		15						
Boraginaceae	mericarp							3	1
Caryophyllaceae	seed	14		1					
Picris sp.	cypsela	14					80		
Ononis sp. cf.	seed						80		
Medicago sp.	pod fragment	70							
Euphorbia helioscopia	seed		1						
Thalictrum sp.	achene		1						
Carex sp.	nutlet	42							
Eleocharis sp.	nutlet						40		
Schoenoplectus sp.	nutlet	10							
Scirpus sp.	nutlet		16	10	2		40		2
Cyperaceae	nutlet								2
Acacia sp.	seed	12							
Tamarix cf. *aphylla*	twig fragment	84	15	7			203	12	3
Tamarix sp.	twig fragment	50	16	5				54	1
Indeterminate		105	25	18	10	7	469	27	10
TOTAL RECORDS		**2290**	**1063**	**110**	**64**	**33**	**6342**	**978**	**114**

Table 3. Seeds and fruits from room FW5 of Fewet (volumetric sample = 3 litres).

Chronological Phase		**Classic Garamantian**	
Rooms (FW)		**FW5**	
Archaeological layer		**F1**	**109**
Archaeological sample		**C 154**	**C128**
Carpological Sample (= CS; * = volumetric)		**CS1***	**CS2**
Phoenix dactylifera	seed	27	7
	fruit	7	7
Hordeum vulgare	caryopsis	564	
	rachis fragment	3	
Panicum sp.	caryopsis	5	
	lemna/palea	10	
Setaria sp.	caryopsis	5	
Paniceae	caryopsis	280	
	lemna/palea	2	
Vicia/Vigna	seed	88	
Acacia sp.	seed	9	
Leguminosae	seed	6	
Punica granatum	seed (uncharred)	2	
Indeterminate		3	
TOTAL RECORDS		**1011**	**14**

Garamantes, and markers of the Fezzan landscape at that time. Cultivated plants were mainly used for food. Date palm pollen may also have been collected and stored for use in artificial pollination and fertility ceremonies (Mercuri & al. 2005).

Ever since the first Garamantes settled in this area, at the beginning of the first millennium BC, there have been citadels like Zinkekra, which was a producer site surrounded by cultivations spread along the Wadi Al-Ajal. Its archaeobotanical record included a very large amount of waste products generated, in fact, throughout the various stages of crop processing (van der Veen 1992). As rightly observed by Pelling (2005), crops characteristic of Near Eastern, Mediterranean and Egyptian regions, based on emmer wheat (*Triticum dicoccum*), barley (*Hordeum vulgare*) and perennial fruits including grape (*Vitis vinifera*), fig (*Ficus carica*) and date (*Phoenix dactylifera*), would have been already widely cultivated in Fezzan. African cereals, on the other hand, such as pearl millet and sorghum, were not found at Zinkekra, suggesting that local exploitation of wild species was fairly limited. In those early phases, it seems that agriculture in the area principally developed by introducing crops from elsewhere rather than expanding local resources (Pelling 2005). More productive crops would have been sustained by the soils near the river valley which supplied the species with sufficient water and nutrients. The water regime was probably distributed well, but differently depending on the diverse geomorphological features of the

Table 4. Charcoal from the rooms of Aghram Nadharif, and from room FW5 of Fewet. There are naked eye and volumetric samples (1-6 litres each). Samples with less than 10 records were omitted (+ = observed in AS11 from room AN7).

Rooms (AN = Aghram Nadharif; FW = Fewet)	**AN6**	**AN8**	**AN17**		**AN18**		**AN22**	**FW5**	**AN1**	**AN3**			**AN6**	**AN7**	
Layer	5	6	3		3		7		2	2			3	2	
Archaeological sample	**00C519**	**00C37**	**01C516**	**01C523-E2**	**01C517**	**01C522**	**00C515-E1**	**C 120 + C121 + C128**	**97C16**	**99C18 + 99C20**	**99C16**	**99C19**	**00C20**	**99C42 - E1**	**99C39**
Anthracological Sample (= AS; * = volumetric)	**AS8**	**AS13**	**AS14***	**AS15***	**AS16***	**AS17***	**AS18***	**AS1 + AS2 + AS3**	**AS2***	**AS3 + AS4**	**AS5***	**AS6***	**AS7***	**AS10**	**AS12***
Acacia			4	1					2		2		2		6
Cadaba							1								
Calligonum														+	
Capparis		59					2								
Chenopodiaceae										1					
Commiphora															
Pinus										1					
Hyphaene										1					
Monocotyledons indet.				1		1					2		2		
Nerium oleander			1												
Phoenix dactylifera	20	5	28	2	21	2	3	3	29	21	52	14	5	3	4
Salix										1					
Tamarix	21	65	120	35	97	56	26	26	42	45	66	30	117	31	15
Zygophyllum							2								
Indeterminate		1	1			7	1	194		7		4		2	2
Number of records per sample	**41**	**130**	**154**	**39**	**118**	**66**	**35**	**223**	**73**	**77**	**122**	**48**	**126**	**36**	**27**

Table 5. Synthesised pollen spectra from Aghram Nadharif (selected pollen quoted in the text).

Chronological Phase		**Classic Garamantian**			**Late / Post Garamantian**									**Post Garamantian**		**Late Mediaeval**	
Rooms (AN)		**AN17**		**AN18**	**AN1**	**AN3**		**AN7**	**AN11**		**AN22**	**AN22**	**AN22**	**AN14**	**AN22**	**AN4**	**AN5**
Layer		3	3	3	2	2		2	5		7			5	5	2	3
Archaeological sample		01C516	01C523-E2	01C517	97C16	99C16	99C19	99C38 / 39	01C36	00C54	01C27-P1	01C31-F1	01C26	00C524	01C29	99C35	00C7
Pollen Sample (= PS)		PS10	PS11	PS12	PS1	PS2	PS3	PS6	PS7	PS8	PS14	PS15	PS16	PS9	PS13	PS4	PS5
Concentration (pollen/gram)		6553	29432	43550	8085	17014	7744	15294	6062	1651	28680	13058	19464	5308	1761	2861	3763
Woody plants																	
Arecaceae	*Phoenix dactylifera*	1,5	30,6	45,2	3,5	17,8	24,0	1,7		25,1	13,6	12,8	22,1	0,9	2,4	2,0	1,2
	Arecaceae undiff.											0,3					
Tamaricaceae	*Tamarix*	3,0	2,5	4,5	4,3	0,6	12,2	14,0	4,6	2,8	2,7	3,7	10,4	11,0	1,5		32,3
Moraceae	*Ficus*	0,3	3,8	0,5	3,1	0,6		0,5	1,0	3,7	0,6	1,2	0,6	2,6	3,0	3,2	1,7
Zygophyllaceae	*Zygophyllum* cf. *album*	0,3	0,5	0,5	1,6	0,3	1,2	2,7		0,5	1,5	0,9	0,3	15,1		1,0	0,2
Chenopodiaceae	*Anabasis*						0,8		0,2			0,6					
	Arcthroctenum cf.	0,5	0,5			0,3			0,2					1,7			0,2
	Cornulaca cf. *monacantha*		1,4	0,3	0,4		2,0	0,7			0,3	0,6	2,9	1,7	0,3	0,2	
	Chenopodiaceae undiff.	2,5	5,5	4,8	3,1	7,3	11,4	3,9	2,9	2,8	8,3	4,0	12,0	7,5	5,1	0,2	0,2
Oleaceae	*Olea* cf.	0,3						0,5									
Rosaceae	*Prunus* cf.														0,3		
Other woody plants		6,8	1,1	4,0	31,9	2,2	2,0	13,8	3,2	7,9	11,5	12,2	12,0	4,9	4,5	1,7	1,2
Herbaceous plants																	
Gramineae	Gramineae wild group	10,0	10,1	6,1	10,5	7,3	17,7	16,2	31,5	18,6	10,9	11,9	5,8	15,7	14,9	11,8	25,2
	Lygeum spartum				0,4												
Gramineae	*Phragmites communis* cf.		5,2	2,9		1,6			0,2	0,9			0,3	1,7		0,2	
(cerealia)	*Hordeum* group	1,5	0,8	0,5	13,6		0,8	3,4	6,3	10,7	0,6	4,3	0,6	1,2	0,6	2,7	5,2
(cerealia)	*Avena/Triticum* group	7,3		0,8	0,8			8,6	8,8					0,6	2,7	1,2	11,9
(cerealia)	*Panicum* type	0,5				0,3	0,4	0,7	4,9							1,0	0,7
Typhaceae	*Typha angustifolia* type	18,0	13,4	14,9	2,3	21,3	9,8	6,9	6,8	11,2	13,0	14,6	5,2	8,1	16,4	3,7	3,0
	Typha latifolia type	30,0	14,2	6,1	3,1	30,3	8,7	16,7	20,8	13,5	21,2	26,8	10,1	11,3	39,0	60,5	10,9
	Typha cf. *minima*															3,7	
Other herbaceous plants		17,0	10,1	8,8	21,0	9,9	7,5	9,6	7,6	2,3	15,9	5,8	17,2	15,1	8,9	5,1	4,9
Undeterminated		0,8	0,3		0,4		1,6		0,7			0,3	0,3	0,9	0,6	1,7	1,0
Undeterminable (out of %)		*0,7*	*2,1*	*0,3*	*1,5*	*1,3*	*1,6*	*2,4*	*0,5*	*5,3*	*0,9*	*0,3*	*1,0*	*2,0*	*2,9*	*1,4*	*1,0*
POLLEN SUM		**400**	**366**	**376**	**257**	**314**	**254**	**407**	**409**	**215**	**339**	**328**	**308**	**345**	**336**	**408**	**405**

wadis. Accordingly to Mattingly & al. (2000), the *foggara* system was based on subterranean irrigation channels, constructed to tap the higher water table at the foot of the escarpment on the southern edge of the Wadi Al-Ajal; water was then gravity-fed along the *foggara* to the wadi centre for agricultural use much like in the *qanats* of Arabia and Persia. Though *foggaras* were widespread in the Wadi el-Ajal region, they were not present in the Wadi Tanezzuft area, where a system of small channels, exploiting water from the wells was most fruitfully used for irrigation (Brooks & al. 2005; Cremaschi & di Lernia 1998; Liverani 2005). Overall, agriculture proved so advanced at this stage that the landscape would have been clearly marked by the cultivations.

Later on, the Aghram Nadharif deposit shows a fairly different archaeobotanical record, in accordance with the different geographical position and chronological phases of the two sites, which suggests they were differently organized (Castelli & al. 2005). Moreover, while part of the Fewet settlement was abandoned following a fire which burnt the roof covering, sealing the content of some of the rooms (FW5 included), the Aghram Nadharif site was abandoned for some time, but then brought back into use as a shelter in post-Garamantian phases. Though it is plausible that taphonomical problems contributed to the poorer preservation of carpological remains in this site, two critical points must be underlined: a) though cereal pollen was frequent and sometimes abundant, the macroremain waste products were much fewer than previously; b) some African crops, including *Pennisetum* and other Paniceae millets, entered the record.

As regards the first point, cereal fields would have been distributed throughout the Barkat oasis, and possibly near the wadi centre. The cereals would have been cleaned in open sites, and then transported to the rooms of Aghram Nadharif and processed with grindstones (Mercuri & al. 2005). There were different concentrations of botanical remains in the rooms: for example, cereal pollen was concentrated in some rooms (AN5, AN11; Table 6), and dates in other rooms (AN3, AN17; Table 2). Therefore, the archaeobotanical record suggests several hypothesis: a) the above-mentioned rooms would have been used prevalently for storage or crop processing; b) the same room would have served different purposes such as storage, food cooking and living space. Actually, as the rooms were part of very simple residential units, all the rooms would have been put to a mixture of uses, including storage and/or domestic activities.

In AN3 (sample 99C27), many ovicaprine coprolites were also found in a fill from a small, rectangular, rough-brick storage room, as well as animal bones showing signs of butchery. This could suggest that this room was set aside for food preparation practices. Nevertheless, it must be considered that coprolites may have been contained in the row of bricks, and that bones were also found in other rooms (Liverani 2005). The presence of a storage structures (a circular pit filled with some dates, and the aforesaid rectangular storage room) also suggests that this room would have served mixed storage/food preparation purposes.

As regards the second point, in the last centuries BC/early centuries AD, African crops entered the archaeobotanical record of Aghram Nadharif, and likewise the Tinda and Jarma records (*Pennisetum glaucum* and *Sorghum bicolor*; Pelling 2005). A good amount of Paniceae indet. were found at Fewet, in addition to barley and pulses. Minor cereals, frequently including less productive species, were probably adopted because the soils had begun to suffer from some kind of overexploitation and decreasing water availability, and more drought-resistant species were favoured, at least in lean periods. Wild species, such

Table 6. Seed-fruit analyses from the five Garamantian sites with archaeobotanical analyses (*Pelling 2005 - ° this paper, Tab. 2 and Tab. 3).

Crops plants from Garamatian deposit (archaeocarpological records)					
Wadi	Wadi Al-Ajal*			Wadi Tanezzuft°	
Site	**Zinkekra**	**Tinda**	**Jarma**	**Fewet**	**Aghram Nadharif**
Chronology	900–400 BC	370–110 BC	400 BC – 750 AD	200–0 BC	50 BC - 1200 AD
Garamantian Phase	Formation phase	Late phase	Mature to Late phase	Mature phase	Classical phase to Mediaeval period
Fruits					
Phoenix dactylifera	+	+	+	+	+
Vitis vinifera	+	+	+		+
Ficus carica	+	+	+		+
Prunus amygdalus			+		
Prunus persica					+
Punica granatum			+	+	
Rhus tripartita	+				
Ziziphus spina-christi			+		
Ziziphus sp.					+
Olea europea			+		
Citrullus sp.			+		
Citrullus colocynthis	+				+
Cucumis melo/sativus			+		
Cucurbitaceae indet.			+		
Cereals and *Gramineae*					
Hordeum vulgare	+	+	+	+	+
Triticum dicoccum	+		+		+
Triticum cf. *dicoccum*			+		
Triticum aestivum/durum		+			+
Triticum aestivum type	+		+		
Triticum cf. *durum*			+		
Triticum sp.					+
Digitaria sp.					+
Panicum cf. *repens*					+
Panicum sp.				+	+
Pennisetum sp.					+
Pennisetum glaucum		+	+		
Setaria cf. *italica*					+
Setaria sp.				+	+
Sorghum bicolor		+	+		
Sorghum bicolor race *caudautum/durra*		+			
Sorghum bicolor cf.			+		
Cerealia					+
Paniceae				+	+
Gramineae					+
Pulses and Leguminosae					
Vigna unguiculata cf.					+
Vicia/Vigna				+	
Vicia faba cf.			+		
Vicia sp.					+
Pisum sativum cf.			+		
Medicago sp.					+
Leguminosae			+	+	+
Fiber Crops					
Gossypium sp.			+		
Linum usitatissimum			+		
Others					
Apium sp.					+
Apium graveolens	+		+		
Anethum graveolens	+				+
Coriandrum sativum cf.			+		
Foeniculum vulgare cf.	+				+
Petroselinum sp.					+
Umbelliferae					+
Amaranthus sp.					+
Atriplex sp.					+
Chenopodium sp.					+
Chenopodiaceae					+
Polygonaceae					+
Carthamus tinctorius cf.			+		
Lagenaria sp.			+		
Portulaca oleracea	+				+
Ricinus communis cf.			+		
Sesamum indicum cf.			+		

as *Tamarix* and *Typha*, were exploited, probably for thatching and matting. The presence of *Zygophyllum* refers to alogypsophilum communities in areas which remained uncultivated because the substratum was unsuitable for crops (Mercuri & al. 2005).

At that time, some changes in wheat species exploitation were observed: those used gradually changed from emmer (*Triticum dicoccum*; Zinkekra) to free-threshing species (*Triticum aestivum* and *T. durum*, with different degrees of identification; Tinda, Jarma). Moreover, new Mediterranean/Near Eastern crops (*Punica granatum* - Fewet, Jarma; *Olea europaea* - Jarma) were found. The range of food plants continued to centre on palms, fruit trees, cereals and pulses, much like in the Classical (50 AD) to the Late phase (approx. 600 AD).

In more recent phases, northern and eastern crops (e.g., peach - *P. persica* and cotton - *Gossypium*, respectively) in Aghram Nadharif and Jarma indicated both the well developed trade economy and the continuous introduction of new cultivations in the region. In fact, in Mediaeval times, peach trees (*Prunus persica*) were probably grown and wood from tropical regions (*Commiphora*) was imported. The cultivation of exotics in Fezzan has been documented by explorers and naturalists since recent times (Corti 1942; Hammer & Perrino 1985). Even today, kitchen gardens with fruit trees, vineyards and small fields of barley and pulses are grown in oases in the shade of the palms (as is the case in Fewet for example, beneath the homonymous archaeological site).

Conclusion

Based on the cultivated and wild plant records buried in the archaeological deposits, data showed that the characteristic species of the area comprised: (a) cultivated plants such as *Phoenix dactylifera*, *Ficus carica*, *Vitis vinifera*; cereals such as *Hordeum vulgare*, *Triticum dicoccum, T. aestivum/durum*, *Pennisetum glaucum*, *Panicum* and *Setaria*; pulses as *Vigna unguiculata*, *Vicia* and *Pisum*; aromatics and vegetables such as *Anethum graveolens*, *Coriandrum sativum*, *Foeniculum vulgare*, *Petroselinum* sp. and *Portulaca oleracea*; (b) wild plants such as *Tamarix*, and *Typha*. These help to reconstruct the plant landscape's main traits and the dwellers' plant economy. The Garamantes' plant economy would have been mainly based on date palms and cereals cultivated together with other fruits such as grapes and figs. Therefore, the Central Sahara study presented in this paper, underlines that the date (*P. dactylifera*) was an important source of valued foodstuff, like in the Saharo-Arabian region and for the Roman culture of the time (Cappers 2006). Plants were planted in the oasis, along channels and in gardens, or imported by trade and exchanges.

In conclusion, it emerges that the Garamantes knew the limits and potentialities of the environment they inhabited, which was already in the current hyperarid climatic phase. This meant the environment was strongly shaped into a cultural landscape influenced by their activities, with plantations occupying much of the oases and wild vegetation restricted to the more distant wadi bed areas. For example, they grew male (pollen) and female (fruits) specimens of date palms, and the female specimens would have been more abundant to obtain more fruits per unit of surface area. Trees were arranged in lines along irrigation channel networks. The land between the trees would have been intensively cultivated with cereals and other crops, and arranged in small fields, like kitchen gardens.

Grapevines, pomegranates and other fruit trees were also grown by exploiting the palm shade. Trading completed the diversity and circulation of food and other commodities. This allowed a great, environmentally well-balanced culture to flourish over the centuries which saw the Garamantes occupying an increasing dry and hostile environment, as revealed by archaeology in the Central Sahara.

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A. Nedelcheva, D. Pavlova & S. Tonkov

Bulgarian Serpentine Flora – a new thematic collection in the Sofia University Herbarium

Abstract

Nedelcheva, A., Pavlova D. & Tonkov S.: Bulgarian Serpentine Flora – a new thematic collection in the Sofia University Herbarium. — Bocconea 23: 395-401. 2009. — ISSN 1120-4060.

The object of the present study is a collection stored in the Sofia University Herbarium (SO) which is the oldest Bulgarian herbarium with more than 104600 specimens. The Bulgarian Serpentine Flora Collection is a result from the investigations on the serpentine terrains in the Rhodopes Mountains and the Vlahina Mountain (South Bulgaria) which started since 1997. Currently, the collection comprises 354 herbar specimens - 253 taxa of higher plants from 55 families and 163 genera. Most of them are mediterranean, euro-asiatic and middle-european geoelements. The bulgarian endemics are *Saponaria stranjensis* Jordanov, *Stachys cretica* ssp. *bulgarica*, *Verbascum adrianopolitanum* Podp. and *V. nobile* Velen. A database for this collection is under construction following a specific model for archiving, retrieving and demostrating the information in electronic format. Electronic tables in Microsoft Excel are used setting up as relative database in Microsoft Access. Original illustrations in digital format are prepared and electronically published. This investigation offers possibilities for assessment of the SO herbar collection state as a systematic structure related to biodiversity, thus helping in evolving a strategy towards the enrichment of the collections and the optimization of the herbarium structure. The investigation included data sorting and relative analysis by different criteria – chorology, taxonomy and systematical structure, Latin and common plant names, synonyms, author names, etc.

Introduction

Sofia University Herbarium (SO) is the oldest national herbarium in Bulgaria founded in 1891 in the Department of Botany. Prof. Stefan Georgiev was the founder of the department and the herbarium. The collection now comprises more than 104600 specimens.

Different herbar collections were organized over the years due to the efforts of numerous botanists and plant collectors such as Ivan Neitchev (vascular plants) and Sava Kazandzhiev (cryptograms), Prof. Stefan Petkov, Prof. Nikolai Stojanov and Prof. Boris Stefanov. Later on, one of the most active botanists Prof. Daki Jordanov (1926-1940) enriched the herbarium with about 15 000 gatherings of plants mainly from the steppe and hilly regions of the country. Prof. Boris Kitanov, Prof. Asen Janev, Prof. Stoju Vălev and Prof. Ivan Penev also contributed to the richness of the herbarium in the period 1936-1970.

In 1980 Prof. B. Kitanov donated his large collection of pteridophytes and ferns from Cuba and 5000 herbar specimens from Macedonia and Albania. The international exchange realized through Centuria and duplicates with the most famous Europaean herbaria and from other parts of the world contributed also to the present richness of the herbarium.

The Bulgarian Serpentine Flora Collection (SO-BSF) is a thematic collection established in 2000 as a result from the investigations on the serpentine terrains in the Eastern and Central Rhodopes Mountains and the Vlahina Mountains (South Bulgaria) which started since 1997 (Pavlova 2001, 2004; Dimitrov & Pavlova 2002; Pavlova & al. 2002, 2003, 2004, 2006, Nedelcheva & Pavlova 2006). It is connected with the study of the plant diversity on serpentine areas in Bulgaria.

Study area

The Balkan peninsula is one of the most interesting parts in Europe with vast territories of ultramafic rocks, located predominantly in its western parts – Albania, Bosnia, Serbia, Monte Negro, Greece and Macedonia (Tatic and Veljavic, 1992, Stefanovic et al., 2003). In Bulgaria the total serpentine area is considerably small. The largest serpentine bodies are located in the Eastern and Central Rhodopes, Vlahina, Ogražden and Belasitza mountains (Pavlova 2004).

The serpentines in the Eastern (7 sites), the Central Rhodopes Mts. (2 sites) and Vlahina Mt. (3 sites) were investigated until now (Fig. 1). The area of these sites differs and the largest one is in Eastern Rhodopes Mts. and the smallest in Vlahina Mt. The displacement is between 150 and 650 m. The study area belongs to the South-Bulgarian climatic region where the Mediterranean influence is well pronounced.

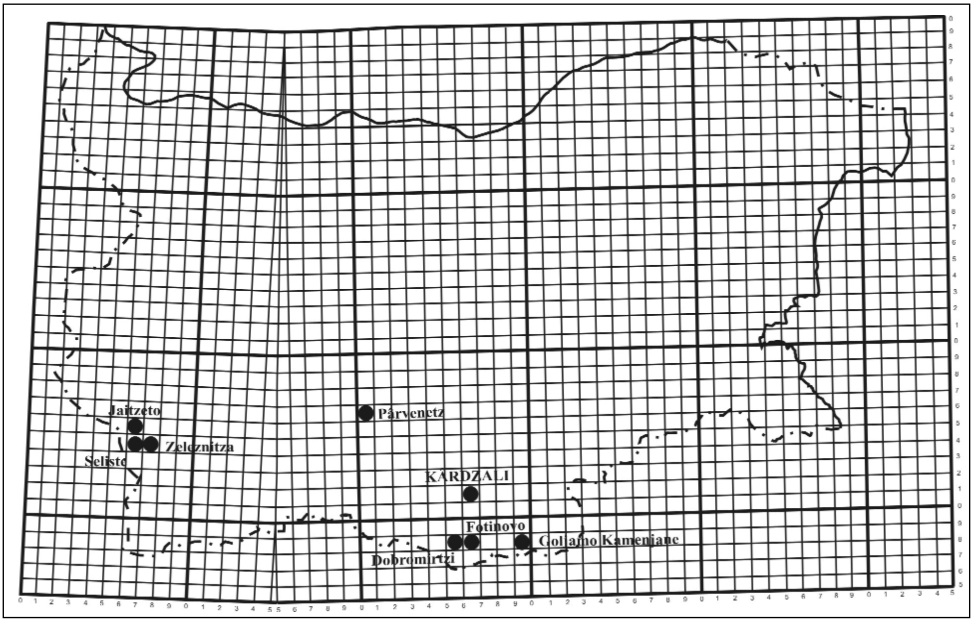

Fig. 1. UTM Grid map of the study area. Scale bar 1:1 500 000.

Material and methods

Specimens preparation (plants pressed, dried and mounted on sheets of light cardboard), collection arrangement, storage (cardboard boxes in wooden cabinets) are according to SO traditions and modern herbarium technique requirements (Kozuharov 1994; Bridson & Forman 1998). The specimen numbers are incorporated in the general herbarium but the sheets are stored separately in a special collection.

A database for this thematic collection is under construction following a specific model for archiving, retrieving and demostrating the information in electronic format. The electronic tables in Microsoft Excel are used setting up as relative database in Microsoft Access. Original illustrations in digital format are also prepared.

Results

Currently the collection comprises 354 herbar specimens - 253 taxa of higher plants from 55 families and 163 genera. The number of specimens will exceed 650 after the inclusion of all specimens collected.

Systematic structure

All seed plants, with the exception of *Juniperus oxycedrus,* are representatives of *Magnoliophytina*. The dicotyledons prevail with over 75%. The participation of *Polypodiophyta* is with 1.5 – 2.3% and *Bryophyta* with 1.73 – 2.8%. The families with the largest number of species and infraspecific taxa are *Poaceae* (11.2%), *Fabaceae* (10.9%), *Asteraceae* (9.3%), *Caryophyllaceae* (7.4%), *Lamiaceae* (6.3%), *Rosaceae* (4.4%), *Scrophulariaceae* (3.9%), *Rubiaceae* (3.2%), etc. (Fig. 2).

The structure about the life forms shows the characteristic features of the mid-latitude floras the perennial herbs dominate followed by the annuals, trees and shrubs.

Most of the species in the collection are xerophytes with the prevailance of representatives from genera *Alyssum*, *Silene*, *Dianthus*, *Thlaspi*, *Onosma*, *Festuca*, *Koeleria,* etc.

The majority of the taxa (65%) are submediterranean, mediterranean, euro-asiatic, middle-european, oriental-turanian and middle-european geoelements.

Most important plants in the collection are the endemics, rare and plants with conservation value. Kruckgeberg (1992) groups plans distributed on serpentines according to their affinity to the serpentine substrate in three types of floristic elements. As plant taxa of great importance for the serpentine flora are included serpentine endemics closely bound to the serpentine substrate. This group now is presented of newly described species *Aethionema rhodopaeum* D. Pavlova only (Fig. 3) (Pavlova, 2007).

Local serpentine indicator species, but not restricted to the serpentines, are *Asplenium cuneifolium* Viv., *Convolvulus boissieri* Stend. ssp. *parnassicus* (Boiss. & Orph.) Kuzm. and *Thymus bracteosus* Vis. ex Bentham.

The group of widely distributed endemics and rare species in different habitats, serpentine and non-serpentine terrains included, is very well represented (66.6% of all taxa). A considerable number of the endemics in the collection (25%) can be related to the group of exceptions for the ultrabasic terrains – *Stachys cretica* L. ssp. *bulgarica* Rech. f., *Festuca thracica* (Acht.) Markgr.-Dannenb., *Centaurium turcicum* (Velen.) Ronninger ex Fritsch, *Oenanthe millefolia* Janka, *Galium velenovskyi* Ančev, *Serapias vomeraceae* (Burm.) Briq., *Verbascum nobile* Velen.*,* *Silene lydia* Boiss.*,* etc.

The Balkan endemics are *Bupleurum apiculatum* Friv., *Hypericum rumeliacum* Boiss., *Moenchia graeca* Boiss. & Heldr., *Centaurea chrysolepis* Vis., *C. affinis* Friv., *Petrorhagia illyrica* Ball & Heyw. ssp. *illyrica*, *Scabiosa triniifolia* Friv., *Iris reichenbachii* Heuff., *Koeleria simonkaii* Adam., *Delphinium balcanicum* Pawl. and *Gallium macedonicum* Krendl.

The Bulgarian endemics are represented by *Saponaria stranjensis* Jordanov, *Stachys cretica* ssp. *bulgarica*, *Verbascum adrianopolitanum* Podp. and *V. nobile.*

Seven species, among them *Limodorum abortivum* (L.) Schwartz. and *Fritillaria orientalis* Adans., are included in The Red Data Book of Bulgaria and 12 species - in The Law of Biological Diversity (MOEW, 2002) as protected.

As medicinal plants are considered 35% of the taxa in the collection according to the Law of the Medicinal Plants (MOEW 2000, 2004).

Voucher herbar specimens of chorological, floristical and biosystematical studies are also kept in the collection.

Model demonstrative object:

Label information (incorporated in the table):

Herbarium Universitatus Sophiensis
Flora Bulgarica (SO-BSF)
№ 101 429
Convolvulus boissieri Stend. ssp. *parnasicus* (Boiss. et Orph.) Kuzm.
Eastern Rhodopes, serpentine terrains, southwestern from village Fotinovo, 450 m a.s.l.,
11.06. 2000 Leg./Det. D. Pavlova, D. Dimitrov

Table information:

- Family: Convolvulaceae
- Synonyms: *Convolvulus compactus* auct. bulg. non Boiss.
- Locality: UTM: LF-68
- Local name: Skalna povetitsa
- Distribution (Bu): Eastern Rhodopes Mts., villages Dzhebel and Balabanovo
- Geoelement: Submed-med-or
- Voucher specimen: Pavlova & al., 2003 (Polish Bot. J.)
- The Red Data Book of Bulgaria: category Rare
- The Law of Biological Diversity: yes, as protected.
- Ancillary collections: photographs (plant in nature, habitat, pollen, calyx hairs)
- Economical importance: no
- Medicinal plant: no
- Chromosome number: no
- Literature cited: Pavlova & al., 2003 (Polish Bot. J.)
- Biological type: perennial, xerophyte

Conclusions

The collection reveals the current stage of investigation of the serpentine areas in Bulgaria. It resembles an extract of the most characteristic and interesting species. The analysis of the composition and structure of the collection shows its representativeness in relation to the investigations conducted. The collection is an open system so that all its elements can be expanded.

The future strategy is aimed at the enrichment with materials from all serpentine areas in Bulgaria and exchange with regional Balkan herbaria is also planned. The electronic publication and digital images of the herbar specimens will constitute an important part in the functioning of the data-base in the internet space.

Acknowledgements

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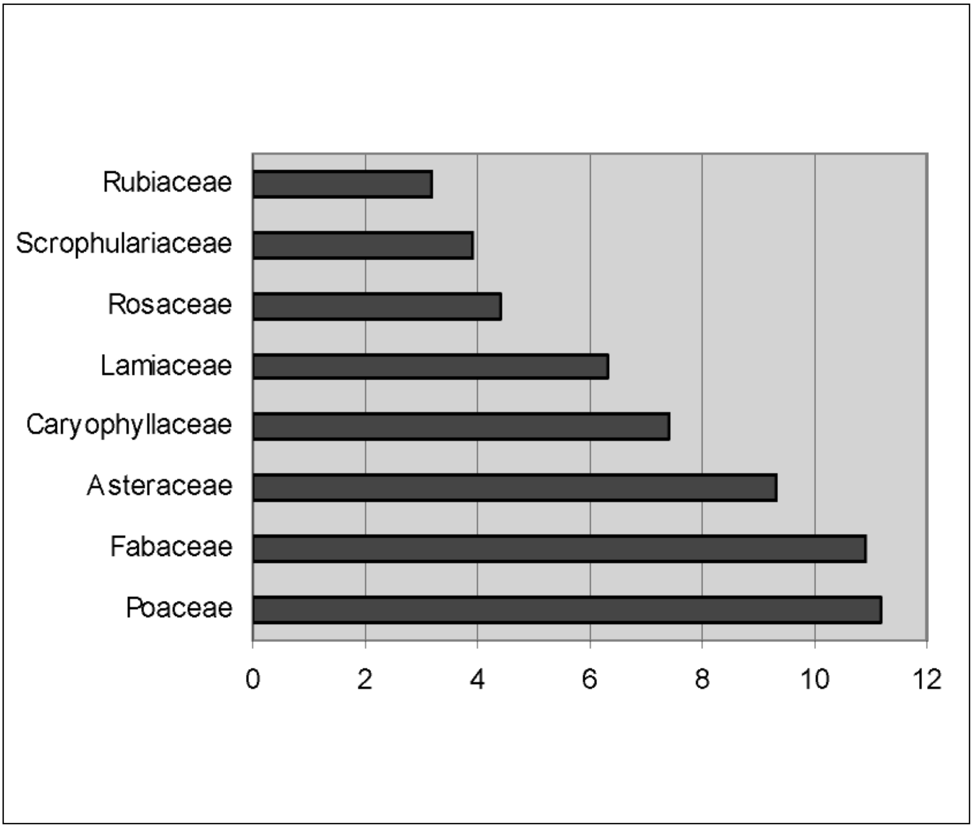
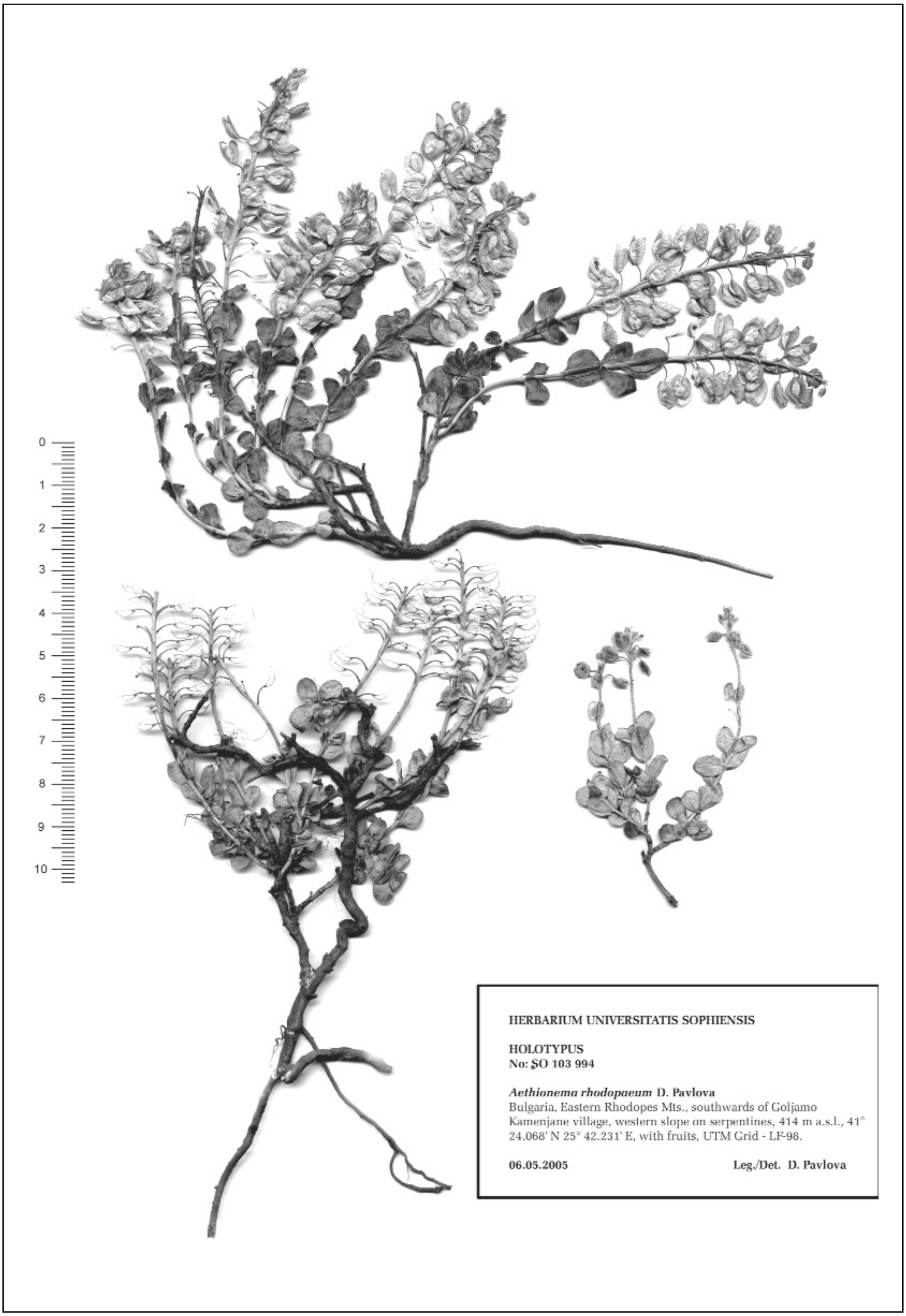


Fig. 2. Systematic structure of the herbar collection (in %).



HERBARIUM UNIVERSITATIS SOPHIENSIS

HOLOTYPUS
No: SO 103 994

Aethionema rhodopaeum **D. Pavlova**
Bulgaria, Eastern Rhodopes Mts., southwards of Goljamo Kamenjane village, western slope on serpentines, 414 m a.s.l., 41° 24.068' N 25° 42.231' E, with fruits, UTM Grid - LF-98.

06.05.2005 **Leg./Det. D. Pavlova**

Fig. 3. *Aethionema rhodopaeum* D. Pavlova (Holotype, SO).

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D. Isocrono, C. Bono, G. Rossi, A. Rampa, E. Savino, M. Valcuvia, L. Mangano, G. Santamaria & F. Sartori

"Carta Naturalistica della Lombardia": a geographic information system for managing and visualizing data

Abstract

Isocrono, D., Bono, C., Rossi, G., Rampa, A., Savino, E., Valcuvia, M., Mangano, L., Santamaria G. & Sartori F.: "Carta Naturalistica della Lombardia": a geographic information system for managing and visualizing data. — Bocconea 23: 403-409. 2009. — ISSN 1120-4060.

The electronic data base system "Carta Naturalistica della Lombardia", an instrument for handling scientific data about vascular plants, habitats, fauna, lichens, fungi and geomorphologic aspects of Lombardy region, is presented.

Introduction

The assessment and conservation of biodiversity are the prime objectives at global, national and regional levels in various agreements (CBD, GSPC, EPCS, CD2010 and Agenda 21). The sustainable use and management of biodiversity require that information be available for scientists and decision-makers (Spellerberg & al. 1991). The transformation of landscape has accelerated drastically in the last decades and this process requires in-depth studies and knowledge of the naturalistic characteristics of the most interesting areas, allowing a better understanding and improving environmental quality.

As the knowledge of an area's resources is essential for its correct conservation and use, in 2003 "Regione Lombardia – Qualità dell'Ambiente" Sector promoted the collection of naturalistic data and the development of a regional georeferenced information system called *Carta Naturalistica della Lombardia*.

A preliminary project has been in existence since 2001, when the Interreg IIIC Project "*Base des données et biodiversité*" led to a database which contains data about four themes: Fauna, Vascular Plants, Habitats and Abiotic Emergences (Margiocco & Mariotti 2001). Data from all themes could be cartographically represented by polygons; queries were possible through MS Access (Mariotti & Margiocco 2002). No internet access was provided so the availability of collected data was very limited.

In 2003 Regione Lombardia updated the former database to comply with the recent Geographical Information System technology. G.I.S. technology allows users to manage and analyze large datasets and to correlate data with their location references. All data previously submitted were transferred to the new database.

Lombardy, one of the most industrialized and inhabited region in Italy, is 23.800 km^2 in size. The high Lombardy’s biodiversity richness (Blasi & al. 2007) is justified by its about 4000 m difference in elevation and its geologic, geomorphologic, climatic and environmental heterogeneity. There is a northern alpine sector marked by alpic, arctic – alpine and boreal elements; a prealpine sector, which develops along the insubric lakes (Garda, Iseo, Como, Maggiore), with many endemic and Mediterranean entities; a southern part called *Appennino Pavese* characterized by submediterranean elements and finally the Po Plain sector in which agriculture, water irrigation nets and urbanization have caused a sensible fall of natural conditions.

The naturalistic knowledge of Lombardy is heterogeneous. There is an in-depth knowledge of alpine areas, but only a basic knowledge of the Po Plain, north western areas and *Appennino Pavese*. Research activity has often been focused on a single taxonomic group (e.g. Bona & al. 2005) or on circumscribed areas very important from a naturalistic point of view (Rossi & al. 2005).

The “Carta Naturalistica della Lombardia” project intends to be the link between all kinds of naturalistic data available for Lombardy and a valuable instrument for newly collected data.

Database Structure

Abiotic Features, Fauna, Fungi, Habitats, Lichens, Vascular Plants are the six considered topics. A hierarchically structured catalogue, regarding all the topics, has been compiled. The catalogue has required hard scientific-research work for its preparation and validation. Each list can be updated on the basis of new submissions by experts and taxonomic revisions. It presently includes 117 Abiotic Features units, 1487 Fauna units, 2504 Fungi units, 107 Habitats units, 3073 Lichens units, 7726 Vascular plants units (on the basis of field surveys and literature). Except for the Abiotic Features, each topic unit represents a taxonomic unit arranged in a hierarchical structure, typically related by subtype-supertype (also called parent-child) relationship. The abiotic characters list has obviously a different organisation, even if a hierarchical structure is maintained.

The inventory comprises *taxa* known for Lombardy and the various lists are presented in the following:

1 *Abiotic Features* This list distinguishes between geomorphologic aspects which are interesting for biologic elements and those which are not. Records derive from petrology, geology, mineralogy, palaeontology, pedology, for example gullies, springs, glaciers, different kinds of soil and other.

2 *Fauna* Both vertebrates and invertebrates *taxa* listed in Directive 92/43/EEC Annexes II and III are included in this section.

3 Fungi checklist At the moment, it refers only to macrofungi belonging to the phylum Basidiomycota, class *Basidiomycetes*. It is based on the systematic criteria adopted in Dictionary of Fungi (Kirk & al. 2001). The data related to macrofungi in Lombardy were extrapolated from the first Italian Checklist (Onofri & al. 2005) and modified according to the expert mycologists collaborating to the project.

4 Habitats This list is organized according to Directive 92/43/EEC Annex I; some units derive also from CORINE biotopes (Commission of the European Communities, 1991). Both typological lists were developed by EU as tools for the description of sites of importance for nature conservation in Europe. These lists have been chosen in order to ensure data compatibility with European documentation or appropriate assessment of plans and project implications for Sites of Community Importance (SCI).

5 *Lichens* The list is built retrieving data from an information system on Italian lichens (Nimis 2003) selecting *taxa* known for Lombardy and updated with new species reports published after 2003.

6 *Vascular plants* In this section, hierarchy is built from taxonomic units and data are retrieved from the regional checklist (Banfi & Galasso 2005).

The system envisages the handling of three types of information: field data, herbarium and literature (with or without the reference specimen).

Data source - "Carta Naturalistica" can receive field, bibliographical and herbarium data; the main sources of this data are described below.

Regarding the field work, many data come from the fundamental contribution of expert volunteers, instructed to collect in a standardized way. They have a deep knowledge of the territory and can provide updated and unpublished data. All floristic records have been checked by researchers of Universities of Pavia and Turin before being inserted in the database.

Accepted bibliographic data sources are monographs, unpublished degree thesis, scientific publications, field censuses from national surveys, pedologic and geologic cartographies. Other sources must be evaluated singularly: for example impact assessment studies, management plans or local studies may be considered proper sources if they are based on field data. Date, author and cartographic reference are compulsory in order to submit viewable data.

Exsiccata collections are a source of information concerning the past that can be combined with the field data to show the degree of development or variation of a local flora over the time. All herbarium sheets information can be recorded in "Carta Naturalistica". If label information is incomplete or some difficulties occur to locate the sample, data can be entered anyway as "historical data". This possibility is available also for literature data.

Data entry. - Since the software can be used by several persons with different levels of training, data entry process is controlled by a set of rules, designed to obtain a correct and validated data set linked to the spatial distribution of data. Codified data acquisition is guaranteed by a special software called CNAT (from "Carta NATuralistica") that allows to post biological, ecological and geographic information. Geographic coordinates (in Gauss Boaga projection system) can be indicated too. Pre-set lists available as pull-down menus during data entry are provided to help the use and the standardisation of data. This system ensures data uniformity and reduces error possibilities.

Sensitive data, for example information on threatened species or nest–building sites, to which access restriction must be set, could be entered by checking a "confidential" box. In this way only species name and no other information are visible to website users.

Data consultation. - Entered data can be consulted through a free search. All data have a geographical reference so they can be displayed on maps, that are different for the various topics. Flora, Fungi and Lichens data are localized using grid squares, according to Central European Mapping Flora system (Ehrendorfer & Hamann 1965). The squares are delimited byparallels spaced by six minutes and by meridians spaced by 10 minutes, resulting in an approximate size of 11.2 × 12.0 km for each square at the level of Central Europe.

They are identified by four-figure numerical codes where the first couple of figures indicate the row and the other the column. It is also possible to use a more detailed division into quarters. 786 CEU (Central European) quadrants are referred to Lombardy.

Fauna, Habitats and Abiotic emergences are instead represented by means of areas encompassed by a series of connected lines (polygons). Such polygons can be drawn in CNAT directly or imported by other GIS.

Cartographic outputs can be performed at various scales. A useful possibility, for obtaining up-to-date distribution maps, is to overlap data layers with informative layers (such as roads, railways, municipal and provincial administrative borders, natural protected areas, etc.).

All described “Carta Naturalistica”’s functionalities described in this report are available via Internet. Web access to information is an important feature of the project implemented in Lombardy. The dedicated website (www.ambiente.regione.lombardia.it/webqa/carta%20naturalistica/cnat_home.html) provides tools for queries and sets of maps to visualize distribution of the entered data. Thanks to the web platform, it is possible to browse *taxa* list, to enter queries about species’ presence in Lombardy or frequency at square grids level. It is possible to zoom in on an area and examine data within geographic layers. Query results can be exported in comma-separated values file format, as tables showing all information about a submitted record.

Results

The management system has been recently completed and 114.073 records have been loaded till now (Tab. 1). Most of the data come from studies focused on Natural parks and other protected areas.

Abiotic Features - most of the 2031 submitted records derive from territorial municipal or provincial plans. Many others come from APAT (Agency for Environmental Protection and Technical Services of Italy), project “*Censimento dei geositi italiani*”, a standardized catalogue of all sites forming part of the Italian geologic patrimony. Data are localized in all Lombardy provinces, except Mantova.

Fauna - in 2003 and 2004, Lombardy Region organized a monitoring activity in sites belonging to the Natura 2000 network). Most records have been gathered from this activity. Data regard protected areas in all sites and non-protected areas in the provinces of Pavia and Varese.

Fungi - till now about 37.300 field data have been collected but only a minimum part of them are located in the website due to technical problems. Lombardy was divided into

Table 1. Records available on line in the Carta Naturalistica web site.

Abiotic Emergencies	Fauna	Fungi	Habitats	Lichens	Vascular Plants
2031	5797	3172	19270	1064	82739

five areas, each one represented by al least one expert mycologist, belonging to the scientific group of A.M.B. (Mangano & al. 2007). They collected and, above all, checked the data sent to the University of Pavia. The results obtained so far are not homogeneous. At the moment, only the Varese province has been investigated almost entirely, while others have been investigated in a sporadic fashion, such as Oltrepo and Ticino Valley, Prealps (Lecco province) and the eastern area in the province of Brescia. Above all, data from the mountainous northern part are not present. Moreover, there are many historical data that should be included (Savino & al. 2007).

Habitats – data source is mostly the cited monitoring study about Natura 2000 sites. As a consequence, habitats data are concentrated in SCI areas and only a small percentage of Lombardy territory is covered by data on habitats.

Lichens – online data come from both field surveys and herbarium sheets. Literature historical data should be also entered in the future. Herbarium data refer to samples preserved in *Herbarium Universitatis Ticinensis* (PAV) and in *Herbarium Universitatis Taurinensis* (TO). Submitted data have been chiefly found in the provinces of Pavia (143 records from lowlands of Oltrepo Pavese, Lomellina, Appennino Pavese) and Brescia (793 records from Adamello Natural Park and Alto Garda Bresciano Natural Park). Scattered data came from the provinces of Bergamo, Como, Milano and Sondrio.

Vascular Plants - 80710 records are presently available on the website. It is necessary to explain the reason of the considerable discrepancy between vascular plants' data and other subjects' records. "Carta Naturalistica della Lombardia" inherited the tested organization of the foregoing project "Floristic Cartography" of Lombardy region, in which both a specific catalogue and a database were prepared. All data registered in this project have been made available in "Carta Naturalistica della Lombardia". Presently, floristic data are missing only in 10% of grid squares. In the last two years, floristic knowledge has been increased above all in areas where data are missing, such as Oltrepo Pavese, Lomellina and southern Po plain. Next year the floristic data collection should be completed by covering all grid squares and adding records to reach 150/200 species for each grid square.

Discussion and conclusions

Computerized cataloguing helps to organize, retrieve and manage all data under various headings and represents an important tool for further critical analysis and new research at many levels.

The designed informative system met the need for standardizing and relating very heterogeneous datasets, linked to many themes and to highly specialized study subjects.

"Carta Naturalistica" includes the collecting data produced in other, separate projects or scientific researches (Bonafede & al. 2001; Poldini & al. 2002; Romani & al. 2001; Bona & al. 2005; Bonali & al. 2006; Selvaggi & al. 2002) with the added value of joining all naturalistic themes.

Management of the data has been easy for field data, which can be collected according to standardised procedures, but difficult for historical and bibliographical data, owing to varying levels of completeness and precision of the information.

The project takes advantage from the valuable experience of volunteers that have developed a deep knowledge of Lombardy territory. Some volunteers are specialists in particular systematic groups and concentrate their survey on that topic.

An important goal of the project is the possibility of updating the information on the distribution of different *taxa*, to compare the past and actual presence and frequency in order to represent an efficient starting point to analyse thoroughly an area or a critical situation.

Finally the availability of data is also crucial: interfacing of the programme with the WEB allows more extensive use of previously somewhat inaccessible information. Without the availability of consistent information at all levels decision-makers could not be able to quickly access data that will help them to synchronize their efforts to reach a set of common goals.

“Carta Naturalistica” is constantly updated and the information about biodiversity of Lombardy is immediately available to all users.

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F. Rexhepi, F. Millaku & E. Krasniqi

Some species of Mediterranean floristic element in Albanian Alps-Kosova

Abstract

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Albanian Alps, situated in the western part of Kosova, are very rich in plant species, some of which belong. to the Mediterranean floristic element. Kosovar Albanian Alps are not far from the Mediterranean sea and the influence of Mediterranean climate reaches Kosova through the Drini i Bardhë river valley and its branches. Therefore in some localities of Kosova territory typical Mediterranean units are recorded, some of them can be identified in the Kosovar Albanian Alps as well.

Introduction

The Kosova territory is situated in the central part of Balkan Peninsula, 90 km away from the Adriatic sea and 220 km from Aegean sea respectively Its territory is formed by two plains (Kosova plain and Dukagjini plain), surrounded by the outlines of Sharri mountains, Koritnik, Pashtrik, Albanian Alps, Kopaonik etc. It culminates at 2656 m a.s.l. (Gjeravica Mountain in Kosova's part of the Albanian Alps) and descends to 265 m a.s.l. in the Drini i Bardhë valley. Most of the Kosova's territory is hilly or montaineous; it shows varied and interesting geology, combined of old rocks of different type and origin such as carbonate, silicate and ophiolitic bedrock (Rexhepi 1994, 1997, Millaku 1999).

Kosova has a modified continental climate toned down with apparent Mediterranean – sub Mediterranean influences. These climate characteristics depend on geographical position and reliefs, the distance from the Sea and the influence of Mediterranean draughts which entry in Kosova through the Drini i Bardhë valley (Rexhepi 1994, 1997).

The first data on the flora of Albanian Alps - Kosova were given by Baldacci (1897), Košanin (1922) and Hayek (1924, 1927-1933) with additional contributions by Hegi (1906-1931), Tutin & al. (1964-1980), Krasniqi (1972) and more recently Rexhepi (1978, 1982, 1986, 1994, 1997, 2007), Josifovič (1970-1986), Horvatič & Trinajstič (1967-1974), Millaku (1993, 1998, 1999, 2005), Rexhepi & Millaku (1996), Krasniqi (2003, 2006), Krasniqi & Millaku (2007) and Polunin 1997.

1. Mediterranean floristic element in Kosova

This element is here considered in a wide sense, as defined by Wulf (1944), Horvatič (1963) and Rexhepi (1994, 2007). It comprises plants that have their centre of distribution in the countries bordering the Mediterranean sea, Southern Europe, Middle East and Northern Africa. Of the 14 floristic elements of Kosova's flora, the Mediterranean one is represented by 5.23% of the total number of species of Kosova's flora (Rexhepi 1994).

2. Mediterranean floristic element in the Albanian Alps-Kosova

Albanian Alps are situated in the western part of Kosova and through the Deçani Strait ang Rugova Gorge they are divided into three parts. These mountains cover a wide area starting from the Liqeni i Shkodres (Shkodra lake), continuing to Plava and Gucia up to Ibri valley and to the Dukagjini plane.

The highest peak is Mt. Gjeravica which reaches 2656 m a.s.l. (Fig. 1). The geological content is various. The greatest part of the Albanian Alps consists of limestone, with a presence of silicate cliffs and in a lesser degree of serpentine rocks. These mountains are very rich in plant species, some of them belonging to the Mediterranean floristic element. According to Rexhepi (1994, 1997, 2007), the flora of Albanian Alps-Kosova can be represented by 6 sub-groups of plants: Mediterranean, Eastern Mediterranean, Western-Mediterraneans, Mediterranean-Pontic, Mediterranean-Central-European and Mediteranean-Submediterranean.

Fig.1. Albanian Alps-Mt. Gjeravica (photo Millaku, F. orig.).

2.1. Mediterranean plants

This group of plants is represented by the following 40 units, generally distributed in the whole Mediterranean region:

Acanthus balcanicus **Hayek et Rich.** Mt. Maja e Rusolisë (Millaku 1993) (Fig. 2).

Alyssum corymbosum **(Gris.) Boiss.** Mt. Maja e Rusolisë (Radavc) (Millaku 1993), Sushicë, Mt. Liçenak, Kurvallë, Plloçicë (Millaku 1999).

Alyssum microcarpum **Vis. var.** ***microcarpum***. Sushicë, Kurvallë (Millaku 1999).

Alyssum montanum **L. subsp.** ***scardicum*** (Wettst.) Hayek. Mt. Maja e Rusolisë, Mt. Liçenak, Koprivnik, Plloçicë, Gjeravicë (Millaku 1999).

Arcethobium oxycedri **(DC.) M. Bieb.** Gubavc-Koprivnik (New location 2007) (Fig. 3).

Bromus squarrosus **L.** Albanian Alps-Gubavc (New location 2007)

Bupleurum praealtum **L.** Mt. Maja e Rusolisë (Millaku 1993).

Calamintha acinos **(L.) Clarv.** Albanian Alps (Millaku 1999).

Cardamine glauca **Spreng. var.** ***glauca.*** Mt. Gjeravicë, Marjash, Mt. of Lumbardhi; **var.** ***pancicii*** **(Hayek) Hayek.** Kurvallë (Millaku 1999).

Cephalaria leucantha (**L.) Schrod.** Albanian Alps-Gubavc (New location).

Colutea arborescens L. Mt. Maja e Rusolisë (Millaku 1993).

Coronilla scorpioides **(L.) Koch.** Mt. Maja e Rusolisë (Millaku 1993).

Danaa cornubiensis **(Torn.) Burnat.** Albanian Alps (Millaku 1999).

Echium italicum **L.** Mt. Maja e Rusolisë (Millaku 1993).

Euphrasia pectinata **Ten.** Peklen, Gryka e Lloçanit, Kurvallë, Mt. of Lumbardhi, Mt. of Deçani (Millaku 1999).

Galanthus nivalis **L.** Albanian Alps (Millaku 1999).

Iris florentina **L.** Zhleb, Mt. Maja e Rusolisë (Millaku 1999).

Iris germanica **L.** Zhleb, Mt. Maja e Rusolisë (Millaku 1999).

Juniperus oxycedrus **L.** Albanian Alps-Gubavc in serpentine (New location 2007).

Linum angustifolium **Huds.** Albanian Alps (Rexhepi 1994, 2007)

Lobularia maritima **(L.) Desv.** Mt. Maja e Rusolisë-Bërdynaj (Millaku 1993).

Nigella damascena **L.** Albanian Alps (Rexhepi 1994, 2007)

Orlaya grandiflora **(L.) Hoffm.** Mt. Maja e Rusolisë-Bërdynaj (Millaku 1993).

Orobanche gracilis **Sm.** Albanian Alps (Millaku 1999).

Oxalis corniculata **L.** Mt. Maja e Rusolisë (Millaku 1993).

Pyrus amygdaliformis V**ill.** Albanian Alps (Rexhepi 1994, 2007).

Pyrus pyraster **Burgst.** Albanian Alps (Rexhepi 1994, 2007).

Rosa glutinosa **Sibth.** Albanian alps (New location 2007).

Silene cretica **L.** Albanian Alps (New location 2007).

Silene italica **(L.) Pers.** Mt. Maja e Rusolisë (Millaku 1993).

Silene macrantha **(Panc.) Neumayer.** Mt. Maja e Rusolisë-Radavc (Millaku 1993).

Stachys annua **L.** Mt. Maja e Rusolisë-Bërdynaj (Millaku 1993).

Stachys germanica **L.** Mt. Maja e Rusolisë-Radavc (Millaku 1993).

Tamus communis **L.** Mt. of Istog. *Ostryo-Fagetum* (New loation 2007).

Teucrium chamaedrys **L.** Albanian Alps (Millaku 1993, 1999).

Trifolium angustifolium **L.** Albanian Alps-Junik (New loation 2007).

Trinia glauca **(L.) Dumort.** Mt. Maja e Rusolisë (Millaku 1993).

***Valerianella coronata* (L.) Dc.** Mt. Maja e Rusolisë-Brestovik (Millaku 1993).
***Vicia melanops* Sibth.** Mt. Maja e Rusolisë-Bërdynaj (Millaku 1993).
***Vinca major* L.** Mt. Maja e Rusolisë-Loxhë (Millaku 1993).

2.2. Eastern Mediterranean plants

This group includes the following 4 units:
***Asyneuma limonifolium* (L.) Janch.** Albanian Alps-Gubavc (New location 2007).
***Euphorbia myrsinites* L.** Mt. Maja e Rusolisë (Millaku 1993) (Fig. 4.).
***Koeleria splendens* Presl.** Mt. Maja e Rusolisë-Radavc (Millaku 1993).
***Scilla bifolia* L.** Mt. Maja e Rusolisë-Bërdynaj (Millaku 1993).

2.3. Western-Mediterranean plants

This group includes only the following unit:
***Juncus anceps* De Laharpe.** Albanian Alps (New location 2007).

2.4. Mediterranean-Pontic plants

These plants show a distribution both on the Mediterrean coasts and on Sarmatic-Irano-Caspic areas. This group includes the following 8 units:

Fig. 2. *Acanthus balcanicus* Hayek. et Rich (photo Krasniqi, E. orig.).

Fig. 3. *Arcethobium oxycedri* (De cand.) M. Bieb. (photo Krasniqi, E. orig.).

Fig. 4. *Euphorbia myrsinites* L. (Krasniqi, E. Photo orig.).

***Chelidonium majus* L.** Mt. Maja e Rusolisë (Millaku 1993).
***Chrysopogon gryllus* (L.) Trin**. Albanian Alps (Rexhepi 1994,2007).
***Haynaldia villosa* (L.)Schur. [Triticum villosum (L.) M. B.].** Albanian Alps (Rexhepi 1994, 2007).
Linum tenuifolium L. Albanian Alps (Rexhepi 1994,2007).
***Marrubium peregrinum* L.** Mt. Maja e Rusolisë (Millaku 1993).
***Polygala major* Jacq.** Albanian Alps (Rexhepi 1986). Mt. Maja e Rusolisë, Zhleb, Grebën (Millaku 1993), Mt. Liçenak, Gjeravicë.
***Scutellaria altissima* L.** Albanian alps (Millaku 1999).
***Teucrium polium* L.** Mt. Maja e Rusolisë (Millaku 1993).

2.5. Mediterranean-Central-European plants

Here are considered the plants with the distribution area in the Mediterranean region, Central Europe, Western Asia and Northern Africa. The group includes only the following unit:
***Prunella laciniata* L.** Albanian Alps (Millaku 1993, 1999).

2.6. Mediterranean-Submediterranean plants

This grup includes the following 11 units:
***Allium cupani* Raf.** Albanian alps-Gubavc (New location 2007).

***Anacamptis piramidalis* (L.) Rich.** Albanian Alps (Rexhepi 1994, 2007).
***Asparagus tenuifolius* Lam.** Albanian alps-Mt. of Istog (New location 2007).
***Cephalanthera alba* (Cr.) Simk.** Albanian alps (Millaku 1993, 1999).
***Cephalanthera rubra* (L.) L. C. M. Rich.** Albanian alps (Millaku 1993, 1999).
***Himantoglossum hircinum (*L.) Spreng.** Albanian Alps (Rexhepi 1994, 2007).
***Luzula forsteri* (Sm.) DC.** Mt. Maja e Rusolisë-in *Fagetum montanum* (Millaku 1993).
***Muscari racemosum* (L.) Lam. et DC.** Albanian Alps (Millaku 1993, 1999).
***Orchis morio* L.** Mt. Maja e Rusolisë (Millaku 1993).
***Orchis tridentata* Scop.** Albanian Alps (Rexhepi 1994, 2007).
***Scilla autumnalis* L.** Gubavc (new loc ation 2007).

Conclusions

On the basis of the present observations we may conclude:
The Flora of Albanian Alps-Kosova is rich in Mediterranean floristic elements;
The total number of Mediterranean floristic element species is 65 (Fig. 5.);
The Mediterranean elements can be subdivided as follows: Mediterranean plants (40 species), Eastern Mediterranean plants (4 species), Western-Mediterranean plants (1 species), Mediterranean-Pontic plants (8 species), Mediterranean-Central-European plants (1 species) and Mediteranean-Submediterranean plants (11 species).

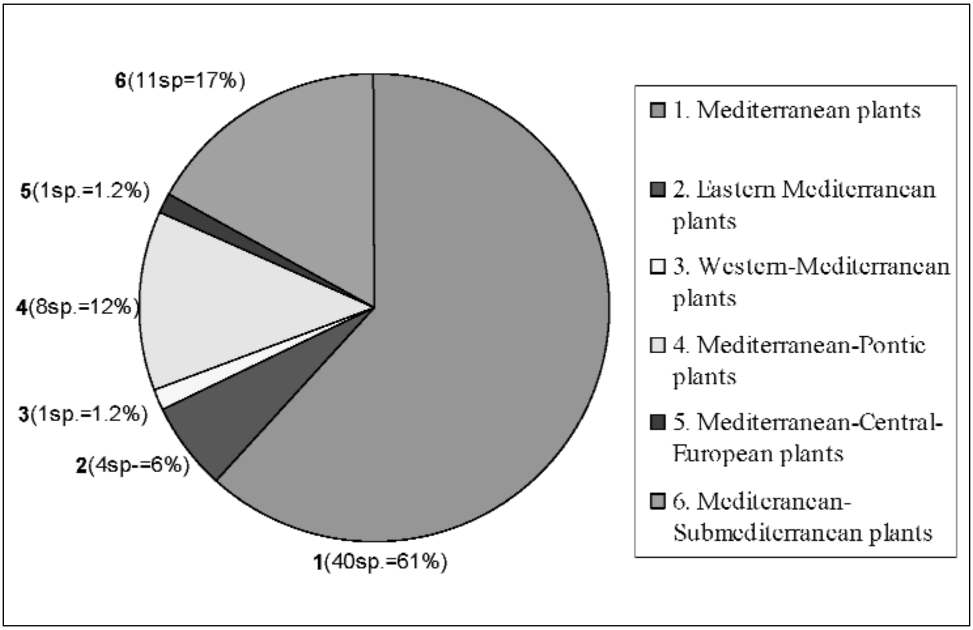

Fig. 5. The frequency of Mediterranean floristic elements in Albanian Alps-Kosova.

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Irini Vallianatou & Artemios Yannitsaros

Flora and vegetation of the island of Patroklos (Saronic Gulf, Greece)

Abstract

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This paper lists a total of 298 plant taxa (5 *Pteridophyta*, 3 *Gymnospermae*, 290 *Angiospermae*) from the island of Patroklos, which belongs to the site GR3000005 and has to be protected according to the "Natura 2000" network. All the listed taxa are reported for the first time from the investigated island and 9 of them are new records for the islands of the Saronic Gulf. A short description of the existing vegetation types is also given.

Introduction

The Saronic Gulf (Saronikos Kolpos) is situated in southeastern Greece, between Attiki and N.E. Peloponnisos, and includes a large number of islands and islets. The flora and vegetation of most of these islands were investigated by us and may be considered well known (Vallianatou 2005, Vallianatou & al. 1994a, 1994b, Vallianatou & Yannitsaros 1992, 1993, 2000). Until recently, however, the island of Patroklos which is situated close to the Sounion National Park (Attiki, Greece) was unexplored and its flora and vegetation were unknown.

The present study started in 2000 when we had to identify and describe the habitat types of the island, which belongs to the site "Sounio - Nisida Patroklou" (sitecode: GR3000005) and has to be protected according to the "Natura 2000" network (Fig. 1). The reason due to which this island is considered to be a protected area is that it provides resort to all migrating birds passing above the Sounion peninsula, thanks to its geographical position. Also, another reason is that the numerous marine caves along its coast can be an excellent refuge for the monk seal {*Monachus monachus* (Hermann 1779)} (Dafis & al. 1996).

Area investigated

The surface of Patroklos (Fig. 2) is about 3.14 km² while the highest altitude is 251 m. The island extends between 23° 56′ 13″ E. and 23° 58′ 02″ E. longitudes and 37° 38′ 36″ N. and 37° 39′ 23″ N. latitudes.

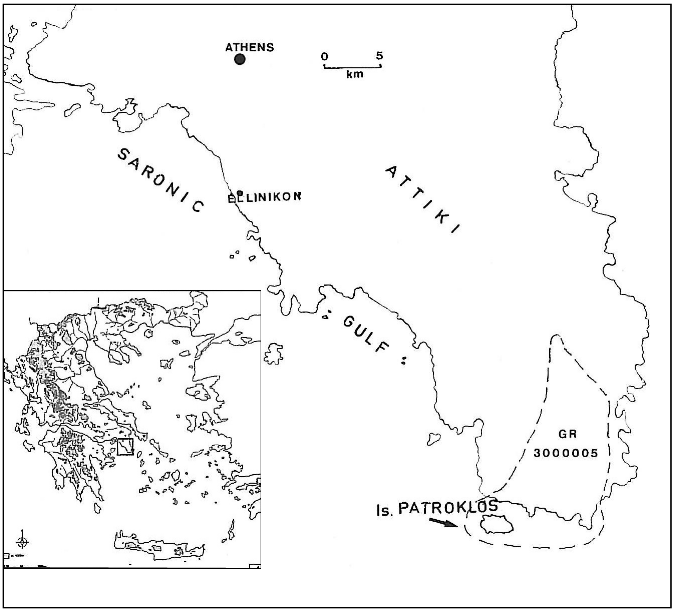

Fig. 1. The geographical position of the island of Patroklos.

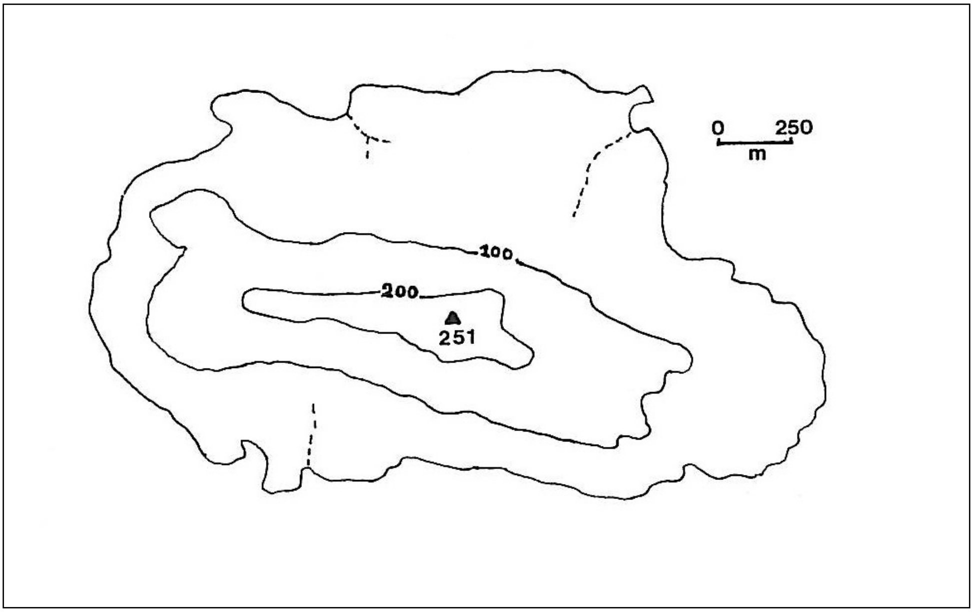

Fig. 2. Map of the island of Patroklos.

The Saronic Gulf originated in the Pliocene era (Creutzburg 1961-1962). The water-level steadied itself at its present level 5000 years ago (Flemming & Webb 1986). Most of the investigated area consists of limestones.

Using climatic data from the Ellinikon Meteorological Station (Fig. 1) and according to the xerothermic index (x = 135.3) of Bagnouls - Gaussen (Bagnouls & Gaussen 1953, Gaussen 1954) the area is classified as strongly thermo-mediterranean, with a long dry period (late March to late September). According to Emberger - Sauvage (Emberger 1955;Sauvage 1961) the area belongs to semi-arid bioclimatic zone with warm winters.

In ancient times the island of Patroklos was uninhabited but it was formed as a fortified military camp by admiral Patroklus, during Chremonidios War (265-261 B. C.) in order to protect Athens against Antigonos (Papahatzis 1994). Nowadays it is an almost uninhabited island with just a few buildings on it. A few swimmers and fishermen are visiting the island especially during summertime and there are a number of fish-ponds around its northern coasts. However man's main effect to the natural ecosystems of the island of Patroklos is due to the grazing. There are two sheep-folds which are situated on the northern-northeastern slopes but especially goats seem to reach every area of the island.

Material and methods

The results of our investigation of the flora of the island carried out during the years 2000, when I. Vallianatou together with Y. Kokkoris and S. Papavassiliou visited Patroklos working for the "Natura 2000" project, and 2007, when I. Vallianatou visited the island five times.

The following catalogue of taxa is mainly based on Vallianatou's collections (herb. I. Vallianatou, duplicates in ATHU), as well as field observations. For identification, Strid & Tan (1997, 2002), Tutin & al. (1968-1980, 1993), Davis (1965-1985), Halácsy (1901-1904) and Rechinger (1943) were mainly used. Nomenclature follows Tutin & al. (1968-1980, 1993) and/or Davis (1965-1985) except for the groups revised by Greuter & al. (1984, 1986, 1989) and Strid & Tan (1997, 2002), when these works are followed and a few other specific cases. Life - forms and chorological elements are mainly determined according to Raunkiaer (1934, 1937) and Oberdorfer (1979) respectively.

Nomenclature of superior syntaxonomic units of vegetation follows mainly Mucina (1997).

List of taxa

All the following taxa are new records for the island of Patroklos and those preceded by an asterisk are to our knowledge new for the islands of Saronic Gulf. We also use the abbreviations: V = I. Vallianatou, obs. = observed (following the date of the first observation), photo. = photograph (following the date of the photographing).

The collecting dates and numbers of the material which has been used in this study may be summarised as follows: 23.4.2000 (V 8007 - V 8045), 31.3.2007 (V 8519 - V 8613), 14.4.2007 (V 8688 - V 8776), 5.5.2007 (V 8825 - V 8903), 2.6.2007 (V 8912 - V 8952) and 1.9.2007 (V 8998 - V 9017).

Pteridophyta

POLYPODIACEAE

Asplenium ceterach L. – rock crevices, 23.4.2000, V obs.
Cheilanthes acrostica (Balbis) Tod. – rock crevices, V 8532
Cosentinia vellea (Aiton) Tod. – crevices in calcareous hill ridge, 23.4.2000, V obs.
Polypodium sp. – crevices in calcareous hill ridge, 23.4.2000, V obs.

SELAGINELLACEAE

Selaginella denticulata (L.) Spring – rocky places with phrygana, 31.3.2007, V obs.

Spermatophyta - Gymnospermae

CUPRESSACEAE

Juniperus phoenicea L. – rocky places with phrygana, 23.4.2000, V obs.

EPHEDRACEAE

Ephedra foeminea Forsskål – degraded macchia, V 8722; calcareous hill crest, 2.6.2007, V obs.

PINACEAE

Pinus halepensis Miller – small pine forest in the northern-north eastern slopes, 23.4.2000, V obs. & photo.

Spermatophyta - Angiospermae - Dicotyledones

AIZOACEAE

Mesembryanthemum nodiflorum L. – waste places near the small port, 14.4.2007, V obs.

ANACARDIACEAE

Pistacia lentiscus L. – calcareous hill ridge, dry stony slopes and pine forest, 23.4.2000, V obs. & photo.

BORAGINACEAE

Anchusa aegyptiaca (L.) DC. – calcareous slope with phrygana, V 8026
Anchusa hybrida Ten. – waste land and along cart tracks, V 8556
Anchusella variegata (L.) Bigazzi, Nardi & Selvi – calcareous slope with phrygana, V 8030
Echium arenarium Guss. – gravelly to sandy seashores, V 8040; open places with sandy soil, V 8554
Myosotis incrassata Guss. – calcareous slopes with phrygana, V 8020
Neatostema apulum (L.) I. M. Johnston – dry stony places, V 8557

CAMPANULACEAE

Campanula drabifolia Sm. – calcareous slopes with phrygana, 23.4.2000, V obs.
Campanula erinus L. – stony ground, V 8847

CARYOPHYLLACEAE

****Arenaria muralis*** (Link) Sprengel – dry stony places with phrygana, V 8831

Arenaria leptoclados (Reichenb.) Guss. – dry stony places with phrygana, V 8747, 8859
Cerastium comatum Desv. – calcareous slope with phrygana, V 8025
Herniaria hirsuta L. – dry stony ground with phrygana, V 8833
Minuartia mediterranea (Link) K. Maly – calcareous hill ridge, V 8010; stony places with phrygana, V 8530
Paronychia macrosepala Boiss. – gravelly to sandy shore, V 8039; dry stony ground, V 8611; open places with sandy soil, V 8703
Polycarpon tetraphyllum (L.) L. – gravelly to sandy coast, V 8044
Silene colorata Poiret – gravelly to sandy beach and waste ground, V 8879
Silene nocturna L. – dry stony places, V 8754
****Silene sartorii*** Boiss. & Heldr. – ruderal seashore near the small port, V 8746
Silene sedoides Poiret s.l. – seashores, V 8704, 8846
Silene spinescens Sm. – calcareous hill ridge, V 8950
Spergularia bocconei (Scheele) Graebner – gravelly to sandy seashores, V 8043, 8599
Spergularia salina J. Presl & C. Presl – gravelly to sandy seashores, V 8558, 8758
Stellaria pallida (Dumort.) Piré – courtyard of a building, V 8889

CHENOPODIACEAE
Beta macrocarpa Guss. – open place with sandy soil, V 8881
Chenopodium murale L. – courtyard of a building, V 8888

CISTACEAE
Cistus creticus L. subsp. ***eriocephalus*** (Viv.) Greuter & Burdet – dry stony places, V 9015
Cistus monspeliensis L. – dry stony places and pine forest, 23.4.2000, V obs. & photo.
Fumana arabica (L.) Spach var. ***incanescens*** Hausskn. – dry stony ground, V 8757, 8860
Fumana thymifolia (L.) Webb var. ***thymifolia*** – dry stony places, V 8035, 8692
Helianthemum salicifolium (L.) Miller – dry gravelly ground, V 8878
Tuberaria guttata (L.) Fourr. – dry gravelly places, V 8756

COMPOSITAE
Aetheorhiza bulbosa (L.) Cass. s.l. – calcareous slope with phrygana, 23.4.2000, V obs.
Anthemis tomentosa L. – seashores, V 8038, 9016
Asteriscus aquaticus (L.) Less. – dry gravelly ground, V 8690; open sandy places, V 8914
Atractylis cancellata L. – open sandy ground, V 8533
Carduus pycnocephalus L. s.l. – slopes with phrygana, V 8689
Carlina graeca Heldr. & Sart. – dry stony places with phrygana, V 8915
Carthamus lanatus L. – waste land, V 8999
****Centaurea asperula*** Halácsy – along cart tracks, V 8845, 9012
Centaurea raphanina Sm. subsp. ***mixta*** (DC.) Runemark – rock crevices, 23.4.2000, V obs.
Centaurea spinosa L. var. ***spinosa*** – seashores, V 9007
Chondrilla juncea L. var. ***juncea*** – along cart tracks, V 8528; gravelly to sandy beach, V 9005
Chondrilla ramosissima Sm. – waste land, V 8775
Crepis dioscoridis L. – stony ground, V 8608, 8610, 8829

Crepis foetida L. s.l. – stony ground, V 8597, 8749, 8827
Crepis hellenica Kamari subsp. ***hellenica*** – stony places, V 8701
Crepis zacintha (L.) Babcock – under *Pistacia lentiscus* bushes, V 8912
Evax pygmaea (L.) Brot. s.l. – dry gravely to stony places, V 8607
Filago cretensis Gand. s.l. – stony ground with phrygana, V 8022, 8023
Hedypnois cretica (L.) Dum. - Courset – gravelly to sandy beach and stony ground, V 8945
Helichrysum conglobatum (Viv.) Steudel – dry stony places, V 8844
Hyoseris scabra L. – calcareous slope with phrygana, 23.4.2000, V obs.
Hypochoeris achyrophorus L. – calcareous hill ridge, V 8535; stony places, V 8541; pine forest, V 8732
Hypochoeris cretensis (L.) Bory & Chaub. – stony ground, V 8699, 8828
Inula verbascifolia (Willd.) Hausskn. subsp. ***methanaea*** (Hausskn.) Tutin – calcareous hill ridge, V 8933
Leontodon tuberosus L. – stony places with phrygana, V 8034; pine forest, V 8705
Logfia gallica (L.) Cosson. – dry stony places, V 8849
Notobasis syriaca (L.) Cass. – disturbed and waste land near the small port, V 8913
Onopordum sp. – courtyard of a building, V 8900
Pallenis spinosa (L.) Cass. subsp. ***spinosa*** – dry stony places and pine forest, V 8880
Phagnalon graecum Boiss. & Heldr. – calcareous hill ridge, stony places with macchia and phrygana, V 8866
Ptilostemon chamaepeuce (L.) Less. – calcareous hill ridge, 2.6.2007, V photo.
Reichardia picroides (L.) Roth – calcareous hill ridge, 23.4.2000, V obs.
Rhagadiolus stellatus (L.) Gaertner s.l. – calcareous slope with phrygana, 23.4.2000, V obs.
Scolymus hispanicus L. – disturbed and waste land, 2.6.2007, V photo.
Scorzonera crocifolia Sm. – calcareous hill ridge, 23.4.2000, V obs.
Scorzonera sublanata Lipsch. – along cart tracks, V 8848
Senecio vernalis L. – calcareous hill ridge, 23.4.2000, V obs.
Senecio vulgaris L. – calcareous slope with phrygana, V 8534
Sonchus oleraceus L. – stony place, V 8562; disturbed and waste land, V 8737, 8887
Taraxacum megalorrhizon (Forsskål) Hand. - Mazz. s.l. – calcareous hill ridge and stony places, V 8748
Tragopogon porrifolius L. subsp. ***porrifolius*** – stony places, V 8736, 8943
Urospermum picroides (L.) Scop. ex F. W. Schmidt – stony places and seashores, 23.4.2000, V obs.

CONVOLVULACEAE

Convolvulus althaeoides L. – open places, V 8568
Convolvulus elegantissimus Miller – stony ground with phrygana, V 8898
Convolvulus oleifolius Desr. – littoral places, V 8883
Cuscuta palaestina Boiss. – parasitic on *Sarcopoterium spinosum* (L.) Spach, *Fumana thymifolia* var. *thymifolia* and *Coridothymus capitatus* (L.) Rchb. fil., V 8531, 8695, 8759

CRASSULACEAE

Sedum litoreum Guss. var. ***litoreum*** – rock crevices, V 8027, 8583, 8738, 8928
Sedum rubens L. – rock crevices, V 8008, 8563, 8930
Umbilicus horizontalis (Guss.) DC. – rock crevices, V 8567, 8733

CRUCIFERAE

Alyssum minus (L.) Rothm. – rocky place, V 8944
Biscutella didyma L. s.l. – calcareous hill ridge and slopes and pine forest, 23.4.2000, V obs.
Brassica geniculata (Desf.) Snogerup & Snogerup – waste land, V 8885
Cakile maritima Scop. s.l. – disturbed pebbly beach, V 8895
Capsella bursa-pastoris (L.) Medicus s.l. – waste place, V 8886
Carrichtera annua (L.) DC. – stony places with macchia, V 8544
****Clypeola jonthlaspi*** L. subsp. ***microcarpa*** (Moris) Arcang. – stony places, V 8740
Eruca vesicaria (L.) Cav. s.l. – courtyard of a building, V 8842
Erucaria hispanica (L.) Druce – courtyard of a building, V 8884
Malcolmia flexuosa (Sm.) Sm. subsp. ***naxensis*** (Rech. fil.) Stork – littoral places, V 8553, 8745, 9004
Malcolmia graeca Boiss. & Spruner subsp. ***graeca*** – rock crevices, V 8543, 8774, 8858
Matthiola tricuspidata (L.) R. Br. – gravelly to sandy beaches, V 8837
Matthiola sinuata (L.) R. Br. – littoral cliffs, 31.3.2007, V obs.
Sisymbrium orientale L. – courtyard of a building, V 8841

DIPSACACEAE

Knautia integrifolia (L.) Bertol. – stony places, V 8739, 8857, 8916
Lomelosia brachiata (Sm.) Greuter & Burdet – gravelly ground, V 8836

EUPHORBIACEAE

Euphorbia acanthothamnos Boiss. – calcareous hill ridge and slope, 23.4.2000, V obs. & photo.
Euphorbia peplis L. – gravelly to sandy beach, V 9008
Euphorbia peplus L. var. ***minima*** DC. – stony slopes, V 8024, pine forest, V 8542
Mercurialis annua L. – calcareous hill ridge and slope, 23.4.2000, V obs.

FAGACEAE

Quercus coccifera L. – stony ground, 23.4.2000, V obs.

FRANKENIACEAE

Frankenia hirsuta L. – littoral places, 23.4.2000, V obs.

FUMARIACEAE

Fumaria macrocarpa Parl. subsp. ***macrocarpa*** – stony places V 8012, 8825

GENTIANACEAE

Blackstonia perfoliata (L.) Hudson subsp. ***perfoliata*** – gravelly ground, V 8865

Centaurium tenuiflorum (Hoffmanns. & Link) Fritsch subsp. ***tenuiflorum*** – gravelly ground, V 8707, 8861

GERANIACEAE

Erodium ciconium (L.) L'Hér. – gravelly to sandy ground, V 8564, 8773, 8826

Erodium sp. – rocky to stony places, V 8609, 8612

Geranium molle L. subsp. ***molle*** – stony places, V 8561, 8706

Geranium robertianum L. subsp**.** ***purpureum*** (Vill.) Nyman – shady places, V 8019, 8565, 8772

LABIATAE

Ballota acetabulosa (L.) Bentham – calcareous hill ridge and slopes, 23.4.2000, V obs. & photo.

Coridothymus capitatus (L.) Reichenb. fil. – pine forest, stony, gravelly and sandy places, 23.4.2000, V obs. & photo.

Lamium amplexicaule L. – stony ground, 23.4.2000, V obs.

Phlomis fruticosa L. – calcareous stony to rocky places, 23.4.2000, V obs. & photo.

Prasium majus L. – stony to rocky places and pine forest, 23.4.2000, V obs.

Satureja juliana L. – stony to rocky ground, V 8949

Satureja nervosa Desf. – stony to rocky places, V 8570

Sideritis curvidens Stapf – calcareous slopes with phrygana, 23.4.2000, V obs.

Teucrium brevifolium Schreber – stony places, V 8529

Teucrium capitatum L. – stony ground, 23.4.2000, V obs.

Teucrium divaricatum Heldr. subsp. ***divaricatum*** – pine forest, V 8917

LEGUMINOSAE

Anthyllis hermanniae L. – stony places, 23.4.2000, V obs.

Anthyllis vulneraria L. subsp. ***rubriflora*** (DC.) Arcang. – gravelly and stony places, V 8850

Astragalus hamosus L. – gravelly and stony ground, V 8581

Astragalus sinaicus Boiss. – dry gravelly and stony places, V 8037, 8584, 8751

Astragalus spruneri Boiss. – gravelly and sandy ground, V 8036, 8569

Bituminaria bituminosa (L.) Stirton – gravelly ground, 14.4.2007, V obs.

Calicotome villosa (Poiret) Link – stony places, 23.4.2000, V obs. & photo.

Coronilla scorpioides (L.) Koch – gravelly ground, V 8750

Genista acanthoclada DC. – stony places, 23.4.2000, V obs.

Hedysarum spinosissimum L. – gravelly to stony ground, V 8851

Hippocrepis unisiliquosa L. – gravelly to stony places, V 8591

Lathyrus cicera L. – calcareous slopes with phrygana, 23.4.2000, V obs.

Lotus cytisoides L. – seashores, V 8771

Lotus edulis L. – gravelly to stony ground, V 8572

Lotus ornithopodioides L. – sandy to gravelly coast, 23.4.2000, V obs.

Lotus peregrinus L. var. ***peregrinus* –** gravelly to stony ground, V 8590, 8753

Medicago arborea L. – calcareous hill ridge, 2.6.2007, V photo.

Medicago coronata (L.) Bartal. – gravelly to stony places, V 8580

Medicago disciformis DC. – gravelly to stony ground, V 8577
Medicago littoralis Loisel. var. ***littoralis*** – seashores, V 8041, 8589, 8761
Medicago monspeliaca (L.) Trautv. – stony places, V 8919
Medicago orbicularis (L.) Bartal. – gravelly to stony ground, V 8752
Medicago rigidula (L.) All. – gravelly to stony places, V 8770
Onobrychis aequidentata (Sm.) Dum. - Urville – gravelly ground, V 8571
Onobrychis caput-galli Lam. – gravelly to stony places, V 8576, 8769, 8897
Onobrychis ebenoides Boiss. & Spruner – dry gravelly ground, V 8760
Ononis ornithopodioides L. – gravelly places, V 8899
Ononis reclinata L. – gravelly to stony ground, V 8896
Ononis viscosa L. subsp. ***breviflora*** (DC.) Nyman – gravelly to stony places, V 8901
Scorpiurus muricatus L. – stony places, V 8726
Trifolium boissieri Guss. – gravelly to stony ground, V 8918
Trifolium campestre Schreber – stony places, 23.4.2000, V obs.
Trifolium hirtum All. – gravelly ground, V 8709
Trifolium infamia-ponertii Greuter – gravelly places, V 8755, 8853
Trifolium scabrum L. – gravelly to stony places, V 8605
Trifolium spumosum L. – gravelly ground, V 8710
Trifolium stellatum L. – gravelly places, V 8573, 8744
Trifolium tomentosum L. – stony places, V 8762
Trifolium uniflorum L. – littoral cliffs, V 8604, 8840
Trigonella coerulescens (M. Bieb.) Halácsy – open sandy ground, V 8559, 8708
Trigonella spicata Sm. – gravelly places, V 8728, 8852
Trigonella spruneriana Boiss. – gravelly to stony ground, V 8839
Vicia cretica Boiss. & Heldr. – dry gravelly ground, V 8723
Vicia sativa L. s.l. – gravelly to stony places, V 8743
Vicia villosa Roth subsp. ***microphylla*** (Dum. - Urville) P. W. Ball – gravelly to stony ground, V 8560, 8724

LINACEAE
Linum strictum L. – pine forest and calcareous hill ridge, V 8948

MALVACEAE
Althaea hirsuta L. – gravelly ground, V 8731
****Malva pusilla*** Sm. – disturbed and waste land, V 8891

OLEACEAE
Olea europaea L. subsp. ***oleaster*** (Hoffmanns. & Link) Negodi – stony to rocky places, 23.4.2000, V obs. & photo.

OXALIDACEAE
Oxalis pes-caprae L. – disturbed pebbly beach, 5.5.2007, V obs.

PAPAVERACEAE
Glaucium flavum Crantz – disturbed pebbly coast, V 8894

Papaver rhoeas L. – stony places, V 8537, 8730

PLANTAGINACEAE

Plantago afra L. – sandy, gravelly and stony ground, V 8029, 8545, 8763

Plantago albicans L. – dry open places, V 8540

Plantago bellardii All. – dry gravelly ground, V 8536

Plantago lagopus L. – stony and waste places, V 8890

****Plantago weldenii*** Reichenb. subsp. ***weldenii*** – disturbed and waste land, V 8892

PLUMBAGINACEAE

Limonium echioides (L.) Miller – gravelly ground, V 8920

Limonium graecum (Poiret) Rech. fil. – sandy, gravelly and rocky coasts, V 8042, 9000

Limonium narbonense Miller – littoral places, V 8938

Limonium ocymifolium (Poiret) O. Kuntze – rocky coasts, V 8688

Limonium sinuatum (L.) Miller – waste land, 14.4.2007, V obs.

Limonium virgatum (Willd.) Fourr. – sandy, gravelly and rocky seashores, V 9002, V 9003

Limonium graecum (Poiret) Rech. fil. X ***Limonium virgatum*** (Willd.) Fourr. – sandy, gravelly and rocky coasts, V 8998, 9001

POLYGONACEAE

Emex spinosa (L.) Campd. – disturbed ground, V 8711, 8931

Rumex bucephalophorus L. subsp. ***aegaeus*** Rech. fil. – stony places, V 8574

Rumex tuberosus L. s.l. – calcareous hill ridge and slopes, 23.4.2000, V obs.

PRIMULACEAE

Anagallis arvensis L. var. ***caerulea*** (L.) Gouan – stony places, 23.4.2000, V obs.

Asterolinon linum-stellatum (L.) Duby – stony ground, 23.4.2000, V obs.

Cyclamen graecum Link – pine forest, rock crevices and stony ground, 23.4.2000, V obs.

RAFFLESIACEAE

Cytinus hypocistis (L.) L. subsp**. *clusii*** Nyman – parasitic on *Cistus creticus* subsp. *eriocephalus*, V 8867

RANUNCULACEAE

Anemone pavonina Lam. – stony places, 23.4.2000, V obs.

Clematis cirrhosa L. – calcareous hill ridge, V 8929

Nigella arvensis L. subsp. ***aristata*** (Sm.) Nyman – dry gravelly to stony ground, V 8856, 8868, 8922

Ranunculus paludosus Poiret – along cart tracks, V 8603

RESEDACEAE

Reseda alba L. s.l. – ruderal place near the small port, 14.4.2007, V obs.

RHAMNACEAE

Rhamnus lycioides L. subsp. ***oleoides*** (L.) Jahandiez & Maire – stony place with degraded macchia, V 8855

ROSACEAE

Aphanes arvensis L. – calcareous slope with phrygana, 23.4.2000, V obs.
Sarcopoterium spinosum (L.) Spach – gravelly and stony places, 23.4.2000, V obs. & photo.

RUBIACEAE

Galium aparine L. – calcareous hill ridge and slope, 23.4.2000, V obs.
Galium murale (L.) All. – stony and rocky places, V 8582
Galium setaceum Lam. – rocky places, V 8028, 8694
Galium spurium L. subsp. ***spurium*** **–** stony ground with macchia, V 8921
Sherardia arvensis L. – gravelly to stony places, V 8578
Valantia hispida L. – gravelly, stony and rocky places, V 8597, 8764
Valantia muralis L. – gravelly, stony and rocky places, V 8765, 8854

SANTALACEAE

Thesium humile Vahl – gravelly ground, V 8863

SAXIFRAGACEAE

Saxifraga tridactylites L. – calcareous hill ridge, 23.4.2000, V obs.

SCROPHULARIACEAE

Linaria simplex (Willd.) DC. – gravelly ground with phrygana, V 8923
Misopates orontium (L.) Rafin – stony places, V 8575, 8727
****Scrophularia heterophylla*** Willd. var. ***heterophylla*** **–** calcareous hill ridge, V 8007
Verbascum undulatum Lam. – disturbed and waste ground, V 8924
Veronica cymbalaria Bodard – rocky, sandy places, V 8602
****Veronica glauca*** Sm. – calcareous slope with phrygana, V 8014

THELIGONACEAE

Theligonum cynocrambe L. **–** calcareous hill ridge and slope, 23.4.2000, V obs.

UMBELLIFERAE

Bupleurum gracile Dum. - Urville – pine forest V 8033; gravelly places, V 8742, 8862
Bupleurum semicompositum L. – littoral places, V 8725
Bupleurum trichopodum Boiss. & Spruner **–** calcareous hill ridge, 23.4.2000, V obs.
Carum multiflorum (Sm.) Boiss. s.l. – crevices in calcareous hill ridge, V 8009, 8932
Crithmum maritimum L. – disturbed pebbly coast, V 8893
Daucus involucratus Sm. – dry gravelly places, V 8835, 8864
Eryngium campestre L. s.l. – dry stony place, V 8870
Ferula communis L. subsp. ***communis*** **–** calcareous hill ridge, 23.4.2000, V obs.
Lagoecia cuminoides L. – stony places, V 8547

Opopanax hispidus (Friv.) Griseb. – stony ground, 23.4.2000, V obs.
Scaligeria napiformis (Sprengel) Grande – calcareous hill ridge and slopes, V 8935
Scandix australis L. s.l. – stony places, V 8712
Thapsia garganica L. – stony to rocky places, V 8934
Tordylium apulum L. – stony slopes, V 8767
Torilis leptophylla (L.) Reichenb. – stony and rocky ground, V 8015, 8546
Torilis nodosa (L.) Gaertner – dry gravelly to stony places, V 8766, 8869, 8875, 8925

URTICACEAE

Parietaria cretica L. – calcareous hill ridge and slopes, 23.4.2000, V obs.
Parietaria lusitanica L. subsp. ***lusitanica*** – calcareous hill ridge and slopes and pine forest, 23.4.2000, V 8539
Urtica pilulifera L. – shady base of cliffs being manured by goats, 1.6.2007, V obs.

VALERIANACEAE

Centranthus ruber (L.) DC. s.l. – calcareous hill ridge, 23.4.2000, V obs.
Valerianella discoidea (L.) Loisel – gravelly ground, V 8538, 8713
Valerianella echinata (L.) DC. – calcareous slope with phrygana, V 8013

Spermatophyta - Angiospermae - Monocotyledones

ARACEAE

Arisarum vulgare Targ. - Tozz. s.l. – calcareous hill ridge and slopes and pine forest, V 8527

GRAMINEAE

Aegilops biuncialis Vis. – dry gravelly and stony ground, V 8593, 8601, 8768
Aegilops comosa Sm. subsp. ***comosa*** – dry gravelly and stony places, V 8585, 8715
Aegilops triuncialis L. subsp. ***triuncialis*** – stony ground, V 8588
Aira elegantissima Schur s.l. – calcareous slope with phrygana, 23.4.2000, V obs.
Avena barbata Pott ex Link s.l. – stony places, V 8871
Brachypodium retusum (Pers.) P. Beauv. – from littoral places to the hill ridge, V 8926
Briza maxima L. – stony places, 23.4.2000, V obs.
Bromus intermedius Guss. – gravelly to stony places, V 8551, 8719
Bromus madritensis L. – gravelly to stony places, V 8594, 8598, 8600
Bromus rubens L. – stony places, V 8017
Bromus sterilis L. – stony places, V 8031
Catapodium rigidum (L.) C. E. Hubbard ex Dony subsp. ***rigidum*** var. ***rigidum*** – rocky crevices, V 8566; stony places V 8714
Cynosurus echinatus L. – base of calcareous cliffs, V 8946
Dactylis glomerata L. subsp**.** ***hispanica*** (Roth) Nyman – stony and rocky places, V 8942, 8947
Hordeum murinum L. subsp. ***leporinum*** (Link) Arcang. var**.** ***leporinum*** – disturbed waste land, V 8903
Lagurus ovatus L. – stony places and sandy to gravelly coasts, 23.4.2000, V obs.

Lolium rigidum Gaudin s.l. – sandy and gravelly ground, V 8552, 8586
Lolium sp. – stony places, V 8720, 8734
Melica minuta L. – crevices in calcareous hill ridge, V 8011, 8936
Parapholis incurva (L.) C. E. Hubbard – disturbed and waste ground, V 8902
Poa bulbosa L. s.l. – dry gravelly to stony places, V 8549, 8873
Piptatherum coerulescens (Desf.) Beauv. – calcareous hill ridge, V 8937
Piptatherum miliaceum (L.) Cosson subsp. ***miliaceum*** – pine forest, V 8941
Polypogon sp. – gravelly to sandy seashore, V 9006
Psilurus incurvus (Gouan) Schinz & Thell. – dry gravelly ground, V 8735
Rostraria cristata (L.) Tzvelev var. ***cristata*** – stony places, V 8741
Sporobolus pungens (Schreber) Kunth – sandy to gravelly beach, V 9017
Stipa capensis Thunb. – stony ground, V 8832
Stipa holosericea Trin. – stony places, V 8874
Trachynia distachya (L.) Link – gravelly to stony places, V 8872
Vulpia ciliata Dumort. subsp. ***ciliata*** – rocky to stony ground, V 8595, 8716

IRIDACEAE

Crocus cancellatus Herbert subsp. ***mazziaricus*** (Herbert) Mathew – gravelly ground, V 8876
Gynandriris monophylla Boiss. & Heldr. ex Klatt – cart tracks, V 8548
Romulea sp. – cart tracks, V 8550

LILIACEAE

Allium cupani Rafin. subsp. ***hirtovaginatum*** (Kunth) Stearn – stony places, V 9013
Allium guttatum Steven subsp. ***sardoum*** (Moris) Stearn – stony places, V 8927, 8940
Allium staticiforme Sm. – stony and rocky littoral places, V 8951, V 8952
Allium subhirsutum L. – pine forest and open stony ground, V 8587
Asparagus acutifolius L. – stony places, 23.4.2000, V obs.
Asparagus aphyllus L. – pine forest, V 8939
Asphodelus ramosus L. – stony and disturbed ground, 23.4.2000, V obs. & photo.
Fritillaria sp. – stony to rocky ground, 23.4.2000, V obs.
Gagea graeca (L.) Terracc. – stony to rocky places, 23.4.2000, V obs.
Muscari sp. – dry gravelly and stony places, V 8693
Muscari comosum (L.) Miller – gravelly to stony ground, V 8702
Ornithogalum sp. – stony places, V 8691
Scilla autumnalis L. – gravelly to sandy places, V 9011
Urginea maritima (L.) Baker – stony places, 23.4.2000, V obs.

ORCHIDACEAE

Anacamptis pyramidalis (L.) L. C. M. Richard – gravelly to stony ground, V 8838
Ophrys sp. – stony places, V 8834

Floristic and chorological remarks

A total of 298 spontaneous taxa constitute the flora of the island of Patroklos (Table 1). The proportion of *Monocotyledones* to *Dicotyledones* is 1:4.69, which is in accordance with the corresponding relationship appearing in other Greek similar island floras. There are also 11 cultivated taxa: *Amygdalus communis* L., *Armeniaca vulgaris* Lam., *Asparagus plumosus* Baker, *Cercis siliquastrum* L., *Citrus limon* (L.) Burm. fil., *Citrus* sp., *Ficus carica* L., *Jasminum azoricum* L., *Nerium oleander* L., *Olea europaea* L. subsp. *europaea, Punica granatum* L.

Leguminosae (45 taxa) and *Compositae* (42 taxa) are the richest families (in number of taxa) from *Dicotyledones*, while *Gramineae* (31 taxa) and *Liliaceae* (14 taxa) are the richest families from *Monocotyledones*, as observed also in other Greek floras.

Table 1. The composition of the spontaneous flora of the island of Patroklos.

TAXA	Number of FAMILIES	Number of GENERA	Number of SPECIES	Number of HYBRIDS	Number of SUBSPECIES	Number of VARIETIES	Number of SPECIES, HYBRIDS & INFRA-SPECIFIC TAXA
Pteridophyta	2	5	5				5
Spermatophyta	50	200	243	1	36	13	293
Gymnospermae	3	3	3				3
Angiospermae	47	197	240	1	36	13	290
Dicotyledones	42	159	200	1	28	10	239
Monocotyledones	5	38	40		8	3	51
TOTAL	52	205	248	1	36	13	298

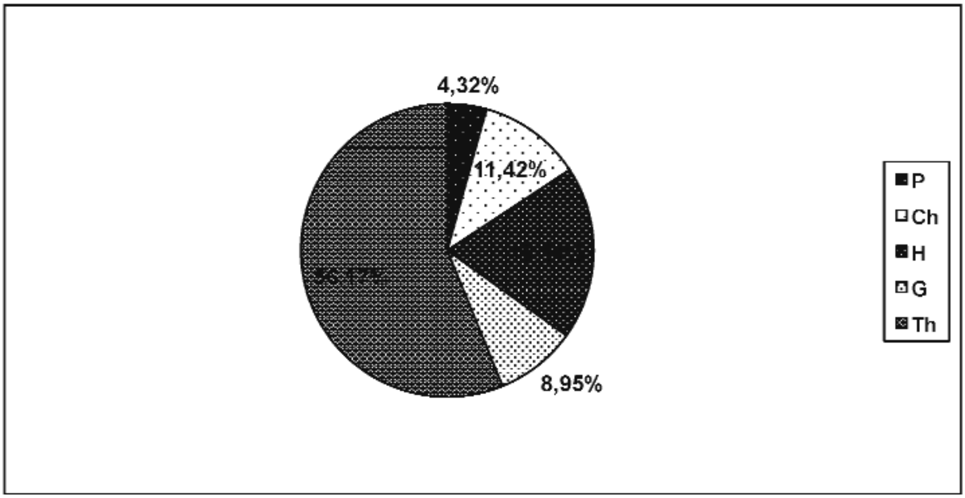

Fig. 3. The biological spectrum of the island of Patroklos.

The dominant life-form is this of Therophytes (56.17%) due to the strong thermo-mediterranean climate type, with a long dry period. A comparison of the biological spectrum of the island of Patroklos (Fig. 3) with the biological spectra from other islands of Saronic Gulf (Vallianatou, 2005) shows that there is a close agreement with them.

For the same reason the Mediterranean and Submediterranean chorological elements predominate (80.49%) (Fig. 4). O*xalis pes-caprae* is the only adventive taxon as the grazing and not the long inhabitation by man is the main effect to the natural ecosystems of the island of Patroklos. Concerning the flora of the island there is none known local endemic taxon mainly because of its short geological history and the fact that it is close to mainland region. However, there are 14 (4.70%) endemic taxa of the Greek flora: *Anchusella variegata*, *Campanula drabifolia*, *Centaurea asperula*, *Centaurea raphanina* subsp. *mixta*, *Chondrilla ramosissima*, *Crepis hellenica* subsp. *hellenica*, *Inula verbascifolia* subsp. *methanaea*, *Limonium ocymifolium*, *Malcolmia graeca* subsp. *graeca*, *Nigella arvensis* subsp. *aristata*, *Onobrychis ebenoides*, *Scorzonera crocifolia*, *Silene spinescens*, *Vicia villosa* subsp. *microphylla*. There are also 8 (2.68%) endemic taxa of the flora of the mainland of Greece and/or the wider Aegean region: *Allium staticiforme*, *Arenaria muralis*, *Carlina graeca*, *Centaurea spinosa* var. *spinosa*, *Filago cretensis*, *Gagea graeca*, *Paronychia macrosepala* and *Vicia cretica*. The vast majority of the taxa that constitute the flora of the investigated island, comprise the flora of the mainland region situated nearby (Attiki) as well. Nine of the taxa of the island are to our knowledge new records for the islands of Saronic Gulf.

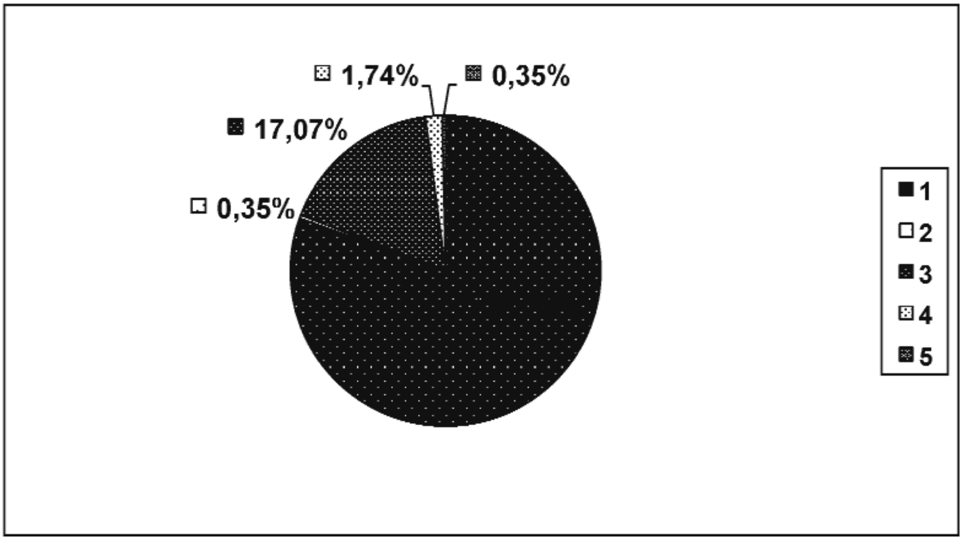

Fig. 4. Chorological elements of the island of Patroklos (note that ten of the taxa identified to the genus level have not been taken under consideration): 1. Mediterranean & Submediterranean, 2. Paleosubtropical, 3. Mediterranean - Extramediterranean & Submediterranean - Extrasubmediterranean, 4. Eurasiatic, European & Continental, 5. South African.

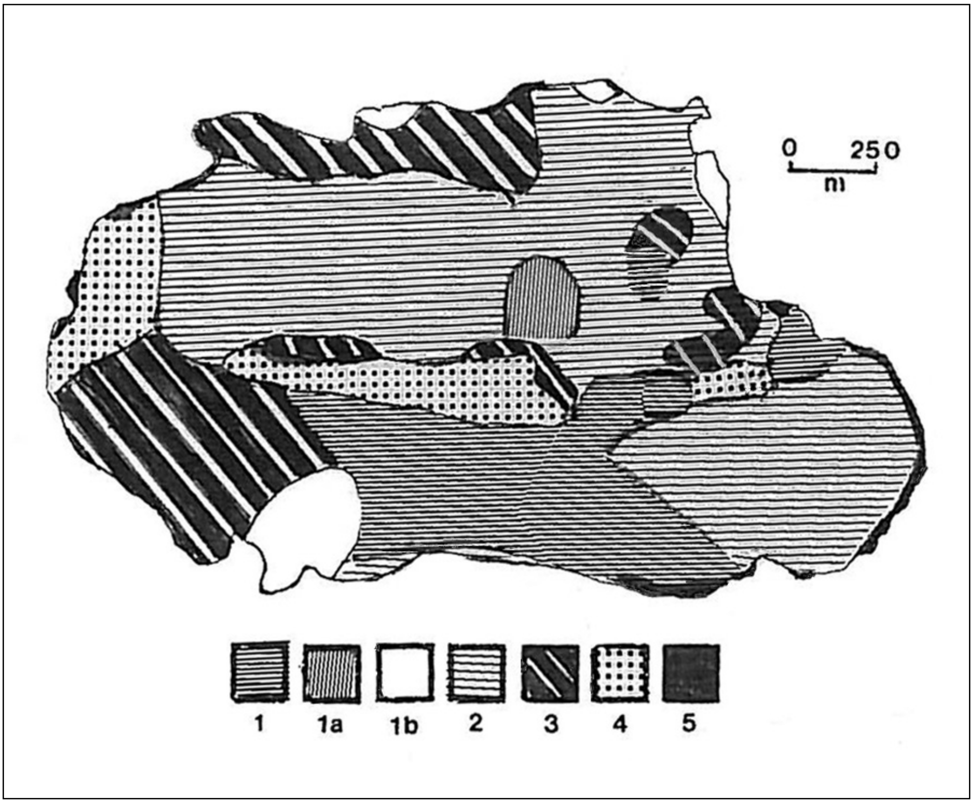

Fig. 5. Map with the main syntaxonomic units of vegetation of the island of Patroklos: 1. *Oleo - Lentiscetum aegaeicum*, 1a. *Oleo - Lentiscetum pinetosum halepensis*, 1b. *Oleo - Lentiscetum juniperetosum phoeniceae*, 2. Transitive situations of *Oleo - Lentiscetum* towards *Cisto - Micromerietea julianae*, 3. *Cisto - Micromerietea julianae*, 4. *Cirsietalia chamaepeucis*, 5. *Crithmo - Staticetea.*

Eight taxa (*Anacamptis pyramidalis*, *Cyclamen graecum, Muscari comosum, Onobrychis ebenoides*, *Ophrys* sp., *Scorzonera crocifolia*, *Silene spinescens*, *Vicia cretica*) are included in international, European and Greek catalogues of plants which are under protection. We suggest the rare species *Gynandriris monophylla* to be included in a future publication of «The Red Data Book of rare and threatened plants of Greece».

The populations of herbs growing in the few areas with herbal vegetation are constantly reducing due to their inability to produce mature fruits as their stems are grazed by sheep. However the most disastrous activity on the island seems to be performed by the goats which potentially reach every area of the island even at the most craggy cliffs. After all, the grazed flowering stems of all the individuals belonging to the Greek endemic chasmophyte *Silene spinescens* constitute a typical example of the fact mentioned at the previous sentence.

Vegetation remarks

The alliance *Oleo-Ceratonion siliquae* Br.-Bl. ex Guinochet & Drouineau 1944 or the degraded forms of it dominates in the island. The reason is the semi-arid mediterranean climate of the region. More specifically, the association *Oleo - Lentiscetum aegaeicum* Krause, Ludwig & Seidel 1963 or the subassociations of it and transitive situations of them towards the class of phrygana *Cisto - Micromerietea julianae* Oberd. 1954, predominate (Fig. 5). The pine - forest *Oleo - Lentiscetum pinetosum halepensis* Barbero & Quézel 1976 occupies only a limited area in the northern-northeastern slopes. The presence of *Oleo - Lentiscetum juniperetosum phoeniceae* Barbero & Quézel 1976 is considerable, especially in littoral sites.

We also meet several associations of more or less degraded *Cisto - Micromerietea julianae.*

Cirsietalia chamaepeucis Horvat in Horvat, Glavac & Ellenberg 1974 occupies the internal elongated rocky hill ridge but also the western littoral rocky slopes, while low chasmophytic vegetation types belonging also to the class *Asplenietea trichomanis* (Br.-Bl. in Meier & Br.-Bl. 1934) Oberd. 1977 are very limited and scattered.

The presence of the class *Crithmo - Staticetea* Br.-Bl. in Br.-Bl. & al. 1947 on the coastal cliffs is considerable.

The vegetation type of sandy seashores dominated by *Centaurea spinosa* var. *spinosa*, belonging to the class *Ammophiletea* Br.-Bl. et R. Tx. ex Westhoff et al. 1946, occupies also some littoral places.

The herb-rich nitrophilous vegetation, belonging to the class *Stellarietea mediae* R. Tx. & al. ex von Rochow 1951 is restricted around the sheep-folds, the small port and the few buildings. The class *Saginetea maritimae* Westhoff & al. 1962 as well as *Cakiletea maritimae* R. Tx. & Preising. ex Br.-Bl. & R. Tx. 1952 are also very limited and scattered, the first especially near the port and the second in a small sandy beach.

Sea beds of *Posidonietum oceanicae* Br.-Bl. 1952 (class: *Zosteretea* S. Pignatti 1953) are being observed at a close range of the northern part of the coast line of the island.

Oleo - Lentiscetum aegaeicum seems to be degraded, due to grazing, even at sites which they are supposed to favor its growth such as the smoother northern slopes. As a result we have transitive situations towards to the class of phrygana or phrygana themselves. Last but not least, a significant enrichment with nitrophilous taxa is taking place at sites where grazing or gatherings of animals occurs.

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Oumessaad Toubal

La flore de l'Edough (NE-Algérie): biodiversité, taxons rares, dynamique végétale et cartographie

Abstract

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The Edough mountain is part of an homogeneous and biogeographical unit represented by the Algerian and Tunisian coast ; it was an old island connected to the continent by Pliocene sediments which covered the depression whose middle is occupied by Fetzara lake. Botanical investigation allowed to estimate the richness of flora: about almost 350 species have been determined, among which 25% are noticeable, with different biogeographical origins, essentially, some relics species attest that. (*Alnus glutinosa, Euphorbia dendroides, Ilex aquifolium*). So it is urgent to protect them.
An important human activities takes part in the degradation of forest ecosystems. It has become important to go thru deeper knowledge of natural environments and ecological possibilities, with an evaluation and valorization of plant genetic resources; preservation and sustainable use of biological diversity requires the protection of habitats and vulnerable ecosystems (wet lands, dunes, relic forest…).

Introduction

L'accent est mis sur la connaissance de la flore, sa diversité, les espèces remarquables ainsi que sur l'aspect phytoécologique, dynamique et cartographique des principales formations végétales.

Proche d'une agglomération urbaine (Annaba) et de sites pittoresques (Séraidi, Chétaibi, La Marsa), l'Edough subit une pression anthropique importante qui se traduit par l'appauvrissement floristique de certaines formations végétales, leur remplacement par des groupements de substitution (maquis, broussailles, pelouses…) et l'érosion à moyenne et basse altitude.

Ces travaux se situent le plus souvent en amont des préoccupations actuelles sur l'environnement, l'aménagement du territoire et une meilleure gestion des ressources naturelles, afin de les conserver, les améliorer et les exploiter de manière rationnelle.

Le milieu

L'Edough est le massif le plus septentrional de l'Algérie orientale. C'est une basse montagne (culmine à 1008m) qui s'étend du Cap de Garde au Cap de Fer sur 80 km .

Le climat est de type méditerranéen avec une pluviosité de 700 mm sur la côte et 1200 mm au sommet ; la proximité de la mer entretient une hygrométrie élevée (80%). Les vents dominants N-NO sont froids et humidifiant et ceux du S-S-E sont chauds et desséchant, ce qui explique le contraste climatique et botanique entre le versant nord et le versant sud ; la température maximale se situe entre 30 et 25°C et la température minimale entre 08 et 04 °C. Le massif se situe entre les bioclimats subhumide chaud et humide tempéré (à partir des données de Seltzer (1946) et de Emberger (1971) .

Les sols sont pour la plupart bruns forestiers à bruns lessivés, le plus souvent à tendance podzolique surtout ceux sur grès numidiens (Durand 1954; Hilly 1962) .

La végétation se range dans les étages de végétation suivants (d'après la nomenclature de Ozenda 1974) : l'étage thermoméditerranéen, domaine de l'oléo-lentisque et du faciès thermophile de la suberaie ; l'étage mésoméditerranéen celui du chêne-liège, merisier et pin maritime et l'étage supraméditerranéen où domine la zénaie avec le faciès à châtaignier (Toubal 1986) ; Meddour (1994) a distingué ces trois niveaux dans l'atlas blidéen.

Matériel et méthodes

Inventaire floristique

Les relevés ont été effectués sur terrain, les espèces ont été dotées du coefficient d'abondance-dominance et de présence. La classification des espèces du tableau 1 est dynamique, phytosociologique et écologique.

Origine biogéographique

Le spectre biogéographique a été établit à partir des espèces que nous avons répertoriées et déterminées, selon les références de Quezel et Santa (1962-63) sur l'origine biogéographique.

Aspect remarquable des espèces

- L'endémisme : nous avons trouvé des endémiques algériens, algéro-tunisiens, nord-africains et numidiens ; 04 niveaux
- La rareté : également 04 niveaux, AR (assez rare), R (rare), RR (très rare), RRR (rarissime); l'endémisme et la rareté ont été déterminés selon la nomenclature de Quezel et Santa (1962-63). La richesse floristique en espèces rares est consécutive à la diversité des milieux particuliers, notamment les biotopes vulnérables (dunes, zones humides, forêts reliques…).

La cartographie

L'interprétation des photos aériennes a été faite à l'aide de stéréoscope ; on a ainsi pu observer que les essences résineuses sont représentées en noir, les essences feuillues en grisé avec des nuances de blanc pour les caducifoliées en pleine feuillaison (Toubal 1986).

Tableau 1. La forêt du chêne-zéen.

Numéro de relevés	1	2	3	4	5	6	**Présence**
Altitude (m)	900	760	600	550	540	430	
Roche – mère	Gneiss	Gneiss	Gneiss	Grès	Gneiss	Gneiss	
Exposition	N	N	N.O	N.O	N.E	N	
Recouvrement I (%)	80	80	80	70	80	80	
Pente		3	3	4	4	3	
Caractéristiques de la forêt de Quercus canariensis (DEBAZAC 1959)							
Quercus canariensis	4	5	4	4	3	3	V
Prunus avium	+	+	2	1	1	1	V
Rubus incanescens	1	1	.	2	1	1	V
Campanula rapunculus	+	+	.	.	.	.	II
Cyclamen africanum	.	+	.	.	+	.	II
Geranium lanuginosum	+	+	.	.	.	.	II
Espèces sylvatiques ubiquistes							
Crataegus monogyna	2	+	+	.	+	+	V
Hedera helix	1	1	+	+	+	.	V
Lonicera etrusca	.	+	+	+	+	+	V
Tamus communis	+	.	.	.	.	+	II
Asplenium adiantum- nigrum	.	+	+	+	.	.	II
Asperula laevigata	.	.	.	.	.	+	I
Caractéristiques des Quercetea, Quercetalia et Quercetum ilicis (Br. Bl. 1931, 1936, 1947)							
Quercus suber	+	+	1	1	3	3	V
Cytisus triflorus	1	1	.	2	1	1	V
Myrtus communis	.	1	1	1	1	2	V
Phillyrea angustifolia	.	+	.	1	2	2	IV
Arbutus unedo	.	.	+	1	1	1	IV
Viburnum tinus	.	.	+	.	1	1	III
Rubia peregrina	+	.	.	+	.	+	III
Espèces acidophiles							
Pteridium aquilinum	1	1	+	1	+	1	V
Erica arborea	.	1	+	1	2	2	V
Castanea sativa	1	+	+	.	+	.	IV
Briza maxima	.	.	+	.	+	+	III
Espèces ripicoles							
Alnus glutinosa	.	1	+	.	1	.	III
Laurus nobilis	.	.	+	.	+	+	III
Hypericum androsaemum	.	+	+	.	.	.	II
Ruscus hypophyllum	.	+	+	.	.	.	I
Ilex aquifolium	.	1	.	.	.	.	II
Mentha aquatica	.	.	+	.	+	.	II
Lythrum salicaria	.	+	+	.	.	.	I
Espèces nitrophiles							
Urginea maritima	+	+	.	+	.	.	III
Cerastium glomeratum	.	+	.	+	+	.	III
Allium ursinum	.	+	+	.	.	.	II
Fumaria capreolata	+	.	.	+	.	.	II
Anagallis arvensis	+	.	.	+	.	.	II
Espèces compagnes							
Ampelodesmos tenax	+	.	+	+	+	+	V
Umbilicus pendulina	+	+	+	.	+	+	V
Stachys hirta	.	+	+	.	+	+	IV
Asphodelus microcarpus	+	.	+	+	+	.	IV
Chlora grandiflora	.	.	+	.	+	+	IV
Centaurium pulchelum	+	.	+	+	.	.	IV
Ranunculus sardous	+	+	.	.	.	+	III
Geranium atlanticum	+	+	.	.	+	.	III
Aristolochia longa	+	+	.	.	.	+	III
Salvia verbenaca	.	.	+	.	+	.	II
Ononis hispida	+	+	.	.	.	.	II
Evax pygmea	+	.	.	.	+	.	II
Geranium robertianum	.	+	.	.	.	.	I

Richesse floristique

L'investigation botanique a permis de mieux connaître la flore du massif de l'Edough; elle est assez riche et comprend environ 350 espèces (Toubal 1986), déterminées selon la nomenclature de Quezel & Santa (1962-1963);elle appartient au domaine Mauritanien – Méditerranéen, secteur numidien. Le tableau 2 regroupe les espèces remarquables (rares ou endémiques), avec leurs origines biogéographiques (au sens de Quezel).

La flore présente des affinités tropicales certaines (*Paspalum distichum*, *Ricinus communis*) associées à d'autres nettement européennes (*Ilex aquifolium*, *Cerasus avium, Quercus suber*) ainsi que d'autres typiquement méditerranéennes (*Euphorbia dendroides*). Il existe également des espèces endémiques nord-africaines, (*Cyclamen africanum, linum numidicum*) et des espèces paléotempérées (*Alnus glutinosa*, *Populus nigra, Trapas natans). Castanea sativa* constitue, ici, une exception dans toute l'Algérie ; *Alnus glutinosa* et *Pinus pinaster* sont à la limite sud de leur extension géographique en Algérie.

L'Edough fait partie d'une zone qui se situe le long de la mer entre Skikda et le frontière tunisienne et qui recèle un grand nombre de mares, marais, lacs et oueds qui abriteraient des reliques d'une faune et d'une flore qui lui confèrent un intérêt biogéographique certain selon (Junqua 1955). Cet auteur parle de *Nymphea alba* dans la région d'El-Kala (lac Oubeira) comme de la seule localité nord-africaine. Mais il semblerait que cette espèce existe également au NW du Maroc dans la région de Larache.

La proportion des espèces remarquables par rapport à la totalité des taxons inventoriés dans l'Edough est de 24.5 % , celle par catégorie de taxon est la suivante :
-Espèces assez rares : 4.3 % -Espèces rares: 7.1 %
-Espèces très rares : 6.3 % -Espèces rarissimes: 0.8 %
-Espèces endémiques: 6.3 %

L'origine biogéographique des espèces est exprimée par la figure 1 ; les espèces qui semblent le plus menacées, sont surtout : l'aulne glutineux à cause de l'utilisation de son bois (caisseries et ustensiles ménagers), le houx et la violette cueillis par les fleuristes, *Nymphea alba* et *Veronica scutellata*, à cause de la pollution et de l'assèchement des marais.

Principales formations végétales

La zénaie : Elle occupe les sommets et les versants N-NO au-dessus de 900 m et forme de véritables forêts-climax, avec un sous-bois à *Pteridium aquilinum, Crataegus monogyna et Rubus incanescens* (rare) ; dans le versant sud, on trouve *Viola sylvestris* (rare).

Castanea sativa, souligne, ici, l'originalité du massif. Elle est très rare mais cultivée parfois dans les jardins. Le long des talwegs, on trouve *Hypericum androsaemum* (rare) et *Ilex aquifolium* (rare) qui est menacée d'extinction, car très cueillie par les fleuristes.

A la limite de son aire écologique, le chêne-zéen forme un groupement mixte avec le chêne-liège ; le dernier est favorisé par sa plasticité écologique le premier par sa résistance au feu. Le chêne-zéen arrive tout juste à se maintenir, car nulle part on a l'impression qu'il est en progression (Toubal & al. 1995).

Les cérasaies ou formations à *Cerasus avium*, constituent des forêts reliques qu'il faut protéger. Une association nouvelle à*Cerasus avium* a été décrite (Toubal 1998). Il se

Tableau 2. Les espèces remarquables de l'Edough.

Espèces	Origine Biogéog.	Espèces	Origine Biogéog.	Espèces	Origine Biogéog.
		Physospermum actaefolium	Cent. Médit		
Assez rares (AR)		*Polycarpon peploides*	W. Médit.	**Rarissimes (RRR)**	
		Populus nigra	Paléo-temp		
Alnus glutinosa	Paléo-temp	*Ranunculus sardous*	Médit.	*Delphinium emarginatum*	Ibér.Maur.Sic
Athyrium filix-femina	Circum. bor	*Retama monosperma*	Ibéro-maurit.	*Odondites lutea*	Eur.
Carex remota	Circum-bor	*Rubus incanescens*	W. Médit.	*Veronica scutellata*	Eur.
Crataegus azerolus	E.Médit	*Sambuscus nigra*	S. Eur.		
Erica scoparia	Médit-Atl	*Stachys marrubifolia*	Thyrrh		
Euphorbia cuneifolia	Ital. alg. Tun.	*Trapa natans*	Paléo-temp.	**Endémiques (E)**	
Lonicera etrusca	Sud. Eur.	*Tuberaria vulgaris*	W. Médit.		
Mentha aquatica	Paléo-temp.	*Viola silvestris*	Euras.		
Pinus pinaster	W.Médt.			*Andryala nigricans*	End.
Prunella vulgaris	Euro-Médit			*Chrysanthemum grandiflorum*	End. Alg.Tun.
Satureja calamintha	Euras.	**Très rares (RR)**		*Convolvulus durandoi*	End.
Solanum dulcamara	Paléo-temp			*Cyclamen africanum*	End. N. A.
Verbascum rotundifolium	Médit.	*Brassica cretica*	E.Médit.	*Euphorbia cossoniana*	End. N. A.
Vitex-agnus-castus	Médit.	*Bromus racemosus*	Atl. Médit.	*Gallium tunetanum*	End.N. A
Ziziphus lotus	Médit.	*Castanea sativa*	End. Médit.	*Genista ferox*	End. N. A
		Centaurea cineraria	Ital. Dalm.	*Genista numidica*	End.
		Centaurium maritimum	Médit.Atl.	*Genista tricuspidata*	End. N.A.
Rares (R)		*Conopodium capillifolium*	W. Médit	*Genista ulicina*	End
		Ceratophyllum submersum	Eur.	*Geranium atlanticum*	End. N.A.
Agrostis elegans	W.Médit.	*Daucus carata*	Médit Atl.	*Helianthemum helianthemoides*	End. N. A.
Anthyllis barba-Jovis	Médit.	*Euphorbia dendroides*	Médit.	*Hypericum afrum*	End. Num.
Cardamine hirsuta	Circum-bor	*Geranium lanuginosum*	C. Médit.	*Linaria pinnifolia*	End. N. A.
Centaurium pulchelium	Paléo-temp	*Limonium foerulaceum*	Médit.	*Linum corymbiferum*	End. N. A.
Cerastium dichotomum	Méd.Iran.Tour	*Limonium vulgare*	Médit.Atl.	*Linum numidicum*	End. N. A.
Euphorbia biumbellata	w. Médit.	*Lithospermum rosmarinifolium*	E. Médit..	*Phlomis Bovei*	End.
Eryngium barrelieri	Médit.	*Lotus creticus*	Médit.	*Quercus afares*	End. Alg. Tun.
Eryngium tricuspidatum	W. Médit.	*Nymphea alba*	Euras.	*Satureja hispidula*	End.
Hypericum androsaemum	Médit. Atl.	*Scirpus inclinatus*	Trop.	*Scilla aristidis*	End. Alg. Tun.
Hypericum montanum	Eur.As.	*Spiranthes aestivalus*	Euras.	*Scilla lingulata*	End.
Ilex aquifolium	Eur.	*Tuberaria guttata*	Médit.	*Thymus numidicus*	End. Alg. Tun.
Luzula alpestris	Cosm.	*Veronica montana*	Eur.	*Vulpia myuros*	End.
Orchis provincialis	Eur.	*Veronica persica*	W. As.		
Paspalum distichum	Trop.	*Vicia villosa*	Eur Médit		
		Woodwardia radicanS	Maca.thermo.bor		
		Oenanthe lachenalii	Eur.		

mélange parfois au chêne-zéen mais dans les zones d'interférence ils semblent s'exclure. Il s'associe volontiers avec le chêne-liège.

La suberaie : Se situe entre 400 m et 900 m ; de part son amplitude écologique et sa diversité floristique, on y distingue, de haut en bas :

- **Une forêt dense** de chêne-lièges séculaires, dont l'état physiologique ne permet pas de produire du liège à nouveau ; elle est pauvre en espèces.
- **Une forêt claire**, stade de dégradation de la forêt dense dans laquelle les ouvertures de la strate sont occupées par les espèces de maquis : *Arbutus unedo, Erica scoparia* (assez rare*), Cytisus triflorus*, *Laurus nobilis* qui fait l'objet d'une exploitation régulière et peut, à moyen therme être menacée. On trouve aussi *Myrtus communis* et *Erica arborea* ; ici le liège est de bonne qualité.
- **La suberaie à lentisque** qui constitue un faciès thermophile et qui réalise une zone de téléscopage dans laquelle on a, d'une part les remontées d'espèces thermophiles de l'étage inférieur et d'autre part, une transgression des espèces mésophiles de l'étage immédiatement supérieur (Toubal 1989).

  On y trouve *Rhamnus alaternus*, *Pistacia lentiscus*, *Phillyrea angustifolia, et Genista*

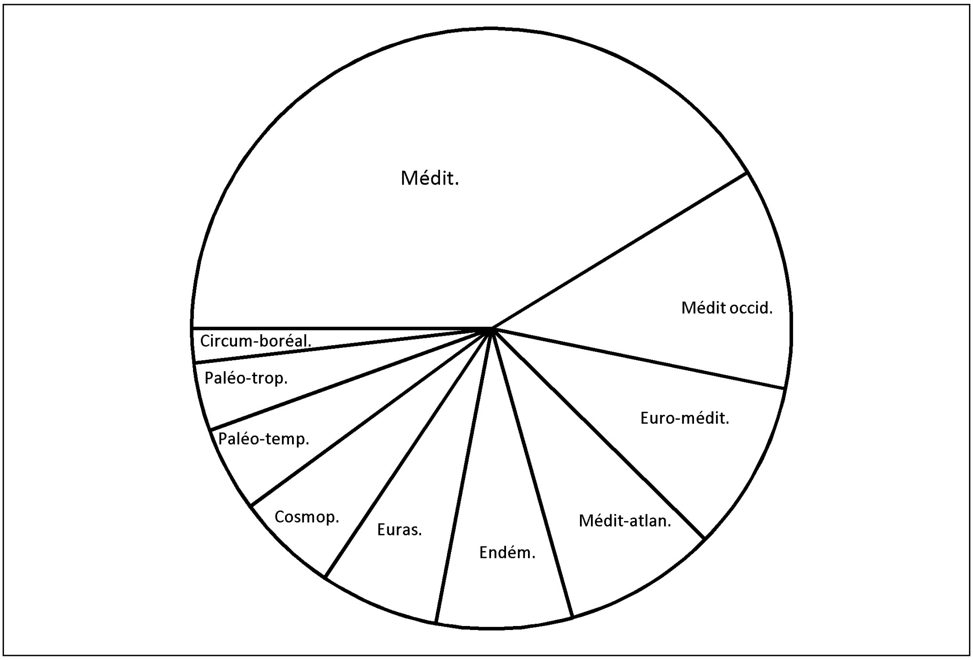

Fig. 1. Spectre biogéografique.

tricuspidata); Thymus numidicus (endémique) est très récoltée pour un usage culinaire. Proche des points d'eau, pousse *Physospermum actaefolium* (rare). Sur sol argilo-sableux, le chêne-liège forme un groupement mixte avec *Quercus coccifera*. Khelifi (1987) a décrit une sous-association à *Quercus suber et Erica scoparia.*

La pinède à *Pinus pinaster*: Espèce assez rare, elle forme des îlots dispersés dans la suberaie et s'y mélange parfois, à la faveur de l'incendie et on parle alors d'enrésinement de la forêt. La pinède possède, de ce fait, le même sous-bois que la suberaie. De race littorale ici, le pin maritime constitue un plésioclimax.

La formation à olivier et lentisque : Elle occupe les bas de pentes, le bord de mer et joue un rôle de substitution à la chênaie dégradée. On y trouve *Euphorbia dendroides* (très rare), *Anthyllis barba-jovis* (rare), *Genista numidica* sur micaschistes, *Chamaerops humilis, Olea europaea, Ceratonia siliqua, Cistus monspeliensis et Erica multiflora.* A l'embouchure des oueds, on trouve *Vitex agnus-castus* (assez rare). Sur substrat sableux et dunes du littoral, *Quercus coccifera, Juniperus oxycedrus et Nicotiana glauca* .

Les nuisances et leurs impacts

Les pressions anthropiques, les facteurs de dégradation et les conditions de milieu ont imposé un certain dynamisme à la végétation (Fig. 2). Il s'agit principalement de l'incendie, du défrichement, de la coupe de bois, du surpâturage occasionnel et de la pollution.

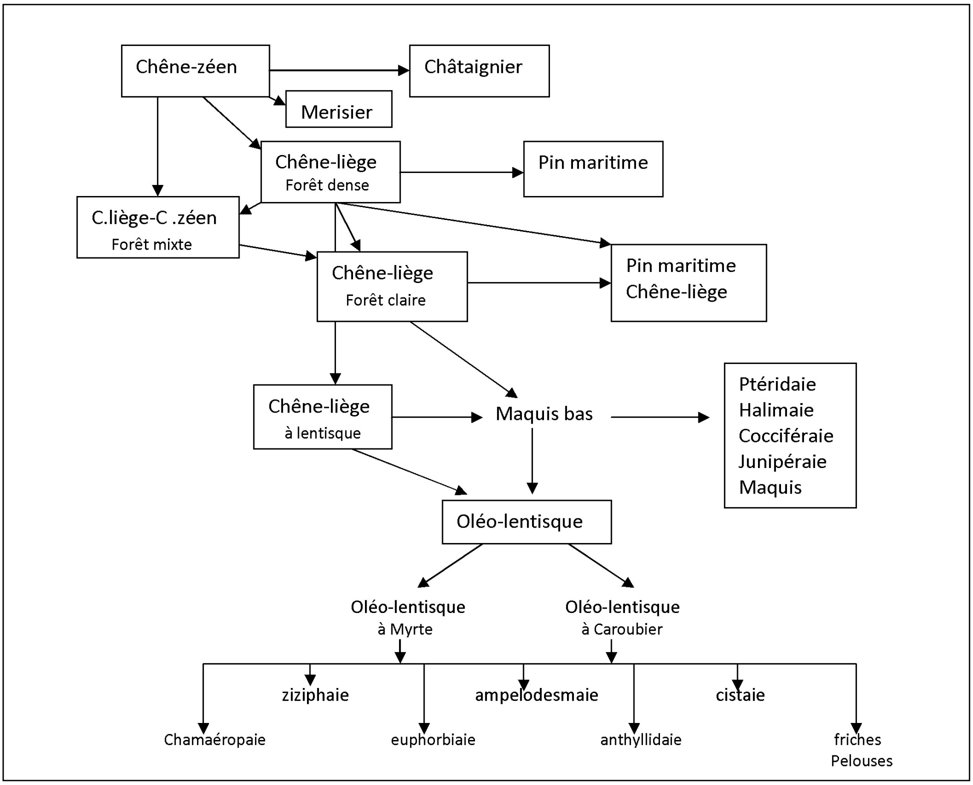

Fig. 2. Schéma semplifié des relations dynamiques entre les principaux groupements végétaux.

L'incendie de 1983 a été spectaculaire et destructif . Après le feu, la régénération est difficile pour certaines espèces, mais plus facile pour d'autres (*Erica arborea*, *Arbutus unedo et Pinus maritima*). La figure 2 représente les groupements végétaux naturels observables sur le terrain ainsi que leurs formes de dégradation.

L'action parfois conjuguée de ces facteurs amène la destruction de l'écosystème forestier, perturbe l'équilibre biologique, ce qui entraîne un appauvrissement floristique et l'installation de structures régressives (maquis, pelouses, broussailles...). Il s'en suit également la formation de groupements monospécifiques arbustifs de substitution, le plus souvent à déterminisme édaphique qui rehaussent la particularité de cette zone.

Les Groupements végétaux de substitution

Les maquis :

- Le maquis élevé (4m) à *Erica arborea* et *Arbutus unedo* qui est le premier stade de dégradation de la suberaie. C'est une formation subclimacique (Ozenda 1975) qui s'installe quelques années après incendie.
- Le maquis à Eri*ca arborea*, *Erica scoporia* et *Phillyrea angustifolia*

- Le maquis à *Myrtus communis*, *Pistacia lentiscus* et *Lavandula stoechas*
- Le maquis à *Erica arborea* et *Myrtus communis*
- Le maquis bas à Génistées, Cistées et Ericacées, sur relief pentu et substrat pauvre.

Les formations monospecifiques arbustives :

- Les cistaies, à *Cistus monspeliensis* sur les parcours d’incendies répétés, les endroits découverts exposées au soleil (friches, pare-feu, dunes fixées).
- La chamaeropaie à *Chamaerops humilis* sur substrat calcicole (Bouhamra) et terres marneuses rubéfiées (Cap de garde). Une association à palmier nain a été décrite (Toubal 1998). La chamaeropaie caractérise un stade de dégradation avancé de la forêt sur les basses collines, c’est aussi un groupement préforestier et périurbain.
- La garrigue à *Euphorbia dendroides* à Cap de garde sur cipolin et paléosol à terra-rossa. Nous en avons découvert et décrit une station nouvelle à O. Begrat (Toubal & Toubal A. 1995) sur gneiss et micaschistes imprégnés de calcaire métamorphique. Cette espèce serait un bon réactif de climat plus chaud et plus humide. Elle colonise les carrières abandonnées, les falaises et serait donc un stade de reconquête du milieu. Avec son aspect charnu elle peut constituer un pare-feu naturel. Une association à *Euphorbia dendroides* et *Chamaerops humili*s a été décrite (Toubal & al. 1995). Barbero (1980) parle d’une association chasmophile qui serait une transition avec les groupements rupicoles.
- La cocciferaie à *Quercus coccifera* sur substrat sablo-argileux et dunes littorales.
- La ptéridaie à *Ptéridium aquilinum* ou lande à fougère aigle, à haute altitude sur le versant nord de Aïn Barbar et Chétaïbi. Elle résulte du déssouchement de la strate arbustive (sous chêne-liège ou chêne-zéen) et prolifère grâce aux labours .
- L’halimaie à *Halimium halimifolium*, stade de dégradation de la suberaie sur sol acide, sablonneux à lessivage important.
- La genistaie à *Genista numidica*, exubérante sur les versants chauds, constitue un stade de dégradation de la suberaie et réalise une forme de transition entre elle et l’oléo-lentisque. Sadki (1988) a décrit un faciès à *Genista numidica*. Une association à *Genista numidica* a également été décrite (Toubal 1998).
- La ziziphaie à Zi*ziphus lotus* sur les talus, les bas de pentes et décombres.
- La juniperaie à *Juniperus oxycedrus* qui fixe les dunes du littoral et se mélange parfois au chêne-liège; cette formation est menacée par les travaux forestiers.
- L’anthyllidaie à *Anthyllis barba-Jovis* vient sur substrat rocheux du littoral

Les constructions sauvages de maisons en pleine forêt, ont détruit la suberaie. L’assèchement des marais a fait disparaître certaines espèces hygrophiles (*Veronica scutellata* est rarissime) et régresser les zones humides.

Les zones humides

Elles vont pratiquement sans interruption de Skikda à la frontière tunisienne derrière l’écran montagneux formé par le Fifila, l’Edough et la Medjerda. Dans notre dition elles vont des plaines de Senhadja-Guerbes jusqu’à la plaine de Annaba en passant par le lac Fetzara et la plaine de Kharreza. Ces zones concernent les prairies humides, les lacs, étangs et marais .

La dépression salée du Fetzara contient des espèces halophiles appartenant aux genres (*Salsola, Atriplex, Salicornia, Chenopodium, Scirpus, Diplotaxis*).

Le cordon dunaire possède des lentilles argileuses créant un niveau imperméable empêchant l'évacuation de l'eau et son infiltration. Ainsi l'oued Kebir, gêné dans son embouchure, crée des retenues d'eau où se localise *Trapa natans* (châtaigne d'eau). En plus de l'existence d'une nappe phréatique, cette région est une zone d'épandage naturel de toutes les pluies tombant sur l'Edough.

Le tableau 2 montre des espèces d'origines biogéographiques diverses : tropicales (*Paspalum distichum*, *Scirpus inclinatus*), méditerranéennes *(Physosperum actaefolium, Hypericum audrosaemum, Vitex agnus-castus*), européennes (*Veronica montana*,..) Quezel & Santa (1962-1963) ont signalé à Senhadja la présence de *Veronica scutellata* (rarissime), *Isoetes velata*, *Najas graminea, Potamogeton scirpus* et *Numphaea alba*. On notera en plus, la présence de *Mentha aquatica, Nasturtium aquaticum*, *Thypha latifolia, Lythrum salicaria*.

Une véritable gestion des zones humides doit être mise en place pour la sauvegarde des espèces aussi bien animales que végétales. C'est un réservoir de biodiversité qui implique la prise en compte de la diversité territoriale, la protection et la valorisation de ces zones. Il convient de limiter le drainage et bannir l'assèchement des marais qui favorise le développement des espèces pyrophiles. Semraoui & al. (1997) ont fait une étude sur la zone humide de Senhadja-Guerbes.

La cartographie de la végétation

L'étude biogéographique illustrée par la carte traduit la répartition spatiale des groupements végétaux en fonction de leurs affinités écologiques mais également consécutive aux facteurs de dégradation dont le plus important est l'incendie qui contribue très souvent à modeler les paysages végétaux (forêt, maquis, broussailles…) et des conditions de milieu. En effet la complexité des reliefs et de la lithologie sont à l'origine de la diversité des biotopes des différentes formations végétales rencontrées ; pour cela la carte demeure un outil indispensable.

La carte (Fig. 3) réalisée, concerne la totalité de la feuille de Séraidi 3-4 et correspond à la partie la plus élevée, la plus humide et la plus boisée du massif. On y trouve les plus belles forêts de chêne-liège et de chêne-zéen avec le pin maritime, le merisier et le châtaignier ; la majorité des groupements végétaux de l'Edough y sont représentés. Toutes les cartes que nous avons réalisées seront groupées dans l' « Atlas des cartes de végétation d'Algérie ».

Conclusion

L'Edough constitue en fait un point chaud régional de biodiversité végétale menacée essentiellement par l'anthropisation (incendie, surpâturage, défrichement) et les conditions de milieu (climat sec…); il y a 24 % d'espèces remarquables qu'il faut protéger. Vela & al. (2007) parlent du Nord-est algérien comme un point chaud de biodiversité végétale en Afrique du Nord et citent l'Edough comme particulièrement riche et encore sauvage.

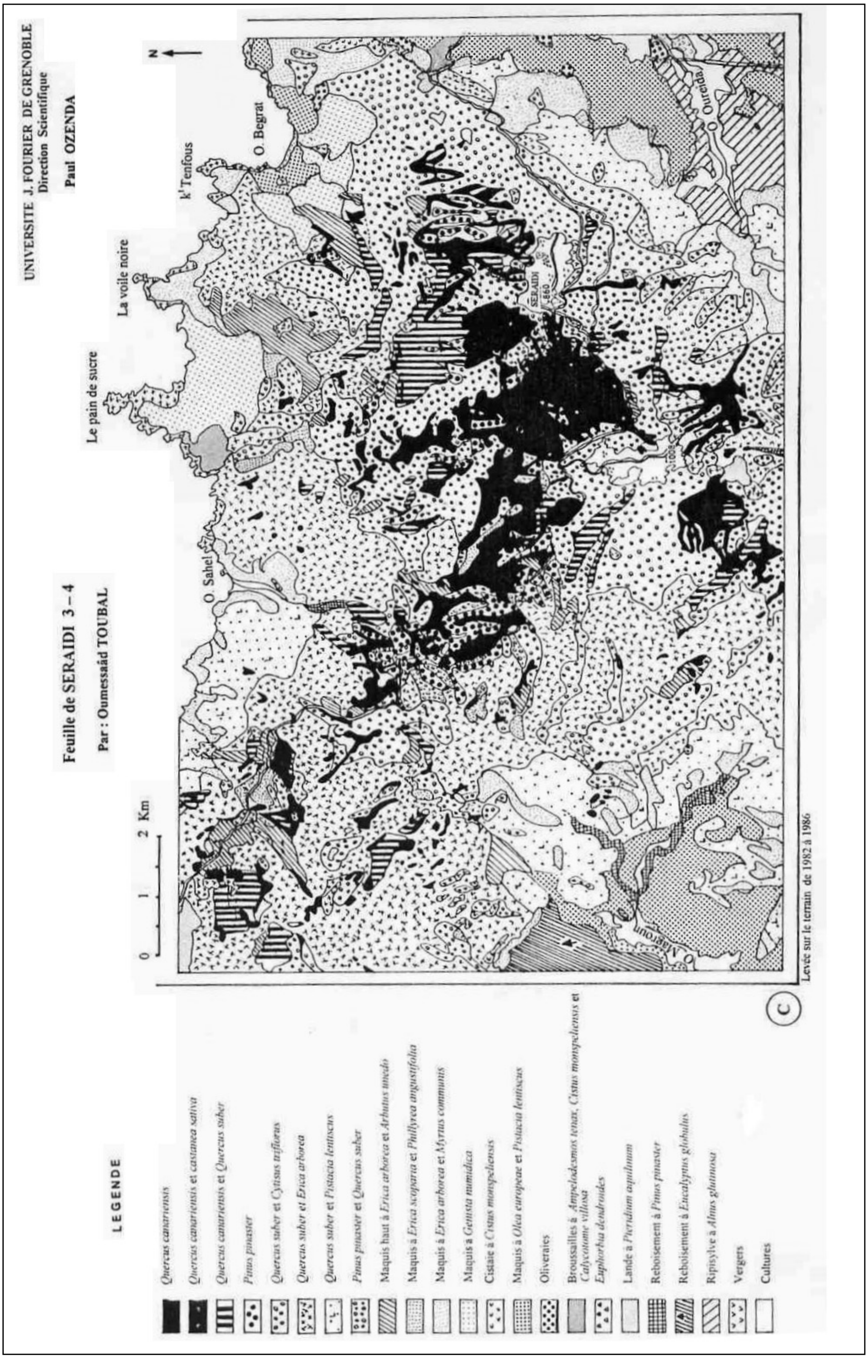

Fig. 3. Carte des groupementes vegetaux de l'Edough.

Une connaissance approfondie des milieux naturels en compte de la diversité territoriale est devenue impérative, afin de conserver les éléments des écosystèmes vulnérables et protéger les sites d'une aussi grande diversité phytogénétique.

Une attention particulière doit être accordée à *Euphorbia dendroides* qui serait un bon indicateur de zone où est possible l'implantation d'espèces exotiques (Ozenda 1975) ; en effet, ces dernières peuvent servir en reboisement ou en ornementation dans le littoral touristique. Il serait intéressant de comparer cette euphorbe avec les euphorbes d'Afrique occidentale, celle du Hoggar et celle de Mauritanie, qui constituent des espèces reliques à la faveur des conditions désertiques moins sévères, pluies orographiques pour la première et influence atlantique pour la seconde.

L'équilibre de la végétation étant précaire, les techniques de reboisement doivent être judicieuses et tenir compte des conditions locales de la végétation spontanée. Il convient de lutter contre les méthodes de débroussaillage systématique des banquettes cause d'érosion.

De nombreuses subéraies arrivées au terme de leurs possibilités de rendement en liège et déjà sur le déclin, sont à reconstituer. Ceci est possible par l'amélioration des techniques de régénération naturelle et artificielle ainsi que par la restauration et la réhabilitation de leurs biotopes dégradés. Leur mise en défens devient urgente Tout le massif doit être un parc national (Toubal & al. 1998).

Il est très important de sensibiliser la population aux problèmes de sauvegarde de la biodiversité. Pour cela il faut réconcilier le paysan avec la forêt en le faisant bénéficier des produits de cette forêt, par le maintien de l'agriculture de montagne, par exemple. Une équipe pluridisciplinaire doit travailler conjointement avec les décideurs et les paysans en faisant un suivi des études d'impact.

Le diagnostic phytoécologique associé à la carte de végétation, permet de poser de manière rationnelle le problème de l'aménagement de la forêt, sa préservation et l'utilisation durable de sa diversité biologique.

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L. M. Bellani, L. Salvini & A. Scialabba

Characterization of *Brassica fruticulosa* seeds

Abstract

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The structure and vitamin E (tocopherol and tocotrienol), fatty acid and phytosterol content and composition of seeds of *Brassica fruticulosa* Cyr. (*Brassicaceae*) were characterized. Seed size and elevated content of γ- tocotrienol, and γ- tocopherol and low of α- tocopherol can be useful for distinguishing seeds of *B. fruticolosa* from those of Sicilian *Brassica* sect. *Brassica*. The concentration of the tocotrienol is about one third of the vitamin E content. This profile makes this wild species worth to be recovered as food source and its germplasm preserved in a gene bank.

Introduction

Brassica fruticulosa Cyr. (*Brassicaceae*) is a species with Mediterranean distribution (Tutin & al. 1993), common in southern Italy and the surrounding islands (Pignatti 1982).

Brassicaceae are employed as vegetables, forage, fertilizers and as a source of industrial and edible oil (Prakash & Hinata 1980). Some species have medical properties (Podsędek 2007), while others are harvested for ornamental purposes. Lignas and neolignans extracted from the leaves of *B. fruticulosa* have herbicidal effect (Cutillo & al. 2003) while terpens have insecticidal and/or insect deterrent properties (Cutillo & al. 2005). Some accessions show resistance to cabbage root fly (Jensen & al. 2002), cabbage aphid (Ellis & al. 2000) and green peach aphid (Cole 1997). Cooked leaves and young shoots of *B. fruticulosa* are consumed as vegetables in eastern Sicily (Branca & Iapichino 1997; Branca & Fisichella 2003).

Taxonomic studies of *Brassicaceae* have found tocopherol (Toc) (Goffman & al. 1999; Goffman & Becker 2002), fatty acids (Velasco & al. 1998) and phytosterols (Gul & Amar 2006) of systematic interest. Relative percentages of single isoforms and total content of Toc are a useful biomarker for discriminating seeds of Sicilian *Brassica* sect. *Brassica* at species rank, whereas the profile and content of fatty acids and phytosterols have not been found useful for this purpose (Bellani & al. 2003; Scialabba & al. 2009).

Toc and tocotrienols (Toc-3) are liposoluble molecules produced by plants, occurring as α, β, γ and δ isoforms with antioxidant properties known collectively as vitamin E (Munnè-Bosch & Alegre 2002). Toc play an essential role in nutrition and human health, α- and γ-isoforms having major biological effect for cancer prevention (Campbell & al. 2003). Toc-

3 have strong cholesterol-lowering, anticancer and neuroprotective properties not often exhibited by Toc and symptoms of α-Toc deficiency are alleviated by Toc-3 (Sen & al. 2007). Although Toc-3 belong to the natural vitamin E family, articles on Toc-3 constitute only about 1% of the total literature on vitamin E (Sen & al. 2007).

Phytosterols have structural (Piironen & al. 2000) and metabolic functions (Moreau & al. 2002) while storage lipids in oil seeds are an essential carbon source for seedling growth (Gerhardt 1993).

The aim of the present research was to characterize seeds of *B. fruticulosa* investigating the structure and content and composition of vitamin E (Toc and Toc-3), fatty acids and phytosterols.

Materials and methods

Brassica fruticulosa seeds were collected in Linosa island (Italy), sealed in glass bottles and stored at -20° C at the Germplasm Bank of the Botanical Gardens of Palermo University. Seeds were sputter-coated with gold and micrographed on a Philips XL 20 scanning electron microscope at 10 kV for morphological analysis.

Dry seeds were frozen and sectioned with a cryostat. Sections 10 μm thick were cut and stained with bromophenol blue for total proteins**,** Lugol's solution (IKI) for starch and sudan black B for lipids and ruthenium red for mucilages (Ruzin 1999). They were observed and photographed with a Leica DMRB microscope equipped with Axio Cam MRC5 ZEISS camera.

Dry weight was determined by placing a hundred seeds in an oven at 103° C for 18 h.

For quantitative analysis of Toc and Toc-3, fatty acids and phytosterols 100 mg of unimbibed seeds, homogenized in n-hexane at 4°C for 60 seconds, was centrifuged at 10000 g for 20 min. An aliquot of the extract was derivatized with N,O-bis (trimethylsilyl) trifluoroacetamide (BSTFA) and 0.5 μl was injected in a Saturn 2000 (Varian, Walnut Crick CA, USA) GC-MS system equipped with a Rtx-5 (Restek Corporation, Bellefonte PA, USA) capillary column (30 m x 0.25 mm ID x 250 μm film thickness). Column temperature was held at 220°C for 1 min, then raised to 290°C at 5 C°/min and held for 10 minutes for analysis of Toc and phytosterols, while the column was held at 100°C for 1 min, then raised to 300°C at 20 C°/min and held for 10 minutes for analysis of fatty acids. The mass range was 450-520 *m/z* for Toc and phytosterols and 250-550 *m/z* for fatty acids.

Calibration curves of Toc, fatty acids and phytosterols were plotted by injecting α-, γ- and δ-Toc, n-pentadecanoic acid and cholesterol, respectively, dissolved in n-hexane. All standards were purchased from Sigma Chemicals. The chemical characterization of Toc, Toc-3, fatty acids and phytosterols was repeated three times. The quantitative data are expressed in mg/kg dry weight (d. w.) as mean ± standard deviation (S. D.).

Results

Brassica fruticulosa seeds were observed to be small, round, with a diameter of 1 mm (Fig. 1). Seed surface architecture was reticulate (Fig. 2) with undulated walls. The hilum

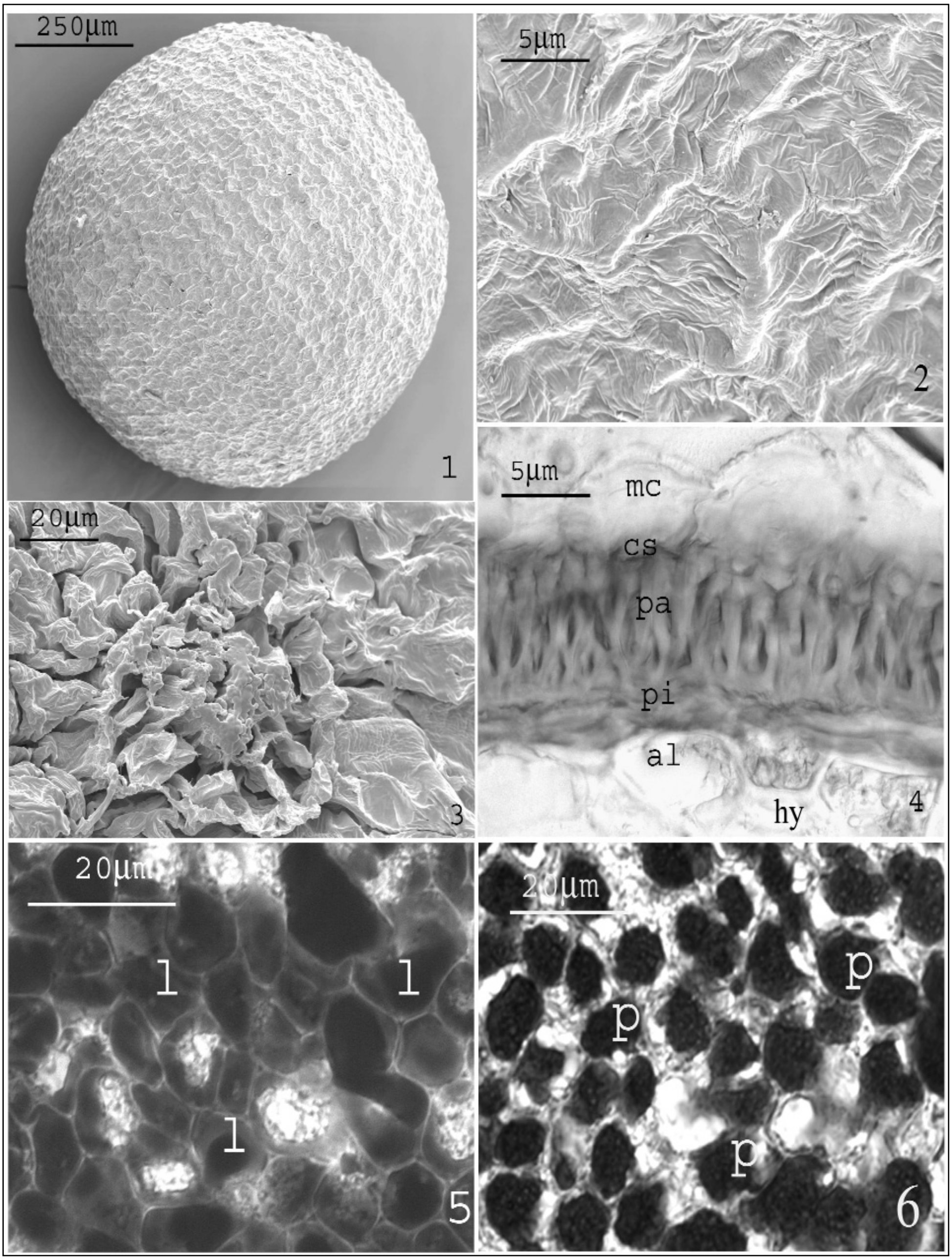

Fig. 1-6. Micrographs of dry seed of *Brassica fruticulosa* Cyr. SEM observations: whole seed (1), fine structure of integument (2), hylum region (3).

Transverse section of integument: mucilaginous cells (mc); crushed subepidermal (cs), palisade layer (pa), crushed pigmented cells (pi), aleurone cells (a), hyaline layer (hy) (4).

Cotyledon stained with sudan black B for lipids (l) (5). and bromophenol blue for proteins (p) (6).

was circular (Fig. 3) with cells orientated around the vascular scars of the funiculum. Transverse sections of the seed coat (Fig. 4) showed in sequence: an external layer of mucilage cells with thickening on outer tangential wall, a crushed subepidemal layer, a palisade layer with thickened walls, a layer of crushed pigmented cells, a single layer of aleurone cells, a hyaline layer. The cotyledon cells contained lipid (Fig. 5) and protein (Fig. 6) reserves. Starch grains were not detected.

Biochemical analysis of unimbibed seeds revealed α-, γ- and δ-Toc isoforms but not β-Toc (Table 1). Total content of vitamin E was 321.5 mg/kg d. w. Toc content was 221.4 mg/kg d. w., 93 % of which was γ-Toc and 3.3 % α-Toc. Toc-3 consisted solely of the γ-isoform, quantified at 100.1 mg/kg d. w. which was 31.1 % of total vitamin E (Table 1).

Total phytosterol content was 685 mg/kg d. w., the most abundant phytosterol was sitosterol (68%), followed by brassicasterol and campesterol (Table 1).

Unsaturated fatty acid content (1050 mg/kg d.w.) was higher than that of saturated fats (763 mg/kg d.w.). The most abundant unsaturated and saturated acids were C 18:1 and C 16:0, respectively (Table 2).

Discussion

The seed coat microsculpture of wild seeds of *B. fruticulosa* collected in Linosa island well matched that described by Koul & al. (2000). Mature dry seeds have an outer layer of mucilage cells which expand on imbibition. These cells are postulated to play a role in germination as oxygen barrier as well as in seed dispersal (Gutterman & Shemtov 1996). The hygroscopic properties of mucilage suggest that it enhances water uptake during germination (Penfield & al. 2001). The testa structure of *B. fruticulosa* seed does not show exclusive or very distinct characters with respect to *B. villosa* Biv. and *B. rupestris* Raf. groups (Scialabba & Raimondo 1995).

A considerable amount of γ-Toc was detected with respect to other isoforms. The α/γ Toc ratio as low as 0.04 has not been detected in a germplasm collection of *B. napus* L. where a ratio from 0.36 to 1.23 was reported (Goffman & Becher 2002), nor in populations of Sicilian *Brassicaceae* (unpublished data). The total amount of Toc was not significant-

Table 1. Vitamin E and phytosterol content and composition (mg/kg d. w. ± S. D.) of *Brassica fruticulosa* seeds. Individual Toc, Toc-3 and phytosterol are expressed as % of the total Vitamin E and total phytosterols, respectively. Toc (Tocopherol), Toc-3 (Tocotrienol); Brassic (Brassicasterol); Campest (Campesterol); Sitost (Sitosterol).

	α-Toc	δ–Toc	γ-Toc	γ-Toc-3	Brassic	Campest	Sitost
mg/kg d. w. ± S. D.	7.3 ±1.2	8.2 ±1.1	205.9 ±18.5	100.1 ±7.9	113.4 ±9.1	100.0 ±8.5	471.6 ±12.3
Percentage	2.3	2.6	64.0	31.1	16.6	14.6	68.8

Table 2. Fatty acid content (mg/kg d. w.± S. D.) of *Brassica fruticulosa* seeds. C 16:0, palmitic acid; C 18:0, stearic acid; C 18:1, oleic acid; C 18:2, linoleic acid; C18:3, linolenic acid; C 20:0, arachidic acid; C 20:1, gadoleic acid; C 22:0, beonic acid; C 22:1, erucic acid. Individual fatty acids are expressed as % of the total fatty acids.

Fatty acid	C16:0	C18:0	C18:1	C18:2	C18:3	C20:0	C20:1	C22:0	C22:1
mg/kg d. w. ± S. D.	265.2 ±10.3	171.1 ±6.9	263.2 ±13.3	212.4 ±14.1	169.4 ±8.7	158.0 ±9.3	176.3 ±5.9	158.0 ±6.6	231.0 ±14.2
Percentage	14.7	9.5	14.6	11.8	9.4	8.8	9.8	8.8	12.8

ly different from that in Sicilian populations of the *B. rupestris* group, but was lower than reported in the *B. villosa* group and in *B. incana* Ten. (Scialabba & al. 2009). Little is known about the physiological role of Toc-3 or of their distribution in the plant kingdom. On the basis of the similar structures of Toc and Toc-3, it has often been assumed that they play similar functional roles in plants (Munnè-Bosch & Alegre 2002). In 80 species studied, a somewhat unusual and restricted distribution was observed with the highest Toc-3 concentrations in the latex of *Hevea brasiliensis* Müll. Arg. and in rice seeds but absent in *B. napus* L. and *B. oleracea* L. seeds (Horvath & al. 2006). The amount of γ-Toc-3 (100 mg/kg d. w.) detected in *B. fruticulosa* was much higher than in other *Brassica* species endemic to Sicily where Toc-3 has only been detected in *B. villosa* subsp. *bivoniana* (Mazzola & Raimondo) Raimondo & Mazzola (25 mg/kg d. w.), *B. rupestris* subsp. *rupestris* (12 mg/kg d. w.) and *B. macrocarpa* Guss. (1.1 mg/kg d. w.) (data not shown). The profile and amount of fatty acids and phytosterols detected matched the chemical composition of Sicilian populations of the *Brassica* sect. *Brassica* group (Bellani & al. 2003). The development of varieties with high or free of C 22:1 acid are important breeding objectives (Velasco & al. 1998). High C 22:1 acid content in oil is suitable for industrial applications but not desired for human consumption. Therefore *B. fruticulosa* can be suitable for development of low erucic acid lines.

Seeds size, γ-Toc-3 levels and the α/γ ratio were peculiar to *B. fruticulosa* seeds and are therefore useful to distinguish *B. fruticulosa* from those of *Brassica* sect. *Brassica* seeds. *B. fruticulosa* is a relatively unexploited food species, but of interest because of its high γ-Toc-3 content. The Toc and Toc-3 profiles also make this species interesting for plant breeders wishing to improve the antioxidant content. As a wild plant species used as food *B. fruticulosa* could be recovered and existing genotypes conserved in germplasm bank and by cultivation in vineyards and apple orchards.

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Alessandra Di Turi & Gaudenzio Paola

First note about the management of exotic and native weeds on the urban stone walls of Genoa (Liguria, Northwestern Italy)

Abstract

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This study has been designed to solve some of the green management problems affecting the city of Genoa. The purpose of the research is to determine whether different urban species can be introduced in selected environments to substitute undesirable weeds. Two main fields of study have been selected: aesthetic improvement of poor quality green areas, usually caused by irregular maintenance, and restraint of allergenic species, first and foremost *Parietaria judaica* L. above all in "sensitive" sites (areas where children are present, hospitals, school gardens, etc.). The first step was to pick out aesthetically attractive species amongst the urban weeds, which could tolerate such environments and, as a consequence, would require limited management. The selection of species for the walls has been limited due to the extreme specificity of this habitat. At the moment we have chosen the exotic *Erigeron karvinskianus* DC., and the native *Cymbalaria muralis* s.l. Gaertn. B. Mey & Scherb., *Viola reichenbachiana* Jord. ex Boreau. Seed sowing and vegetative reproduction experiments have been carried out to evaluate the possibilities of spreading these species on Genoa's stone walls and, subsequently, of choosing those with the greatest likelihood of success. Data collected so far show that *Erigeron karvinskianus* should be the easiest to grow and have the best chance of taking root in urban walls. More tests are in progress to verify these initial observations.

Introduction

This study, which began in the first months of 2007, has been designed to solve some of the green management problems affecting the city of Genoa, utilising environmental-friendly methods wherever possible. The purpose of the research is to determine whether different urban species can be introduced in selected environments to deprive undesirable urban weeds of some of their ecological space.

Two main fields of study have been taken into consideration:

a. aesthetic improvement of poor quality green areas, usually caused by irregular maintenance;

b. restraint of allergenic species, above all in "sensitive" sites (areas where children are present, hospitals, school gardens, etc.).

The two themes are strictly related and, as it will be described here, all the proposed aesthetic improvement actions are linked with those aimed at restraining allergenic species especially *Parietaria judaica* L. one of the most allergenic species in Italy and in other Mediterranean countries (Guardia & Belmonte 2004).

Due to the extensive variety of environments in urban settings, the first stage of the research focused on two particular habitats:

- green areas with limited (or no) maintenance, due both to a lack of resources and to real difficulties in terms of maintenance. These areas, in Genoa, are characterized by a high density of trees and/or shrub cover, soil without grass, sometimes on steep slopes, and often - illegally - used for walking dogs;
- stone walls, very common in Genoa, a city which, because of the hilly nature of its territory, has developed an urban structure over the centuries with several overlapping levels, that also includes a widespread use of masonry retaining walls. Many examples of this habitat are found in sensitive areas, where it is particularly important to intervene because of the high presence of *Parietaria judaica* which, in addition to being unattractive, is unfortunately also the most widespread species growing on stone walls in Genoa and is usually controlled through chemical management, using glyphosate.

The experiments that are being carried out to analyse the possibility of restraining the diffusion of *Parietaria judaica* are based on the use of two different and integrating approaches.

The first one focuses on testing alternative physical weed control actions or combining them with the chemical method. The second line of the research aims at evaluating methodologies to introduce other species on stone walls in order to inhibit *Parietaria judaica*'s domination in such an environment and to deprive it of some of its ecological space.

The data here presented regard this second line of research and are relative to some preliminary experiments carried out to find out species which are capable of competing with *Parietaria judaica* on the stone walls of Genoa.

Materials and methods

Selection of species **-** The selection of species of urban flora to challenge *Parietaria judaica* has been limited up to this time due to the extreme specificity of walls as a habitat.

For the first experiments the 10 most frequent entities on the walls of Genoa have been chosen: this list of species was drawn up from research on urban city flora carried out between 1992 and 200 by Barberis and Di Turi (Barberis G. & Di Turi A., 2000, unpublished). In this phase shrubby Angiosperms (i.e. *Hedera helix* L. s.l.) and Pteridophytes have not been considered.

To the entities in this way identified, a value has been given related to the aesthetic aspect, slightly modifying the system indicated by Signorini (1996), which considers the duration of flowering, the pleasantness of the leaves, the general aspect in the various seasons and climatic conditions. Each species has therefore been given a numerical value according to the following scale:

1 = plants which do not look attractive at all or very little
2 = average attractive plants
3 = attractive and nice plants

Finally, the capability of these species of giving a more or less extensive covering has been valued. The covering data have been taken from the surveys carried out according to the Braun-Blanquet method, between 1992 and 1994, by Barberis e Di Turi (Barberis & Di Turi 1994, unpublished).

A numerical value has therefore been given to each species examined according to its covering capability following this scale:
1 = low covering with values on Braun Blanquet's scale ≤ 1
2 = moderate covering with values equal to 2
3 = good covering with values ≥ 3.

The results of this selection are shown in Table 1. For the experimentation the species for which the sum of the two values of covering (C) and aesthetic (E) was equal or more than 5, have been selected. However in this first phase of the research we chose not to consider *Centranthus ruber* ssp. *ruber* as it is a chamaephyte with a high capability of damaging the wall substrata, nor *Sedum dasyphyllum* as it is a species which grows quite slowly. Therefore the experimentation has been carried out on the three hemicryptophytes *Viola reichenbachiana*, *Erigeron karvinskianus* and *Cymbalaria muralis.*

Spreading experiments - Seed sowing and vegetative reproduction experiments have been carried out on the three chosen species using a soil taken directly from urban walls as a cultivation substratum in order to reproduce the context in which these plants usually live.

The sowing was carried out in spring (14th May 2007) by putting 150 seeds of the three indicated species in pots with a diameter of 5 cm filled with soil taken from the urban walls. In each pot 5 seeds were planted, with a total of 90 pots (30 for each species) which were set on a shady seed terrace in the Botanical Gardens and watered periodically, to keep

Table 1. List of the 10 most common species on the walls of Genoa (Barberis & Di Turi 2000). F: frequency by percentage of each species on the walls of Genoa calculated on a total of 213 recordings of data; E: aesthetic value (from Signorini 1996 modified) 1=low, 2=good, 3=excellent; C: covering value. The species in bold type have been chosen for the first experiments. More details in the text.

	Taxon	F	E	C	E+C
1.	*Parietaria judaica*	70.42	1	3	4
2.	***Erigeron karvinskianus***	**32.86**	**3**	**3**	**6**
3.	*Centranthus ruber* ssp. *ruber*	29.11	3	2	5
4.	*Sedum dasyphyllum*	28.17	3	2	5
5.	***Cymbalaria muralis***	**24.88**	**3**	**2**	**5**
6.	*Umbilicus rupestris*	24.41	3	1	4
7.	*Antirrhinum majus*	21.60	3	1	4
8.	*Veronica cymbalaria*	21.60	2	1	3
9.	*Sonchus oleraceus*	15.96	1	1	2
10.	***Viola reichenbachiana***	**14.08**	**3**	**2**	**5**

the substratum humid. Every week the trays on which the pots were set, were moved to uniform the sun intake as much as possible. The observations lasted 3 months, from 14th of May 2007 to 14th September 2007.

To measure the vegetative spreading 30 cuttings were taken and 30 basal tufts with roots of the three species, from spontaneous plants present in some city stations. The cuttings and the tufts were immediately put in little plastic pots with a diameter of 4 cm, one in each pot, which had been previously filled with the same substratum taken from the city walls and watered regularly to keep it humid. Also in this case the observations lasted three months, from 14th May to 14th September 2007.

Results and discussion

The selection phase has made possible the identification of some species commonly found on Italian urban walls (Anzalone B., 1951; Hruska K., 1987; 1995), well-established and represented on Genoa walls too (Barberis G. & Di Turi A., 1994, 2000): the alien *Erigeron karvinskianus* DC., and the native *Cymbalaria muralis* s.l. Gaertn. B. Mey & Scherb., *Centranthus ruber* (L.) DC. *ssp. ruber, Sedum dasyphyllum* L., *Viola reichenbachiana* Jord. Ex Boreau (Table 1).

The spreading experiments have been carried out on the species *Viola reichenbachiana*, *Erigeron karvinskianus* and *Cymbalaria muralis* and show, so far, that both *Erigeron karvinskianus* and *Cymbalaria muralis* seem to develop successfully from seeds (Table 2). As a matter of fact about 40% and 30% of their seeds put to germinate have produced little plants that have nicely developed during the three months observation. On the contrary, *Viola reichenbachiana* has shown a low germinability of its seeds at least for the short period of observation.

Both *Viola reichenbachiana* and *Erigeron karvinskianus* seem to be more efficient in the vegetative reproduction, showing very high percentages of taking root especially in the tufts splitting (the first 90% and the second 70 %) in the relatively short period of three months. *Cymbalaria muralis* seemed, in these first experiments, unable to reproduce in a vegetative way, at least in the substratum used and in the short observation period. *Erigeron karvinskianus* seems, in this phase of the reasearch, the most successful species.

Table 2. Seed sowing and vegetative reproduction experiments on *Viola reichenbachiana*; *Erigeron karvinskianus*; *Cymbalaria muralis* to evaluate the possibilities of their spreading on Genoa's stone walls. Testing period 14/05/07 - 14/08/07; Number of seeds per species: 150; number of cuttings per species: 30; number of tufts per species: 30.

Species	**% seeds germination**	**% cuttings taking roots**	**% tufts taking roots by splitting**
Viola reichenbachiana	5	30	90
Erigeron karvinskianus	40	50	70
Cymbalaria muralis	30	0	0

It has turned out to be the easiest to grow of the three species and has the best chance of taking root in urban walls.

Choosing *Erigeron karvinskianus* could look risky at a first glance as it is an alien species well-known for a long time as being potentially invasive (Weber 2003). As a matter of fact, it is a terrible scourge on the island of Reunion (MacDonald & al. 1991) and it is amongst the species which are being checked on, in the global data bank of invasive species of IUCN (2004). In Europe it is amongst the exotic species of France 'to be controlled' (Muller 2004), while in Spain it has been put on the list of the naturalised species showing a potential threat to Spanish ecosystems (Sanz-Elorza & al. 2001; Dana & al. 2001).

The risks involved with its expansion within urban "sensitive" sites (areas where children are present, hospitals, school gardens, etc.) in Genoa, however, seem limited and less than the advantages involved with its possible capability of substituting *Parietaria judaica*.

The areas in which we are meant to take action, as a matter of fact are characterised by a compact urban texture, often in deteriorated contexts which are little or not at all maintained by public services, if not by irregular clearing of weeds with chemical herbicidal. In these habitats *Erigeron karvinskianus,* a species which has not yet been inserted amongst the allergenic ones like the well-known *Parietaria judaica*, seems at a considerable advantage both from the aesthetic point of view and from the allergenic one which is the most important. In Genoa, in the last years, as a matter of fact, there has been a progressive increase of *Parietaria judaica* which has made the citizens complain because of hygienic-sanitary problems that its spreading brings.

Moreover, even if it is a species to be kept under observation, *Erigeron karvinskianus* has not shown in Liguria, at least up till now, uncontrollable invasive capabilities: known at least since 1949 (Ravenna 1949; Puccini 1950), this species, cultivated and by now naturalized in habitats like walls, rocks, embankments, ruins, edges of pedestrian paths on limestone (Peccenini 1992a, 1992b), in the region it has never come out of urban contexts or strongly disturbed ones. Even the most recent data gatherings about exotic plants in Liguria see it confined to humanized habitats (Peccenini *in verbis*).

Finally necessary evaluations have been carried out even about the possible problem connected to biodeterioration that this and the other mentioned species can cause on walls. Regarding this matter it must be said that the areas where we intend to take action have very little or absolutely no architectural value, on the contrary they are often already widely colonised not only by herbaceous plants, but also by shrubs. The proposed species, according to a danger index (Signorini 1996) that expresses numerically, for every plant species, its danger for architectural buildings, would be placed amongst those with a medium or low level, not having much influence therefore on the wall structures. A future colonisation of the 'selected' species would on the contrary qualify local unpleasant or deteriorated situations.

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Mirjana Ocokoljić & Nadežda Pavlović

Effect of urban habitat on individual variation of horse chestnut pollen

Abstract

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Research of morphological and physiological variation of pollen at the level of the species, and especially at individual level, is of high significance for the improvement of the species that have a small range, or are endemics, such as horse chestnut. For this reason this study is directed to individual and group variation of several morphological – physiological properties of fresh pollen of horse chestnut grown in the urban coenoses of Belgrade and its surroundings. The study confirms the high variation of the analysed pollen properties, which enables the selection of pollinator trees which are the bearers of pollen quantity and quality.

Introduction

Pollen grains of woody species have a more or less specific form, size and colour, based on which palinograms are made for many species and the degree of the species relationship can be determined. The differences of pollen characteristics are lower if the species are closer related, although the species which are not systematically close can have pollen grains of the same type, and the species of the same genus can have several types of pollen grains (Tucović 1989).

Material and method

The analysis of genotypes consists of 15 trees - three from 5 studies localities in Belgrade. The pollen was collected from the inflorescences taken always from the lower third of the crown, from its southern exposure, in the same stage of maturity. Fresh pollen was extracted by the method of »water cultures« (Ocokoljić 2002). Immediately after bringing to the laboratory, it was placed in the containers with water. The impurities were removed by sieving through a series of screen meshes, the last of which was 0.2 mm. The length and width of dried pollen grains were measured.

Germination percentage was assessed by sowing pollen on the drop of nutritive medium (Kobel's method). The media were 0%, 10%, 20% and 30% solutions of sucrose in distilled water. Each tree had its petri dish with specially made aluminium bearers for 4 microscopic plates with 4 different nutritive media. Pollen was sown on 3 drops separately for each concentration of sucrose. One to two hours after pollen sowing, the germinated pollen grains were numbered (the grains with pollen tube length greater than ½ of its width i.e. length of the grain). Germination percentage was determined as the percentage of germinated grains compared to the total number of pollen grains in the visual field of the microscope.

Germination energy was assessed by the growth of pollen tube expressed in micrometer units (10^{-6}m), although it is a physiological process. Pollen tubes were measured 1-2 hours after pollen sowing in the experiment used for the analysis of pollen germination percentage. All measurements in the experiments had to be terminated in the given time period, because after that time, pollen tubes split and further work is impossible.

Based on the study results of the variability of pollen morphological and physiological parameters, the main statistical parameters were determined. They were complexly analysed per each item of the analysis of variance and dendrogram analysis.

Results and discussion

Horse chestnut is a species with finer-sized pollen and horse chestnut pollen grains, in the dry state, are elongated oval - more or less ellipsoid. Only individual grains deviate from the above form and have the globular form. This was recorded in exceptionally fine grains, more rarely in some coarser grains. After immersion in water or water solution of sucrose, pollen grains swell soon and change into a more or less globular form.

The analysis of statistical parameters leads to a conclusion that there is individual variability of pollen grain mean length and mean width. The tree number 19 excels, the locality Avala at the population level is the locality with the largest pollen (pollen length 34.95 ± 0.41 μm and pollen width 15.27 ± 0.20 μm). The tree number 63 from the locality Topčiderska Zvezda has the finest pollen (pollen length 26.18 ± 0.41 μm and pollen width 11.29 ± 0.17 μm). A two-way analysis of variance was based on the measured values of the pollen morphological characteristics. There are significant differences among the localities, as well as among test trees within each locality. Insignificant differences were identified between the repetitions (Table 1).

Cluster analysis shows clearly that mother tree number 19 (with the largest pollen) is singled out, while the tree number 63 (with the finest pollen) belongs to another homogeneous group with the trees 47, 48 and 37. The remaining trees form another homogeneous group with homogeneous pairs grouped at small distances between each other, and at great distances from other pairs and groups. The results of the dendrogram analysis confirm the individual variability of the pollen morphological characteristics of the selected trees, and

Table 1. Analysis of variance of pollen morphological characteristics.

Variability factor	Sum of squares	F-calculated
Pollen width (μm)		
Factor A: locality	6.32	23.27
Factor B: tree	0.23	0.87
Interaction: A x B	4.93	18.15
Pollen length (μm)		
Factor A: locality	34.23	29.68
Factor B: tree	3.82	3.31
Interaction: A x B	17.24	14.92

on this basis it can be concluded that pollen size is under strong genetic control.

Based on the review of mean values at the individual level, regarding the average of all the analysed media, the highest germination percentage was reached by the tree number 9 (72.00 ± 1.25) and the lowest germination percentage was reached by the tree number 23 (9.33 ± 2.56). A high germination percentage (higher than 60%) was also attained by the trees 4, 6, 19, 47 and 49. The best media were 10% and 20% solutions of sucrose which showed high values of germination percentage of all tested trees.

The difference in pollen germination percentage between the tested trees was also assessed by the analysis of variance. High significance levels were obtained in all study combinations between the factors – locality, tree and medium. The interaction of analysed factors was also highly significant (Table 2). The highest level of significance was recorded between localities, but also a high level of significance occurred between the trees within each locality. The differences in variability of pollen germination percentage between populations (factor-locality) in addition to the differences in genetic constitutions should also be assigned to the differences in ecological factors.

Based on the literature data (Richards 1983; Guntenpregen & al. 1983), the necessary minimum of pollen germination percentage in *in vitro* tests for normal seed germination is the percentage of 40%. The analysis of the study results shows that, except the 5 trees (23, 28, 32, 63 69), all other trees satisfy this condition.

Based on the mean length of pollen tube at the individual level (considering the average of the four nutritive media) the tree number 70 from Topčiderska Zvezda has the highest germination energy (mean length of pollen tube 146,02 ± 9,11 µm). The tree number 63 from the same locality has the lowest germination energy (mean length pollen tube 63.27 ± 3.54 µm). The best media for the growth of pollen tube are different for individual trees, which indicate the different demands of sugar concentration. The high values of germination energy in all trees were also measured in pure distilled water, but the highest values were measured at 10% sucrose concentration. The trees 4, 6, 9, 19, 69 and 70 have high germination energy, i.e. pollen tube length above 100 µm. They can be considered as pollinators with the highest germination energy. It can be expected that these trees will have greater efficiency in the process of fertilisation. The variability of tested trees regarding pollen germination energy based on the length of pollen tube was also confirmed by the analysis of variance. There are significant differences between the localities and tested trees, and the highest level of significance occurs between the nutritive media. The interaction of analysed factors is also highly significant (Table 3).

Cluster analysis was performed based on the mean values of germination energy and

Table 2. Analysis of variance of pollen germination percentage.

Variability factor	Sum of squares	F-calculated
Factor A: locality	11440,8	126,82
Factor B: tree	901,0	9,99
Factor C: medium	670,3	7,43
Interaction: A x B	3156,1	34,98
Interaction: A x C	276,5	3,06
Interaction: B x C	857,3	9,50

Table 3. Analysis of variance of pollen germination energy.

Variability factor	Sum of squares	F-calculated
Factor A: locality	20562,4	24,43
Factor B: tree	49016,6	58,25
Factor C: medium	154040,4	183,05
Interaction: A x B	40936,1	48,64
Interaction: A x C	11847,1	14,08
Interaction: B x C	6873,8	8,16

pollen germination percentage, for all nutritive media. Just as in the case of the pollen morphological traits, the hypothesis that all trees will be grouped in five groups depending on their origin was not confirmed.

Test tree number 49 with high germination percentage and pollen germination energy in all nutritive media, is singled out. The closest position has the homogeneous pair (70 and 69) with the highest average values of the study properties, but they are not constant in all concentrations of sucrose. Other trees form homogeneous pairs and groups at small distances between each other, and at great distances from other pairs and groups.

Conclusion

Horse chestnut pollen has an elongated-oval form. The comparison of the study results with the pollen grain size shows that horse chestnut is a species with finer-sized pollen. The results of variation-statistical analysis prove that the environment has not a great effect on pollen size, and that pollen size is under strong genetic control. It can be observed that the other study characteristics are partly under genetic control, which is shown by the fact that the test trees from the same locality produced pollen of superior or inferior morphological or physiological characteristics, but they are also under the effect of environmental factors.

The study data are a significant contribution to a better knowledge of the horse chestnut genetic potential which is necessary for the production of good-quality planting material for urban habitats; as well as for the production of seeds as the raw material for chemical and pharmaceutical industries. The concluded high individual variability of the analysed pollen morphological and physiological characteristics, enables the selection of test trees that can be considered as pollinators – bearers of pollen quantity and quality. Still, it is only by their confirmation by progeny tests that they will be given the significance in the further program of horse chestnut improvement.

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A. Rosselló-Graell, I. Marques, D. Draper & J. M. Iriondo

Flowering and fruit set in a fragmented translocated population

Abstract

Rosselló-Graell, A., Marques, I., Draper, D., Iriondo, J. M.: Flowering and fruit set in a fragmented translocated population. — Bocconea 23: 471-477. 2009. — ISSN 1120-4060.

Narcissus cavanillesii A. Barra & G. López (*Amaryllidaceae*) is a threatened geophyte in Portugal with only two populations. The southernmost population, which is fragmented in several patches, was translocated in 2001 to prevent its extinction due to the construction of a dam. Our main goal was to determine if the translocated patches show a common pattern or function differently allowing the identification of different management units. We hypothesized that flowering and fruit set response in the different patches could be used as criteria to solve this question and identify the most appropriate management units. In 2005 phenological, biotic and abiotic variables were recorded to model flowering and fruit set in a hierarchical approach with regions, substrates and patches nested in regions and substrates as independent variables. Differences in the percentage of flowering and fruit set were assessed using a generalized linear model (GLM). Results suggest that the percentage of flowering plants mainly depends on substrate type and patch. This information provides a relevant input in the definition of management guidelines for the long-term maintenance of the studied translocated population.

Introduction

Plant species frequently present patchy distributions at several different spatial scales. This patchiness has been further accentuated by human activities through habitat destruction and fragmentation processes (Schemske & al. 1994; Eriksson & Ehrlén 2001), which are considered a threat to the maintenance of biodiversity (Young & al. 1996; Matthies & al. 2004). In that sense, there is broad consensus that small, fragmented populations of rare or threatened species are at a greater risk of extinction than larger populations due to environmental and demographic stochasticity and genetic erosion, as well as their interaction (e.g. Oostermeijer & al. 2003; Lienert 2004).

Within the framework of conservation actions, translocations are used in some scenarios to reduce the extinction risk of rare or threatened plant species (Milton & al. 1999; Krauss & al. 2002; Jusaitis & al. 2004). The main objective of translocations is to establish secure, self-sustained populations of taxa otherwise threatened with extinction. However, these conservation actions are both difficult and complex, and assessment of their long-term success is often lacking (Falk & al. 1996).

Narcissus cavanillesii is a threatened species in Portugal where it is represented by only two populations. The Montes Juntos population presents a patchy distribution and was translocated in 2001 to prevent its extinction by the construction of the Alqueva dam. Considering the vulnerability of fragmented populations and the uncertain success of translocations, how is this patchy translocated population likely to evolve? In such a scenario, good knowledge of biological, genetic and reproductive traits and habitat requirements, as well as demographic monitoring data are needed to adopt management decisions that achieve the ultimate goal of a translocation: the establishment of a self-sustained population.

With these considerations in mind, our main goal was to determine if the translocated population could be effectively managed as a single unit or if several management units are needed to attend the particular needs of specific groups of patches. Since flower production and fruit set are crucial processes for species' reproductive success, and therefore, a critical component of the conservation strategy for a population (Cunningham 2000; Kéry & Matthies 2004; Aguilar & al. 2006), phenological, biotic and abiotic variables were recorded on each patch to model flowering and fruit set. We hypothesized that if flowering and fruit set varied significantly among the patches, different management units could then be defined based on this criterion. Because interactions between patches can be linked by spatial hierarchical levels, we employed a multi-scale approach using a generalized linear model. Specifically we aimed to answer the following questions: (1) Do flowering and fruit set vary among patches? (2) If so, what factors have the greatest influence on flowering and fruit set? (3) What are the implications of the obtained results in the management of this population and in the conservation of this species in Portugal?

Methods

Study species and population

Narcissus cavanillesii is a small autumnal blooming geophyte. This species is self-compatible with a mixed mating system generally presenting only one bright yellow flower per plant. This species is endemic to northern Africa and the southwestern Iberian Peninsula with only two known populations in Portugal (Malato-Beliz 1977; Rosselló-Graell & al. 2003). In this country, *N. cavanillesii* is classified as critically endangered (CR) (B2ab(ii, iv)) according to IUCN criteria (2001) (Rosselló-Graell & al. 2004) and is also listed under Annexes II and IV of the Habitats Directive of the European Union (EEC 92/43). The two Portuguese populations, Ajuda and Montes Juntos (Alentejo region), are approximately 30 km apart and both were originally located along the Guadiana River where the substrate is mainly composed of river clay deposits with some acidic rocky formations. Both populations were affected by the construction of the Alqueva Dam, the largest water reservoir in Europe.

We focused our study on the Montes Juntos population, which is the southernmost locality. The population is fragmented in ten patches of 0.3-10 m^2 and was originally distributed ca. 500 m along the Guadiana River. The entire population along with its substrate was translocated to a safe site in 2001 maintaining the original spatial structure of the patches. The new site was selected considering species suitability, and similarity and proximity to the original site (Draper & al. 2004). Three types of substrate were identified depending on the patch: rock, soil and a mixture of rock and soil. The rock is made out of metamorphic formations dominated by schist and mica-schist whereas the soil is clay-loam (27% sand, 36% silt and 37% clay) and it has low drainage, high water retention and low porosity, characteristic of alluvial soils. The soil is acidic (pH=5.2), which renders a low availability of nitrogen, phosphorous and potassium (Rosselló & al., unpublished results).

Sampling design

Phenological, biotic and abiotic data were recorded during October and November 2005. All individuals in the population patches were censused and tagged for monitoring. Flowering and fruiting phenology of reproductive plants were assessed every 3 days. Flowering and fruiting percentages were calculated for each patch. Final fruit set was calculated as the percentage of flowers that formed mature dehiscent fruits, excluding those fruits that had been predated. The translocated area was structured into two regions and ten patches according to spatial criteria, and into three substrates (rock, soil and a mixture of rock and soil) (Fig. 1).

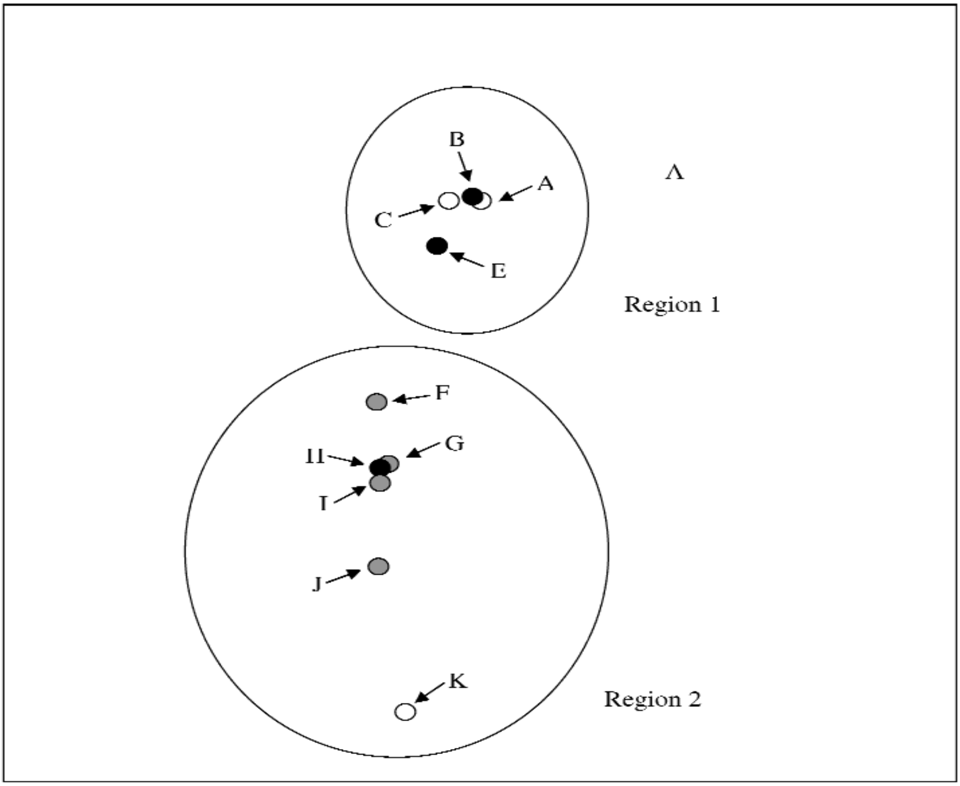

Fig. 1. Spatial distribution of patches and regions in the studied population. Patches are identified using letters. Colours correspond to substrate type: white = soil, black = rock and grey = mixture of rock and soil.

Data analysis

The effects of patch, region and substrate on flowering and fruit set were analyzed by means of generalized linear modelling techniques. The model assumed a hierarchical approach, with regions, patches nested in regions and substrates as independent variables. Flowering and fruit set were used as dependent variables. Calculations were made using the software SAS 9.0 (binomial distribution, logit link function, PROC GENMOD) and were corrected for overdispersion (dscale option, PROC GENMOD) (SAS Institute 2002).

Results

Total population size was 3741 individuals. The number of individuals per patch is shown in Fig. 2.

The percentage of flowering plants varied among population patches. This suggests that the studied population does not present a general flowering pattern among patches (Fig. 2). A higher percentage of reproductive individuals was found in soil (22%) than in rock (13%) and an intermediate value was obtained in the mixed substrate (16%) (Fig. 3). Fruit set also varied among patches; however, no clear trend in response was found with regard to substrate. Our modeling results indicated the substrate (*P* = 0.0012) had the most significant effect on flowering. Nevertheless, the effect of patch (region x substrate) interaction on flowering was also significant (*P* = 0.0024) (Tab. 1). No significant differences in flowering probability were found between regions when region was considered as the only independent variable. When fruit set was modelled no significant effect was found for any of the tested variables.

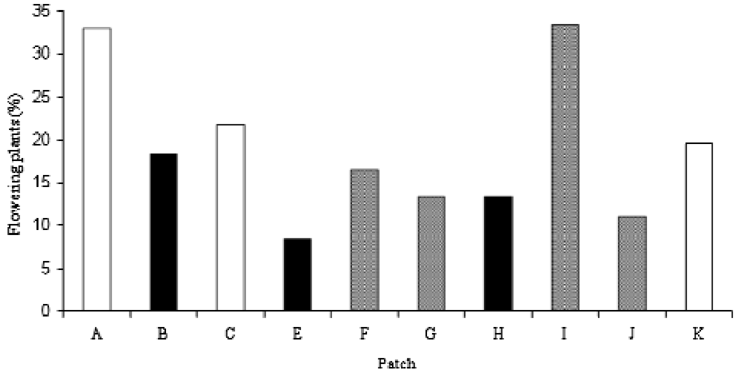

Fig. 2. Percentage of flowering plants per patch. Substrates types: white = soil, black = rock and grey = mixture of rock and soil. Letters correspond to population patches. Number of individuals per patch: A=152, B=38, C=877, E=119, F=242, G=268, H=1079, I=36, J=27, K=903.

Table 1. Generalized linear model analysis of flowering and fruit set. Significant values are shown in bold.

Source		Flowering		Fruit set	
	d.f.	χ^2	p	χ^2	p
Region	1	2.94	0.0836	0.14	0.7074
Substrate	2	13.39	**0.0012**	0.04	0.9809
Patch (region x substrate)	6	20.49	**0.0024**	4.84	0.5642

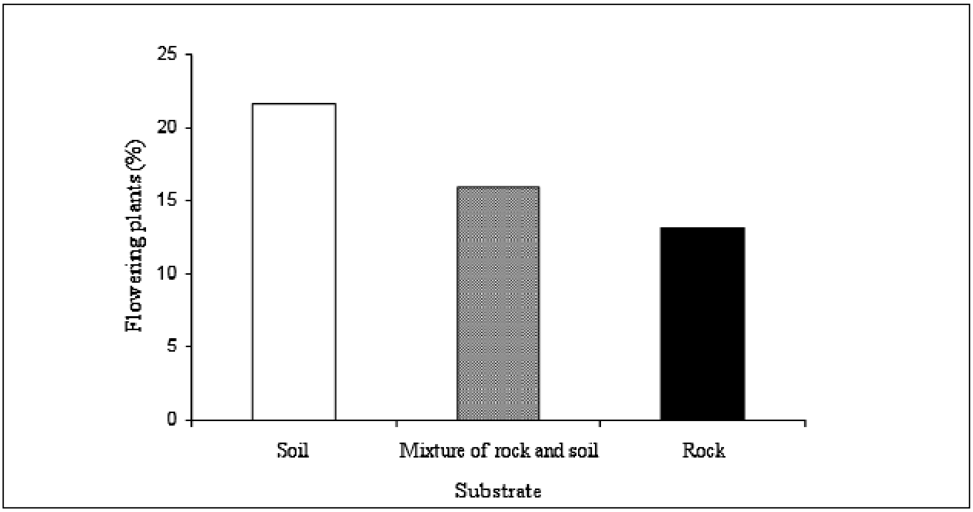

Fig. 3. Percentage of flowering plants per substrate type. Number of individuals: soil = 1932, mixture of rock and soil = 573 and rock = 1236.

Discussion

As resources for preserving biodiversity are often limited, conservation managers are faced with the need to develop criteria to prioritize efforts to develop effective conservation strategies. The definition of management units based on biological processes can provide a basis on which to formulate conservation guidelines. Cunningham (2000) analyzed the effect of habitat fragmentation on the flowering and fruit set of several species and concluded that the studied fragments functioned differently and therefore may require different management practices.

Our analysis found no consistent pattern of flowering or fruit set among population patches. However, both substrate and patch had a significant effect on flowering response. The effect of substrate may be partially due to a divergent impact of translocation on the substrates. Data collected before and after the translocation revealed that the percentage of flowering plants had a different response throughout time depending on the substrate (Rosselló-Graell & al. 2002). On the other hand, previous studies in other plant species have shown a differential flowering response depending on the type of substrate (e.g.

Albert & al. 2001). Thus, the translocation may have interacted with a possible inherent effect of substrate on flowering and contributed to the overall flowering variability detected among the population patches. The lack of effects of the tested variables in fruit set might be due to interaction with additional biotic factors, such as pollination success and fruit predation, where the effects of region, patch and substrate may act differently.

From a reproductive perspective, our results revealed that substrate type is the recommended criterion to identify different management units in this population. This is an interesting result since geographical criteria are more likely to be applied when dealing with fragmented populations. This information became a relevant input in the definition of management guidelines that may be used as a starting point for the long-term maintenance of this translocated population.

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M. Skoula, C. Dal Cin D'Agata & A. Sarpaki

Contribution to the ethnobotany of Crete, Greece

Abstract

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Relics of traditional knowledge still survive today, in several rural areas of the Mediterranean, as an expression of the diachronic interaction between people and plants. The ethobotanical study in Crete, concerns the preservation of the intangible cultural heritage of the island, together with some insight into the sustainable development of rural areas. For the research, two rural sites were selected, and some 100 pre-selected elder people were interviewed. The largest number of wild plants recorded were food plants, where 173 different plant species were recorded. These include greens, ('horta'), aromatic plants, plants used as condiments tea infusions, and desserts. Traditional medicine was represented by the next largest number of wild plants, 160 plant species, including some cultivated, were reported. The medicinal uses reported were for skin, wounds, inflammations, digestive, respiratory, cardiovascular, urinary, reproductive, endocrinological, myo-skeletal problems, sedatives, and against poisoning. Insect repellents was also a separate collected class of plants, as they are very important to local food stores and consequently affected the agricultural economy. It is noteworthy that half of food plants were also considered important in traditional medicine. Regarding materials used for various crafts, 175 plant species, including some cultivated ones, were reported. Out of these, 73 were species known as sources of tannins and dyestuff. Furthermore, 36 species were used for woodcut objects, such as spoons, boxes, furniture, walking-sticks, agricultural tools. Another 25 plants species were used for their fibres for baskets, ropes, chairs, hats, mattresses, cushions, saddles, brooms. Nine (9) species were known for making glues, eleven (11) for musical instruments, and, finally, five (5) species were known to be used for toys.

Introduction

Relics of traditional knowledge of the use of wild plants still survives today in several rural areas of the Mediterranean, asserting the interaction through time and space between peoples and plants. The ethnobotanical study in Crete is based on tapping this oral knowledge, which is an intricate and intangible part of the local cultural heritage (UNESCO 2007) and is aiming to not only preserve in archival form and Herbarium specimens the amassed data, but to disseminate this knowledge on various levels. The first stage of the collection and archiving of the data for comparative studies in other areas of the Mediterranean is of paramount importance together with its accessibility, to other scholars and institutions concerned with the same motives. Secondly, results would return to the donours of the information in the form of seminars at cultural societies and local authorities. Thirdly, and most importantly, schools and children should receive this knowledge in digestible forms so as to make them participate in this search for their own plant-people interaction. They should prove the best ambassadors for the survival of these traditions on a popular level. This could prove decisive, in the future, when sustainable developments would go hand in hand with economic and social growth.

The intangible cultural heritage is incapsulated in (UNESCO 2007):

a) knowledge and practices concerning the nature, which include intuitive knowledge, know-how, skills, practices and expressions initiated, developed and perpetuated by communities in interaction with their natural environment.
b) traditional craftmanship which is expressed in many forms creating an interface between people and the plant world. Expressions demonstrating in practically all aspects of livelihood whether concerned with the protection and adornment of the body (such as clothing and jewellery), or tools vital to subsistence and survival (shelter, agricultural, husbandry, storage, transport, household utensils, medicines and so forth), or even crafts connected to rituals, amusement and the metaphysical (musical instruments, incense, ritual tools, toys etc.)

The study in Crete focused on plants currently used or known, within living memory, to have been used in, all aspects of life, as mentioned above.

Materials and Methods

For the research which was conducted during 2004-2005, which followed the participatory approach, two rural sites were selected, one at the easternmost part of the island, specifically the area of Itanos and Leuki and the other on the western part of Crete, the area of Apokorona, east of the city of Chania. In order to select suitable informants, 500 questionnaires were sent to schools in each one of the two areas, half of which were completed and returned. The most 'interesting' questionnaires led us to 109 elder people, 47 men and 62 women (mean age approximate 75 years old). They were interviewed in depth, while, at the same time, plant and photographic materials were collected for documentation. Informants were requested to provide information on current uses of the plant or, even, on past uses, if they remembered having been practiced in their presence. Regarding food plants the information we aimed for was restricted to wild plants, including native and naturalised plants of the areas concerned. For plants used in traditional medicine and for crafts, both wild and cultivated plants were annotated. Voucher specimens of all collections are kept in the Herbarium of the Park for the Preservation of Flora and Fauna, Technical University of Crete (TUCCG).

Results and Discussion

More than 1400 replies (vernacular plant names) were received on food plants revealing that 173 native and naturalised species were consumed, most of which were leafy vegetables eaten raw, boiled or cooked in olive oil. Others were aromatic plants which are used fresh or dry as condiments or for infusions; some fruits are used for desserts and jams; roots were also used, as shown in Table 1. The reported wild food plants belong to 38 plant families (Figure 1), with 60% belonging only to four families, *Asteraceae* 29%, Lamiaceae 14%, *Apiaceae* 10% and *Brassicaceae* 7%. It is of note that the variety of wild food plants used in Crete is remarkably high when compared to other Mediterranean countries (Hadjichambi & al. 2008). The 10 most frequently mentioned species are given in Table 2.

Regarding traditional medicine ca. 600 reports (vernacular names) were received revealing 169 native, naturalized and cultivated plant species. Table 3 illustrates the different body system disorders (Cook 1995) as treated by the medicinal plants reported, in their respective order of importance. Furthermore, about 10 wild species are known to have been used to treat animal diseases (Peroni & al. 2006).The medicinal plants reported cover a wider range of plant families, than the food plants, representing 50 plant families. Figure 2 displays the number of medicinal plant species within each family, the most important being *Asteraceae* with 25% of the whole, while 14% are of the *Lamiaceae*, 5% are

Table 1. Plant parts, food types and preparations used in, for food plants

Plant part / type of food / preparation used in	**No of species**
Leafy greens, stems and inflorescences, raw, boiled, cooked or sauté	122
Roots, rhizomes and bulb	10
Fresh herbs	15
Dried herbs for cooking	16
Dried herbs for beverages	24
Fruits, Desserts – jams – pickles	18
Total	**173**

Table 2. Ten mostly mentioned food wild plants

Family	**Species**	**Mention frequency %**
Apiaceae	*Scandix pecten-veneris* L.	69
Lamiaceae	*Prasium majus* L.	45
Asteraceae	*Sonchus oleraceus* L.	44
Papaveraceae	*Papaver rhoeas* L.	43
Apiaceae	*Scaligera napiformis* (Spreng.) Grande	40
Apiaceae	*Torilis arvensis* (Huds.) Link subsp. *arvensis*	40
Lamiaceae	*Mentha longifolia* (L.) Huds.	38
Lamiaceae	*Mentha spicata* L.	38
Lamiaceae	*Mentha suaveolens* Ehrh.	38
Asteraceae	*Scolymus hispanicus* L.	38

Apiaceae and 5% are *Rosaceae*. The ten most frequently mentioned medicinal plants are given in Table 4.

An important observation of the study was the strong relation that seems to exist between food and medicinal plants, as half of food plants were also considered important in traditional medicine. The same comment was made by Rivera & al. (2005) for Spain.

Table 3. Body system disorders treated by wild and cultivated medicinal plants

Body system disorders	No of species
Digestive system	44
Urinary system	43
Circulatory system	39
Respiratory system	38
Infection / infestations / injuries	36
Skin	34
Endocrine system	25
Mental/nervous system	15
Inflammation	8
Pain	8
Muscular-skeletal system	6
Poisoning	6
Reproductive system	3
Total	**170**

Table 4. Ten mostly mentioned medicinal plants

Family	Species	Mention frequency %
Lamiaceae	*Salvia fruticosa* Mill.	32
Lamiaceae	*Micromeria juliana* (L.) Benth. ex Rchb.	28
Lamiaceae	*Micromeria nervosa* (Desf.) Benth.	28
Lamiaceae	*Salvia pomifera* L. subsp. p*omifera*	24
Poaceae	*Cynodon dactylon* (L.) Pers.	21
Lauraceae	*Laurus nobilis* L.	20
Malvaceae	*Malva silvestris* L.	20
Asteraceae	*Matricaria chamomilla* L.	19
Lamiaceae	*Mentha longifolia* (L.) Huds.	19
Lamiaceae	*Mentha spicata* L.	19

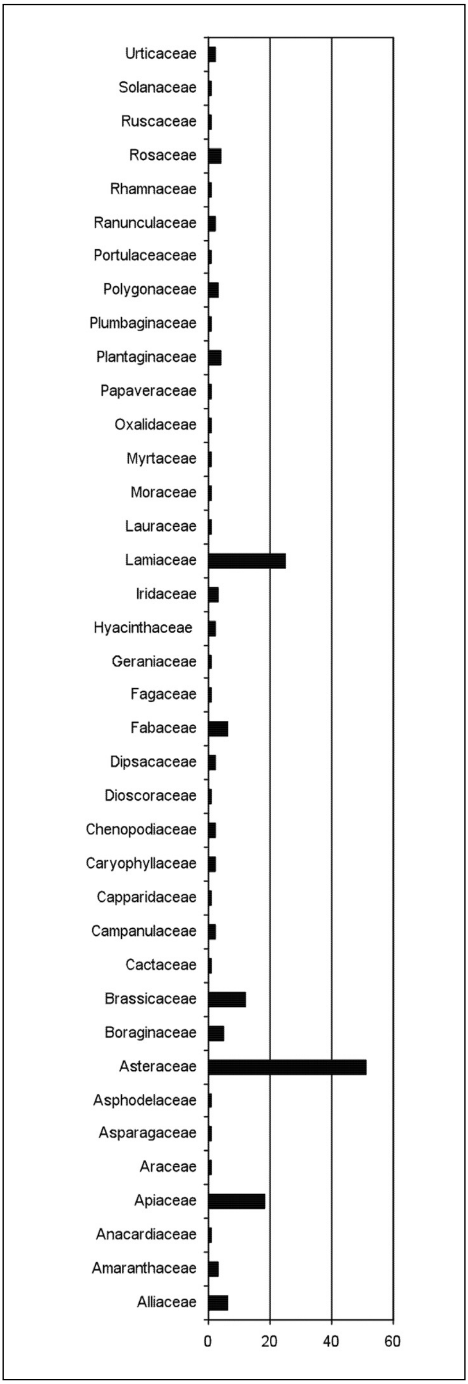

Fig. 1. Representation of families of wild food plants, with number of species in each family.

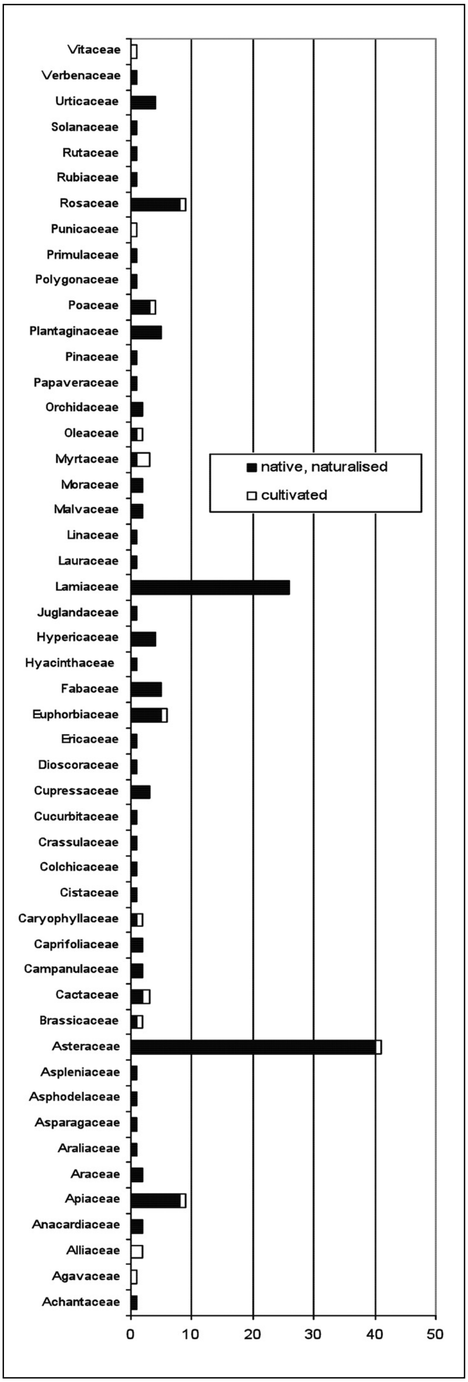

Fig. 2. Representation of families of medicinal plants,with number of species in each family.

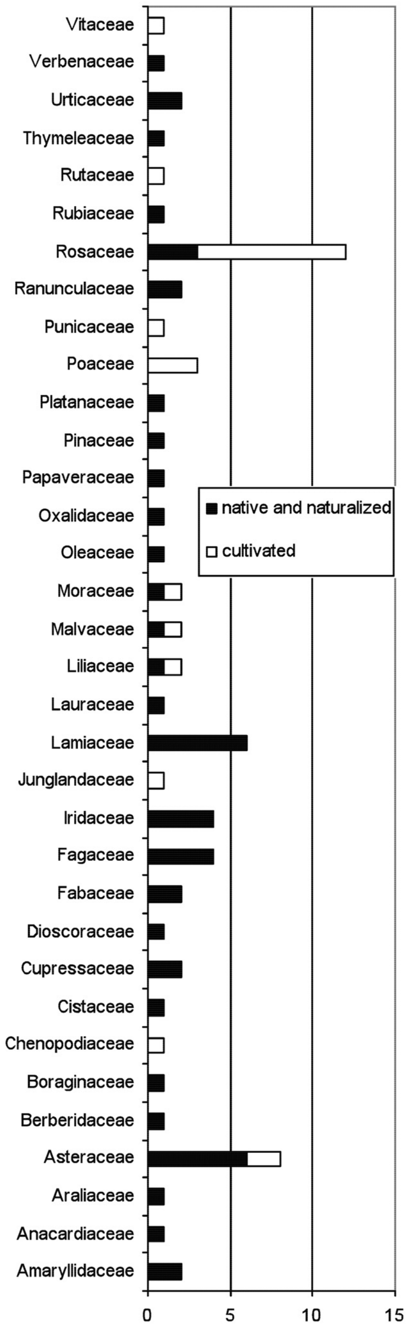

Fig. 3. Representation of families of plant sources of tannins and dyestuff, with number of species in each family.

The pharmacological properties of food plants are widely recognized in many cultures and Johns (1990) suggested that pharmacologically active phytochemicals may have been deliberately included in the traditional diet.

Approximately 700 mentions by vernacular names were received during the interviews on materials including tannins and dyestuff, wood for timber and carved wood, fibers for basketry, weaving, plaiting, and stuffing, musical instruments, gums and resins, toys and jewels (Table 3). These correspond to 175 native, naturalised and cultivated plants. Out of these plants, the most numerous group of these are the plant species that are known as sources of tannins and dyestuff. These include 73 species belonging to 34 families, the most important being Rosaceae making 16% of the whole, although the majority are cultivated (Skoula and Sarpaki, 2005). Others are Asteraceae comprising up to 11%, Lamiaceae 8%, Fagaceae and Iridaceae 5% respectively (Figure 3). Dyeing is applied on mainly textiles, such as silk, wool, linen and cotton (71 species), but also on Easter eggs (6 species) and on body decoration, such as hair dyes (11 species) and rouge for the face (2 species). The colours obtained by plants are mainly yellow and brown, but also red, green, purple and black (Table 5). Furthermore, 36 species, mostly trees, were used for woodcut objects such as spoons, boxes, furniture, walking-sticks, agricultural tools; Some 25 plant species, mostly Poaceae, were used for their fibres for baskets, ropes, chairs, hats, mattresses, cushions, saddles, brooms Nine (9) species, usually bulbs, were known to be used for glues; Eleven (11) were used for musical instruments, and finally five (5) species were known to be used for toys.

In total 332 species were reported as used, from which 280 are native, 16 are naturalized and 36 are cultivated. Even though the great majority of the plant species that are used are rather common, there are 14 species endemic to Crete representing 10% of the total Cretan endemic flora, some of which are legally protected. These are*: Allium bourgeaui* Rech.f. subsp. c*reticum* Bothmer, *Pimpinella tragium* Vill. subsp. *depressa* (DC.) Tutin, *Centaurea idea* Bois & Heldr., *Centaurea raphanina* subsp. *saxatilis* (K.Ooch) Greuter, *Onopordum bracteatum* Bois.& Heldr. subsp. *creticum, Campanula pelviformis* Lam., *Petromarula pinnata* (L.) A.DC., *Origanum dictamnus* L., *Origanum microphyllum* (Benth.) Vogel., *Phlomis lanata* Willd., *Satureja cretica* (L.) Briq,, *Sideritis syriaca* L. subp. *syriaca*, *Zelkova abelicea* (Lam.) Boiss. Although the study did not cover the whole island, and more information is yet to be collected, the number of reported used species represent ca. 20% of the Cretan flora. (Turland & al. 1993; Chilton and Turland 1997; Chilton & Turland 2007).

Nowadays, the intensive application of herbicides in vineyards and olive groves, has reduced the diversity of wild species in favour of invasive alien plants that tend to form monocultures. Therefore, the luxury of days gone by where just walking in the open air to collect the “greens” for the day is not an available option any more. In addition, lately, a new wild plant food market is thriving in Crete in a most unsustainable manner. Plants are systematically uprooted and/or are not allowed the chance to flower and set seed, and are sold, mostly, in the local market as greens, spices, herbal infusions and cut flowers for ornaments. Although an effort is made to cultivate wild plant species, the appetite for purely wild, pesticide-free edible species is rising and depleting the natural plant resources.

One of the unfortunate outcomes of the present study is the realization of the very rapid loss of knowledge amongst country and urban Cretan populations. Furthermore, there

Table 5. Material types that different plants are used for.

Types of materials	**No of species**
Tannins and dyestuff	73
Wood (timber and carved wood)	36
Fibers (basketry, weaving, plaiting, stuffing)	25
Musical instruments	11
Gums and resins	9
Toys	5
Jewels	2
Total	**175**

Table 6. Colours obtained from plants.

Colours produced	**No of species**
black	8
brown	30
yellow	42
green	8
red	13
purple	6

seems to be a confusion of the information among interviewees, demonstrating that traditional knowledge related to plant uses has already started to, dangerously, erode. For example, people, often remembered a vernacular plant name and a corresponding property, however, at times, they were unable to identify the plant. In other cases, people identified a plant as medicinal, but were unable to give further details about how to apply it.

Cultural heritage is deposited in human mind and is automatically inherited from one generation to the next. It is shared within a community, performed collectively; and is the cohesive factor which binds a community and gives it a sense of identity. Underlying this transmitted knowledge, is a sense of respect for the environment, especially for what it provides to the community at large.

Today, however this heritage is in danger of disappearing because of globalization, lack of means, lack of appreciation, and lack of interest among the younger generation. The systematic documentation of ethobotanical information is urgent in the whole Mediterranean area as well as passing it on, to the next generation.

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