BOCCONEA– 28

Proceedings of the Meeting
Botany at the intersection of Nature, Culture, Art and Sciences

Dedicated to Werner Greuter on the occasion of his 80th birthday

Archaeological Park, Selinunte (Sicily), 28-30 June 2018

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Presentation

What initially could have been a simple opportunity to bring together the top of Mediterranean botany in a symbolic site, rich in history and memories, like that of Selinunte, turned out to be a good opportunity to present and discuss not only systematic and biogeographical topics but also themes closely related to the nature and landscape of archaeological areas. This topic, in general, is often undervalued and mostly neglected because mainly the historic and archaeological aspects are discussed in these places, as if the context was secondary, while it is not only essential but, most of the time, it was the origin of the choice of the place where founding a city, a colony. Reconsidering the approach to the study of an archaeological site, mostly in a place as Selinunte, one of the greatest ancient cities and, in spite of its peculiar ruins, today among the sites that, better than others, save this close connection between nature and artifice, must be the beginning of a new trip towards Knowledge, aiming at all the elements that well characterize this place. I think that this one can be the opportunity for a new reading of the context and of the wonderful relicts of the primordial landscape which still survive and which are waiting to be revealed yet, hoping in a new impulse for this kind of study. Therefore an important occasion also for the Park that in two days of intense scientific work has been able to record a qualified presence of scholars of different nationalities. The botany declined according to the problems suggested by the hosting context was therefore a useful occasion for guests and for the host location.

Combining culture, nature, art and science together is not an everyday thing. Trying to do it in a historical context like the one offered by the archaeological site of Selinunte has been a unique occasion of its kind.

As director of the regional archeological Park, I am grateful to OPTIMA to have chosen to organize a special and focused scientific meeting in Selinunte, Sicily. The Symposium, which was convinced of its support, was also an unrepeatable opportunity to show and discuss the problems of landscape recovery in the Park area; at the same time a propitious circumstance to present to the scientific community the results of the studies started on its botanical heritage conducted in collaboration with botanists of the University of Palermo; qualified moment of results verification of the interventions of recovery and redevelopment of the host landscape site - carried out since 1975 - following an approach then recommended to the Superintendent former, professor Vincenzo Tusa, from the botanists Di Martino and Raimondo. I am particularly grateful to him to have continued to direct and advise on the path to follow both to extend the landscape redevelopment project to the entire archaeological area, and also for giving us greater awareness of the floristic and vegetational heritage present within it. Our friend Franco Maria Raimondo deserves further thanks for the qualified opportunities and for the scientific support given to this Direction when it was necessary to solve the problems, even in a legal way, of an inappropriate use of the territory of the Park not always dictated by legitimacy and not always endorsed by past administration actions based on impartiality and transparency.

It is my duty here to thank all those present at the Symposium, some of whom have seats far from our Island, and all the institutions and those who have made it possible to host the participated scientific meeting in the ancient city of Selinunte and, today, to publish and disseminate the relevant scientific contributions. Among these, I thank in particular the Regional Administration of Cultural Heritage and Sicilian Identity for having granted the necessary resources. Finally, let me give a grateful thought to our Councilor, Professor Sebastiano Tusa, for his willingness and for the attention he has always given to Selinunte and for having kindly – as he always uses - conveyed the greetings of the entire Regional Government at the Symposium.

Selinunte, July 2018

Enrico Caruso
Director of the Archaeological Park of Selinunte and Cave di Cusa
Interim Superintendent of the Cultural and Environmental Heritage of Trapani

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Introduction

The scientific meeting for which the Proceedings are published in this volume 28 of Bocconea was not organized by mere chance. It was designed as an appropriate way to celebrate the 80th anniversary of Professor Werner Greuter, tireless protagonist of OPTIMA and key figure in Mediterranean, European and, by certain of his skills, indeed world botany. The suitable opportunity of organizing the meeting, some months later than the actual date of the birthday (intervened on 27 February 2018), came about in Palermo, at OPTIMA's operational headquarters, seat of its Presidency and Secretariat. It is generally known that Professor Greuter, at the end of his long scientific activity and demanding administrative leadership in prestigious European research institutions in Geneva, Athens and Berlin, even before his academic commitment in Germany came to an end, elected Palermo in Sicily as his permanent residence, considering it as the capital city of Mediterranean botany. He indeed transferred to Sicily his whole, sizeable scientific heritage, formed of his books and plant collections, with a view to help implementing the OPTIMA-sponsored project of a large international herbarium, to be built in the Sicilian capital and devoted to the botanical study of the Mediterranean countries. During seven terms of mandate as secretary or president of OPTIMA, he remained in the lead of this organization, that he himself had founded in 1974 together with Vernon H. Heywood (Reading), Hans Rhunemark (Lund), and Guido Moggi (Florence), for the initial four decades of its existence, spending his best energies to give the scientific community interested in the phytotaxonomic investigation of the Mediterranean area the much-needed common platform for communication and the basic cognitive tools. Strong also of his previous experience of research on the flora of Crete, and of Greece in general, he always had a predilection for the flora of the Mediterranean biogeographic region and devoted to it much of his greatest commitment, summarized in the substantial and complex work "Med-Checklist", to the conclusion of which only the two final volumes are missing.

It seemed therefore dutiful to us to seize the fortunate opportunity of his anniversary to assemble the scientific community connected with OPTIMA around the charismatic figure of Werner Greuter. For that event we chose the archaeological site of Selinunte, the ancient Selinus, one of the most extensive Hellenistic monuments extant in Sicily; and, most appropriate for that scenery and the event itself, we chose for its general theme: "Botany at the intersection of Nature, Culture, Art and Science".

The idea of organizing a symposium dedicated to exploring the connecting links between nature, culture, art and science – meaning, botany – around the Mediterranean could find no better stage than the spectacular, mythical archaeological area of Selinunte.

Enrico Caruso, Director of the Selinunte and Cave di Cusa Archaeological Park, readily declared himself available as supporter of the idea. We were privileged to receive the moral and financial support of the esteemed Regional Councilor, professor Sebastiano Tusa, whose premature, tragic death we sadly deplore and who remains present in our memory for his great competence, culture and uncommon generosity.

The two-day Symposium was also sponsored by the Section of Botany and Plant Ecology of the STEBICEF Department of the University of Palermo and received substantial support from the Selinunte and Cave di Cusa Archaeological Park, the International Foundation Pro Herbario Mediterraneo, and the Foundation Herbarium Greuter. The scientific programme comprised four sessions with invited speakers, plus a poster session. About one hundred scholars from many countries, young and old, were in attendance, including the authors of reports, lectures, and posters.

Some of the papers assembled in this proceedings volume have been published in advance in Flora Mediterranea, volumes 28 (2018) and 29 (2019). Also included here are texts contributed, as a testimony of esteem, by some of professor Greuter's friends who were unable to be present at the meeting.

Palermo, July 2019

Francesco Maria Raimondo
President of OPTIMA

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Enrico Caruso

Archaeological Landscape of the "Punic Epicracy" of Sicily

Abstract

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Since most ancient times, rarely a land had as many different populations and cultures as Sicily.
The eastern part of the Island was inhabited by Sicels, who had moved native people, the Sicanians, westwards, where Elymians already settled in the cities of Erice, Segesta, Iato and Entella. Sicilian coasts were frequented by Phoenician merchants who, during Greek establishment in the East, firmly settled in three cities quoted by Thucydides: Motya, Panormus and Solunto.
The Greeks conquered the eastern coasts and then the northern and southern ones as well starting their hegemony on almost all Sicily.
This expansion pushed Carthage to strongly settle in the Island and slowly, though unavoidable, to build a kingdom, called Eparchy, which led to the foundation of Lilybaeum, a new defense city close to Motya.
The urban landscape of the Eparchy cities was characterized by a strong penetration with the territory, for the choice of the sites placed on flat peaks of isolated mountains or integrated with the sea. Phoenician cities were placed on islands, such as Motya, or on promontories, such as Panormus, and Solunto. Elymian cities, on the contrary, were placed on suggestive mountains, such as Iaitas, Segesta, Entella and Erice.
The capital of the Carthaginian Eparchy, Lilybaeum was characterized by the most complex defensive works in the ancient times.
The last actions of the possession of Punic Eparchy were the foundation dated 260 B.C. of Drepanon and the deportation of Erice inhabitants and the people exodus from Selinunte to Lilybaeum, where a new residential area was created. The Carthaginian domination in Sicily, was terminated by Romans' arrival, who conquered the Island after the Egades battle in 241 B.C.

Key words: Western Sicily, Carthaginians, urban settlements.

Genesis of the Punic Epicracy

With the destruction of Selinus in 409 BCE by the Carthaginians, who arrived in Sicily to bring aid to the Elymians in Segesta, and with the subsequent destruction of Motya in 397 BCE by Dionysius I of Syracuse, the decision to take a less neutral and more active stance to exert control over Sicily matured definitively in the city of Carthage. The first step taken was to abandon Phoenician Motya to its fate, as it had proven to be indefensible because of its insular position in the light of the new tactics of war, and to found a

Carthaginian stronghold on the western tip of the island, namely Lilybaeum. This city was strongly fortified and was able to play a leading role in the western part of Sicily for defensive and offensive purposes and, last but not least, for trade. The foundation of Lilybaeum can be dated around 396 BCE and, under full Carthaginian control and with a far-reaching plan, the city set out to take over the surrounding territory. This territorial control became increasingly clear when the peace treaty between Carthage and Dionysius I in 374 BCE acknowledged that Carthage’s supremacy over Western Sicily was a matter of fact and that the Punic Eparchy was a reality that would come to an end only with the Roman conquest of Sicily. With their victory of the Aegates Islands battle in 241 BCE, which marked the end of the hostilities in the First Punic War, the Romans conquered almost all of Sicily with the exception of the Hieron’s reign, tyrant of Syracuse: just thirty years later, with the end of the Second Punic War hostilities, in 211 BCE, the entire island of Sicily was completely under Roman rule, thus changing the course of its history.

The urban landscape in the Punic Epicracy in Sicily

The time from the eighth century BCE to the arrival of the Romans saw the consolidation of the system of Sicily’s most important cities, most of which still retain their preeminence today. Almost all the main cities of modern-day Sicily, indeed, the most populous cities, have ancient roots and date from this period. There are 40 main urban centers such as Palermo, Catania, Messina, Syracuse, Agrigento, Trapani, Marsala, Enna, etc. Most were founded along the coasts of the island during the long years of Greek colonisation of eastern Sicily. In southern and northern Sicily, however, the island’s westernmost Greek settlements were two outposts: Selinus and Himera. Both were destroyed in 409 BCE by Carthage. The other cities in the west are of Phoenician and Punic origin, such as Panormus (Palermo), Lilybeum (Marsala) and Drepanon (Trapani). There are instead about 140 more towns, including Caltanissetta, the only provincial capital, founded mostly in the Middle Ages, on high ground, some of which date from the Islamic period.

Among the ancient cities, some were destroyed and never rebuilt after bloody battles that marked their end and abandonment, including Motya, in 397 BCE. Selinus, however, was evacuated in 250 BCE when the Carthaginians deported the inhabitants to Lilybaeum (but the discovery of the early Christian baptistery of the fifth century CE, of certain Byzantine origin, suggests a different occupation of the site even after its abandonment and at least until the Middle Ages).

The cities present in the Punic Eparchy, founded in the archaic age, include the most ancient Phoenician colonies, such as Motya, Panormus and Soluntum (Thucydides, VI 2,6).

Alongside them, the Elymian cities of Eryx and Segesta lived and prospered, while Selinus was the westernmost of the Greek cities that later merged into the Carthaginian kingdom. Among the new cities founded by Carthage to ensure physical control of the territory, the most important was Lilybaeum but, over a century later the Carthaginians, in particular General Hamilcar Barca, in attempt to save the Eryx’s inhabitants and to protect them from the Romans conquest, founded the city of *Drepanon* among the many islands that bordered the slopes of Mount Erice at sea. Other cities, such as archaic Soluntum, were abandoned.

The Phoenician colony of Motya was built in the 8th century BCE in the Stagnone lagoon of Marsala (Fig. 1), a city whose archaic layout was based on blocks freely distributed within the walls perimeter that bordered the coast. The urban layout was very similar to that of the city of Kerkuane, another Phoenician city in Africa, built on Cape Bon. Many elements of the urban structure of Motya characterise several Phoenician cities, such as Cothon, traditionally intended as a port basin for small boats within the island, and now considered a lustral basin at service of Cothon's Temple, dedicated to Baal Hammon. The houses in Motya were typical of the residential structure of the Phoenician East, although some elements found within them show how its inhabitants were influenced by the prevailing Greek culture of the eastern part of Sicily. Equally ancient was the Phoenician colony of Panormus (Palermo). However, its layout responded to a more rational urbanisation, based on a *plateia* (wide road) running from east to west on which a series of narrow and elongated blocks, designed by *stenopoi* (narrow streets), running very close and parallel to each other, were organised at right angles. The map of the walled city of contemporary Palermo (Fig. 2) still bear clear signs of this original core as the heart of the city that expanded according to a medieval plan resulting from the transformations made under the Arabs and later by all the other conquerors who followed, thus making it an increasingly important urban settlement and becoming the capital of Sicily under Arab rule. The city retained this role under all the following rulers of Sicily after the year one thousand.

Fig. 1. *Island of San Pantaleo (Mozia)*. From Rooms and lands of the Palermo's College properties, ms. 181, f.37, Fardelliana municipal Library of Trapani.

Fig. 2. Palermo (Panormo) - in red the Phoenician city (graphic elaboration of Giulio Caruso from: Casamento & al. (1984: tav. 13)

Selinus was, instead, a Greek city founded in western Sicily - inhabited by Elymians, Sicans and Phoenicians - by Megara Hyblaea, a colony in turn founded on the Ionian coast by Megara Nysea, located on the isthmus of Corinth. Megara, in fact, had sent its inhabitants to found *apoikie* (city-colonies) both in the east and west, like Byzantium on the Bosphorus and, in Sicily, Megara, which added Hyblaea to the name of the mother city, in honour of the Sikelian King Hyblo, who had given the Megarians the land on which to found the new city. After only three generations, around 650 or 628 BCE, its inhabitants, together with Megarian settlers who had arrived from Greece, decided to found Selinus on the other side of Sicily, in an area already inhabited and perhaps hostile. But the city was able to live in peace, engaging in profitable trade with these foreign civilisations that were already living in the western part of the island and with which relations made it possible to hellenize their customs to the point that the inhabitants went on to take on names, the art of writing and manners typical of the Greeks.

An offshoot of two Megaras, Selinus was an immense city, covering over 112 hectares with outer walls stretching over 4.5 km (Caruso [in press (b)]) (Fig. 3). From the beginning, it stood on a series of hills running from north to south with two watercourses on both sides, to the east and west, i.e., Gorgo Cottone and the river Modione, called Selinus in

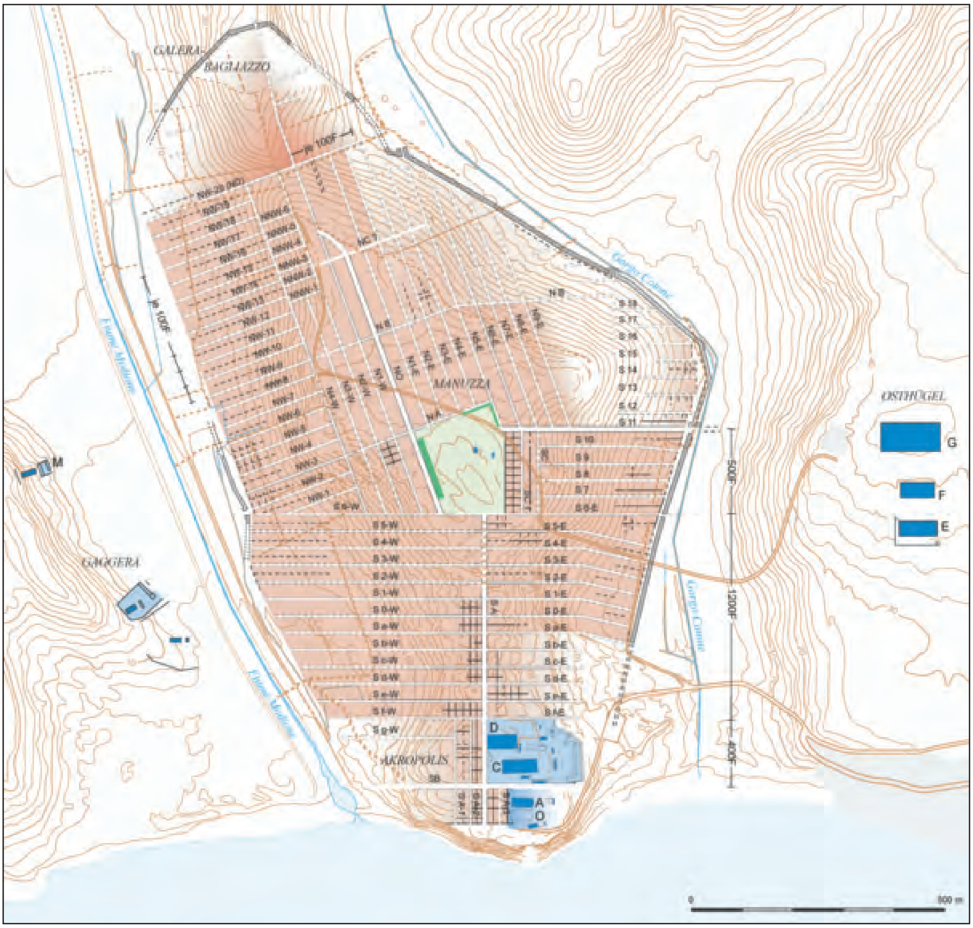

Fig. 3. Selinunte: urban plant. The worship places in blue (from Mertens 2006: fig. 303).

ancient times for the presence of wild *Apium* (celery/parsley) that the Greeks called *selinon*, and that gave the name to the city.

It was magnificent (Fig. 4), surrounded by walls along the two watercourses and with a system of very elongated east-west blocks, aligned along the *stenopoi* (secondary roads) running orthogonal to the main *plateiai* (wide roads) arranged according to the median axes of the north and south hills (Mertens 2010b: 95-99). These met ideally in the agora, the city's trapeze-shaped square - similar in design to Megara Hyblaea's main square. It was over thirty thousand square metres (Mertens 2010b: 99-106). The city's skyline was marked by the presence of enormous religious temple structures that rose to south, in the area dedicated to the city's cults, dominated by Apollo Temple, one of the first and largest archaic peripteral Doric temples erected in Sicily (Mertens 2010a: 70-73). It is surrounded by other proto-Doric temples and small sanctuaries. Another 3 temples, designated by let-

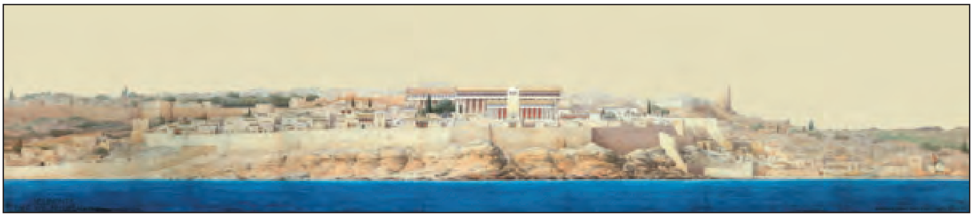

Fig. 4. Sélinonte. Face Sud. Restauration. From Hulot & Fougères (1910: tav. XIII).

ters of the alphabet E (Hera), F (Athena or Dionysus) and G (Zeus Olympius), had been erected outside the walls, on the eastern hill, among which emerged the Temple G, the second largest among the Greek temples built in antiquity. In the west, instead, there were numerous sanctuaries, more modest in size but among the most beloved by the Greek population who went there to pay homage to cults that were practiced there. These cults were also very popular with the indigenous peoples who adopted the Greek deities who were venerated there. These deities had intriguing names such as *Malophoros, Ekate, Zeus Meilichios, Hera Matronale*, each with a *temenos* (enclosure) where the rites were officiated. And in this part of the city, the evolution of the archaic *megaron* temple (Mertens 2010a: 64-67) was experimented with and followed through, as in the case of *Molophoros* (bearer of fruits, probably Demeter), whose archaic proto-Doric temple could be accessed through the *propylaea* (monumental entrance) (Mertens 2010a: 90-92) next to which was the pilgrims’ portico, where the faithful were sheltered from the sun or rain, waiting for the temple to open.

This city that traded with neighboring peoples and produced wheat and ceramic items among the most popular in the ancient world, was rich and had such a vast territory (the *chora*) that also included three important towns such as *Mazaris* (now Mazara del Vallo), *Adranon* (Mount Adranone-Sambuca di Sicilia) and *Heraclea Minoa*, the latter founded east of Selinus already in the sixth century BCE beyond the river Platani, guarding the border with the mighty polis of *Akragas* (Agrigento). Despite the vastness of the territory under its control and the attacks of the city of Akragas that for a certain period even succeeded in conquering Heraclea Minoa, Selinus was constantly warring with the nearby Elymian city of Segesta, with the aim of winning the lands along the borders of the two cities. This effort was so dogged that the people of Segesta finally called for Carthage’s aid, obtaining it.

In 409 BCE a mighty army landed in Sicily, in the very place where only fifteen years later the city of Lilybaeum would rise, besieged Selinus and after just ten days conquered and destroyed it (Diodorus XIII 43). Immediately afterwards the army headed towards the other large Greek colony on the border with the Punic Phoenician world, Himera, and destroyed that city as well. It would not be rebuilt until 2-3 years later on a new site, under the name of *Thermai Himeraíai* (Diodorus XIII 79, 8). Selinus, on the other hand, was rebuilt only in the southern part of the ancient city (Fig. 5), where the city’s temples stood. But it would be a town of modest size, having gone from the initial 112 to 12 hectares of land, with fortifications of only 2.5 km compared to the original 4.5 km. The city, now firmly in Punic hands while maintaining a strong Greek identity, was ultimately abandoned when, in 250 BCE, the

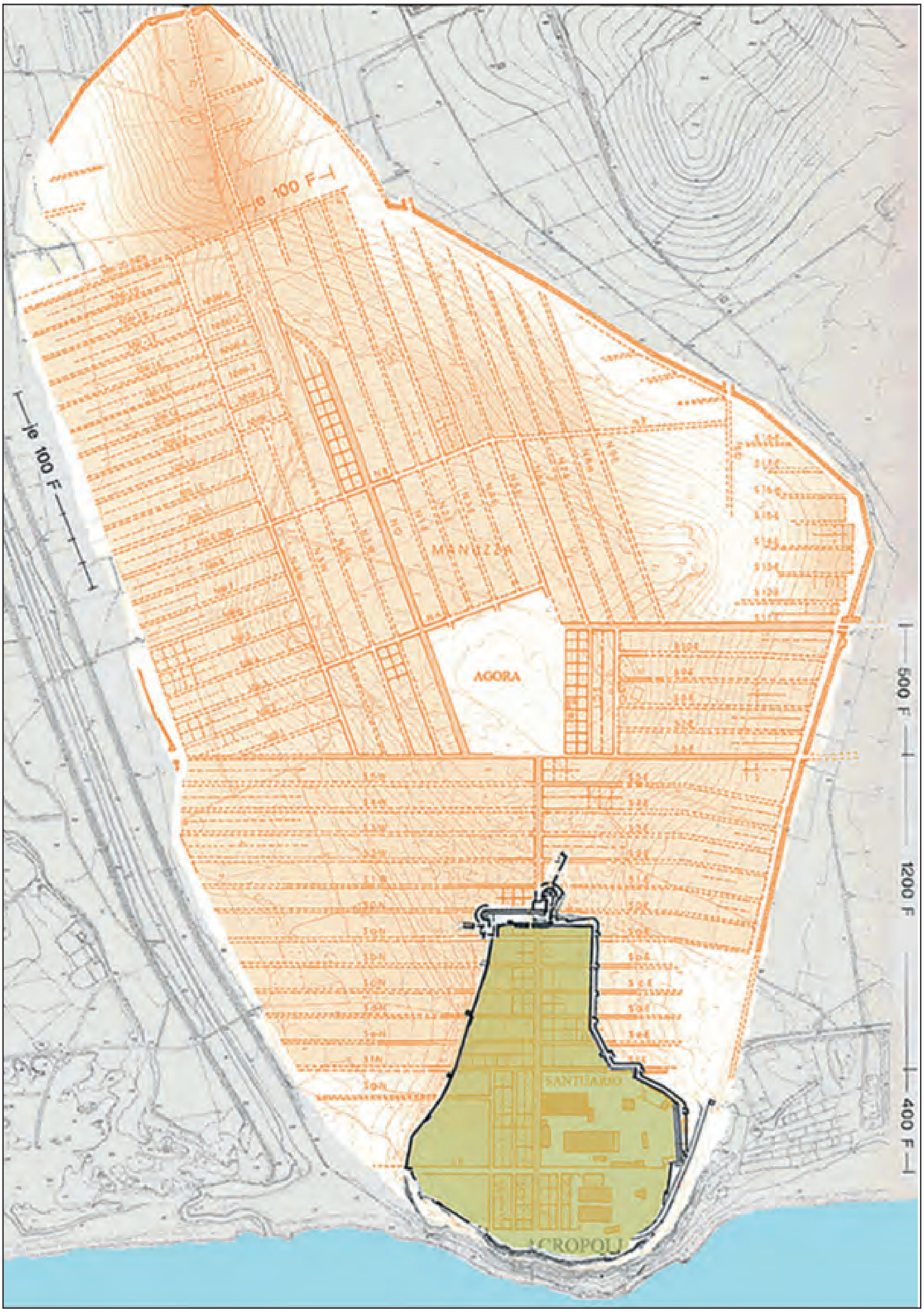

Fig. 5. Selinunte: the Hellenistic city related to the archaic city. From Caruso & Fourmont (2017: fig. 33).

Punics deported the inhabitants to Lilybaeum, settled in a new neighborhood, built for the occasion in the north-western part of the city (Caruso 2017: 109-111; 2019b: 14).

The fourth century BCE was marked by great ferment and saw the construction of new cities, as in the case of Soluntum, a coastal site of Phoenician origin, whose inhabitants sought refuge from the peninsula of Solanto where it was originally located high up on Mount Catalfano (Coarelli 1992: 33).

The city built there is placed on top of the hill according to a plan among the most modern of its times, with large 1 × 2-metre blocks arranged on the slopes thus creating that particularly original type of Hellenistic city whose urban landscape follows the sloping terrain, with houses that are arranged on two floors, taking advantage of the steep slope and thus creating degrading terraces that afforded a magnificent landscape, suspended over the sea.

But the most important and challenging urban settlement founded in Sicily, as already mentioned, was the one built directly by Carthage to set up a military and political garrison aimed at controlling the vast territory of the nascent Eparchy, as it was in fact being shaped at the beginning of the fourth century BCE and that would become absolute and recognised by the peace treaty of 374 BCE, namely Lilybaeum. The first city founded by Carthage was almost certainly planned by General Himilco in 396 BCE, before his departure to eastern Sicily where he was set on taking the offensive against Syracuse, guilty of having destroyed Motya. Himilco went on to besiege it and almost conquered it if there had not been a plague that decimated his army, forcing him to come to terms with Dionysius I, losing in fact that advantage with which he wanted to return to Carthage appearing before his fellow citizens both as the winner of the Sikeliot Greeks and as founder of the city, events that would have allowed him to be named King (Caruso 2019: 457-458).

Lilybaeum (Fig. 6) is a city that has many similarities with Carthage, which certainly served as a model for its construction: the urban layout orientation and some elements such as the Tophet (Caruso 2000: 234-240) position, south of the city and not north of it as in Motya, where they worshipped Baal Hammon, as in Tyre, the city of origin of the Phoenicians, and not Tanit, the goddess worshipped in Carthage whose cult is clearly attested instead in the tophet of Lilybaeum. The city has a *strigas* plan, that is with regular blocks with a ratio of 1: 3 or 1: $3^1/_3$ set on no less than 6 *plateiai* and at least 23 *stenopoi*, running orthogonal to the former. The plan follows the contour and slopes, thus explaining their orientation even for the normal drainage of surface water. However, this regular plan had exceptions in the northern part of the city where the blocks were arranged parallel to the *plateiai* as opposed to most of the blocks arranged orthogonally to the main streets. A first hypothesis based on the observation of these plans variations (Caruso 2003: 154-157, 2008: 77-79) together with the study of some archaeological assays that dated the first settlement in this part of the city to the third century BCE, has led us to believe that this part was built at the time of the Selinuntines arrival in Lilybaeum, an event that occurred in 250 BCE. Recent research, carried out at the time of the Museum reorganisation to renew its exhibitions allowed the (re)discovery of three fragments of tiles found in 1972 and never studied and/or displayed, which bear the mark of the "*selinon*," namely the symbol that identified the Selinuntines who had adopted it on their coins since the archaic age, impressed in the clay before firing. This shows that this was the Selinuntine district and that the city had a complex urban genesis, the study of which will provide further ideas to better define it.

Fig. 6. Lilibeo: the urban layout. From Caruso & Spanò Giammellaro (2008: fig. 4).

Fig. 7. Lilibeo: the Punic fortifications. From Caruso & Spanò Giammellaro (2008: fig. 5).

In the south of the city was the agora, built not far from the tophet and, perhaps, near the southern port if this was, as the current city of Marsala, located to the south, just like in Carthage (Caruso 2019: 457).

Originally designed as a fortress, Lilybaeum (Fig. 7) was a city built to withstand any kind of siege, with walls almost 6 meters thick, no less than 30 metres from the inner edge of the moat, which was also originally no less than 20 metres wide and then probably expanded to 30 metres. The walls on the two sides of land that bent forming a right angle at the highest point - which is now about 25 metres above sea level - were no less than 2.2 km long, with a perimeter wall whose total length was probably no less than 3.5 km. They were about 12 metres tall; marked by circular battlements like those in Motya (Ciasca 1992: 80, 1993: 30) and Carthage (Rakob 1985: fig. 17), they had towers about 14 × 14 metres wide, placed at a regular distance of 38 metres from each other to form a rudimentary structure, creating an infallible system capable of launching very heavy stones with catapults at considerable distances, placed at right angles to the line of defence. From the towers, about 18 metres tall, the catapults could throw stones at the attackers even further away from the walls, from a higher position and in radial directions, varying by 180 degrees, creating a system of deadly crossfire with an offensive force and destructive power that were really difficult to sustain. In addition to this system, in itself complex and unique in Sicily, and not only, there was yet another particularly relevant weapon of defense consisting of underground tunnels typical of the Punic world, which, passing under the moat, allowed the besieged to attack enemies from the rear or to try skirmishes to destroy their war machines, usually made of wood, that the besiegers devised to seize the walls and gates of the city with the help of rams and tortoises.

According to sources, Lilybaeum was sieged at least five times without ever being conquered: in 368 BCE by Dionysus I of Syracuse (Diodorus XV 73, 2; Caruso 2006: 291, [in press (a)]), in 340 BCE by Timoleon (Plutarch, Life of Timoleon, 25) and in 278 BC by Pyrrhus, King of Epirus, who during his expedition to Sicily left the island after the useless siege of Lilybaeum (Diodorus XXII 10, 5), the only city not to fall into his hands, and returned to Italy, and from there to Epirus, without obtaining any advantage for his kingdom. During the long years of the Roman conquest (Diodorus XXIV 1, 1), the city was surrounded by more than ten years of unsuccessful siege, finally being surrendered to Rome as a result of the peace treaty following the Battle of the Aegates Islands in 241 BCE. The Roman offensive in the Third Punic War started from Lilybaeum, with the ships anchored in the port before crossing the Sicilian Channel, which led to the destruction of Carthage. In the second Servile Wars (103-98 BC), the rebel Athenion dared to besiege the “impregnable Lilybaeum” in vain (Diodorus XXXVI 5, 1). This concluded the series of inconclusive attempts to conquer the fortified city, which only returned in vogue at the end of the first century BCE during the war between Octavian and Sextus Pompey. A plaque from 39-36 BCE, kept at the Lilibeo Museum in Baglio Anselmi, shows that its defences were clearly reinforced, after at least a century of neglect, with the restoration of the gate and the walls by Lucius Pliny Rufus, Pompey’s legate. But this concerns the last restoration of a fortified structure that soon became useless when the Roman Pax definitively led to the abandonment of its once mighty ramparts.

In the late Roman age, the city was enriched with Italic houses. The vast *domus* of Cape Boeo features large mosaic surfaces on floors and spas, these too embellished with beautiful mosaics depicting hunting animals, as in the case of the *frigidarium* of the spa where four different beasts attack four different quadrupeds.

But there is, finally, another piece of puzzle to understand the strength of Carthage’s intervention at the western tip of Sicily, the territory of the Punic Eparchy. At the Romans arrival, the Punics barricaded themselves in two particular points: Lilybaeum and Eryx. But General Hamilcar Barca, who was tasked with leading the defense of the Carthaginian territory, in addition to Lilybaeum and Palermo, decided that the defense of Eryx (Caruso [in press (a)]), at the top of the mountain was difficult to sustain because it took very little to starve the city, since it was enough to surround the mountain at the base to prevent the food and water needed to sustain a long siege from reaching the top. The Carthaginian General Hamilcar Barca decided to leave Eryx moving the inhabitants down from the mountain, to a site located near the sea where several islets barely emerging from the waters were distributed in a lagoon where the bends of the coast formed a continuous series of sickle-shaped roadsteads, called *drepane*. The new city founded by the forebear of the Barca dynasty took its name from this system: *Drepanon* (Caruso 2019: 459-466). Built on an island and therefore easily accessible by Carthaginian ships thanks to the numerous navigable canals between the islands, the newly founded city had a more modern layout than the late classical 1:3 ratio of Lilybaeum. In Drepanon, the ratios of rectangular blocks were 1: 2, typical of Hellenistic town planning. Only a small part of this plan can still be traced in the north-western part of the urban layout of the ancient Casalicchio district, which corresponds to the original city. It has survived as a town with a long life spanning the Punic, Roman, Byzantine, Islamic and Norman ages. Then, in the Middle Ages, the city doubled its original size thanks to the intervention of King James I (Caruso 2019: 460, fig. 10).

The urban layout of Drepanon (Fig. 8) was based on a system of orthogonal streets with 6-metre-wide *plateiai*, arranged almost with an east-west alignment, and with orthogonal *stenopoi* between 3 and 4 metres wide creating blocks measuring 25 metres × 50-55 metres. The necropolis was outside in the north-western part of the ancient city, now occupied by the City Hall, the Post Office, the Provincial Offices and Prefecture and, finally, the Police Headquarters.

Fig. 8. Drepanon: hypothesis of the city plannning (blue), the walls route (red) and the Punic necropolis (yellow). From Caruso (2019a: fig. 15).

With this revolutionary gesture, with the foundation of Drepanon and the relocation of the inhabitants from Eryx, as happened before to the Selinuntines deported to Lilybaeum, the Punic Eparchy tried in vain to resist the Roman offensive that now aimed at the total conquest of Sicily, which was achieved after 241 BCE, with the victory of the Aegates Islands Battle: the Roman fleet defeated the Punic fleet and, with the peace treaty that followed, Sicily became the first Roman province.

The resulting landscape was one of several towns that would become ever more famous and richer following the conquest of Africa by the Romans. They would go on to become part of a lively *koinè* based on trade with Africa, establishing a continuous flow of trade and permanent commercial relations as well as cultural and human exchanges between the shores of Sicily and Africa. These relations were bound to thrive over the centuries to the point of characterising the life of the Sicilian Channel as a place of uninterrupted passage from one shore to another of goods and, above all, of people up to this very day.

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G. Pambianchi, M. Materazzi & F. Pallotta

The geomorphological landscape of the archaeological park of Selinunte

Abstract

Pambianchi, G., Materazzi, M. & Pallotta, F.: The geomorphological landscape of the archaeological park of Selinunte. — Bocc. 28: 27-28. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: landscape evolution, photointerpretation, drones, sedimentology.

The research, still in progress, is aimed at the reconstruction of the landscape evolution (since early Holocene) in the area of the Archaeological Park of Selinunte. Through field surveys and indirect investigations, it is bringing a fundamental contribution to the knowledge of the natural and anthropic events that characterized the development of the Selinunte's civilization.

The research includes:

a) Geomorphological investigations and landscape evolution during historical times.
The use of Li.DAR images, aerial photos and field surveys allowed to reconstruct the ancient coast morphology, characterized by wide gulfs at the mouth of the major rivers and to hypothesize the existence of river channels favorable to navigability with small boats for long sectors inward.

b) Climate change and relationships with historical events.
The geomorphological analyses and the reconstruction of the paleoclimatic context allowed to hypothesize an arid-cold climatic phase in the period of maximum development of the Selinunte's civilization (between 6th and 4th centuries B.C.), which caused, as proven by historical sources, the formation of swampy and unhealthy areas with consequent spread of diseases and pestilences. In this regard, the same studies have also provided a hypothesis on type and location of the famous hydraulic work and reclamation work carried out by Empedocle in 444 BC. (described by Diogene Laerzio in the III century BC).

c) Geological and sedimentological investigations on building materials.
During the study, numerous rock samples were taken from the main mining areas and subjected to mineralogical-petrographic analyses. The results confirm age and compo-

sition of the materials constituting the geological bedrock and are allowing to correlate the different buildings with the areas of origin.

d) Hydrogeological investigations and studies on water resources availability.
The information gathered on the current water resource availability and hypotheses on the water demand in historical times, allowed to formulate some hypotheses on location, type and consistency of the springs in the period of maximum development of the Selinunte's civilization.

e) Indirect investigations: use of Unmanned Aerial Vehicle (UAV - drones) and geophysical prospecting

The use of drones equipped with photocameras and thermal cameras made it possible to highlight, on the whole area of the archaeological park the presence, on the ground or in the immediate subsoil, of numerous anomalies attributed to anthropic activities and presence of manufacts. These anomalies may be confirmed in the future and investigated through essays or excavation campaigns.

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Mary Taylor Simeti & Susan Pettee

The Garlands of the Gods. Wild Flowers from the Greek Ruins of Sicily

Abstract

Simeti, M. T. & Pettee, S.: The Garlands of the Gods. Wild Flowers from the Greek Ruins of Sicily. — Bocc. 28: 29-36. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

For visitors from Northern Europe making the Grand Tour during the 18th and 19th centuries, the encounter with the exuberant vegetation of Sicily had almost as great an impact, emotionally and aesthetically, as did the sight of the fallen temples of Magna Graecia. The average modern tourist tramps the excavation sites with little information offered that might enable him to share the experience of his predecessors.

Over twenty-five years in the making, and fruit of a collaboration between an American writer living in Sicily and an American botanical illustrator, the idea for "The Garlands of the Gods" has evolved from creating a simple tool for identifying the most common wildflowers growing among the ruins, to including a broader look at these plants in mythological, literary and historical terms, and a brief consideration of what the flower-decked remnants of the classical world meant to visitors over the last centuries.

The entire project was published in Palermo in December of 2018 as a light and easily transportable volume that examines some one hundred plants together with an introduction to seven of the most frequented sites. It is the hope of the authors that their efforts may eventually provide some small stimulus towards the establishment of a program for the promotion of botanical tourism.

Key words: grand tour, Sicilian flora, botanical tourism.

Introduction

I have been very honored by Professor Raimondo's invitation to present our project to the Selinunte Symposium and to have this presentation in the Acts. I have absolutely no claim to membership in such a distinguished group of botanical scientists, but belong, rather, to the long list of visitors from abroad who have become enamored of the beauty of the Sicilian flora. From Jean-Pierre Houel to Guy de Maupassant, from Johann Wolfgang von Goethe to Frances Elliot and Marianne North, travelers from northern climes have been astounded by the sheer exuberance of Sicilian vegetation, entranced by the aesthetic experience it offered, and increasingly drawn to romantic musings on the rapport between flowers and fallen temples.

My own initiation into this coterie took place right here in Selinunte, as I celebrated my first Easter in Sicily, over fifty years ago. Here I had sat, dumbfounded, on a bit of column, staring at ruined temples floating on a sea of many-colored blossoms. I was later to learn that the ancient Greeks thought it useless to hunt with dogs in the Sicilian spring, when the scent of the wildflowers would overpower that of the prey, but at this first encounter, it was I myself who was overwhelmed. The seed for the project that I am presenting to you here was planted then, I believe, but the idea of celebrating this marriage between Flora and the gods has been slow to mature: decades of false starts and abandoned notes passed before it began to find its proper form, and before I chanced to reconnect with Susan Pettee, a college classmate who unbeknownst to me had become a botanical artist.

For the past nine years Susan and I have been exploring Sicily's principal archeological sites and researching and painting the flowers growing there, those that we have found most beautiful, most eye-catching, or most interesting. Our intention was to produce a handbook for tourists, an agile tool for identifying the most common blossoms that the tourist would encounter when visiting the excavations. In our fieldwork we limited ourselves to seven of the most important and most visited of the classical sites: Segesta, Erice, Selinunte and the quarries at Cusa, Agrigento, Morgantina and Syracuse. Each of these is spectacularly beautiful, and each has its own botanical fascination: the giant fennel of Segesta, beloved by Goethe; the muted and resinous vegetation typical of the Mediterranean that proliferates at Selinunte and Cusa; the breathtaking variety of flowers - orchids, narcissus, hyacinths - that carpet Morgantina.

The research involved, the repeated visits with Susan to the sites at different seasons in the year, the hours spent first in libraries and then increasingly on the Internet, have taken us into unexpected quarters and posed novel questions. I began with the naive and uninformed notion that most of the flowers growing in Sicily today, especially those whose scientific names were derived from the characters of Greek mythology, were known to the classical world. I therefore expected that Greek poetry would be rich in quotable botanical allusions, but I was soon to discover that for the most part the classical poets draw upon a stock bouquet of roses, narcissus and hyacinths, and that even the exact identity of the plant they were referring to is still a matter for scholarly debate.

The Greek writers tended to restrict their attentions to plants that were useful, be it as ornament, as food or as medicine: Theophrastus, writing in the third century B.C.E., named five hundred in his *History of Plants*, but today there are more than three thousand different wildflowers growing in Sicily alone. Some were obviously too useless or too insignificant to gain a place on the classical page, but some of the eye-stoppers must—I thought—have arrived more recently.

It has become trite to refer to Sicily as a palimpsest, yet it is nonetheless an accurate metaphor, not only for the art and architecture but, I discovered, for the island's botany as well: each invasion, each conquering people have brought new fruits and flowers that have taken root in Sicily's fertile soil. The prickly pear, staple in time of famine and iconic in the eyes of many Sicilian graphic designers, was introduced from the New World in the sixteenth century, while the omnipresent and exuberant yellow sorrel, *Oxalis pes-caprae,* has only flourished here for two hundred years, a brief moment in the millennia of Sicilian history.

To understand more of the evolution of Sicilian flora I turned to those sources which had greatly helped me years ago when I was doing research on the history of Sicilian cui-

Fig.1. *Acanthus mollis* L.

Fig. 2. *Ferula communis* L.

Fig.3. a) *Ophrys lutea* Cav.; b) *Ophrys sphegodes* Mill., c) *Ophrys speculum* Link; d) *Ophrys biancae* (Tod.) Macch.

sine, the ladies and gentlemen who visited Sicily on the Grand Tour and wrote home describing what they had seen. These tourists of the 18th and 19th centuries were lavish in their praise of the island's exuberant vegetation: theirs was, in part, a northerner's genuine astonishment at the flamboyant generosity of the Mediterranean landscape, described by W.H. Bartlett as "the spontaneous prodigality of nature under the ripening sun of the south". In the later years, botanical curiosity becomes an expression of Romantic sensibility as well, an appreciation of what Ruskin called "the creatures whose office it is to abate the grief of ruin by their gentleness."

Fig.4. *Mandragora autumnalis* Bertol.

Some, enthralled by the vision of classical grandeur in decay, name only the more obvious plants, the almond trees that blossom about the temples of Agrigento or the dwarf palms that bristle throughout the ruins of Selinunte. Others note with surprise, and with occasionally uncertain identification, the cactus and the agaves and other Latin American imports that had run wild since their arrival with the Spanish *conquistadores*; still others methodically record a list of the wildflowers that grow so densely around the classical remains. The temper of their writings evolves through the decades, from the optimistic and almost light-hearted curiosity of the eighteenth-century travelers such as Houel or Goethe, to the judgmental and self-righteous prejudices of the late Victorians. Even within a narrow range of time, the tone of the diaries reflect their authors' personalities: the slightly oppressive note in Mrs. Frances Elliot's description of the flora in the Latomie of Syracuse echoes

Fig.5. *Laurus nobilis* L.

her conviction that the Sicilian people are born brigands, whose violent and lawless character is reflected with Lombrosian certitude in their dark coloring and sharp eyes, while Marianne North, a contemporary whose other writings reveal the imperialist racism of her time, describes the Sicilian people she encounters with the same detachment and delight that she spends upon the Sicilian vegetation.

The journey has been enriching, both intellectually and emotionally. Going back to the sites year after year and season after season brings both the satisfaction of instant recognition and the thrill of new discoveries. Although I cannot claim to have achieved more than a tenuous acquaintance with the science involved, I have greatly enjoyed the hours spent with the diaries of earlier visitors. There has been something very satisfying in learning that the same excitement and wonder that Susan and I have felt today at seeing the classical ruins garlanded with blossoms has been part of the Sicilian experience for almost three centuries.

Alas, this is rarely the case today. If the Grand Tourists, like most cultivated ladies and gentlemen of the 18th and 19th centuries, had some sketchy acquaintance with botany and could identify or at least make an informed guess at the flowers that girded the classical ruins, very few of today's tourists are so equipped. Specialized groups coming under the aegis of garden clubs and horticultural societies bring their own experts to guide them, but the average tourist tramps through the ruins with no botanical baggage, and no help offered. At present the powers that be assign no importance to the identification and the appreciation of the flora as a facet of the "Sicilian experience", and no information is available at the sites.

It is our hope that *The Garlands of the Gods* will make a contribution, however minor, to altering this situation. In book form, published by the Palermo University Press in December of 2018, it comprises some ninety-odd illustrations (five of which are reproduced here) dedicated to an individual flower or a set of related flowers, each accompanied by a short text providing a minimum of information necessary for identification, and a short paragraph of observations, and of classical or literary references where available. All the original illustrations are watercolor paintings by Susan Pettee. A special section is dedicated to the principal shrubs of the 'Mediterranean *macchia*', particularly evident in the archeological parks of Selinunte and Segesta. An introduction to the seven sites examined is integrated by a selection of descriptions taken from the accounts of the Grand Tour or from literary sources, as well as a sampling of 18th and 19th century drawings and engravings that show the classical sites as they appeared in the past.

A small number of the paintings by Susan Pettee that illustrate the book, and their accompanying texts, were exhibited at the Arnold Arboretum of Harvard University in May of 2017, and a larger exhibit was hung at Palermo's Orto Botanico in December, 2018. Five samples of these paintings accompany this paper.

It is by no means certain to what extent future visitors to Sicily will find the botanical wonders that we have been privileged to behold. Sicily's biodiversity is under siege, both from climate change and from the Sicilians themselves. The use of herbicides is increasing, not only in the fields and the vineyards, but in the archeological parks as well, a trend driven by the rising costs of maintenance.

Ideally we would like to be instrumental in initiating a discussion about botanical tourism. Numerous groups are already coming, although they pass under the radar; still more would come if they were better informed and better facilitated, a development that could be significant in incrementing tourism revenues. This might, in turn, bring the people of Sicily to realize that their flora has economic as well as aesthetic value, and that it is yet another facet of the immense patrimony which is theirs to cherish and preserve.

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Girolamo Cusimano

Growing up with trees. Autobiography of a research study*

Abstract

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Agricultural landscapes and fruit plants unmask, in a backward journey, the subjectivity of the researcher between space, culture and investigative reflection.

Key words: cultural geography, rural landscape, memory.

The opportunity

Yesterday

In June 2018, when my colleague Franco Maria Raimondo invited me to attend the Symposium "Botany at the intersection of Nature, Culture, Art and Science," I asked myself: "Why should I be there?".

The first immediate answer was the friendship that ties me to Franco Maria and our shared engagement to develop research in living territories and communities; and, moreover, the desire to tell about my long relationship with the farming world, its culture and the plants embodying the centuries-old process of harnessing Nature.

I also wanted to bear witness to a collective player who, under Professor Antonino Buttitta's guidance, who passed away a few months ago, had shared with me a huge effort of recording the traditional ergological cultures related to the agricultural world in Sicily.

It was an opportunity to bear witness to each and every colleague, whether mine or not, directly involved like me during the 1970's and 1980's in that challenging investigation work, but also to the farmers, the privileged witnesses who gave me an extraordinary lesson of knowledge and life.

The opportunity, the ancient Greek Καιρός, on which Aristotle dwelled at length in his Rhetoric, was a gift for me, i.e., to communicate and share a story of research and engagement which, I was sure, would have reached deep inside the hearts and minds of the audience, because every single story makes sense only in many people's actions and in

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*The text reproposes some parts of a lecture given during a cultural Geography meeting held in Trento in 2000.

research, a dimension which I believe is a fundamental ethical value.

Today

In the time of the written word, to submit what I had the opportunity to say on that occasion to the more durable memory of paper, I asked myself once again whether Καιρός, the opportunity, would offer me greater inspiration from having been there. Actually, since then, something changed in the world of the human ties belonging to a community: in Selinunte, on that day of June, Sebastiano Tusa too was present. He also attended, with all his talents, the kaleidoscopic integration of scientific perspectives and intuitions typical of events organized by Franco Maria.

Sebastiano is no longer among us today. He is one of the victims tragically involved in the air disaster happened in Ethiopia on March 10th 2019.

And so, being there back then is today also an emotional opportunity of remembrance and commemoration for a passionate mind who left us suddenly.

But that day, in telling about my experience as a researcher, I mentioned several times the help and the advice I received from Giuseppe “Pino” Aiello who, among the several colleagues and friends I mentioned, companions of a period among the most exciting of the anthropological investigations of those happy years, was for me the most important presence for his deep knowledge of the farming world and for his extraordinary capacity to transform every tool and every motion of agriculture into a drawing. For me, his passing away marks the end of a period, leaving it to history.

Three trees, three worlds.

The grapevine

A grapevine initiated me in a mysterious knowledge that had the forbidden taste of non-geographic world. An old farmer told me that the graft is like a baptism, because it tames the rebel nature of the rootstock. The grapevine is similar to humanity: a baptism is needed to redeem its uncontrollable nature. The fast and sure gesture guided by the grafter’s experienced hand, which, with a sharp knife, inserts a bud in the living body of the bark and with a blade of ampelodesmos thread makes a perfect suture, repeats, grapevine by grapevine, row by row, year after year. It is the ritual of a sacred gesture at the centre of the myths of every people, the passage from nature to culture, and the action by which humans become stewards of the world. Following the satisfied look of the author of these geometrical shapes of the farming space, much appreciated in literature and art, I learned to recognise disquieting projections of secret desires in it.

At the same time, among the abundant grapevines, full of branches appropriately tied in the upper part to the stake I can all but see the charming sinuous shapes of the ‘ladies’ who, elegantly along the slopes, motionlessly, go on covering the horizon with their shadows, waves of a dark green sea; the sacred and profane.

The olive tree

The companion of the time, the olive tree is one the signs that has deeply and permanently marked the Mediterranean landscapes. To me, it was the intermediary to find, within the absolute logic of a folk saying, one of the main characters of the sense of human action, the need to deliver the cultural heritage to posterity. A saying goes : "Your grandfather's olive trees, your father's mulberry, your vineyard." Each plant belongs to a human generation, each biological and reproductive rhythm corresponds to a phase of the existence of a community in its process of transferring culture and property. In a universe that we are told to be orderly and unchanging, the olive tree has the task of conveying duration. It is history, together with the family and community, it is the continuity of the present in the past. The tree of peace, it is also the sign of progeny and a gift passed on from generation to generation, steeped in sacredness that becomes a metaphor of human civilization in its highest expression. Memory relies on it. Planting it means defying time, performing an action which is forever, going beyond one's own existence to blend it with that of those who will follow, while testifying to the ultimate gesture of self-sacrifice: the fatigue will help others who will harvest its fruit and message. Saving it means accepting the inheritance of a space made eternal by a promise: fathers and sons.

The lemon

Called golden apples in the Bible, citrus fruits afford a rich image of Mediterranean agriculture. Outside the metaphor, the development of growing citrus fruits for Italy's *Mezzogiorno* meant a bet with progress. Nevertheless, talking about citrus fruits involves an approximation forgivable only to those who have a general relationship with the plants or for whom they are numbers to be accounted for: the lemon tree has its own personality. It is the tree of abundance, defying the seasonal aridity of the Mediterranean climate, stimulating the development of a sophisticated technology and of hydraulics. It represented, for some parts of Sicily, the opportunity to make a qualitative leap in the capitalistic sense of agriculture: a myth, a dream perhaps, but full of a propulsive thrust that marked, with its very fast and impetuous spread, some not very large but extremely compact stretches of our coastlines and coastal plains. The landscapes of lemon groves, full of intoxicating scents, take us into a world where technical expertise and commercial ability lived together in a relationship beating disquieting implications, characterising the communities involved with very peculiar and polymorphic social and cultural traits. Losing myself in the labyrinths of the canals that give lifeblood to a plant always in love, I discovered how a community can represent itself through the management and control techniques of its own source of material and cultural reproduction and how the observer's gaze, whether an insider or outsider, can be distant from this world.

Epilogue

The landscapes and the plants that embody their meaning, over which I thought I could exercise the analytical rigour of the interpretation models, unmasked my bias in the complex relationship with other biases, those of the cultures and of the individuals who made them.

Other trees, keepers of different landscapes, upset my dreams. These are symbolic plants that reorganise the urban spaces around the worship of modern redemption: they are the several Falcone trees in many Sicilian squares, the offshoots of the one growing in Palermo, full of *ex-votos* and messages, commemorating an exemplary martyr.

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Ignazio E. Buttitta

Plants in Sicilian holy simbology

Abstract

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The Sicilian religious festivals present a rich and varied plant symbolism. In addition to the widespread practice of decorating processional statues with flowers, fruits, ears of wheat, green beans depending on the season and the phases of the agricultural cycles, the use of carrying processionally simple branches of laurel or more complex plant artifacts is widely observed. These uses are particularly present in the ceremonies of the Holy Week, in the spring festivals dedicated to Saint Joseph (March 19) and to the Holy Cross (May 3), in the summer ones dedicated to the patron saints. These are phenomena that clearly testify the continuity of ritual structures and symbols and which presently renew the cultural memory of a Sicilian society, lived for millennia of agriculture and farming.

Key words: feast, ritual symbolism, laurel, wheat.

In Sicily, there are still institutional manipulations, albeit among unaware transformations, recoveries and true inventions, ceremonial practices and cultural acts that reveal, formally at least, a strong bond with the typical needs of an agricultural and pastoralism civilization. Among them, suffice it to mention: bonfires, ritual masking, palanquin dances and races while carrying the statues of saints, ritually formalized food production and consumption, and the processional use of plant foliage. The spreading and types of this rich symbolic legacy testify to the vitality of traditional religious culture and its adaptability – re-semantisation and re-functionalisation - to the ongoing changes in social and economic conditions and in existential regimes.

This "resilience" of religious traditions, apart from being ascribed to their ability to meet timeless anthropological needs (protection, nutrition, reproduction) and to offer, from a religious point of view, answers to the new forms of precariousness affecting Sicilian society, can be surely traced back to the needs of several communities to save and restore a cultural memory perceived as qualifying and establishing the sense of *being there* in asserting a specific identity, as well as policies for building a legacy and the promotion of "local products" for tourism, not infrequently promoted by external agencies.

Sometimes formally unchanged, though based on new senses and functions, other times recovered and transformed also in formal aspects, archaic ritual symbols and behaviours, therefore, up to this very day, year after year, testify to the persistent continuity of ritual structures and symbols and to renew the memory of a society that lived for thousands of years on agriculture and pastoralism.

Looking at the space-time organisation and at the symbolic contents (actions, words, material elements and so on) of the celebrations that mark the time of the island communities, mostly those located in internal and peripheral areas we can also observe how the main ritual elements are connected to the key moments of the traditional ergological agricultural and grazing cycles and are based on symbols of the related forms of production.

In particular, the organisation of the traditional cerimonial calendar is clearly connected to the wheat cycle. Within it, we can find three periods, only partially attributable to seasonal changes. The ceremonial cycles marking the three periods are: All Saint's Day – All Soul's Day, St. Joseph – Holy Week, St. Anthony of Padua – St. John the Baptist – St. Calogerus. They are real transitions: the first one connected to an external-internal movement of the wheat seed; the second to the transition from inside to outside of the sprouted plant; the third one to the removal of the plant from the ground, that is the harvesting and storage of the seed. Indeed sowing is done between the end of October and the beginning of November; complete sprouting and plant growth occur between March and April; the harvest starts in June.

These periods are generally different from the qualitative point of view and, as regards the celebrations, they are characterised by the presence of peculiar ritual symbols: the ceremonies in the autumn/winter period reveal their relationship with the chthonic dimension through the presence of the dead represented by masks, poor people, or children as well (all of them being protagonists of offertories or collective meals), by the ritual eating of unmilled seeds, by lighting bonfires with particular connotations; the spring/summer ceremonies, more evidently linked to the uranic dimension, are mainly rich in palanquin dances and races, of games and fights, the offering of the first fruits, the procession of plant elements, offerings and ritual eating of bread; the time from the harvest to the next sowing is, finally, articulated into several celebrations of Saints from June to September. They are "thanksgiving" celebrations, where several elements not immediately connected to agriculture activities, converge. In the celebrations of the Saints, in fact, society celebrates itself, its wealth, its devotional dependence, and its belonging to the "uniqueness" of worship.

Of this rich and complex celebration universe, we will only mention here some ceremonies characterised by a more explicit plant symbolism, pointing out only incidentally on the one hand the widespread practice of displaying flowers and fruits on the procession simulacrum, that is, with a clearer reference to the productive cycles, broad beans and bunches of wheat ears, an event observed in particular during spring celebrations devoted to St. Joseph (March 19th) and the Holy Crucifix (May 3rd) and the summer feasts devoted to the patron Saints; on the other, the occurrence in Sicily, as well as in other European regions, of "arboreal" Madonnas.

Plant elements in St. Joseph's celebrations. The laurel or other evergreen plants form the decoration of St. Joseph's shrines and of particular artefacts connected with his celebration. For instance, *a)* In Villabate, a small town of rural origin close to Palermo, *u vastuni,* a spruce shaft, about 2-metres long, adorned with multi-coloured strips, flowers, fruit and plant foliage framing one of St. Joseph's pictures, is carried in procession by a skilful bearer on the afternoon of March 18th among the streets of the built-up area and the following day it stays ahead of the Saint's float during the procession; *b)* In San Biagio Platani and in Sant'Angelo Muxaro a peculiar ceremonial artefact, *u cannistru*, is a traditional votive offering during St. Joseph's celebrations. The preparation of *cannistru* usually starts on Wednesday. It is made up of four pieces of wood and iron fit on a small float (*vara*); the family who made the vow to the Saint writes the name of the Holy Family's member to whom this structure is devoted around its sides. The structure is then covered with foliage from the citrus fruits usually collected in the family's "private garden", and with an interesting manipulation of *aspàrachi* (asparagus). Oranges and lemons ordered in sequences are placed outside the four boards, several food offerings (wheat and sweets) are placed on the *vara*. Multi-coloured paper flowers complete the decoration. The various *cannistri*, accompanied by three people impersonating the Holy Family, are carried in procession on the morning of March 19th in the Umberto Square where a shrine is set up and where an auction is held with food products offered by the faithful as votive offerings; *c)* The presence of laurel is recorded in Ribera too; there, the tradition of St. Joseph's "tables" is still alive. In this village, the tradition of "the entrance" of a laurel bearers' parade walking along the town's streets has now ended, but laurel remains the main element of the *stràula:* a cylindrical structure of reeds, about 4 m tall, completely covered with laurel and donut-shaped bread loaves (*purciḍḍata*), and with the Saint's portrait inside a small shrine arranged among the branches. The *stràula* is carried in procession on a small cart pulled by a donkey on the morning of the 19th among the town's streets and then accompanies St. Joseph's statue along its evening route. Remarkably, in the past, this interesting structure was placed also in the Easter celebrations and its bread was given to poor, that is those same people receiving the offerings for St. Joseph.

Holy Week. During Holy Week in Sicily, official liturgical traditions coexist with unorthodox practices, also in terms of plant symbolism. Together with the traditional palms, though particularly shaped in some towns such as Gangi, with the traditional but unorthodox *lavureddi*, wheat sprouts and at times legumes, adorning the graves exhibited on Maundy Thursday, laurel is still present in the celebration ornaments of the Saints during the *rigattiati* in Burgio, Caltabellotta, Villafranca, Lucca Sicula, and so on and, in some other cases, fava beans are used, as in Bronte, revealing Easter's nature as a spring feast and new beginning.

The Easter message is, after all, rebirth, and the renewal of the cosmos. The Risen Christ advances and brings back life and abundance as is clear in the bows of Casteltermini or in the *mazzuna* of Misilmeri.

Laurel celebrations. A particular kind of celebration characterised by laurel branches variously styled that are carried by the faithful in processions can be observed in several celebrations in the Nebrodi area: as already said, in Tortorici the laurel in procession appears during St. Sebastian's winter celebration; in Troina, St. Sylvester's laurel is carried in procession, after some devotional pilgrimages for its harvesting, on two different occasions: the second to last Sunday of May, on foot (*i rama*), and the last Sunday of May, on horseback (*u ḍḍàuru*); in Gagliano Castelferrato long poles

Fig. 1. Caltabellotta (Ag), Easter *rigattiata* of Archangel St. Michele (ph. Russo-Muccio).

Fig. 2. Regalbuto, Feast of San Vito, Procession of the Laurel (ph. Buttitta)

Fig. 3. Villabate, Feast of San Giuseppe, procession of the vastuni (ph. Russo-Muccio)

Fig. 4. Gangi, Palm Sunday, *i parmi* (ph. Russo-Muccio).

Fig. 5. Santa Croce Camerina, feast of St. Joseph, the altar (ph. Russo-Muccio).

decorated with laurel and strips of coloured tissue paper (*i virghi*) are carried in procession in honour of St. Cathal (August 29th); in Cerami, duringcelebrations for St. Sebastian (August 27th) and the *Madonna della Lavina* (September 7th), some complex artefacts for the processions are totally made up of laurel branches (*i bbanneri*), in order to be carried in procession with the respective statues. Laurel is also carried in procession in Regalbuto, on August 8th, for St. Vito (*i ntinni*), in Naso, the first Saturday after Easter for the *Madonna delle Grazie* (*u ḍḍàuru*), and in San Marco D'Alunzio, on July 31st, for St. Basil the Great.

In some cases, as in Cerami, laurel is used in several events (St. Sebastian's celebration, feast for the *Madonna della Lavina*, winter celebrations in honour of St. Anthony Abbot, St. Sebastian and St. Blaise), taking different shapes and names.

The characters of the ceremonies of the passing of the seasons are present in all these rites: the presence of evergreen plants, the exhibition/display of manly behaviours by younger members, the ostentation and prefiguration of food abundance through storage and re-distribution of food.

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Donato Chiatante

The higher plants: beauty and intelligence

Abstract

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Key words: plant morphology, evolution, adaptation.

Two are the best paradigms used to define the plant's beauty: the colors and the shapes. The color strikes the human imagination directly and it elicits strong emotions. The shapes of plants are less obvious, and only a trained eye is able to separate them from colors. By studying the shapes one realizes that it does not exist randomness in the plant kingdom, but shapes are often characterized by a limitless repetition of units being always the same. The shapes of higher plants can be often mathematically diagrammed onto the Fibonacci Sequence (1, 1, 2, 3, 5, 8, 13,….) and the Golden Ratio (3/2=1.5; 5/3=1.6; 8/5=1.6; 13/8=1.6; ….). Recent studies have shown that these specific shapes represent the result of a long evolutionary adaptation which provides the best developmental conditions that could not be obtained by different shapes. However, one question arises: beside being beautiful, are plants also intelligent living beings? The answer to this question starts with an examination of the most accepted definition of intelligence. A second step forward is represented by a comparison between the most simple living beings (unicellular) that show an intelligent behavior even if they lack a brain tissue. Finally, the presence of intelligence in higher plants is demonstrated with examples of how they are capable of: cognition, communication, information processing, computation, learning, and memory. The hypothesis of occurrence of a plant tissue able to provide intelligent responses to environmental stimuli is presented.

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Consolata Siniscalco

From North to South: a voyage through plant biodiversity in the Italian mountains*

Abstract

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Italy is among the European countries richest in biodiversity, mainly due to a wide variety of geomorphological and climatic conditions. Its very high plant diversity is also the result of its geographical position, acting as a bridge between Central Europe and the Mediterranean Sea and producing the coexistence of different biogeographic elements with a high contingent of endemic plant species, which amounts to more than 15%. As in many other mountains of the world, both the Alps and the Apennines host an extremely rich flora which forms peculiar plant communities characterizing several priority habitats listed in Directive 92/43/EEC and forming wonderful mountain landscapes, where nature and human work merge increasing biodiversity. The voyage from North to South through the Italian mountain plant diversity is an opportunity to observe the responses of plant species and habitats to climate and land use changes that very rapidly are transforming our mountain landscapes, not only at lower altitudes, as expected, but, surprisingly, along the whole altitudinal gradient. Recent results on changes of the summit flora (GLORIA and Summit flora projects), as well as on abandonment of the traditional grazing and forestry activities in some mountain areas and on the spread of nonnative species, produced significant changes at levels of species, habitat and landscape. On one hand the responses of plants to these changes confirm that they are a threat for plant biodiversity, but on the other hand that plants have a surprisingly rapid capacity to face abrupt climatic or land use variations.

Key words: alpine habitats, plant biodiversity, conservation.

Plant biodiversity in Italy is one of the highest of all European countries, both in terms of species richness and of vegetation communities. Knowledge in these two fields is continuously increasing and researches at the national level collect data that are the results of a great number of studies at the regional and local levels.

Examples of these studies at the national level are well represented by the recent checklist of the vascular flora native to Italy (Bartolucci & al. 2018) and the checklist of the alien flora (Galasso & al. 2018), both updating the Checklist of the Italian vascular

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flora (Conti & al. 2005), the newly published Flora d'Italia (Pignatti & al. 2017-19), a paper on endemic plant species (Peruzzi & al. 2015) and a recent book "Flora in Italia" (Blasi & Biondi 2017). To all these, and also other publications, a high number of botanists, representing all Italian regions, collaborated in order to provide an accurate analysis of the updated knowledge.

Following the Checklist of the vascular flora native to Italy 8195 taxa occur in our country and 1708 are endemic of one or more regions, highlighting an extraordinary floristic richness, due to the Italian geological, geomorphological, climatic, latitudinal and elevational variability. Some of these features have been studied and their variability has been represented on maps as in the phytoclimatic map of Italy (Blasi & Michetti 2007) or in the Map of the Important Plant Areas (IPAs) in Italy (Blasi & al. 2010) and culminated with the Map of vegetational series (Blasi, 2010) that documented the presence of more than 240 vegetational series occurring from North to South and from West to East.

All data agree on the fact that a very high floristic and vegetational richness is located in mountain areas, both in the Alps and in the Apennines, and that rare and endemic species occur mainly in the alpine belt, confirming that mountains are characterized by concentrated geological as well as climatic variability in restricted ranges, following the elevation gradient. For the above mentioned reasons mountains experienced typical climatic histories, in particular during the glacial periods, with an ice cover in some areas, in particular in the Alps and at the higher summits of the Apennines and with the absence of ice cover in other areas. These differences at least partly explain the actual distribution of rare species and, consequently, of rare plant communities.

For these reasons it is highly recommended to explore the Italian mountains, in order to have a look on some of the most interesting areas, taking time for a voyage from the Western Alps to the Southern Apennines, to observe the rich, magnificent flora but also to have a glance on the ecological observations that resulted from the analyses that have been carried out in those places.

Our voyage begins in the Western Alps, and specifically in the Aosta Valley, where the highest summits occur: Monte Bianco (Fig. 1), Monte Rosa, Gran Paradiso, Cervino, all above 4000 m a.s.l..

In this region the summit alpine flora was studied in the past by several botanists, and in particular by Lino Vaccari, who published his "Flora cacuminale della Valle d'Aosta" (Vaccari 1901) a reliable and complete study on a high number of summits. The re-survey of the same summits studied by Vaccari was carried out by Elena Barni and co-workers in the framework of the Summit Flora Project,

coordinated by Sonia Wipf, working at Davos (Steinbauer & al. 2018).

In this work the botanists used a dataset of repeated plant surveys from 302 mountain summits across Europe, spanning 145 years of observation, to assess the temporal trajectory of mountain biodiversity changes as a globally coherent imprint of the Anthropocene, and in particular of climate variability. As on the Aosta Valley summits, the authors found a continent-wide acceleration in the rate of increase in plant species richness, with five times as much species enrichment between 2007 and 2016 as fifty years ago, between 1957 and 1966. This acceleration is strikingly synchronized with accelerated global warming and is not linked to alternative global change drivers. The accelerating increases in species richness on mountain summits across this broad spatial extent demonstrate that accelera-

Fig. 1. The Mont Blanc seen from Mont La Saxe (Photo Siniscalco).

tion in climate-induced biotic change is occurring even in remote places on Earth, with potentially far-ranging consequences not only for biodiversity, but also for ecosystem functioning and services.

On ecosystem functioning several studies have been carried out in the Aosta Valley to highlight how subalpine grasslands react to the summer heat wave that more and more often occurs during August: the dry grassland vegetation, and in particular dry grasses as *Nardus stricta* L. stop their activity and only after the first rainfalls, at the end of August, become green and active, while forbs as *Trifolium alpinum* L., *Arnica montana* L., and *Geum montanum* L. continue to carry out their activity even under very dry summer conditions (Cremonese & al. 2017). Climate change causes very clear responses on the grassland community, even when snow melt begins earlier than usual in April or May because without snow the soil and plant temperature can be several degrees under zero, causing damages to the plants.

One important point in these studies is that we have to concentrate on the community but also on the single species response, trying to analyse the plant traits, in order to understand their ecological needs and to predict which will be their response to interannual climate variability.

Moving on to South, we stop in Valle di Susa, one of the most interesting endo-alpine valleys because, if compared to the others, as Engadin and Valais in Switzerland, Val

Venosta and Valle d'Aosta, its flora is enriched by several Mediterranean species, in particular in the driest areas, located in the middle of the Valley. This confirms what was observed by Aeschimann (Aeschimann & al. 2004): the richest flora in alpine areas is located where, in addition to the typical species, ranging on the chain, Mediterranean species arrived in the past, in warmer periods.

In the Xero-thermic oasis South facing slopes (SIC IT1110030 "Oasi xerotermiche della Valle di Susa - Orrido di Chianocco e Foresto) the very dry climate, less than 600 mm yearly precipitations, with strong winds blowing everyday, justify the occurrence of two priority habitats included in the Directive 92/43/EEC (Habitat Directive), "Dry semi natural grasslands (*Festuco-Brometalia*)-important orchid rich sites" (6210*), and the "Steppic, sub-pannonian grasslands" (6240*). Both grasslands need grazing to be maintained, so that a Life Project was carried out (Life 12NAT/IT/000818 Xero-Grazing) for the Semi-natural dry-grassland conservation and restoration in Valle Susa through grazing management.

The most wide spread Mediterranean species are *Euphorbia sulcata* Lens, *Asterolinon linum-stellatum* (L.) Duby, *Linum strictum* L., *Ononis reclinata* L., *Leuzea conifera* (L.) DC., *Crupina vulgaris* Cass., *Linum suffruticosum* L., *Lavandula angustifolia* Mill., *Helianthemum apenninum* (L.) Mill., *Ononis minutissima* L., *Coronilla minima* L., and *Juniperus oxycedrus* L. (Fig. 2). Moreover, 29 orchid species occur in the dry grasslands, e.g. *Ophris fuciflora* (F.W. Schmidt) Moench, *Ophrys tetraloniae* W. P. Teschner, *Neotinea tridentata* (Scop.) R. M. Bateman, Pridgeon & M.W. Chase, *Neotinea ustulata* (L.) R.M. Bateman, Pridgeon & M.W. Chase, *Anacamptis pyramidalis* (L.) Rich., *Epipactis atrorubens* (Hoffm.) Besser, *Cephalanthera longifolia* (L.) Fritsch and *Cephalanthera rubra* (L.) Rich. In the steppic, sub-pannonian grasslands, which have been observed for the first time in such Western alpine areas and were not expected to occur outside their typical range, *Stipa pennata* L. and *Cleistogenes serotina* (L.) Keng characterize physionomically the grasslands, and are to be referred to the alliance Stipo-Poion carniolicae.

This area is very interesting to visit, being an island of Mediterranean vegetation in the middle of the Alps.

Moving South in our voyage, we arrive in the Maritime Alps, one of most interesting hot spots of the Italian flora, where the influence of the Mediterranean sea avoided the presence of a continuous ice cover during the Quaternary glaciations and the formation of neoendemic species, after this period. This uncommon conditions in an area of the Alps, justifies the actual occurrence of several rare, endemic species (Fig. 3) as for example *Saxifraga florulenta* Moretti, *Saxifraga lingulata* Bellardi, *Primula allionii* Loisel, *Viola valderia* All., *Campanula alpestris* All. and *Fritillaria tubaeformis* subsp. *moggridgei* (Boiss. & Reuter ex Planch.) Rix. All these species are typical of rocky slopes or of alpine grasslands, where competition with other species is low. The researches on these and of other species allow confirming the historical, geomorphological and genetic reasons of their survival or their more recent formation in this very interesting area of the Alps.

Moving once more to South, and having an interest on the previously cited topics linked to the history of the Italian mountain flora, we arrive to the Gran Sasso and Majella groups.

The secondary prairies with dominant *Bromus erectus* Huds. are quite similar to the ones that we saw in Susa Valley, with *Helianthemum apenninum* (L.) Mill., *Medicago minima* (L.) L., *Neotinea ustulata* (L.) R.M. Bateman, Pridgeon & M.W. Chase, *Anacamptis*

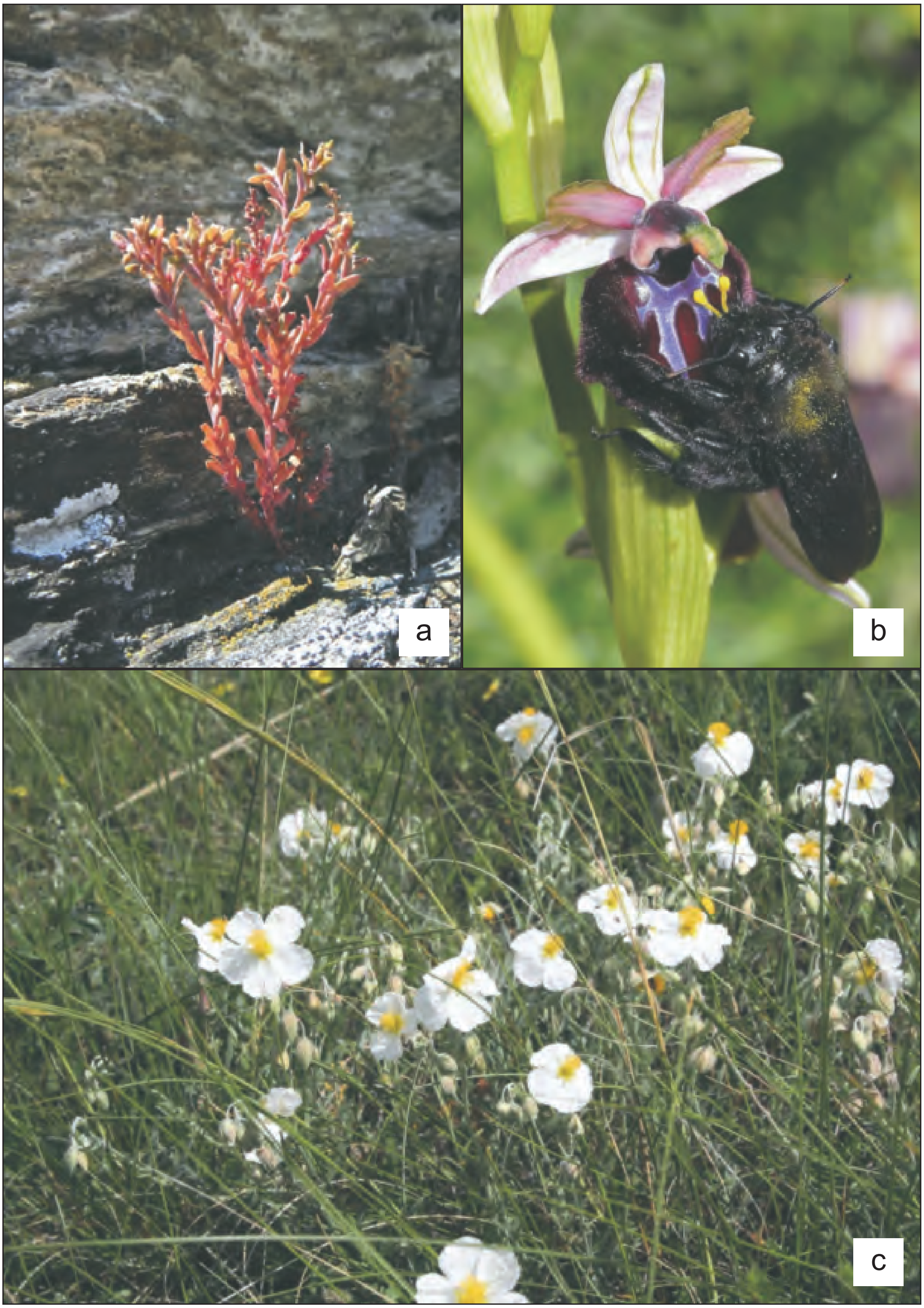

Fig. 2. a) *Euphorbia sulcata* in Susa Valley dry grasslands (Photo Gorlier); b) *Ophys fuciflora* in the Susa Valley dry grasslands (Photo Davì); c) *Helianthemum apenninum* (Photo Gorlier).

Fig. 3. a) *Viola valderia* and b*)* *Primula allionii* in the Maritime Alps (Photo Masante); *Fritillaria tubaeformis* subsp. *moggridgei* in the Maritime Alps (Photo Mucciarelli)

Fig. 4. a) *Ranunculus magellensis* in Majella (Photo Nicolella); b) Fig. 13. *Viola magellensis* in Majella (Photo Nicolella).

Fig. 5. *Saxifraga oppositifolia* subsp. *speciosa* (Photo Pirone).

pyramidalis (L.) Rich. and other species that very interestingly vicariate the Susa Valley ones, as *Eryngium amethystinum* L. at the place on *Eryngium campestre* L., *Trinia dalechampii* (Ten.) Janch. at the place of *Trinia glauca* (L.) Dumort.

When we arrive to the highest elevations, above the timberline, it is possible to see a magnificent flora, characterized by an extraordinary high biodiversity described by Pirone (2006) and Pirone and Frattaroli (2011). Migration, mainly from North and East, and speciation processes lead to a very rich floristic diversity that includes, beyond endemic species, a relevant number of relict species, similarly to what we have seen in the Maritime Alps. These species have wonderful flowers that evolved to respond to the scarce number and variety of pollinator insects at those elevations. An analytical analysis of these species is reported in Blasi and Biondi (2017), with notes on distribution, habitats and conservation, as for *Ranunculus magellensis* Ten., *Viola magellensis* Porta & Rigo, *Saxifraga oppositifolia* subsp. *speciosa* (Dörfl. & Hayek) Engl. & Irmsch. and *Androsace mathildae* Levier (Figs. 4-5). This last species is listed in the Habitat Directive and in Abruzzo Red List, as many other species of the high elevation habitats of Gran Sasso and Majella.

This virtual voyage that brought us to visit examples of some of the most interesting Italian mountain systems is an invitation to go and visit them on the field. These excursions confirms the extraordinary high biodiversity of the mountain flora also in terms of biogeographical as well as evolutionary value. On these bases the need is confirmed to monitor the presence and conservation status of these species and vegetation communities in the future, in order to control the effects of climate and eventually land use changes on their survival and functionality.

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Pampean-grassland heterogeneity on the intersection of science, art, and culture*

Abstract

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Since prehistoric times, temperate grasslands have provided favorable habitat for human subsistence. Ease of exploitation, however, has caused that temperate grasslands are among the most destroyed terrestrial ecosystems. The region known as the Pampas or Rio de la Plata Grasslands, extending over some 750,000 sq. km in central eastern Argentina, Uruguay and southern Brazil, comprises the largest temperate grassland area in the southern hemisphere. Flat topography, humid temperate climate, grassy natural vegetation, and absence of large native herbivores have conditioned multiple aspects of human life in the region, like patterns of population settlement, techniques for acquisition and transportation of goods, aesthetic preferences, and social structure. In this article, we present some writers inspired by the Pampas, we briefly summarize the main results of scientific research on the drivers of vegetation physiognomy and heterogeneity in the Pampas, based on the invaluable floristic database compiled by Professor Rolando J. C. León, and we sketch one of Professor León´s scientific-historic tours to the Pampas. Finally, we call attention to currently threats to the persistence of Pampean Grassland.

Key words: Rio de la Plata grasslands, climatic drivers, vegetation survey, biological invasions.

Introduction

Temperate grasslands have provided habitat for human subsistence since prehistoric times. These ecosystems, characterized by open grassy vegetation, occur in regions where factors such as drought, fire, or herbivory have prevented tree dominance (Walter 1970; Bond & Keeley 2005; Sankaran & al. 2008). Grasslands have been recognized and appreciated around the world, receiving local names like *prairies*, *veldts*, or *pampas*, and have become home for some renowned cultures. In these regions, cultural and economic history cannot be dissociated from the characteristic provision of basic resources for human life, so readily accessible for use for animal herding and agriculture. Ease of exploitation, how-

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ever, has caused that temperate grasslands are among the terrestrial ecosystems with highest extension of destroyed area and smallest proportion of area devoted to nature protection (Hoekstra & al. 2005).

The region known as the Pampas or Rio de la Plata Grasslands, extending over some 750,000 sq. km in central eastern Argentina, Uruguay and southern Rio Grande do Sul in Brazil, from 28ºS to 38ºS, comprises the largest temperate grassland area in the southern hemisphere (Hudson 1895; Parodi 1947; Cabrera 1976; Soriano 1992; Gibson 2009). The essential characteristics of this vast region are flat topography, humid temperate climate, natural vegetation dominated by coarse grasses with virtually no trees, and absence of large native herbivores. These characteristics have conditioned multiple aspects of human life in the region, from patterns of population settlement, to techniques for acquisition and transportation of goods, perceptions and appreciations of space, time, and effort, aesthetic preferences, social structure, and the history of human competition for resources and power. Since the arrival of the Spaniards to the Río de la Plata in the sixteenth century, aboriginal peoples from the Pampas were gradually displaced from the plains (Hudson 1895). This determined a deep transformation in the pattern of land occupation and use, as the aboriginals had lived in nomadic communities wandering on the plains in the pursuit of livelihood, whereas the European colonists who replaced them settled as small groups on fixed locations widely separated from each other (Sarmiento 1874). After European settlement, the land was incorporated into cattle herding. As a result, vegetation physiognomy and landscape structure of the Pampas started a process of unprecedented changes. Tall dominant grasses were replaced by shorter gramineous species and exotic forbs by effect of fire and grazing by confined animals, and runoff patterns were deeply modified by canals, railways, and later by roads and highways constructed across the region (Hernández 1882; Hudson 1895; Sbarra 1964). In recent decades, the area devoted to cattle production was greatly reduced due to the expansion of increasingly sophisticated crop agriculture (Baldi & al. 2006; Viglizzo & al. 2011). This is resulting in further transformations of the Pampas, where nowadays vegetation comprises large areas of species-poor crop fields and fallow land covered by short turf or invaded by shrubs or exotic trees, and human-population density has dropped dramatically (Ghersa & al. 2002; Hora 2018).

Because the national economy is highly dependent on agricultural exports, the history of exploitation of the Pampas has been in good measure modulated by state initiatives. These range from the historical distribution of land, to the building of transportation infrastructure, interventions in the market of agricultural products and services, and the continued development of technology and human resources. In particular, botanical studies of the Pampas, acquired impulse in the twentieth century in the context of state universities and research institutes. Distinguished botanists produced a corpus of knowledge of plant taxonomy and phytogeography that has served as the basis for a currently active field of ecological research in the region. An essential contribution to the progress of vegetation ecology in the Pampas is the life-long work of Professor Rolando J.C. León (1932 – 2015) to characterize their compositional heterogeneity. Systematic vegetation surveys conducted over the years by Professor León and his disciples across the region produced an invaluable database of floristic information that allows exploring the drivers of species distribution and community composition at varying spatial scales, and serves as a detailed reference for assessing the ongoing transformation of the grassland. In addition, Professor León was an extremely active and committed educator who, both in and outside the academy, taught botany and ecology as articulated with history, art, and literature in the Pampas and elsewhere. He often led students and researchers from overseas on scientific-historic tours across the Pampas to appreciate the amazing natural diversity concealed under the apparent homogeneity of the grassland. In this article, we present some art and literature inspired by landscape of the Pampas, we give a brief summary of the main results of scientific research on the drivers of the physiognomy and heterogeneity of vegetation in the Pampas, and we sketch one of Professor León´s scientific-historic tours to the Pampas. Finally, we call attention to current threats to the persistence of Pampean Grassland.

Literature

Since colonial times, Argentine culture has been marked by a tension between contrasting valuations of countryside and city life experiences. This tension originates, at least in part, in the fact that Spanish conquerors had little interest in the Pampas, as the grassland offered neither precious metals nor abundant people to enslave, and concentrated their attention on the services produced by the cities (Hora 2018). For them, the plain appeared as an obstacle for travelling and transportation, especially because of the lack of navigable waterways, the difficulty for finding water, and the softness of the soil, where vehicles often became stuck in the mud (D´Orbigny 1998). Under this tension, rural and city people of the Pampas have tended to look on each other with suspicion (D´Orbigny 1998; Sarmiento 1874) and developed two separate literary traditions.

Rural people, the *gauchos*, produced a type of anonymous orally-transmitted poetry (known as *payada*) reflecting their refusal to accept rules, intolerance to alien manners, violence, and a mixture of melancholy and witty irony associated with the harshness and isolation of their lives (D´Orbigny 1898; Sarmiento 1874). This literary genre entered in the cannon of Argentine literature when José Hernández published his epic poem *Martín Fierro* in 1872: *"Mi gloria es vivir tan libre / Como el pájaro del cielo: / No hago nido en este suelo / Ande hay tanto que sufrir, / Y naides me ha de seguir / Cuando yo remuento el vuelo*" ("My glory is to live as free / as the bird in the skies: / I don´t nest in this land / where there´s so much to be suffered / and nobody shall follow me / when I take flight"). It also shows up in the well-appreciated Argentine folklore, as for example in *Coplas del payador perseguido* by Atahualpa Yupanqui: *"Yo sé que muchos dirán / que peco de atrevimiento / si largo mi pensamiento / pal rumbo que ya elegí / pero siempre he sido ansi; /galopiador contra el viento…"*("I know that many will say / I´m falling into impertinence / if I let my thoughts go free/ the way I´ve already chosen / but I´ve always been so / a galloper against the wind…").

In the cities, an abundant literature produced by cultured writers has reflected the environment and the life in the Pampas. Writers in this tradition have been people with a strong rural experience often because they belonged to landowner families or had otherwise grown up or travelled extensively in the countryside. Here we can only mention a few examples.

A recurrent theme in this literature is the incommensurability and emptiness of the plain, making it difficult to discriminate land from sky. See for example a fragment of the epic *La Cautiva*, by Esteban Echeverría (1837): *"Gira en vano, reconcentra / su inmensidad, y* *no encuentra / la vista, en su vivo anhelo / do fijar su fugaz vuelo / como pájaro en el mar …"* ("Spins in vain, gathers / its immensity, and fails / the eager eye to find /where to rest its fleeting flight/ like a bird over the sea …"); or this one of *Facundo*, the foundational essay by Domingo F. Sarmiento (1874): *" ... el horizonte siempre incierto, siempre confundiéndose con la tierra entre celajes y vapores tenues que no dejan en la lejana perspectiva señalar el punto donde el mundo acaba y principia el cielo"* ("… the horizon ever uncertain, ever confused, with the land among cloudscapes and thin vapors that impede fixing in the far distance the point where the world ends and the sky begins."). The vastness of the plain has also provoked the awe from the celebrated writer Jorge Luis Borges in his story *El Fin* (*Ficciones*, 1944): "*Hay una hora de la tarde en que la llanura está por decir algo; nunca lo dice o tal vez lo dice infinitamente y no lo entendemos, o lo entendemos pero es intraducible como una música…"* ("There is a time in the afternoon when the plain is on the verge of saying something. It never says it, or perhaps it says it endlessly and we fail to understand it, or we understand it butit is untranslatable like music …"). The immensity of the plain and the comparative minuteness of the plants covering it are the likely causes of the literary preference for a panoramic view. Some authors, however, have displayed also amazing powers of description at conveying a closer view of elements from the Pampas, though often choosing the once relatively exceptional trees. See for example, a gaze on a *tala* (*Celtis ehrenbergiana* (Klotzsch) Liebm.) thicket by Sara Gallardo in her novel *Los galgos, los galgos* (1968): "*No era solo de talas ese monte sino también y en segundo grado de acacias negras, individuos de cuerpo gris, medio calvos, con hoja fresca pero insuficiente, como señores de edad mediana irreprochables y tediosos de los cuales uno solo, que zumbaba como un poste eléctrico, nos inspiró interés. Cuando su examen nos condujo a un agujero hirviente de abejas emprendimos la retirada.*" ("Not just of*talas* was that thicket but also and in second term of black *acacias*, gray bodied individuals, halfway bald, with fresh though insufficient leaves, like irreproachable and boring middle-aged gentlemen among which only a single one, which buzzed like an electric pole, attracted our attention. When the examining of it took us to a hole boiling with bees, we marched in retreat.").

Scientific research

While documenting patterns of landscape heterogeneity through rigorous observation and quantitative methods, Dr. Rolando León and his disciples contributed to the construction of a large database of floristic evidence. The information contained in this database allowed answering interesting questions about determinants of diversity at different scales. As part of those studies, it was necessary to geo-reference some vegetation samples to allow them to be linked with climatic and land use information. While doing this, it was surprising to find at each step, that Google Earth images seemed copied from the field map made by Dr. Rolando León during the '70s in the era before the GPS (Fig. 1).

On the broadest scale, a recent overview involving studies in Brazil, Uruguay and Argentina (Andrade & al. 2018) explored the complete gradient in floristic composition over the entire extension of the Pampean Grasslands to generate the consensus species list, a first step towards enhanced understanding of the biogeography and ecology in the Rio de

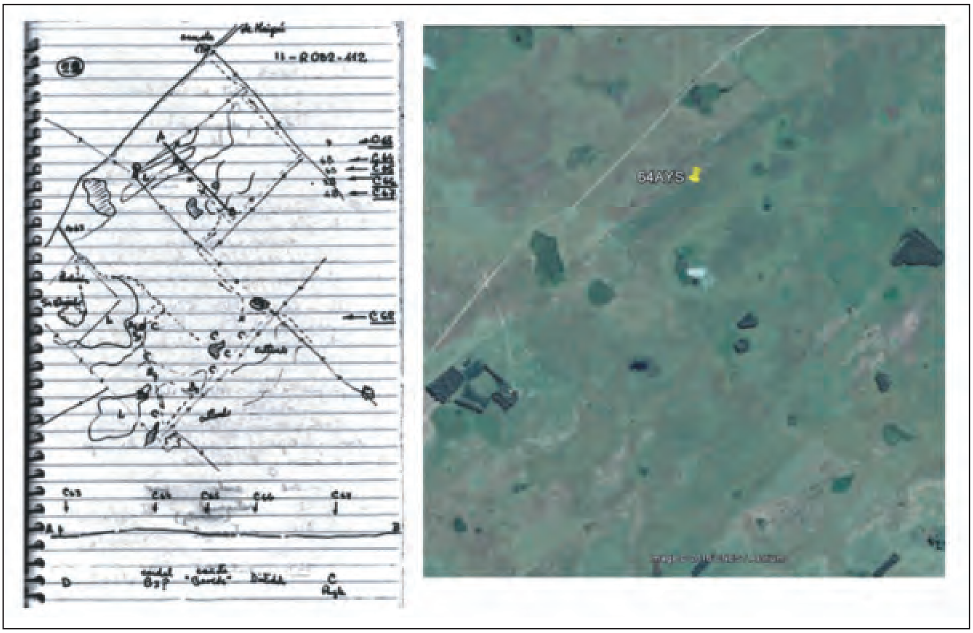

Fig. 1. Vegetation *releves* were georeferenced to generate links with the climatic and land use information.The capture from Google Earth seemed copied from the field map made by Dr. León in the era before GPS.

la Plata grassland biome. The number of almost 5 thousand vascular plant species across a total extent of 750 000 km^2 clearly establishes the Río de la Plata grasslands as a highly biodiverse region in South America. The high species richness found in this region is likely due to its location in a biogeographical overlap zone: the subtropical to temperate transition (Andrade & al. 2018). The East-West gradient in vegetation heterogeneity was also studied for remnant grasslands located on high agronomic potential soils along a five degree-east-west transect in the Rolling Pampa (Burkart & al. 2011). In this gradient the main driving factor of floristic heterogeneity was water availability, determined by climate and soil characteristics. These remnant grasslands which cover small areas as isolated stands are hot spots of native biodiversity(Fig. 2), as more than 80% of the species recorded in early vegetation surveys are still present there (Burkart &al. 2011).

Another study focused on the zonal community (mesophytic grasslands) but spread over a large scale (i.e. along a 600km gradient of five degrees latitude) assessed the relative importance of climate and land fragmentation by agriculture as controls of the diversity and composition of the grasslands (Perelman & al. 2017). Mesophytic grasslands on fertile soils, which have been largely replaced by crops due to their agricultural aptitude, are surrounded by matrices with varying proportions of remnant grassland and crop fields in different Pampean subregions (Baldi &al. 2006; Viglizzo & al. 2011). A multivariate analysis method applied to order samples using as the sole input the list of plant species present in each site, with no addition of any geographical or climatic information, revealed the exis-

Fig. 2. Details of native species embellishing the grassland in the Pampas. The textures and colors of grasses and forbs certainly enhanced the beauty of these lands, inspiring naturalist and artists. (a) The hand of Prof. Rolando León pointing to *Borreria dasycephala* (Cham. & Schltdl.) Bacigalupo & E.L. Cabral. This white flowered forb is a cool-season species characteristic of mesophytic meadows across the Pampas (Leon & al. 1979; Burkart & al. 1990). (b) *Briza subaristata* Lam. and (c) *Melica brasiliana* Ard. are cool-season grasses that co-dominate grassland (Burkart & al. 2011). Flowers and fruits of these grasses embellish the grassland during December. (d) The colorful *Senecio pulcher* Hook. & Arn. contrasts with the grayish-green background of the Flooding Pampa grasslands during early summer. This yellow hearted daisy is the delight of both, bugs and photographers. (e) View of a tussock grassland. The combination of cool-season (e.g. *Nasella trichotoma* (Nees) Hack. ex Arechav, golden spikes) and warm-season grasses (e.g. *P. quadrifarium* Lam., green tussock leaves) maintains continued primary production in the year. (f) The delicate flowers of *Discaria americana* Gillies & Hook. contrast with their strong, pugnant aroma. This shrub is typical of the western, sandy grassland of the Inland Pampa. Photos: (a) Marina Omacini. (b-f) Pedro Tognetti.

tence of species turnover among the mesophytic grasslands of different subregions (Perelman & al. 2017). But, more surprisingly the pattern of site distribution in the ordination graph resembled the geographic location of the samples!. Underlying variables controlling the water-energy dynamics: mean annual precipitation, inter-annual precipitation variability and minimum temperature are associated to latitude in this region. At the same time landscape fragmentation and variability of intra-annual precipitation are related to continentality or distance from the Atlantic Ocean. Climatic factors associated to latitude were also strong determinants of regional diversity: gamma diversity decreased linearly with increasing distance from the Equator, as did the rate of species accumulation with expanding area. By contrast, the current diversity in the sites of remnant vegetation showed association with the pattern and intensity of agricultural perturbation, as local species richness was more influenced by landscape fragmentation and remaining grassland cover. Moreover, the main environmental factor that explained the variation in local richness in multiple regression models was mean patch size of native grassland (Perelman & al. 2017). It seems that local diversity in these zonal grasslands is no longer coupled with factors linked to biogeographic, evolutionary and dispersal history that modeled the regional flora and still drive gamma diversity.

In previous studies, we analyzed cross-scale vegetation patterns in a more limited 90000km^2 area of natural grasslands in the Flooding Pampa where most of the area was still devoted to extensive rangeland (Fig. 3a & 3b; Perelman & al. 2001, 2007). In the Flooding Pampa, soil salinity and flooding are the primary underlying cause of coordinated species turnover. At very fine spatial scales associated with topographic features that determine the intensity and duration of the floods we can observe large proportion of the entire variation in species composition. The main floristic change is related to topographic differences, sometimes just a few meters apart but more often only tens of centimeters, that determine the intensity and duration of the floods, and to halomorphic differences of the

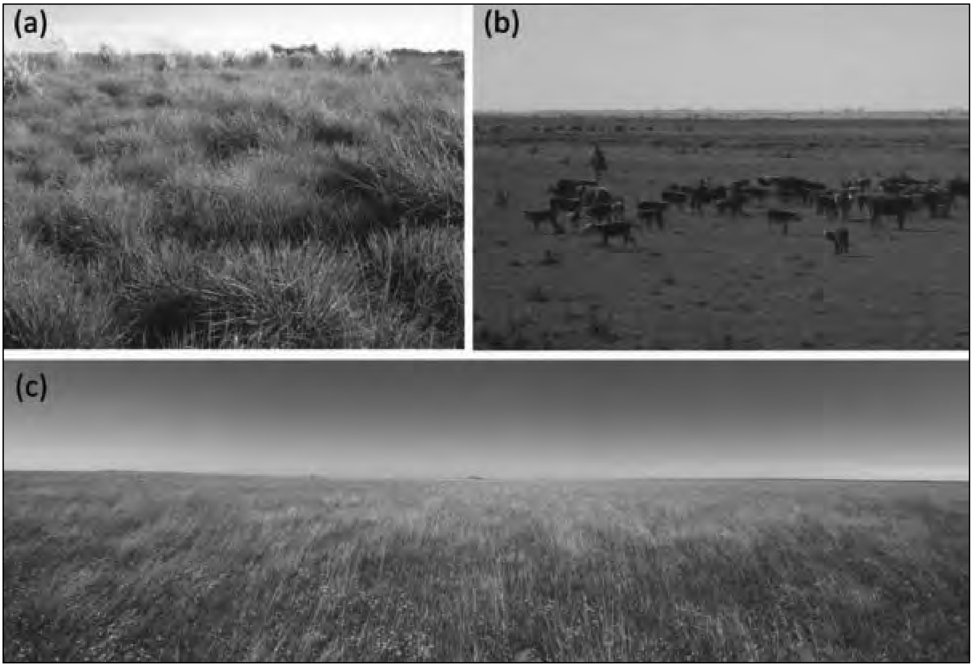

Fig. 3. Landscape views of the Pampas, with their infinite horizon. (a) Grassland stand near C. Casares, Buenos Aires, dominated by tall tussock grasses, *Paspalum quadrifarium* Lam. and *Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn. These two species might have formed the matrix in the pristine communities. (b) Gauchos herding cattle, near Pila, Buenos Aires. Cattle, sheep, and horses introduced by Europeans deeply changed the physiognomy of the Pampas (Hudson 1895). (c) Early summer view of a grassland in the Flooding Pampa, near Pila, Buenos Aires. Across the region, the grassland hosts numerous exotic species like *Lolium multiflorum* Lam., the gold colored grass, and *Lotus tenuis*, the yellow flowers (Perelman & al. 2007). Photos: Pedro Tognetti.

soils (Batista &León 1992; Batista & al. 2005; Burkart & al. 1990).The most extended communities are those exposed to prolonged floods where the dominant species are *Setaria geminate* Forssk*, Leersia hexandra* Sw.*, Danthonia montevidensis* Hack. & Arechav.*, Nassella formicarum* (Delile) Barkworth*, Paspalum dilatatum* Poir.*, Eleocharis* species, *Jarava plumosa* (Spreng.) S.W.L. Jacobs & J. Everett, *Nassella neesiana* (Trin. & Rupr.) Barkworth and *Panicum gouinii* E. Fourn.*,* and those exposed to brief floods, with important presence of *Bromus catharticus* Vahl*, Piptochaetium stipoides* (Trin. & Rupr.) Hack. ex Arechav.*, P. bicolor* (Vahl) E. Desv., *Melica brasiliana* Ard. *, Nasella trichotoma* (Nees) Arechav., *Paspalum dilatatum* Poir.*, Jarava plumose* (Spreng.)*, Nasella neesiana* (Trin. & Rupr.) Barkworthand *Bothriochloa lagurioides* (DC.) Herter. These grasslands received a very important contribution both in species richness and biomass of alien species introduced with European colonization and domestic livestock. Functional group composition differed widely between the native flora dominated by perennial species in equal proportions of grasses and herbs and the exotic flora with predominance of annual winter-growing herbs of euroasiatic origin (Fig. 3c; Perelman & al. 2001, 2007; Poggio & al. 2015). Moreover, revisited grassland exposed to moderate grazing intensity during 35 yr (Fig. 4) showed clear differences in richness changes, in degree of homogenization and in species turnover during this period (Puhl & al. 2014), suggesting that the effect of human activities varies among plant communities.

The lack of trees in the Pampas intrigued scientists and travelers visiting these remote lands (Darwin 1878;Schmider 1929;Walter 1967;Yasawa 1989). Interestingly, at the time of Spaniard settlement, some native woody species (e.g. *Phytolaca dioica* L., *Acacia bonaerensis* Hook. & Arn., *Celtis erhenbergiana* (Klotzsch) Liebm.) were concentrated along river banks or ancient calcareous shell deposits (Ghersa &al. 2002; Ellenberg 1962), but until quite recently the plain was covered exclusively by grasslands. The fact that an area with an average annual rainfall of 600-1000 mm was not covered by forests originated a centennial discussion (Walter 1967; Chaneton & al. 2012), without a unique solution and

Fig. 4. View (left) from the bridge (right) over the Buñirigo stream in the North of the Flooding Pampa, near the places where Rolando León, Silvia Burkart and Chiara Movia began the first inventory of physiography and plant communities of the region (Leòn & al. 1979), one of the sites resurveyed after 35 years (Puhl & al. 2014). Photo credit María Zorzón.

with multiple hypotheses (Yazawa 1989). For example, Darwin (1878) suggested that wind would be limiting forest development, whereas Ulrich Schmieder (1929) proposed that it is an anthropogenic grassland originated from the use of fire. This discussion generated "The Pampas problem", as a special case of grasslands existing under these climatic conditions (Schmieder 1929). Lately, other hypotheses were based on water deficit, on soil mineralogy, and on climatic fluctuations (Walter 1967), also on the geological youth of this region (Parodi 1940; Chaneton & al. 2012), and on the competitive exclusion of tree seedlings by grasses (Parodi 1940; Facelli & Leon 1986; Chaneton & al. 2012). Whatever the cause, the limits of the Pampas grassland with the shrub steppes and xerophytic forests that surround it were delineated many times (León & Anderson 1983).

Nowadays trees have become a central element in the life and culture of the inhabitants of the Pampas. Both trees and settlers are newcomers to these lands, with the colonial advance and the establishment of new land uses increased tree abundance (Ghersa & León 2001; Ghersa &al. 2002). On the one hand, native woody species such as *Acacia bonaerensis* Hook. & Arn., or *Celtis erhenbergiana* (Klotzsch) Liebm., were planted (and nursed!) mainly to be build vegetated fences, limiting the movement and giving shelter to livestock (Sbarra 1964; Ghersa & León 2001). On the other hand, the greatest woody advance was from exotic tree species (Zalba & Villamil 2002; Ghersa & al. 2002), including species of numerous genera such as *Eucalyptus* and *Casuarina* from Australia, *Fraxinus*, *Pinus*, and *Gleditsia* from North America, *Ulmus*, *Platanus, Ligustrum* and *Melia* from the Eurasia *Acacia* and *Phoenix* from Africa, etc.

Currently the main concern of Pampean scientists and landowners, it is not the lack of trees but the spontaneous woody establishment and invasion. Different species of trees encroach over agricultural lands, pastures, and grasslands throughout the entire region (Zalba & Villamil 2002; Ghersa & al. 2002; Mazia & al. 2010), blocking the typical Pampas' horizon. Even though native woody species are still present, conspicuous tree establishment and invasion involves exotic species. For instance, *Melia azedarach* L. invades grasslands and savannas in the eastern areas, while the European *Ulmus* invades pastures and roadsides in the driest grassy areas of the west (Facelli &Leon 1986). The invasion of *Gleditsia triacanthos* L. in the Pampas grasslands has been well-studied (Mazia & al. 2001; Chaneton & al. 2004; Mazia & al. 2010; 2013). Supporting the idea of a climatic constraint to the establishment of trees, the invasion of *G. triacanthos* is more pronounced in humid years (Mazia & al. 2010). Interestingly, seed predation by rodents was higher for native than for exotic tree species (Busch & al. 2012), suggesting a differential biological filter among native and exotic species. Together, these evidences contribute to the idea that the geomorphological youth of the Pampas could limit the generation of genotypes adapted to these climatic conditions that, together with grass competition and periods of drought, could limit the advance of native trees in the pampas (Walter 1967; Chaneton & al. 2012).

An ecological and cultural journey into the Pampas

We propose a 700 km journey into the field to recognize the heterogeneity of the Pampas and to explore remnants of the natural grassland (Fig. 5). The journey covers two sub regions with contrasting relief, hydrology, and land-use history, first the Rolling Pampas, and second the Flooding Pampa, the highest expression of the Pampas flat spirit (Oyarzabal & al. 2018). A good supplementary reading for our journey is Ghersa & Leon (2001), who provide descriptions of present-day Pampean landscape and its history since the arrival of Europeans and the introduction of cattle.

Our trip begins by travelling to the north of the city of Buenos Aires, across the Rolling Pampas, where fluvial landforms offer the background to the visible imprint of culture (Ghersa & Leon 1999, 2001). Dense population and industrial compounds do not hide the typical valleys and hills of this region. On the San Isidro cliffs, the "*Quinta Pueyrredón*" offers a view of the banks of Rio de la Plata and the lion-colored river itself. Nowadays, this property houses a Municipal Historical Museum, as it is a landmark in South American

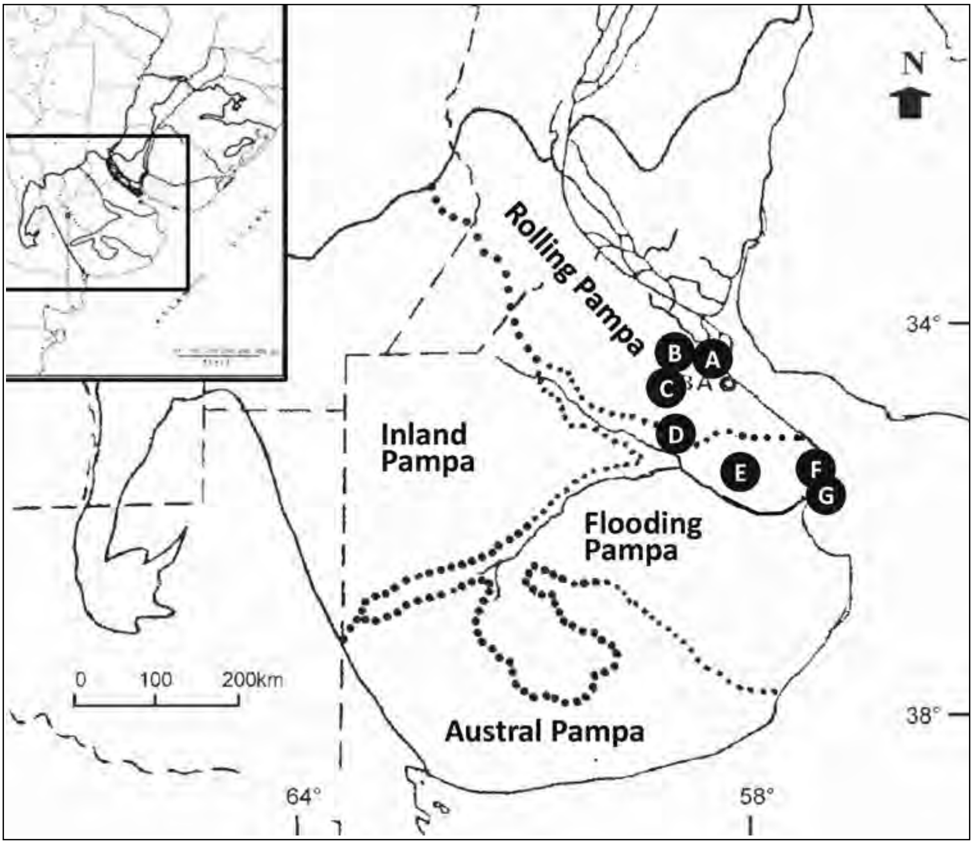

Fig. 5. A tour across the Pampas. Rolling Pampa: (a) Quinta Pueyrredón; (b) Lujan river; (c) La Blanqueada, one of the typical '*Pulperias*' (countryside tabern) where gauchos gathered; (d) Tall tussock grassland remnants. Flooding Pampa: (e) Flat landscape of the Flooding Pampa. (f) *Celtis ehrenbergiana* (Klotzsch) Liebm.thickets (*talares*) over coastal strips of shell deposits; (G) Coastal marsh *Spartina densiflora* Brongn. grassland (adapted from Soriano & al. 1991).

history (http://museopueyrredon.org.ar/ Fig. 6a). The cliffs witnessed the first meetings between aboriginals and Europeans back in the early sixteenth century. In 1810, Cornelio Saavedra, a leader of the May Revolution, departed from here to establish the first Government of what later became Argentina. In the colonial style gardens, a historical tree witnessed the birth of three countries: an *algarrobo* (*Prosopis alba* Griseb.) shelters us with the same shade in which José de San Martín and Juan Martín de Pueyrredón planned the Liberating Expedition of Southern South America. In fact, trees of different species of *Prosopis* characteristic of the Espinal phytogeographical province are represented in the garden (*P. affinis* Spreng. (ñandubay), *P. caldenia* Burkart; Cabrera 1976), as well as other tree species from the river bank thickets such as *tala* (*Celtis ehrenbergiana* (Klotzsch) Liebm.) and *ceibo* (*Erythrina crista-galli* L.) described by the Jesuit priest Thomas Falkner (Falkner 1774). These trees provided essential fire wood for the very first settlers of Buenos Aires (D´Orbigny 1998) and are easily identified, along with the *ombú* (*Phytolaca dioica* L.), in paintings by Prilidiano Pueyrredón, the distinguished Argentine landscape painter who portrayed the Pampas in the nineteenth century — (https://www.bellasartes.gob.ar/coleccion/obra/3170).

Continuing our journey towards the northwest, we leave the river behind and enter the Rolling Pampas. Driving along Provincial Route 41 to the city of Mercedes, we cross a landscape deeply modified by human activity. Soybean (*Glycine max* L.), maize (*Zea mays* L.), or wheat (*Triticum aestivum* L.) fields, and sown pastures alternate with gated neighbourhoods, malls, and industrial buildings (Fig. 6b). In the valley of the River Lujan, we find narrow corridors of grassland vegetation dominated by native grasses of the genera *Nasella*, *Paspalum*, *Aristida* and *Piptochaetium*, and shrubs of genera *Baccharis*, and *Vernonia*. The ancient atmosphere and meals from the Pampas are experienced in traditional taverns (*pulperías*) in San Antonio de Areco (Fig. 6c). The *pulpería* served as grocery store, bar, social club, and fighting arena for the rural life. “La Blanqueada” is a National Historical Museum (http://www.sanantoniodeareco.com/pulperia-la-blanqueada), as it is the setting of “*Don Segundo Sombra*”, a traditional masterpiece of Argentine literature, written by Ricardo Güiraldes.

Our journey continues on route 41, forming a wide arch around Buenos Aires suburbs, toward the city of General Belgrano across the Salado River and into the lowlands of the Flooding Pampa. Crossing the Salado is a meaningful event as this river used to be the limit of European civilization in the Pampas, and significant historical outposts are distributed along its banks. In the Flooding Pampa, we have the opportunity to enjoy the apparent limitlessness of the plain. Sharpening our view, we might also learn to perceive and value the subtle topography of the paleo-dunes and depressions generated under desert climate during glaciation times and of shallow valleys of slow meandering watercourses (Tricart 1973; Burkart & al.1990). In the Flooding Pampas, grasslands are usually grazed by cattle year-round, and the horizon often looks still uninterrupted by trees. There are some grassland stands dominated by *Paspalum quadrifarium* Lam., a native tall tussock grass known as redstraw (Fig. 6 c; Perelman & al. 2003), that are host of a high diversity of native plant and animal species. Near the city of Castelli, we visit remnants of humid grassland communities with characteristic species like *Leersia hexandra* Sw., *Paspalidium geminatum* (Forssk.) Stapf and *Carex phalaroides* Kunth. (Fig. 6d).

Finally, on the trip back to Buenos Aires along PR 11, we visit the coastal landscape where strips of tala(*Celtis ehrenbergiana* (Klotzsch) Liebm.) thicket occupy old marine

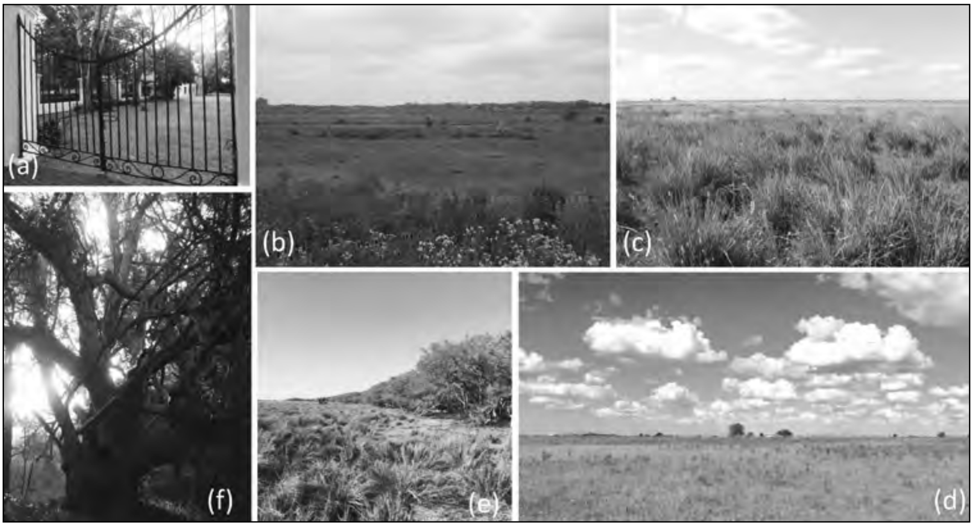

Fig. 6. Images from some the tour across the Pampas grasslands. We purposely present B&W photos to invite future travelers to enjoy the live colours and tints of these lookouts. (a) Gates of the Quinta Pueyrredón. General José de San Martin walked through this gate before starting his military campaign to free Southern South America from Spain. (b) Valley in the Rolling Pampas seen from the upland. This region is characterized by well-defined watersheds tributaries of the Paraná river and Rio de la Plata. (c) Tall tussock grassland dominated by *Paspalum quadrifarium* Lam. near General Belgrano, Buenos Aires. (d) Cloudy, flat landscape, with small tree clusters surrounding houses. These trees were planted by settlers to provide shelter, shade, and wood. Later, some of the planted species have invaded the grassland. (e) Long and narrow *Celtis ehrenbergiana* (Klotzsch) Liebm. thicket (*talar*) in contact with a stand of *Spartina densiflora* Brongn. coastal marsh grassland. These lineal forests support a great plant and animal biodiversity, but are also prone to invasion. (f) Sun flecks inside a ‘talar’ inspired Sara Gallardo to one of the passages of her novel “Los galgos, los galgos” (1968). Photos: (a,f) Marina Omacini; (b-e) Pedro Tognetti.

shell deposits parallel to the coastline which alternate with lowlands covered by tall grasslands dominated by *Sporobolus densiflorus* Brongn. In the thickets, the dominant *tala* (*C. ehernbergiana,* Fig. 6f) is accompanied by *molle* (*Schinus longifolius* (Lindl.) Speg.), *coronillo* (*Scutia buxifolia* Reissek), and *blanquillo* (*Sebastiania brasiliensis* Spreng.) among other woody native species. This forest is nowadays deeply degraded as numerous native species have become infrequent while numerous invading exotics,such as *ligustro* (*Ligustrum lucidum* W.T. Aiton), *acacia negra* (*Gleditsia triacanthos* L.), *almez* (*Celtis australis* L.), *mora* (*Morus* sp. pl.), or *paraíso* (*M. azedarach* L.), often attain dominance (Fig. 6e). Between the forested strips, the *S. densiflorus* graslands (*espartillares*) occupy low longitudinal bands the last of which runs along the muddy coastline dug up by innumerable crabs (Fig. 6e).On returning to the city of Buenos Aires, the travellers can the aftertaste of the Pampas, with Argentine folk music by Eduardo Falú or Francisco Giacobbe, who composed under the inspiration of this wonderful grassland.

Threats to the persistence of Pampean Grassland

As other regions over the world, the Pampas are threatened by human activities that fragment the landscape and cause deep changes in ecosystem structure and function(León & al. 1984; Laterra 1997;Ghersa & Leon 1999, 2001; Laterra & al. 2003; Burkart & al. 2005; Baldi & al. 2006; Chaneton & al. 2002; Tognetti & Chaneton 2015).Transformation of the grassland into crop fields, orchards, cattle feedlots, and tree plantations, within landscapes traversed by elevated highways and artificial waterways, expose the ecosystems to exotic plants and animals and altered disturbance regimes. Under these new conditions, persistence of the Pampean grassland is seriously compromised (Tognetti & Chaneton 2015), and the characteristic open horizon of the region might be condemned to disappear forever.

Conservation strategies for the Pampas must consider that the native grassland not necessarily regenerates after cessation of land use. Secondary succession after land abandonmentfollows contrasting pathways depending on whether previous human perturbation was livestock grazing, agriculture, or tree plantation, and depending on the characteristics of the landscape in different sub regions of the Pampas (Suding & al. 2004; Tognetti 2010; Rodriguez & al. 2016). While spontaneous recovery of the native vegetation appears possible in certain cases (Leon & Oesterheld 1982; Cuevas & Zalba 2009), post-agricultural recovery requires specific restoration intervention (Tognetti & Chaneton 2012), because succession tends to be arrested in a state dominated by exotic plants like the wintergrass *Festuca arundinacea* Schreb. and the summer grasses *Cynodon dactylon*(L.) Persand *Sorghum halepense* (L.) Pers (Omacini & al. 1995; Omacini & al. 2005; Tognetti & al. 2010; Tognetti & Chaneton 2012). Our studies suggest that the dominance of these exotic species may be associated with change in the composition of the regional flora (Ghersa & León 1999; Chaneton & al. 2002) and with the paucity of native vegetation remnants in agricultural landscapes (Burkart & al. 2011; Perelman & al. 2017).Consequently, conservation of the grassland requires active management measurements specific for each sub region of the Pampas.

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Human activities trigger change in marine landscape*

Abstract

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Biodiversity is undergoing rapid and worrying changes, partially driven by anthropogenic activities. Human impacts and climate change (e.g. increasing temperature and ocean acidification), which act at different spatial scale, represent the most serious threats to biodiversity and ecosystem structure and function. In this overview, the effects of anthropogenic pressures on unique and valuable Mediterranean systems, such as *Cystoseira* sp. pl. forest and *Posidonia oceanica* meadows, are examined. These complex systems, characterized by a high associated biodiversity, are regularly exposed to natural and anthropogenic pressures. Due to the central role they have for several important ecological processes in marine ecosystems, their loss can lead dramatic consequences. Since these ecosystems are often unable to recover naturally, it is necessary to reinforce their resilience. Therefore, reintroduction by transplantation and reforestation methods have been recently proposed. Considering future increase in anthropogenic and climatic pressures, understanding how these systems respond to stressors and preserving their resilience should be an essential component of any conservation management plan.

Key words: biodiversity, *Cystoseira* forest, stressors, *Posidonia oceanica* meadows, Mediterranean Sea.

Introduction

The Mediterranean Sea, even though representing a small part of the world's oceans, is inhabited by an unusually rich and diverse biota. It hosts approximately 17,000 species (Bianchi & Morri 2000; Coll & al. 2010). As a result, it is considered as a true hotspot of biodiversity (Bianchi & Morri 2000; Boudouresque 2004; Coll & al. 2010), even by virtue of the high rates of endemic species it supports (25%, Boudouresque 2004), for instance the neo-endemism (of Pliocenic origin) *Cystoseira* genus, considered a key-stone genus with 30 endemic species into the Mediterranean (Cormaci & al. 2012) and the paleo-endemism (of Tethyan origin) *Posidonia oceanica* (L.) Delile. The western basin shows a higher rate of endemism than the eastern one, appearing to be an active center of endemism (Boudouresque 2004).

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Within the Mediterranean Sea, Sicily and circum-Sicilian Islands, as a consequence of their geographical position between the western and eastern sectors, and due to the numerous diverse habitats occurring along their coasts, which are washed by three different seas (Tyrrhenian, Ionian and South Mediterranean) are high-biodiversity areas (Coll & al. 2010; Giaccone & al. 2010; Domina & al. 2018).

At the same time, the Mediterranean Sea is among the most impacted Sea, as a consequence of different anthropogenic pressures on marine ecosystems which are significantly affecting biodiversity and are predicted to increase in the future (Coll & al. 2010, 2012; Lejeusne & al. 2010; Katsanevakis & al. 2013). The Mediterranean is currently experiencing a decline in the number of species and a deterioration of habitats, related to increase of human population, habitat modification and loss, pollution, coastal urbanization, overexploitation and the intentional or indirect introduction of Non-Indigenous Species (NIS, i.e. organisms introduced outside of their natural range) and climate changes, i.e. acidification and warming (Coll & al. 2010; Lejeusne & al. 2010; Zenetos & al. 2012; Katsanevakis & al. 2013; Bianchi & al. 2014).

In the Mediterranean Sea, several valuable, productive and unique habitats, including *Cystoseira* sp.pl. forest and *P. oceanica* meadows, supporting high biodiversity and providing essential ecological goods and services, are under threat (Coll & al. 2010; Lejeusne & al. 2010; Telesca & al. 2015; Boudouresque & al. 2017 and references therein). The sensitivity of these systems to a variety of stressors, makes them particularly vulnerable and susceptible to human pressures which can cause their decline and/or loss.

The aim of the present paper is to overview the effects of anthropogenic activities on these two sensitive Mediterranean coastal communities, *Cystoseira* sp. pl. forest and *P. oceanica* meadows, which are currently under threat in several areas, focusing on Sicilian habitats, also providing examples of management and conservation strategies.

Materials and methods

We looked for scientific papers, grey literature and reports, in order to obtain a representative number of relevant documents. A search was performed using standard scientific databases. The research criteria were based on a list of key terms such as "*Posidonia oceanica*" or "*Cystoseira*" or "*Cystoseira* canopies" or "Fucales" and "status" or "decline" or "regression" or "recovery" and "human impact" or "pressure" or "threat" and "restoration" or "transplantation" or "reforestation" and "Mediterranean Sea" or "Sicilian".

Results and Discussion

Cystoseira *sp. pl. forests*

In the Mediterranean Sea, species belonging to the genus *Cystoseira* (*Sargassaceae*) are the most important canopy-forming algae in shallow rocky bottoms (Ballesteros 1990a, 1990b; Giaccone & al. 1994).

Currently, 41 taxa belonging to the genus *Cystoseira* are reported for the Mediterranean Sea (Cormaci & al. 2012; Taşkin & al. 2012). These long-living brown macroalgae are ecologically relevant as keystone species (Paine 1969) and habitat-forming species (Gianni & al. 2013). They have a fundamental role in sustaining the biodiversity and performing numerous ecosystem services such as controlling spatial habitat heterogeneity, providing high primary production and food, nutrient cycling, suitable habitats, protection from predators and shelter from disturbance (Ballesteros & al. 2009; Sales & al. 2012; Mineur & al. 2015).

For these reasons *Cystoseira* species are listed as "of community interest" according to the Habitat Directive (92/43/EEC), and are considered as reliable indicators of environmental quality in Mediterranean coastal waters (Ballesteros & al. 2007), according to the Water Framework Directive (WFD, 2000/ 60/EC) and Marine Strategy Framework Directive (MSFD, 2008/ 56/EC) (Orlando-Bonaca & al. 2013). Five species are on the list of protected species (Annex I) of the Bern Convention and all the species, except *Cystoseira compressa* (Esper) Gerloff & Nizamuddin, are included in the List of endangered and threatened species of the Annex II of the Barcelona Convention (UNEP, Decision IG.21/09) and are considered vulnerable by several international organizations (i.e. IUCN, RAC/SPA, MedPan).

Anthropogenic pressures

Cystoseira species are particularly sensitive to a variety of anthropogenic stressors such as urbanization, pollution, trampling, overfishing (of large sea urchin predator fish) and climate change (Milazzo & al. 2002; Sales & al. 2011; Mineur & al. 2015; Thibaut & al. 2015; Blanfuné & al. 2016). Consequently, over the last few decades, most of the *Cystoseira* species have experienced a severe decline in many Mediterranean regions and have retracted their ranges (Thibaut & al. 2005; Mangialajo & al. 2008; Iveša & al. 2016; Bulleri & al. 2018). The causes of decline of Mediterranean Sargassaceae are multiple and act not only in a cumulative but also in a synergic way. Recently, it has been suggested the hypothesis of a possible role of the microbial communities in contributing to the declines of populations of *Cystoseira* sp. pl. in the Mediterranean Sea (Mancuso & al. 2016).

As consequence of these pressures, *Cystoseira* systems may shift from a complex and productive state to alternative states with simpler, poorly organised and less-productive communities that are able to inhibit recolonization by canopy-forming species (Connell 2005; Gorman & al. 2009; Perkol-Finkel & Airoldi 2010; Thibaut & al. 2014 and references within; Rindi & al. 2017; Chemello & al. 2018). For instance, pollution can lead to a shift to ephemeral opportunistic species and, affecting the resistance to the invasion and the resilience of the system, can enhance the growth and spread of alien species such as *Caulerpa cylindracea* Sonder (Fig. 1A) (Diez & al. 2014; Gennaro & Piazzi 2014; Gennaro & al. 2015; Piazzi & Ceccherelli 2017). In turn, opportunistic species are unable to avoid the spread of *C. cylindracea* which prevents the recovery of native populations by facilitating the persistence of alternative assemblages (Piazzi & Ceccherelli 2017). Overfishing of large sea urchin predator fish cause an increase in sea urchin density which may lead to a shift to a simpler community, dominated by turf-forming or encrusting coralline algae, the so-called 'barren ground' (Fig. 1B) (Thibaut & al. 2005; Airoldi & al. 2008; Hereu & al. 2008; Sala & al. 2012; Tsiamis & al. 2013; Templado 2014; Agnetta & al. 2015). The sea urchin *Paracentrotus lividus* (Lamarck, 1816) would have a leading role in the formation of barren areas (Agnetta & al. 2015). Indeed, by removing the base of the alga, prepares the substratum for the colonization by encrusting algae (Agnetta & al. 2013).

Fig. 1. A) A population of *Caulerpa cylindracea*; B) a "barren ground" (photo by Paola Gianguzza); C) the infralittoral fringe with *Cystoseira amentacea*.

Instead, the role of *Arbacia lixula* L., which settles in encrusting coralline algae, is the maintainance of 'barren ground' (Bonaviri & al. 2011; Privitera & al. 2011). At Ustica Island, a barren ground interspersed with patches of *Cystoseira* sp. pl. was recently observed by Gianguzza & al. (2010).

The regression of *Cystoseira* sp. pl. forests is mainly related to overfishing and NIS rather than to warming (Boudouresque & al. 2017 and references within). Due to the dramatically accelerating rate of NIS introductions and due to the intense shipping traffic, the Mediterranean Sea may be considered as a true hotspot of marine bioinvasions (Rilov & al. 2009). To date, almost 1000 marine NIS (equivalent to ca. 6% of the total flora and fauna) have been introduced in the Mediterranean (Zenetos & al. 2012). It has been ascertained that alien species may have significant environmental (substitution of native species; biodiversity loss; habitat modifications and alterations in community structure), socio-economic and human health impacts (Vilà & al. 2011; Jeschke & al. 2014; Katsanevakis & al. 2014), consequently they are recognized as one of the major threats to biodiversity. For instance, *Caulerpa taxifolia* (Vahl) C. Agardh, *C. cylindracea* and *Asparagopsis taxiformis* (Delile) Trevisan can outcompete with *Cystoseira* sp. pl., mainly with species growing in the infralittoral fringe such as *Cystoseira amentacea* (C. Agardh) Bory (Fig. 1C), which is a particularly vulnerable area, being subjected to a range of anthropogenic disturbances (Boudouresque & al. 1995; Thompson & al. 2002; Piazzi & Ceccherelli 2006; Mannino & Balistreri 2017; Mannino & al. 2017).

Status along the Sicilian coasts

According to Giaccone & al. (2010), who depicted the ecological status of coastal waters around Sicily, in Tyrrhenian areas (e.g. Ustica Island, the Aeolian Islands) communities with *Cystoseira* sp. pl. (*C. amentacea*, *C. brachycarpa* J. Agardh, *C. sauvageuana* Hamel, *C. spinosa* Sauvageau, *C. zosteroides* (Turner) C. Agardh) were well structured. Conversely, in the Straits of Sicily (e.g. Pantelleria Island and Linosa Island) and the Ionian Sea (Maddalena Peninsula), disappearance of the above-mentioned species of *Cystoseira* and the resulting communities (excluding those occurring in shallow water), and their substitution by less-structured communities of *Dictyotaceae*, *Sphacelariaceae* and *Udoteaceae* were observed. The disappearance of *Cystoseira* in these areas was related by the authors to an increase in the temperature of superficial waters caused by global climate change, together with changes in the deep circulation of the eastern Mediterranean basin recorded in the last 30 years. More recently, Mancuso & al. (2018) observed at Portopalo di Capo Passero the loss of *Cystoseira humilis* Kützing and a notable decrease in the cover of *C. compressa* with respect to previous data (Giaccone & al. 1992).

Management and restoration strategies

The threat of declining/losing *Cystoseira* species is increased by the low dispersal capacity of most *Cystoseira* species, due to rapid egg fertilization and zygote sinking, which makes difficult natural recovery. To stimulate the natural restoration of lost populations, the setting up of Marine Protected Areas (MPAs) could be certainly useful but probably not sufficient. Therefore, artificial reforestation may be a valuable tool to improve the restoration of extinct populations (Falace & al. 2018 and references within).

Nowadays, the interest in habitat restoration is increasing according to the Biodiversity Strategy to 2020 (Target 2; European Commission, 2011), which recommends the restoration of valuable species, such as *Cystoseira* sp. pl. forests, into areas where their historical presence is recorded and the pressures that led to their loss are no longer acting (Mangialajo & al. 2013; Falace & al. 2018).

For *Cystoseira* reforestation, among the techniques now available, transplantation of juveniles or adult thalli is the most used method (Falace & al. 2006; Susini & al. 2007; Sales & al. 2011; Perkol-Finkel & al. 2012; Gianni & al. 2013). Outplanting (culturing germlings, obtained from fertile receptacles, in the laboratory and transferring them into the field), providing many healthy specimens without depleting natural populations, appears to be a more ecologically sustainable technique (Falace & al. 2006; Sales & al. 2015). Since large numbers of germlings are necessary for outplanting in large-scale restoration actions, efficient and cost-effective seedling production system must be planned (Falace & al. 2018). However, restoration of canopy forests makes sense only within the framework of an effective and rapid management of local stressors. Reducing local human impacts would represent the most effective strategy for the conservation and recovery of these systems, but, whenever this is not sufficient, restoration projects can help.

Posidonia oceanica *meadows*

Mediterranean seagrass meadows, such as *P. oceanica*, constitute a major component of coastal marine ecosystems, which provide goods and services in coastal areas (Pergent & al. 2014).

P. oceanica is a slow-growing species endemic of the Mediterranean Sea, where it is the dominant seagrass and it can form meadows or beds extending from the surface to 40–45m depth (Fig. 2A).

According to Telesca & al. (2015), the total known area of *P. oceanica* meadows in the Mediterranean Sea was found to be 1,224,707 ha (12,247km^2). In Italy (337,611 ha) it was characterized by a rather continuous distribution along continental and insular coasts, and it covers 76,000 ha of Sicilian coastal areas (Calvo & al. 2010; Telesca & al. 2015).

Seagrass meadows are presently experiencing a decline globally (Orth & al. 2006), as consequence of several threats, which places them among the most threatened ecosystems (Waycott & al. 2009). Since *P. oceanica* is also susceptible to regression as response to specific impact (Orth & al. 2006; Marbà & al. 2014), its presence and abundance is considered as an indicator of the environmental quality of the coastal zone. Therefore, *P. oceanica* has become one of the main targets of the protection and management of the Mediterranean marine environment (Pergent 1991; Boudouresque & al. 2012). Indeed, the European Union's Habitat Directive (92/43/ CEE) included *P. oceanica* beds among priority habitats (Habitat 1120), and more recently, the Marine Strategy Framework Directive (MFSD) (2008/56/EC) selected *P. oceanica* as representative species of the angiosperm quality elements for the Mediterranean marine environment.

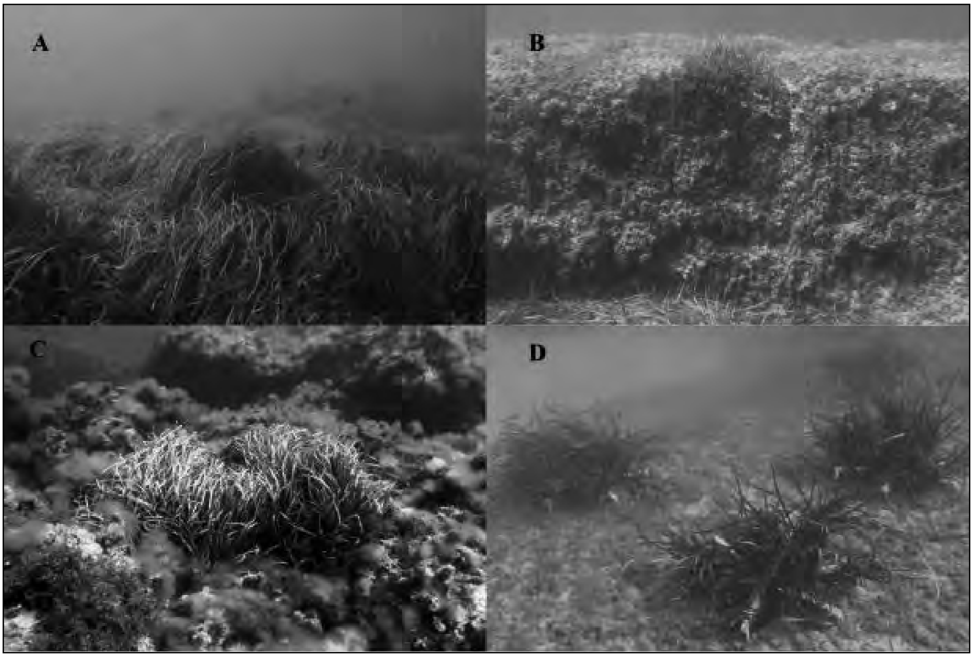

Fig. 2. A) *Posidonia oceanica* meadow; B) *Posidonia oceanica* dead *matte* (photo by Antonino Scannavino); C) the NIS *Lophocladia lallemandii*; D) an underwater anchor modular system for restoration of *Posidonia oceanica* meadows (photo by Antonino Scannavino).

P. oceanica is listed as a species of Least Concern within the International Union for the Conservation of Nature Red List of Threatened Species (IUCN 2015) and included in Annex I of the Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats, 1979) as a protected species. The habitat has been also identified as a priority under the European Commission Habitats Directive (92/43/EEC), and in several European countries the species and/or the habitat are under specific legal protection (Boudouresque & al. 2012).

Anthropogenic pressures

P. oceanica meadows are presently experiencing significant regression generally linked to anthropogenic pressures, such as coastal development, pollution, turbidity, resuspension of sediments, boat anchoring, fish trawling, dredging (Milazzo & al. 2002; Boudouresque & al. 2009; Badalamenti & al. 2011; Abadie & al. 2016). Pressures linked to global change, i.e. the introduction of NIS, warming and sea level rise, can be considered to be among the main responsible of *P. oceanica* regression (Short & Neckles 1999; Boudouresque & Verlaque 2002; Marbà & Duarte 2010; Pergent & al. 2014, 2015). As consequence of its regression, *P. oceanica* may be substituted by "warm" affinity species of lower structural complexity, such as *Cymodocea nodosa* (Ucria) Ascherson (which is also a pioneer species in the succession, allowing for the settlement of *P. oceanica* meadows), *Halophila stipulacea* (Forsskål) Ascherson, or other NIS. Warming is responsible for a reduction of its range near its warm limit and an increase of its range near its cold limit, whereas sea level rise causes a reduction of its lower limit (Boudouresque & al. 2017 and references within). Trawling removes the upper layer of rhizomes of the dead *matte* (Fig. 2B). Anchoring of small leisure boats scars the dead *matte*, whereas the anchor of large boats may remove huge blocks of *matte* (Ganteaume & al. 2005; Boudouresque & al. 2012). Anchoring has a direct adverse effect on cover and shoot density of *P. oceanica* meadow (Francour 1994; Francour & al. 1999; Milazzo & al. 2002). The introduction of NIS, such as *C. taxifolia* and *C. cylindracea*, able to enter into competition with native seagrasses, is a major concern (Boudouresque & al. 2009). Stressed and degraded meadows constitute a very favorable environment for the development of NIS, and this development could in turn exacerbate the regression of seagrass meadows (Fig. 2C). Both invasive *Caulerpa* species are able of invading sparse *P. oceanica* meadows, but fail when shoot density of *P. oceanica* is high (Meinesz & Hesse 1991; Klein & Verlaque 2008).

Status along the Sicilian coasts

P. oceanica is the most common seagrass along Sicilian coasts, whose meadows show the most extensive bottom coverage of all the Italian regions after Sardinia (Calvo & al. 2010).

According to these authors, along the Sicilian coasts, *P. oceanica* is commonly found in a good condition in respect to average Mediterranean conditions. This is demonstrated by the high levels of productivity, leaf biometry and flowering performance which have been recorded. Genetic diversity is also high, with the exception of isolated meadows such as the *Posidonia* banks and the Stagnone of Marsala. Several factors may explain the health status of Sicilian meadows, such as relatively low anthropogenic pressure, sedimentation rate and favourable temperature and photoperiod (Calvo & al. 2010 and references within). In particular, along the western coast of Sicily favorable ecological conditions and highly pristine natural conditions have allowed the development of one of the largest *P. oceanica* meadows in the Mediterranean. Wide and dense *P. oceanica* meadows are present on the sea floor of the calcareous Egadi Archipelago and the island of Lampedusa. In the volcanic islands (Aeolian, Ustica, Pantelleria and Linosa Islands) *P. oceanica* beds settle on rock or volcanic sands mixed with biogenic calcareous detritus. A decline of *P. oceanica* meadows has been observed in "Stagnone di Marsala" (Tomasello & al. 2009; Calvo & al. 2010), a semi-enclosed coastal lagoon along the western coasts of Sicily (Italy), where seagrass forms reef, atoll and tiger meadow types. Signs of evident regression have been also found for meadows close to urban and industrial areas (e.g. Gulfs of Palermo and Augusta).

Management and restoration strategies

Due to the fundamental role played by *P. oceanica* meadows along Mediterranean coasts, and the obvious regression to which they have been subjected, it is crucial to undertake actions to mitigate the threats, promote conservation practices and restore the previous conditions. For seagrass habitat recovery it is necessary to identify and limit and/or eliminate the causes of degradation (Hobbs & Norton 1996). The management of direct impacts, certainly helping recovery and promote resilience, can take an extremely long time from dozens to hundreds of years (González-Correa & al. 2005; Badalamenti & al. 2011; Fraschetti & al. 2013). Full recovery of *P. oceanica* meadows is considered irreversible in human time-scale, because it is a slow-growing species with a low recovery rate a low recovery rate, low flowering and high rates of fruit abortion and predation (Balestri & Cinelli 2003; Díaz-Almela & al. 2006). Transplantation is considered a possible option for speeding up seagrass habitat restoration (Fonseca & al. 1994). The use of vegetative fragments as planting units has proved more effective than seeds, which are less available (Balestri & Cinelli 2003; Díaz-Almela & al. 2006; Terrados & al. 2013). Transplant donor populations of *P. oceanica* with the highest genetic variability showed the best growth performance (Procaccini & Piazzi 2001). Terminal plagiotropic cuttings with three leaf bundles resulted suitable material for transplanting (Piazzi & al. 1998). A careful habitat selection for seagrass transplantation is also needed (van Katwijk & al. 2009). Dead *matte* results the most suitable substratum for *P. oceanica* planting (Di Maida & al. 2013; Terrados & al. 2013). Another focal point of marine restoration projects is monitoring of transplant performance. A monitoring period should last at least 3 years for the selection model outcome and at least 6 years for evaluating the effectiveness of restoration projects (Pirrotta & al. 2015). Limiting anchorage and craft fishing to protect transplants, at least until their stabilization, is also needed.

A new transplantation technique, based on anchor modular system with six arms constructed of starch-based biodegradable materials (bioplastic Mater-Bi), may be an effective technique to successfully restore *P. oceanica* habitat (Fig. 2D) (Scannavino & al. 2014). Cultivated seedlings of *P. oceanica* can be also transplanted in the field with relatively high success and thus can be an important management tool for seagrass restoration (Balestri & al. 1998; Domínguez & al. 2012; Terrados & al. 2013). Since *P. oceanica* fruits are increasingly available in many countries, they may be planted in selected suitable areas to create reservoirs of juveniles for future restoration activities.

Conclusions

Unhealthy *Cystoseira* assemblages and *P. oceanica* meadows are at high risk from anthropogenic and climatic stressors. Since anthropogenic stressors and global change are expected to increase in the coming decades, a strong effort at global scale is required in order to establish and/or implement effective conservation plans for these valuable ecosystems.

A successful conservation plan is possible by reducing anthropogenic stressors and improve the resilience of these systems to future anthropogenic and climatic pressures (Folke & al. 2004; Boudouresque & al. 2009; Sales & al. 2011; Pergent & al. 2014; Strain & al. 2014, 2015).

Additional management strategy can be restoration and protection within MPAs (Susini & al. 2007; Gianni & al. 2013). MPAs are without any doubt precious tools for the management and governance of biodiversity in the Mediterranean (IUCN 2010). For decades the creation of marine reserves has been considered the only means to restore natural communities and protect marine ecosystems.

MPAs may play a fundamental role in the conservation of *Cystoseira* sp. pl. forests and *P. oceanica* meadows, guaranteeing protection from several impacts and representing the source of propagules for the restoration of lost or degraded systems. Unfortunately, the aesthetic appeal of reserves and the facilities provided, together with the increased public awareness of nature, contribute to creating massive tourism in MPAs (Badalamenti & al. 2000).

Moreover, monitoring plans are also required in order to describe how these populations are changing over time, and implement integrated coastal zone management actions for the protection, conservation and/or restoration of these unique, valuable and unfortunately sensible ecosystems (Calvo & al. 2010; Pergent & al. 2014; Mancuso & al. 2016). The creation of early-warning systems, able to valuate early signs of suffering or decline, could be crucial for monitoring these habitats. Since intensive scientific monitoring programs are very expensive, Citizen Science (involvement and active participation of volunteers: tourists, fishermen, divers) could be a useful tool for providing information and scientific data and also to improve the communication between scientists and citizens (Mannino & al. 2018).

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“Re-flowering flowers”: the hope of an eternal blooming since Roman times*

Abstract

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“Re-flowering flowers”, i.e., the metamorphic artistic representations of plants in which one flower gives birth to other ones, are often detectable in the phytoiconography of the Greek-Roman art. Through an extensive analysis of archaeological artworks in the Euro-Mediterranean and West-Asian area, we found the diffusion of this motif starting from the Hellenistic period (IV century B.C.). The metamorphic flowers motif became a dominant element in triumphal arches, and later also in coffered ceilings, forming the so-called “rosettes”. The identification of the single plant elements of these compositions can be carried out both on pottery (among which the best examples come from the Apulian and Greek vases) and on carved structures, where colours are no longer present. We analyzed in detail the botanical compositions of the scrolls of the *Ara Pacis* and in the triumphal Arches of *Titus* and *Septimius Severus* in Rome (Italy). The results enhanced the representation of a relevant floristic richness with some recurrent flowers, such as those of *Lilium*, *Anemone*, *Silene*, *Stellaria*, *Anthemis*, *Calendula*, *Scabiosa*, *Asphodelus*, *Nuphar*, *Carlina* and *Laurus*, but also fruits, shoots, bulbs and floral buds. This motif seems linked to the leading thread of the metamorphosis in the Hellenistic culture and the revived Pythagorean theories of the Augustan age. The continuous transformation of an element into another suggests a spatial translation of temporal concepts: the absence of an end; death as a prelude to a new life. We should better understand the meanings of natural elements in the ancient artistic representations since they were not used only as a mere decorative motif but were part of a widely shared symbolic language.

Key words: flowers representation; plant iconography; phytoiconology; plant symbolism; Roman archaeology.

Introduction

Analyzing art representations in the Greek-Roman culture, spread in western cultures for hundreds of years, we can highlight the presence of “Re-flowering Flowers” (RF), i.e., metamorphic plant images in which one flower gives birth to another one, in sequence

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(Fig. 1). Such scheme is widely recurrent in scrolls and the so-called "rosettes" (Ramage & Ramage 2008), and these iconographic elements had a great fortune from ancient times until nowadays, as they were used in the coffered ceiling of aristocratic palaces, in churches and "classic" architectonic elements (Fig. 2). We can even assume that this type of decoration, highly diffused from Augustan times in the Euro-Mediterranean area, seems to be even more ancient (Vandi 2002).

The archaeological literature neglects these representations in their constitutive polymorphic and metamorphic structure, even in the case of Pompeii, where some attention was given to plant representations in paintings (Comes 1879; Jashemski & al. 2002; Ciarallo 2004, 2006; Caneva 2014). In fact, a description of the composite elements of floristic representations was carried out rarely, such as in the case of the *Ara Pacis* freezes (Caneva 2010), and in other archaeological remains in Rome (Caneva & al. 2014; Kumbaric & Caneva 2014). Despite the absence of specific studies, the ceilings of triumphal arches of Roman Emperors seem to represent a relevant source of examples for understanding the structure and composition of the RF motif.

Moreover, often the floristic parts have been considered only as a decorative motif. It seems contradictory with the knowledge that- in ancient cultures- the representation of an image was the bearer of a message, which needed to be read in relation to its provenience and context to be fully understood (Zanker 1989; Pensabene 2011). For the ancient Roman culture, as for other ancient civilizations, the importance of giving a symbolic meaning to the subject of representations, is clearly underlined by *Vitruvius* in his famous treaty on Architecture (*De Architectura*, Book I, 5th paragraph): *"the architect must possess a good knowledge of history, which permits him to explain to the eventual interlocutors the symbolical meaning with which he often embellishes his buildings".* The primary role of nature in such a means of communication was evident from the literary texts of *Horatius (Odes), Gaius Plinius Secundum (Naturalis Historia), Virgilius (Bucolicae),* and *Ovidius (Metamorphosis),* as well as from an in-depth iconographic analysis of archaeological remains (Caneva 2010; Caneva & al. 2014; Kumbaric & al. 2014; Kumbaric & Caneva 2014). In fact, all the ancient civilizations were in close contact with the natural world, and

Fig. 1. Examples of "Re-flowering flowers", i.e., images in which one flower sprouts from another one, in a sequence of two, three or four elements (from the *Ara Pacis* scrolls, Caneva 2010).

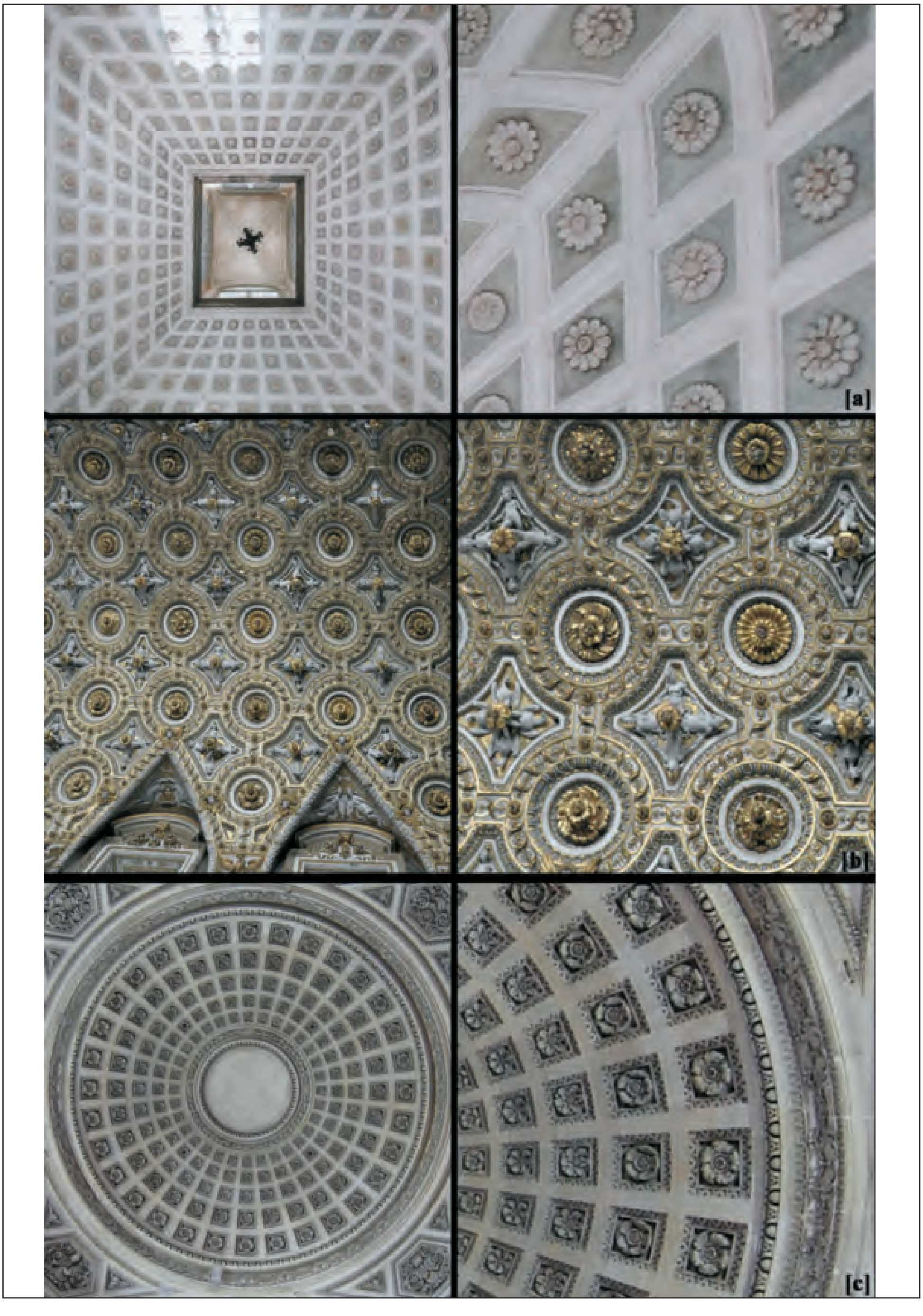

Fig. 2. The RF motif in the coffered ceiling of aristocratic palaces, in churches and in the “classic” architectonic elements: (a) Grimani Palace, Venice; (b) Quirinale Palace, Rome; (c) Pantheon, Paris.

recurrently explained natural phenomena as deity expressions affecting humans (Vandi 2002), and we should better understand the meanings of natural elements in the ancient artistic representations, to better comprehend their culture.

Considering the importance of explaining this recurrent motif, which was insufficiently analyzed, this study aims to define: i) its origin, ii) its symbolical meaning and iii) the variants of the RF motif, taking into consideration a wide range of examples, including some examples of ceilings of triumphal Roman arches. So, in this work, we will discuss its origin and diffusion, the scheme of composition in some relevant monuments and its symbolic and cultural meanings.

Methods

The analysis of the RF motif started from an extensive bibliographic research, looking at different type of architectural, ceramic and jewellery artifacts, mainly from the Hellenistic period in the Euro-Mediterranean area, but also from the Assyrian and Babylonian area (Kleiner 2012). It was useful to analyse both the origin of the motif and its diffusion over time and in different regions. The bibliographic analysis was associated with field research carried out in Rome (Roman *Forum*, Colosseum valley, Imperial *Fori*, Trajan Markets and *Ara Pacis*), to point out how widely this kind of motif was employed and how differently it was realized. We used the collected images together with the results of the bibliographical analysis, to produce a database, which was used to select three outstanding examples of RF representations, which are described here with their historical background and iconographic structure. Following the idea of carrying out a visual “break down” of elements that are in successive transformation, which was suggested for the *Ara Pacis* scrolls (Caneva 2010), we carried out a botanical analysis identifying the “various elementary components”. Specifically, we identified various plant parts (calyx, corolla, stamens, pistils, fruits, bulbs, leaves and derived structures), through the comparison with flora and botanic atlases of reference (Pignatti 1982; http://dryades.units.it/floritaly). The meaning of this motif was finally hypothesized considering the previously cited ancient textbooks of *Plinius, Virgilius, Vitruvius* and *Ovidius*.

The analyzed monuments

The *Ara Pacis* was conceived as an altar dedicated to the peace, which was built (from 13 B.C. to 9 B.C.) to celebrate *Augustus*’s return from his victorious expedition in Gaul and Spain (Fig. 3a). Marking the end of the external rebellions and internal struggles that started with *Julius Caesar’s* murder in 44 B.C., it was an augural tribute for a new peaceful age of Roman dominance coincident with the Empire’s founding (La Rocca 1983; Zanker 1990; Castriota 1995; Cohon 2002). The botanical scrolls are here widely carved in the six panels of the lower parts of the external faces, below the representations of the scenes of the Roman origin and of the finally reached prosperity (four panels), as well as below the two panels representing the parade that was welcoming *Augustus* at his return. This monument can be considered the most relevant example of an extensive use of plant representations for iconographic and symbolic purposes (Caneva 2010).

The arches of *Titus* and *Septimius Severus* in Rome are other earlier and highly representative momuments that include such iconographic motif. The origin of such architectural element (the arch) was possibly related to the *propylaea* of the Hellenistic cities, to the *tetrapylia* of the columnnade streets and elements of *Alexandria* and *Pergamum*. However, the arch seems also to be related to the Etruscan-Italian door of the city, but the first time the word *arcus* appears in a document (of the Decurion assembly in Pisa) was during the Augustan age, when it was referred to the building of the arch of *Caius* and *Lucius Caesar* (4 A.D.) (La Rocca & al. 2008).

The arch of *Titus* (Fig. 3b) was realized in 81 A.D., as an honorific monument built by the Domitian emperor on the *via Sacra*, to reinforce the community consensus on the Flavian dynasty, commemorating the victories of his brother *Titus*, as a deed of pietas (De Maria 1988). It celebrates the *bellum judaicum* and the conquest of Jerusalem in the 71 A.D., and it represents *Titus*'s triumphal return, with the booty of the temple of Jerusalem, a four-horse chariot, crowned by a personification of Victory, and *Titus*'s deification being carried to heaven by an eagle. Other representations in the arch celebrate *Honos* and *Virtus*, Rome and the *Genius* of the Roman people (Torelli & al. 2008).

The arch of *Septimius Severus* (Fig. 3c) was built in the Roman *Forum*, and it was dedicated by the Senate in 203 A.D. to celebrate the *Princeps Virtutis* and his sons *Caracalla* and *Geta,* winning the wars against *Parthia*. The historic relieves, located on the smaller fornix, imitates the triumphal pictures and the friezes of the columns as well. The narration starts from the bottom to the top, showing the salient moments of the war of Mesopotamia (Torelli & al. 2008). The decoration of the arch exhibits a polysemy of meanings. Looking at the archivolt, we can see the Victories carrying trophies, while underneath there are the *Putti* of seasons representing the *aeternitas* of the imperial power. Moreover, the fluvial deities in the smaller fornix symbolize the territorial extension of the Empire, and the arch is rich of images carrying messages connected to peace, prosperity, power and the Emperor (De Maria 1988).

Results

The origin and diffusion of the RF motif

Our bibliographical analysis and field surveys showed as, in ancient times, the *RF* motif was adopted in different architectural elements in ancient Greece and Macedonia, and in the wide *Magna Grecia* area (Tab. 1). Moreover, this motif was not confined only to a fixed context, but it was diffused in a wide artistic production. Examples are present on marble reliefs, in gold necklaces, on mosaic pavements and pottery vases. On pottery, significant examples come from the Apulian and Greek vases where the use of still-visible colour makes easier the analysis of the single elements of composition. In this case, such as on marble friezes or in mosaics, the RF motif includes compositions that start from a central *Acanthus* and end in a flower. In the vault of the arch and ceilings the representation is not connected with other plant elements, and this type of execution is close to examples of the motif in jewellery (e.g., Diadem of Verghina, Taranto necklace) (Becatti 1965).

Considering that the most ancient monuments where the RF motif is detectable, such as the Temples of *Saturnus, Castor* and *Pollux,* and *Apollo Sosianus,* were widely modified during the centuries with the addition of new elements, the most likely origin of such motif seems to be the “red-figure vases” from ancient *Apulia*. The chronology of

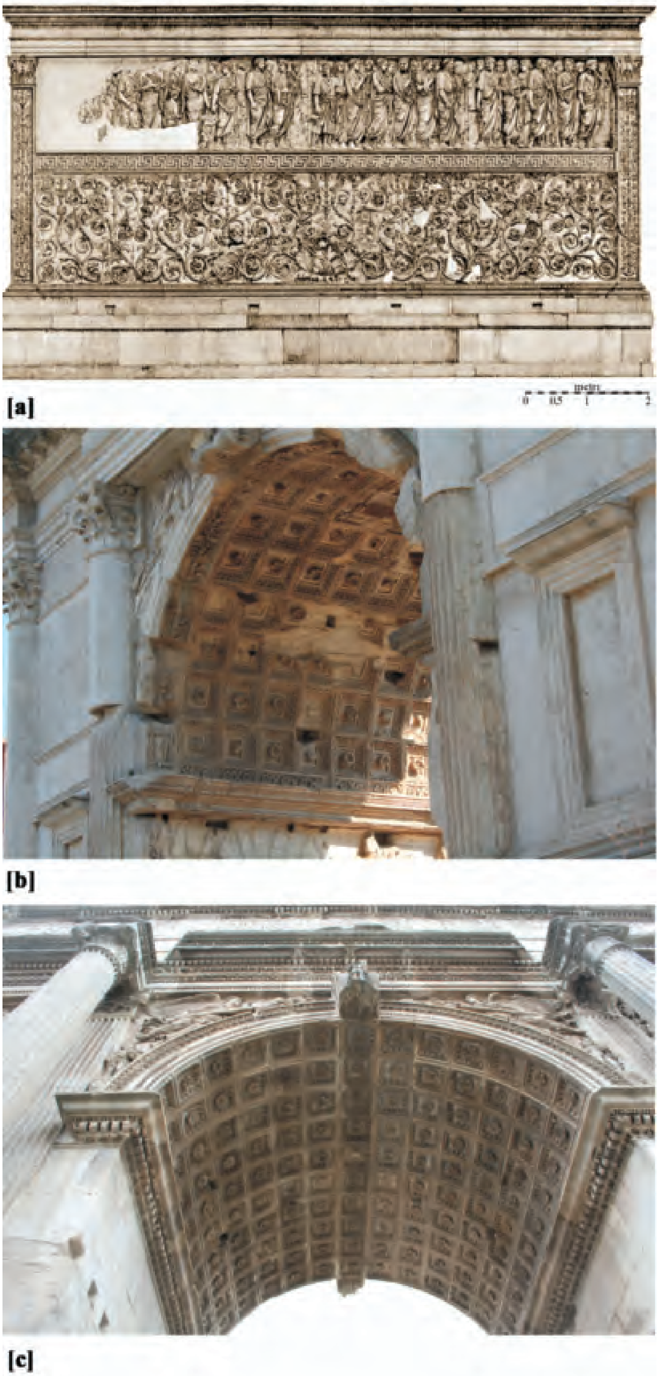

Fig. 3. The analyzed monuments: a) *Ara Pacis*; b) Arch of *Titus*; c) Arch of *Septimius Severus*.

Table 1. A Chronological bibliographic database of RF motifs in the earlier stages of their use.

Object	**Date**	**Originated from**	**Located in**	**Part of**	**Place/ City**
Temple of *Saturnus*	V cent. B.C. (restored in 42 B.C. and 283 A.D.)	Roman *Forum*	Roman *Forum*	coffered ceiling	Rome, Italy
Temple of *Castor* and *Pollux*	V cent. B.C. (restored in 117 and 73 B.C. and 6 A.D.)	Roman *Forum*	Roman *Forum*	coffered ceiling	Rome, Italy
Temple of *Apollo Sosianus*	V cent. B.C. (restored in 353 and 117 and 34 B.C.)	*Campus Martius*	*Campus Martius*	coffered ceiling	Rome, Italy
Gold Necklace	IV cent. B.C.	*Apulia*	British Museum	whole	London, England
The golden larnax	366 B.C.	Tomb of Philip II (Macedonia)	Museum of the Royal Tombs of Aigai	whole	Verghina, Greece
Drape with Acantino decoration	366 B.C.	Tomb of Philip II (Macedonia)	Salonika Museum	whole	Thessaloniki, Greece
Diadem	366 B.C.	Tomb of Philip II (Macedonia)	Salonika Museum	whole	Thessaloniki, Greece
Krater with a mythological scene	350 B.C. (Bari painter)	*Apulia*	British Museum	krater neck	London, England
Krater with the funeral of *Patroclus*	340 B.C. (*Darius* painter)	*Apulia*	British Museum	krater neck	London, England
Krater with *a naiskos* scene	325 B.C. (Baltimora painter)	*Apulia*	British Museum	krater neck	London, England
Mosaic with a hunting scene	316 B.C.	*Pella*	Pella Museum	edge	Pella, Greece
Tomb of *Lucius Scipio Barbatus*	280 B.C.	Sepulchre of the *Scipio* family	Vatican Museum	metope	Rome, Italy
Two marble reliefs	270 B.C.	*Pergamum*, Sanctuary of *Demeter*	Istanbul Museum	whole	Istanbul, Turkey
Mosaic	Eumen II age (197-160 B.C.)	*Pergamum*	Berlin Museum	edge	Berlin, Germany
Tombs of *Larthia*	150-130 B.C.	Chiusi	Archaeological Museum	metope	Florence, Italy

Table 1. continued.

Tombs of *Thanunia Seianti*	150-130 B.C.	Chiusi	British Museum, London	metope	London, England
Basilica Julia	I cent. B.C.	Roman *Forum*	Roman *Forum*	Frieze and coffered ceiling	Rome, Italy
Forum Julium	46 B.C.	Imperial *Forum*	Museum of Trajan markets	coffered ceiling	Rome, Italy
Venus genitrix temple	46 B.C.	Imperial *Forum*	Museum of Trajan markets	coffered ceiling	Rome, Italy
Marble *plutei* relief	First Augustan age (31 B.C.-10 B.C.)	*Horti Sallustiani*	Museum of Montemartini central	whole	Rome, Italy
Ara Pacis	9 B.C.	*Campus Martius*	*Campus Martius*	frieze	Rome, Italy
Forum of *Augustus*	2 B.C.	Imperial *Forum*	Museum of Trajan markets	coffered ceiling	Rome, Italy
Temple of *Mars Ultur*	2 B.C.	Imperial *Forum*	Museum of Trajan markets	capitel	Rome, Italy
Arch of *Titus*	81 A.D.	Roman *Forum*	Roman *Forum*	coffered ceiling of the vault	Rome, Italy
Forum of *Nerva*	97 A.D.	Imperial *Forum*	Museum of Trajan markets	coffered ceiling	Rome, Italy
Trajan’s Market	100-110 A.D.	Imperial *Forum*	Museum of Trajan markets	coffered ceiling	Rome, Italy
Trajan’s *Forum*	112 A.D.	Imperial *Forum*	Museum of Trajan markets	frieze with cupids	Rome, Italy
Temple of *Antoninus* and *Faustina*	141 A.D.	Roman *Forum*	Roman *Forum*	external frieze	Rome, Italy
Arch of *Septimus Severus*	203 A.D.	Roman *Forum*	Roman *Forum*	coffered ceiling of the vault	Rome, Italy

Apulian vases is connected to the period in which Taranto (*Taras*) reached its heights, being a forced waypoint for the commercial routes that connected Greece to Italy, through the Adriatic Sea (Cerchiai & al. 2002).

The most used shapes for the Apulian vases were the “volute-krater” and the *pseudo-panathenaic amphorae*, due to their monumental dimension. In the Apulian vases, the recurrent motifs of the Greek culture were re-elaborated, as the Greek influence bloomed in the Apulian region (Becatti 1965). The subjects of these vases were taken from drama, tragedy and mythology (Trendal 1989). Here, all the floristic elements show the image of double or triple flowers connected with the previous one from the central part (Boardman 1966). Flowers and plants moved from the centre to the side and motifs of RF are usually placed in the lower register (Fig. 4). In the upper register, there are floristic elements, even though they are depicted in a static way (Todisco 2012).

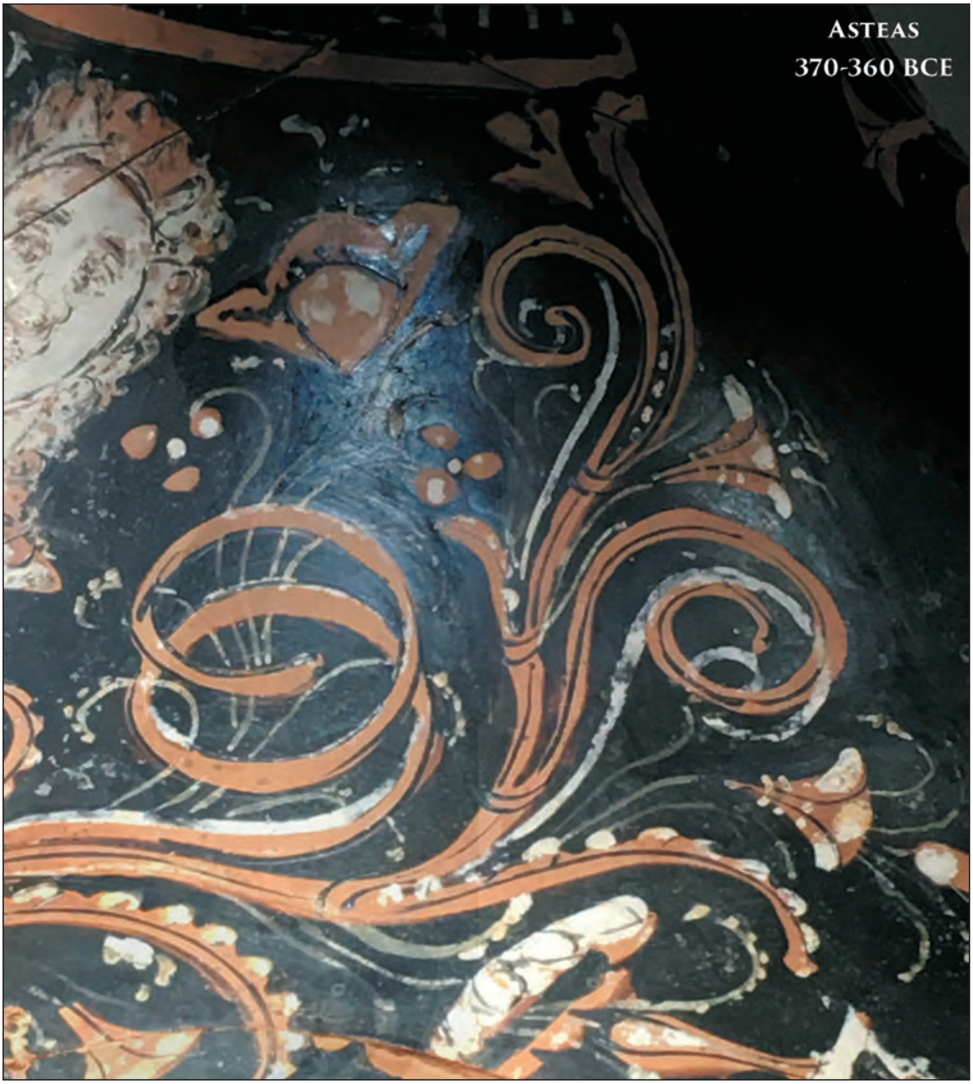

Fig. 4. An Apulian vase (Montesarchio, Archaeological National Museum of Sannio Caudino): Flowers and plants develop from the centre to the side.

A further example of the use of floristic elements is the gold necklace of the second half of IV century B.C., from the grave goods of a tomb from Taranto. The jewel shows a decoration of a triple flower that recalls the floristic elements in the ceramic production. This is a clear demonstration of the motif that switches from different materials (Masiello & Indellicati 2011).

The RF motif was also used in the funeral context like the case of so-called diadem of the princess Meda of Verghina (Macedonia) in one of the three tombs of the Royal *Tumulus* (350 B.C.). There, it was found a gold diadem with a Herculean knot, and a lace embellished with leaves, flowers and petals. It was also discovered a drape with an *acanthus* decoration enriched with flowers and tendrils. In this context, we have a clear archetype of the motif of the re-flowering flowers in both metal and textile materials.

In the earlier Roman context, we also find this motif in the Republican *sarcophagus* of *Lucius Cornelius Scipio Barbatus*, a member of the *Scipio* family that built the *sarcophagus* that was found in the tomb on the *via Appia*. The coffin, carved out in volcanic stone, is modelled on the type of the Greek altar, typical of southern Italy. Here we have a clear example of a mixture of architectural elements of an Ionic temple, provided by the use of volutes on the lid and a Doric temple by the presence of metopes filled with the re-flowering flower elements (Ramage & Ramage 2008). This shows how fast the circulation of art was in the Republican age, where a motif taken far away was re-elaborated and suddenly used in the local art.

A relevant example of the RF motif comes from the stylistic decoration of "*acanthus motif*", which had a big fortune during the III century B.C. Their first examples are found in the tomb gravestones of Thebe, realized as an imitation of the temple trabeation in which the *acanthus* shoot was placed to fill the space in the architrave, *tympanum* and connecting lines of the *acroterion* (Castriota 1995). In the sanctuary of Demeter (270 B.C.) an elaborate vegetal frieze, carved in marble reliefs, arises from a central *acanthus* that develops axial stems and racemes, generating different plants and RF as deities in miniature (Centanni 2007). This composition, such as that on the *Pergamon* altar, had an important role in the study of the Roman art, also considering their symbolic functions (Castriota 1995). Remarkably the representation of the central *acanthus* seems to have a formal affinity with the *Ara Pacis,* built in honour of *Augustus.*

The botanical analysis of RF in the composition in Roman archaeological monuments

The recognized plants in the different examples of RF sum up to about 35 species in the three selected monuments, but this number represents only a part of the original floristic richness of such representations. The botanical composition and their approximate recurrence (Fig. 5) are shown in Tab. 2.

In general, the six external panels of *Ara Pacis* present a very rich flora in their composition, with about 100 species, as previously documented (Caneva 2010). The flora of the scrolls consists of 16 species, with dominance, for the external flowers, of species belonging to *Cardueae,* or the genera *Carlina, Lilium, Nymphaea, Anemone*, *Hedera, Anthemis* and *Scabiosa.* In the case of the central elements (the terminals), the most recurrent elements are fruits of *Asphodelus* and *Malva* or buds and shoots of various species (Tab. 2).

Both *Titus* and *Septimius Severus* arches showed, indeed, a rich coffered ceiling, which was built up respectively by 82 and 140 tiles containing the RF motif. Despite the large use

Fig. 5. Botanical details: External elements (a, b, c) from the *Ara Pacis* (scrolls, Caneva 2010) and (d, e) from the *Septimius Severus* Arch; Central elements (Terminals) (f, g, h) from the *Ara Pacis* scrolls (Caneva 2010) and (i, l) from the Arch of *Titus*.

Table 2. Re-flowering Flowers: Botanical elements in the Ara Pacis and Roman trium-phal arches.

Scientific names	**Features**	**External elements**			**Central elements**		
		Ara Pacis	**Titus Arch**	**SS Arch**	**Ara Pacis**	**Titus Arch**	**SS Arch**
1) *Carduea*	Capoline leaves, often thorny	***					
2) *Carlina* cfr. *utzka*	Capoline leaves with the typical shape	**	*	*			
3) *Lilium candidum*	Flowers (symmetry and number of elements)	**	*				
4) *Nymphaea* sp.	Flowers (morphology and number of elements)	**					
5) *Hedera helix*	Fruits (morphology of single elements)	**				*	*
6) *Lilium* sp.	Flowers morphology (or typical bulb structure)	*	*	*			
7) *Anemone* cfr. *apenina*	Flowers (symmetry and number of elements)	*	*	*			
8) *Anemone* cfr. *coronaria*	Flowers (symmetry and number of elements)	*	*	*			
9) *Scabiosa* sp.	Capoline (morphology of ligulate flowers)	*		**			
10) *Narcissus* sp.	Flowers (symmetry and shape)	*		*			
11) *Helianthemum* cfr. *nummularium*	Flowers (symmetry, margin shape and number of elements)	*					
12) *Alchemilla* cfr. *vulgaris*	Flowers (symmetry and number of elements)	*					
13) *Sedum* sp.	Flowers (symmetry and number of elements)	**r**					
14) *Ecballium elaterium*	Flowers (symmetry and number of elements)	**r**					
15) *Rosa* sp.	Flowers (symmetry and number of elements)	**r**					
16) *Anthemis* sp.	Capoline morphology with a combination of tubulate and ligutae flowers	*	*	*			
17) *Calendula arvensis*	Capoline morphology with many ligulate flowers		*	**			
18) *Silene* sp.	Flowers (symmetry, number of elements, typical petal shape)		**	**			
19) *Stellaria* cf. *media*	Flowers (symmetry and number of elements)		*	*			
20) *Chaerophyllum* cfr. *temulum*	Flowers (symmetry number of elements, typical petal shape)		*	*			

Table 2. continued.

21) *Cerastium* sp.	Flowers (symmetry and number of elements)			*			
22) *Punica granatum*	Calyx (typical shape)			**r**			
23) *Asphodelus* sp.	flowers and fruits (symmetry, number of elements, typical trimerous shape of the capsule)			**	**	*	*
24) *Malva* sp.	Fruits (shape of the mericarps)				**		
25) *Arum italicum*	ripening fruits (transformation of the inflorescence)				**		
26) *Nuphar luteum*	flower buds (typical shape)				*	*	*
27) *Cydonia oblonga*	Fruit (pommes with typical shape)				*		
28) *Panicum miliaceum*	Growing spikelet				*		
29) *Asparagus* sp.	Shoot (elongate growing stem)				*		
30) Orchids	Pollinodia, with elongate structure				**r**		
31) *Biarum tenuifolium*	Acute shoot				*		
32) *Tragopogon* sp.	Flower buds (typical elongate shape)				r		
33) *Petasites* sp.	Flower buds showing composite structure				**r**		
34) *Allium sativum*	Bulb composed by bulbils				*		
35) *Laurus nobilis*	Flower buds					**	**

Legend: ** = frequent, * = 2-3 representations; r = rare

of plant elements, especially in the cases of the tiles of the arches, the identification of most flowers to a specific taxonomic detail is now impossible, due to the bad state of conservation or to the insufficient carved details, and thus we can only suppose the genus or the family of the represented plants. As in the *Ara Pacis* case, the flowers of *Carlina, Lilium, Anemone*, and *Scabiosa* were recurrent in the external elements, but the most frequent were those of *Silene, Stellaria*, and *Calendula,* and also of *Chaerophyllum* and *Asphodelus,* which were rare or absent in the Augustan altar. In the case of central elements (the terminals), the most recurrent still resulted the fruits of *Asphodelus* and *Malva*, but also the flower buds of *Laurus nobilis*, which were absent in the *Ara Pacis* scrolls (Tab. 2).

The general structure is built up by external flowers with actinomorphic symmetry and the terminal elements with flower buds or shoots, and its build-up follows three schemes, respectively constituted by two, three, or four levels. In the *Ara Pacis*, a higher floristic richness is represented with a higher number of selected species. In both arches, the external flowers have from 6 to 14 petals, and the most common representation is that with six petals on the external level and a trimer bud on the internal level. The arch of *Septimius Severus* is in a better state of conservation and appears to have a high number of elements. They all have at least three levels of composition: one external and two internal. Differing from the arch of *Titus,* the composition shows a more elaborate way of execution, and each flower presents a great variety of elements.

The symbolic meaning

In the case of the Apulian vases, the "plant volutes" and the spiralling branches have been associated with the goddess of fecundity (Zanker 1989). In fact, the ceramic production is related to the period in which *Taras* reached its height. The floral spring realized on the neck of the vases is the symbolic representation of this period. The most representative motifs of this production had shoots formed by undulate stems enriched with tendrils encircled in spirals, animated by flowers, corollas, palmettes, and dentate leaves in arabesque volutes; the symbolic representation of the female head in the middle of the floristic elements sets the human representation no longer in a mythological context, but indicating a close relation and fusion with nature (Becatti 1965). The RF motif is presented at the end of the path of the vegetal composition, reflecting the dynamic sense of a process which has no end. The plant decoration is the representation of an eternal blooming that starts with a flower, carrying on in another flower, with the idea of eternal prosperity of the city.

This meaning is evident in the case of monument representations. In fact, the monuments constituted the most relevant elements of a period, and the monuments are the most representative carriers of ideas, and messages of whom decided to build them. A building or its elements are strictly connected with whom committed its construction and with the message that the client wanted to convey. In this way, the single elements that are usually designed as a decorative motif, need to be considered in the same way as the inscriptions or the reliefs.

For the *Ara Pacis* and the monumental arches, the double or triple flower representation is an augural motif that evokes the idea of eternal blooming, in relation to time and its cyclic conception. The use of plant elements is connected with the new *Augustus* political program. In the plant representation, there are also deities' attributes. Specifically, *Dionysus* and *Apollo* specific attributes are represented to celebrate their connection with the Attalid family. In this way, the metonymic presence of the deities in the vegetal frieze of the *Ara Pacis* recalls the *Pergamum*'s reliefs and the will of *Augustus* to be accompanied during its new political program and approved in lineage as *Divus filius* (Centanni 2007).

The architecture of the arches changed its purpose giving more emphasis to both political and propagandistic ideas of power, which was carried through inscription (Mazzilli 2016) and symbolic representations. The interior vaults, accompanied by the deification of the emperors, were made by a coffered ceiling, where the metamorphic flowers in the tiles stand as an augural signal reinforcing the idea of prosperity (Torelli & al. 2008). The recurrence of laurel flower buds in the final elements of the arches has a clear augural meaning of victory, in coherence with the aims of the arches theirselves.

Discussion

The origin and diffusion of the RF motif

Assyrian and Babylon cultures used the representation of metamorphic elements, which gave rise to chimeric animals and "tree of life" structures. The tree of life has been described in the book of the Genesis and in the Assyrian Babylonian culture as a symbolic representation of the garden of Eden, the biblical paradise (Murphy & Murphy 2002). However, we cannot find examples in the Western Asian ancient representations, where flowers were used as single elements for their symbolic meanings (e.g., Ishtar Gate, Babylon) (Kleiner 2012).

The origin of the RF motif from the Apulian area can be explained considering the influence of Spartans colonization, occurred during the VII Century B.C., on the autochthonous culture, which created a new culture. As other southern Italian regions (Campania, Calabria and Sicily) of the so-called *Magna Graecia*, *Apulia* was inhabited by both indigenous and Greek people, and the local artistic production was an elaboration of previous elements merged together with the new ones (Giuliano 1989). The ceramic wares had a key role in this context, and they are considered a means through which the locals assimilated new messages as well as thoughts from Greece (Becatti 1965). First, the ruling class wanted to have the Attic ceramic for auto-representation needs, and then they started to create their ceramics, with a specific structure. Moreover, the ancient city was first ruled by a severe aristocracy that switched to democratic systems after military defeats (Masiello & Indellicati 2011). Moreover, during the time of the Pythagorean *Archytas* (mathematician and philosopher, which assumed a primary role in the city from 367 to 361 B.C.), *Taras* was open to sciences, arts and intellectuals, as testified by the great production of vases, sculptures, terracottas and jewellery (Trendal 1989).

In ancient civilizations, different aspects of other cultures have merged together and influenced each other, and artworks reflect something of the past that can be repeated or simply adopted with a new message. Considering these aspects, it is necessary to look at the phytomorphic images cautiously, considering all the little elements that compose the representation. Thus, there is a connection between the images presented and their meaning. What is shown through artistic representations is the result of many factors that connect various cultural elements within a community.

Then, from the III and II century B.C., when Romans conquered the Greek world, they started to be in contact with the Hellenic culture, which influenced religion, lifestyle and morality (Zanker 1989). Especially the artistic representations of the Republican period seem to have a relationship with the Greek-Hellenistic tradition, especially during the years of the conquest of Macedonia (146 A.D.) (Hölscher 1987). The members of the senator class were fascinated by the new culture, also renamed with the Latin term *asiatica luxuria* (the Latin noun *luxuria* is related to the abundance and wealth that Romans had seen at the Hellenic court). Moreover, the new noble families started to show their cosmopolitism as well as their political ambitions. The Republican years acquired a key role in the development of the Roman art, becoming a prelude of the *Augustus* age. In fact, later *Octavianus* kept many aspects of the Republican structure in his political program. This led the emperor to be in contact with the people, an aspect also reflected in art, where we can underline a relationship of offer and return. This event has to be considered as a key moment in the evolution of art since Rome opened the doors to an entirely new world that slowly disclosed its secrets (Hölscher 1987). In the spoils of the war after *Actium's* battle, around 31 B.C., there were not only riches and artworks but also, and most importantly, Egyptian's scientists, whom, heir of the Assyrian and Babylonian at first, then of the Greek culture, transmitted to the Romans their ancient knowledge.

The recurrence of the RF motif in many celebrative monuments, such as temples, basilicas and in the triumphal arches, can be explained considering the origin of the arch itself, and to their symbolic meaning, which will later be discussed.

The botanical analysis of the RF motif in the Roman archaeological monuments

The botanical identification seems useful to deepen and to contribute to the understanding of the role and use of the RF motif in the architectural decoration of the past. In fact, several flowers and different plant elements were used to create metamorphic structures, and each one had a specific aim, even if the relevance could be different (for more details, see Caneva 2010).

Among the most significant plant elements, we need to consider especially those located in the central area of the motif, i.e., the terminal part of the blooming process. Then, the carving of *Malva* and *Asphodelus* fruits can then be connected to their use in the ritual offering to the Apollonian ceremonies, giving them the meaning of hope of a return of the golden age (Detienne, 1975). Great value should be given to *Laurus nobilis* flowering buds in the central part of the RF motif in the triumphal arches since they express an Apollonian symbol of victory. The bulb of *Allium sativum* is a propitiatory element, known since antiquity for its therapeutic and magical properties, and Romans, such as other cultures, considered it as one of the most important medicinal plants. *Cydonia oblonga* fruits were dedicated to both *Hera/Juno* and *Aphrodite/Venus*, and they bore the significance of driving away the negative/bad influences. *Arum* and *Biarum* species seem elements linked to the idea of fertility and female divinities of maternity. Analogously, *Panicum miliaceum* was a cereal associated to the idea of fertility and *Ceres/Demeter*.

Dealing with the external flowers, as starting points of the metamorphic process, we have observed a high variety of elements. For example, *Cardueae* and related plants had the iconographic significance of reference to the bitterness of the earth, as emerged from biblical texts, by referring to their thorniness and their ability to thus protect themselves. Lilies constituted an emblem of beauty and fertility; ivy, as an example of the noblest blooming, was a Dionysian reference. Anemones were associated to the myth of *Adonis'* death and the idea of the ephemeral, and Narcissus to the idea of beauty, but also death, being a flower associated to the myth of *Narcissus*. Nymphs in general and lotus in particular represented, according to ancient eastern beliefs, the “flower of the sun, of creation and rebirth”. *Silene* flowers were associated with the moon, but also with *Silenus,* who in mythology appears as the clumsy tutor of *Bacchus*. Flowers of *Asphodelus* had a different symbolic meaning with respects to their fruits, and according to Greek mythology grew in the Underworld, where “the shadows of heroes” walked, and that thus they were “flowers of the deceased” planted close to tombs. Their presences in the arches probably honour the deaths in the military campaigns, which concurred to the victory.

The overall symbolic meaning of the RF motif

In this context, the origin of the RF motif is coherent with one of the fundamental ideas of the Hellenic philosophy of the continuous metamorphosis, in particular in the pre-Socratic naturalism. As expressed by the speculative and deeply metaphysical genius of *Heraclitus*, *“to be is to flow”* and *“everything flows, nothing stays”; “the world would consist of a perennial transformation”:* each one of us lives in that one develops, in that one continuously renovates. At the same time the becoming of the being is linked with the non-being, however *“this death is not a total dying, but a transmutation into something else”*. The myth of transformation and metamorphosis was already mentioned in the Alexandrine literature, in *Callimachus'*, *Eratosthenes*’s, earlier than in *Virgilius*, *Catullus* and *Ovidius*. Starting from the Pythagoras’s theory stating the never-ending transformation in the universe, in *Ovidius*'s *Metamorphosis* is shown a lively nature where everything is changing in one eternal mutation, revealing the deceptiveness of the appearance.

The idea of a continuous metamorphosis of one element into another creates both a physical and ideological interconnection between the elements of nature and such a process of generation creates a sort of *unitary link between all the elements of the creation*, which is quite an important leading thread in the Hellenistic culture and the revived Pythagorean ideas of the Augustan age. The idea that the individual is only an element, a means but not an end, emerges from the observation of this continuous ending and transformation into something else contributes to giving the *idea of a starting point of further growths.* The richness of different plant elements contributes to the idea that nature follows such rules.

RF elements found a very suitable place in the ceiling of the arches, which express the purpose of emphasizing both political and propagandistic ideas of power (Mazzilli 2016). They become symbols of victory, and they find in the symbols of a never-ending flowering a perfect symbiosis.

Conclusions

The diffusion of the RF motif started during the Hellenistic period (IV Century B.C.). It became a dominant element in triumphal arches, and later also in coffered ceilings, forming the so-called "rosettes". Through the analysis of specific artworks and monuments, such vases, jewellery, marble reliefs and the Roman arches, we were able to confirm the symbolic value of nature, and its great diversity of plant elements. The floristic elements were often considered only as a decorative motif, neglecting the symbolic language linked to the primary role nature had in the ancient culture. It symbolically expresses the hope on an "eternal blooming" even if today its original meaning is lost.

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Debra Solomon

Art to transform ecologies: report from the field

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Key words: biodiversity, public space greens, urban food foresrry.

Experimental methodologies combining art production, activism and science are increasingly accepted as stimulating transformative research, as it has been shown in the areas of urban agriculture and urban political agroecology. Several methodologies informed by contemporary art traditions, such as land art, conceptual art, and art in the public space, are developed and tested within my own praxis of art production and requisite visualisation and dissemination techniques are discussed in this presentation. Some of these artistic methodologies include *Radical Observation* (an embodied-learning, performance-based observation technique), and the use of soil chromatography, i.e. a visual data format, including the author's own technical innovation of magnifying of the soil organic horizon in the visual data. How and why art/activism-based methodologies are fundamentally different from scientific methods, and whether these methodologies are capable of yielding scientifically valid insights will be examined in the presentation. The examples will be juxtaposed with cases of scientific inquiry, such as the biodiversity study of the Urbaniahoeve plant typologies, and methodologies projected onto a 25HA area in *Amsterdam Nieuw West*, and a soil study of Urbaniahoeve's *DemoTuinNoord* topsoil (both conducted by/with Wageningen University and Research) are included in the survey of projects and requisite analyses.

Aside from accommodating different perceptions of biodiversity and soil fertility, it is shown how the freedom of the artistic practice yields new perceptions towards the relationship among humans with regard to the ecosystem species, and that can guide human behaviour. Perceptions yielded through this methodological lens are capable of forming a basis for new forms of policy and governance of, e.g., public space greens, such as in the case of the urban food forestry work of Solomon/Urbaniahoeve (the author). Experimental methodologies such as these have a legacy of empowerment, but are also forms of critical inquiry into neoliberal urbanisation and commodification which strongly affect the public space, the various commons, and the ecosystems that inhabit these spaces.

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Solunto archaeological park in Sicily: life under mosaic tesserae*

Abstract

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Biodeterioration is a complex process induced by the growing and metabolic activity of a wide range of macro and microorganisms, becoming a revelling problem also for the mosaic tesserae of "Casa di Leda" in the Greco - Roman site of Solunto in Sicily.
In this case-study, a thick biofilm inducing a deep alteration of mortar and consequently the mosaic tesserae detachment has been highlighted during the restoration plan.
The biofilm microbial consortium has been investigated by an integrate approach based on Microscopy analysis (O.M., C.L.S.M.), in vitro culture (Nutrien and Saboraud media) and molecular biology investigation (DNA target sequence amplification, sequencing, sequence analysis).
A microbial diversity has been revealed belonging to bacteria (*Bacillus*) and fungi (*Alternaria*, *Aspergillus*), besides cyanobacteria (*Chroococcus*) and green algae (*Chlorella*).
In order to control the biofilm colonization two essential oils (EO), *Thymus vulgaris* and *Origanum vulgare*, have been utilized and their antimicrobial activity, preliminarily in vitro (agar disc diffusion methods) and after ex situ and in situ evaluated. This experimentation is aimed at identifying and implementing green biocides for the control of microbial colonization, a promising technology with a reduced impact on human health and environment, able to replace traditional biocide action.

Key words: biodeterioration, microsopy analysis, in vitro colture, molecular biology.

Introduction

Stone artworks biodeterioration is related to the combination of biological colonization and environmental factors, as happen in archaeological areas, where complex *biofilm* have been frequently revealed (Thomas & Demas 2013; Marzano & Métraux 2018).

Concerning inorganic specimens, the first colonizers are represented by pioneered photoautotrophic organisms, such as cyanobacteria, algae and lichens, but also oligotrophic or poichilotrophic microbial groups, such as some fungi and chemo-lithotrophic bacteria (i.e. using as oxidation inorganic compounds) have been identified; converting the substrate

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and helping the colonization of other heterotrophic organisms (Tiano & al. 1995; Warscheid & Braams 2000; Caneva & al. 2007).

Moreover, the association as *biofilm* confers a character of resistance to the biocenoses involved (Flemming 1993), becoming problematic to remove (Chorianopoulos 2008).

In this case-study, biofilm was not straightaway seen, since it was spread under several tesserae of the *impluvium*, located in the centre of the "Casa di Leda" *peristylo*, in Solunto (Palermo, Italy) one of the archaeological-park in Mediterranean basin (Marzano & Métraux 2018). Combining biological and biotechnological approaches (Palla & al. 2010, 2013; Di Carlo & al. 2016; Palla & Barresi 2017) microbial taxa such as bacteria, fungi, cyanobacteria and green algae have been identified.

Since the extensive microbial spreading affects both the constitutive materials and the legibility of the artworks (Barranguet & al. 2005), the control of biodeterioration phenomena represents a significant phase in conservation project. In routine practice, microbial colonization is addressed by chemical biocides, which toxicity and persistence in the environment is well known (De La Paz & al. 2006; Guiamet & al. 2006).

In the last decade, in order to develop green conservation strategies, plant products have been applied in prevention and treatment of microbial contaminants (Guiamet & al. 2008; Afifi 2012; Sasso & al. 2013; Fierascu & al. 2014; Stupar & al. 2014; Borrego & al. 2016; Rotolo & al. 2016).

In this study, the antimicrobial activity of two commercial essential oils, *Origanum vulgare* and *Thymus vulgari*s, have been evaluated against microbial species isolated from *biofilms* of floor mosaic tesserae of "Casa di Leda" in the *Greco - Roman site of Solunto* in Sicily (Fig. 1), to control the biodeterioration phenomena, applying novel protocols safe for humans and environment (Rotolo & al. 2017).

Materials and methods

Essential oils (EO)– The *Origanum vulgare* and *Thymus vulgaris* essential oils have been used as pure essence (100%) or diluted solutions (50, 25, 12.5, 6.5 %) in 70% Ethanol.

Fig. 1. Mosaic floor around the *impluvium* in the *peristyle* of Leda's house, in archaeological park - Solunto, Sicily.

Origanum vulgare, is an aromatic hemicryptophyte, belonging to *Lamiaceae*, native to Europe and in particular in the Mediterranean basin, but today cultivated all over the world. The plant is rich in carvacrol, a phenolic monoterpene with recognized anti-inflammatory and antitumor properties (Burts & al. 2007; McCann & al. 2014).

Thymus vulgaris, is a chamaephyte belonging to *Lamiaceae*, including 250-350 evergreen taxa, native to southern Europe, North Africa and Asia.

The aromatic active molecules have a strong antiseptic and antibacterial properties, they also have digestive, warming, spasmolytic, carminative, diuretic and disinfectant action of the urinary tract. In addition they contain phenolic monoterpenes such as thymol (30-70%) and carvacrol (3-15%), oxides such as cineol and thymol methilesters, alcohols such as borneol, geraniol, linalool, esters such as acetate and linalyl, hydrocarbons such as cymene and terpinen (Mitsch & al. 2004; Bolukbasi & al. 2007).

Sampling.– Biofilm aliquots were collected by sterile scalpel or swab, and directly observed by optical microscopy or utilized for *in vitro* culture and molecular investigations.

Microscopy observation.– Cyanobacteria and microalgae, as well as the morphological profile of bacterial and fungal isolated colonies were analysed by Stereo (Wild-M1B, 14X) or Fluorescent (DMR-Leica, 40X) microscopes. Conidiophores and conidia fungal structures were observed by Optical Microscope (Leica, 40X), after Lugol’s iodine staining (Di Carlo & al. 2016).

In vitro culture.– Sabouraud Dextrose Agar + Chloramphenicol (CAF) and Nutrient Agar plates, seeded by biofilm aliquots, were incubated at 30°C (Palla & al. 2006; Pasquarella & al. 2015); after 24/48 h fungi and bacteria colonies

Microbial DNA extraction.– Each isolated bacterial and fungal colony was lysed at 94°C per 2 min in 20 µl of 1X T.E. (10 mM TRIS-HCl pH 7,5 / 1 mM EDTA), extracting the genomic DNA by the *Genomic DNA purification* and *Gene JET Genomic DNA purification* kits (Fermentas).

Polymerase Chain Reaction (PCR) – Genomic DNA molecules were utilized as template for *in vitro* amplification (Polymerase Chain Reaction) of target ribosomal-DNA sequences: 16S-rDNA gene or Internal Transcribed Sequence (ITS – rDNA), specific for bacteria or fungi.

ITS-PCR reactions were carried out by the following oligonucleotides as primers, bacteria: ITS1= 5’-GTCGTAACAAGGTAGCCGTA-3’ and ITS2= 5’-GCCAAGGCATCCACC-3’; fungi: ITS4 = 5’ - TCCTCCGCTTATTGATATGC-3’ e ITS1 = 5’ –CTTGGTCATTTAGAGGAAGTAA - 3’ (Cardinale & al. 2004).

PCR products were analysed by 2% Agarose gel electrophoresis, nucleotide composition determined by MWG Operon Sequencing Service and sequences comparison performed by BLAST platform (Altschul & al. 1997; Palla & al. 2010, 2013; Palla 2012; Palla & Barresi 2017).

Evaluation of antimicrobial activity.– *In vitro* assay: *agar disc diffusion* method was performed utilizing paper disc (6 mm in diameter), wetted with 10µl of each EO at different concentrations (100%, 50%, 25%, 12.5%, 6,25%) and placed onto the surface of Nutrient or Sabouraud agar (90 mm Petri dish), previously seeded by 1x10^6 CFU/mL - bacterial cells or 1x10^4 conidia/mL - conidia suspension (Borrego & al. 2012).

Control assays were performed wetting the paper disc with 70% Ethanol or 0.2% (vol/vol) Benzalkonium chloride + chlorhexidine (BC, one of the frequently used commercial biocides).

After incubation at 30°C for 24/48 h, confluent microbial growth was observed and the diameter (mm) of growth inhibition areas was measured (Balouiri & al. 2016; Rotolo & al. 2016); each test was performed in triplicate.

Ex situ assay: the antimicrobial activity of the two essential oils was also evaluated exposing the biofilm to the volatile compounds. Particularly, eleven colonized tesserae, gathered from specific areas of *impluvium* were placed on paper discs (60 mm, Whatman) into equal in diameter sterile Petri dishes, soaked with: *i*) *Oregano* (100, 50, 15%) EO; *ii*) *Thyme* (100, 50, 15%) EO; *iii*) Biotin-R (100, 50, 15%); *iv*) Ethanol (70%); Petri dishes were sealed by Parafilm membrane (Heathrow Scientific) to prevent evaporation phenomena. The effect of EOs was evaluated after 72h and up to 7 days, analysing both biofilm green pigmentation and auto-fluorescence (MD Fluorescent Microscope, Leica).

In situ assay: biocide activity was also directly evaluated on selected (eleven) *peristyle mosaic* areas. As performed in laboratory assays, differently concentrated Essential Oils (100, 50, 15%) and Controls (100, 50, 15% Biotin-R or 70% Ethanol) solutions were injected (by sterile needle/syringe) through interstitial mortar tesserae.

Results

In order to characterize the microbial species constituting the pigmented *biofilm* revealed below the mosaic tesserae (Fig. 2), an integrated approach was applied (Palla & Barresi 2017). Particularly, a complex microbial community with prevalence of cyanobacteria, belonging to the genus *Chroococcus* and green algae such as *Chlorella* (Fig. 3), was observed by Optical Microscopy. Through *in vitro* culture and molecular investigations, the presence of bacteria, *Bacillus* sp. pl. (Fig. 4) and fungi, *Alternaria* (Fig. 5) sp. and *Aspergillus* sp. (Fig. 6) have been also identified.

The characterization of microbial consortium components is strictly related to the control of microbial spreading, accordingly to the biocide product that will be applied. The aim of this study was also the set-up of alternative biocides, as plant essential oils, less invasive/dangerous than commercial chemical compounds (Guiamet & al. 2008; Afifi 2012; Sasso & al. 2013; Fierascu & al. 2014; Stupar & al. 2014; Borrego & al. 2016; Rotolo & al. 2016).

Performing *in vitro* agar diffusion disc method, different antimicrobial effects of EOs and Controls solutions were defined against *Bacillus* sp. p.l, *Alternaria* sp. and *Aspergillus* sp. colonies, basing on inhibition-halo diameter (Tab.1)

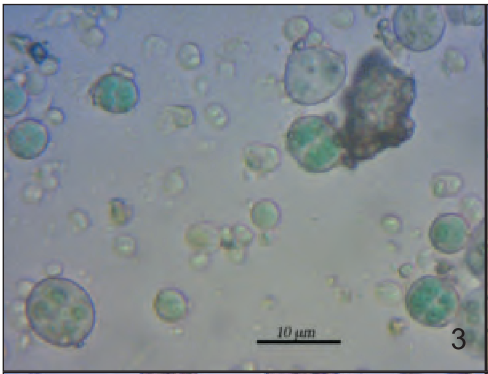
Particularly, *in vitro* assays highlight a stronger antimicrobial activity EOs, as showed in Fig.7a, per *Oregano* solutions (50, 25. 12,5%) *versus Bacillus* sp., compared to the activity of commercial biocide Benzalkonium Chloride solutions (100, 6.25%), showed in fig. 7b.

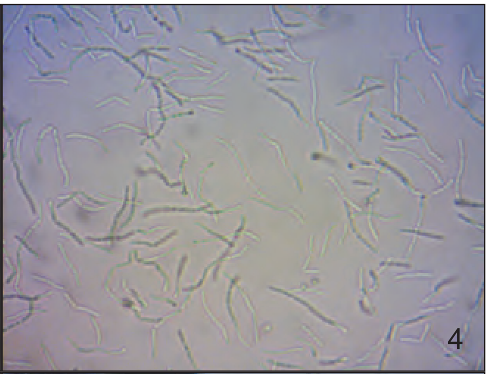
Fig. 2. Pigmented *biofilm* revealed below the mosaic tesserae in some area of the Leda’s house *peristyle*.

Similar strength is showed by *Oregano* solutions (100, 12.5%) vs *Aspergillus* sp. (Fig. 8a) and *Alternaria* sp. (Fig. 8b) colonies, significantly greater comparing the inhibition halo produced by 12.5% Benzalkonium Chloride solution against *Aspergillus* sp. (Fig. 9a) and *Alternaria* sp. (Fig. 9b).

The *ex situ* assays were performed exposing the mosaic-colonized tesserae to the volatile compounds of *Oregano* or *Thyme* EOs, analysing the biofilm after 7 days (will be assessed up one year). As showed in Fig. 10, a different pigmentation can be distinguished between control (D = no-biocidal compound) and treated samples (A= Biotin-R; B= Thyme-EO=; C= Oregano-EO), allowing us to hypothesize that the lack of green pigmentation is related to the reducing in biofilm photosynthetic activity; related Fluorescent Microscope observations performed by Zeiss-Axioskop 2-Plus, are showed in Fig. 11. It is evident only a background of fluorescence in treated samples A, B, C, while defined biological structures are evident in no-treated sample D.

Finally, *in situ* tests were performed injecting below the tesserae, *Oregano* or *Thyme* EOs solutions (100, 50, 15%), through the interstitial space. As showed in Fig. 12, a clear effect on biofilm was revealed for the 15% *Thyme* EO solution, concentrically diffused





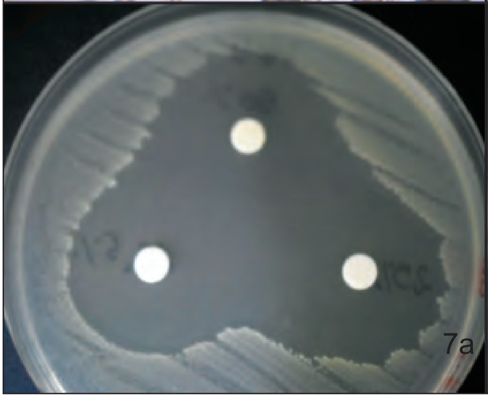


Fig. 3. *Chlorella* sp. colonies observed by Optical Microscope (Leica, 40× magnification).

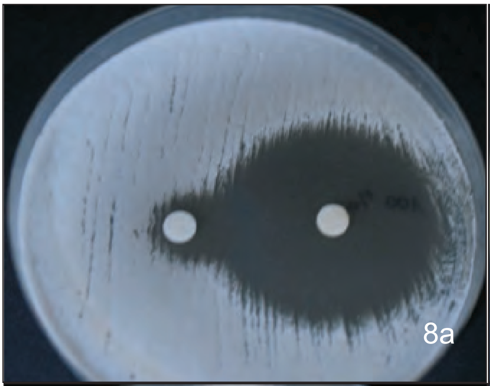
Fig. 4. *Bacillus* sp. bacterial cells observed by Optical Microscope (Leica, 40× magnification).

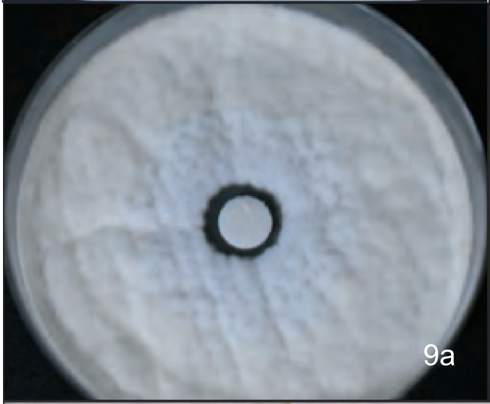
Fig. 5. *Alternaria* sp. spore structure, observed by Optical Microscope (Leica, 40× magnification), after Lugol's staining.

Fig. 6. *Aspergillus* sp. conidiophores and spore structures, observed by OM (Leica, 40× magnification), after Lugol's staining.

Fig. 7a. Antimicrobial activity of *Oregano* solutions (50.0, 25.0, 12.5%) *versus Bacillus* sp., the confluent inhibition halos prove a strong activity of EO.

Fig.7b. Antimicrobial activity of the commercial biocide, Benzalkonium Chloride (6.25%) solution, a confluent inhibition halo is show.





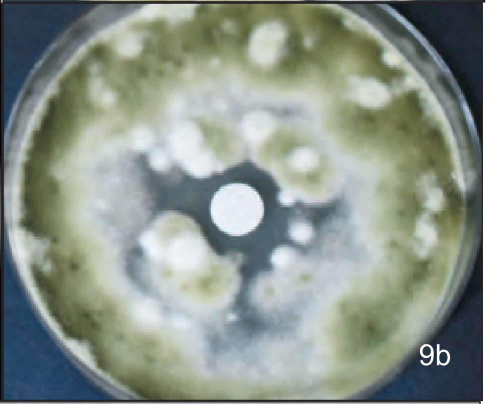


Fig. 8a. Inhibition halo produced by *Oregano* solutions (100, 6.25%) vs *Aspergillus* sp.
Fig. 8b. Inhibition halo produced by *Oregano* solutions (100, 6.25%) vs *Alternaria* sp.
Fig. 9a. Inhibition halo produced by 6.25% Benzalkonium Chloride solution against *Aspergillus* sp.
Fig. 9b. Inhibition halo produced by 6.25% Benzalkonium Chloride solution against *Alternaria* sp.
Fig. 10. *Ex situ* assays. Effect of volatile compounds of Oregano or Thyme EOs, after 7 days of exposure, on the biofilm of mosaic-colonized tesserae: A= Biotin-R (commercial biocide); B= Thyme-EO; C= Oregano-EO; D= no-biocidal compound.

with respect to the injection point (highlighted as red line). Particularly, the biofilm came in contact with the EO solution showed a loss in pigmentation, while a vital green colour is still present in the portion not reached by the oil solution (pointed by a red asterisk). Instead, the 15% *Oregano* OE treatment does not show similar effect, may be related to the presence of inhibitory substances in the completely degraded bedding mortar.

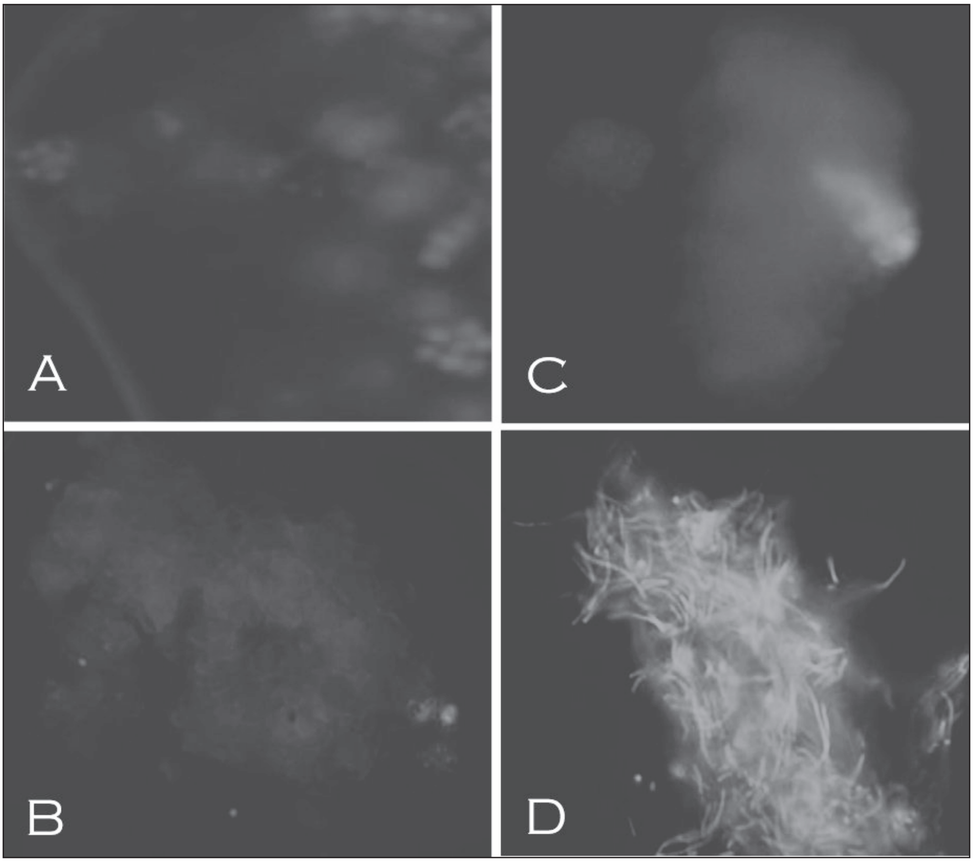


Fig. 11. *Ex situ* assays. The lack of biofilm photosynthetic activity, observed by Zeiss-Axioskop 2-Plus Fluorescent Microscope observations. Corresponding to Fig.10 samples: A= Biotin-R (commercial biocide); B= Thyme-EO; C= Oregano-EO; D= no-biocidal compound (40× magnification).

Discussions and Conclusions

The rich distribution of archaeological assets in the Mediterranean basin, their cultural, artistic, religious significance and high social impact, highlight the requirement of dedicated conservation strategies. The identification of the different factors (biological, chemical, physical) able to induce structural and compositional changes (Warscheid 2000) is of fundamental importance in defining suitable fruition, maintenance and conservation policies.

The role played by micro-organisms in the processes of cultural heritage deterioration (biodeterioration) has been widely demonstrated: growth, development and metabolic activities can bring physical-chemical and aesthetic damage to works of art, inducing negative consequences for their conservation (Fort & al. 2006).

Many species of microorganisms (bacteria, fungi, unicellular algae) can find favourable conditions for their development both on statues and monumental works and on archaeo-

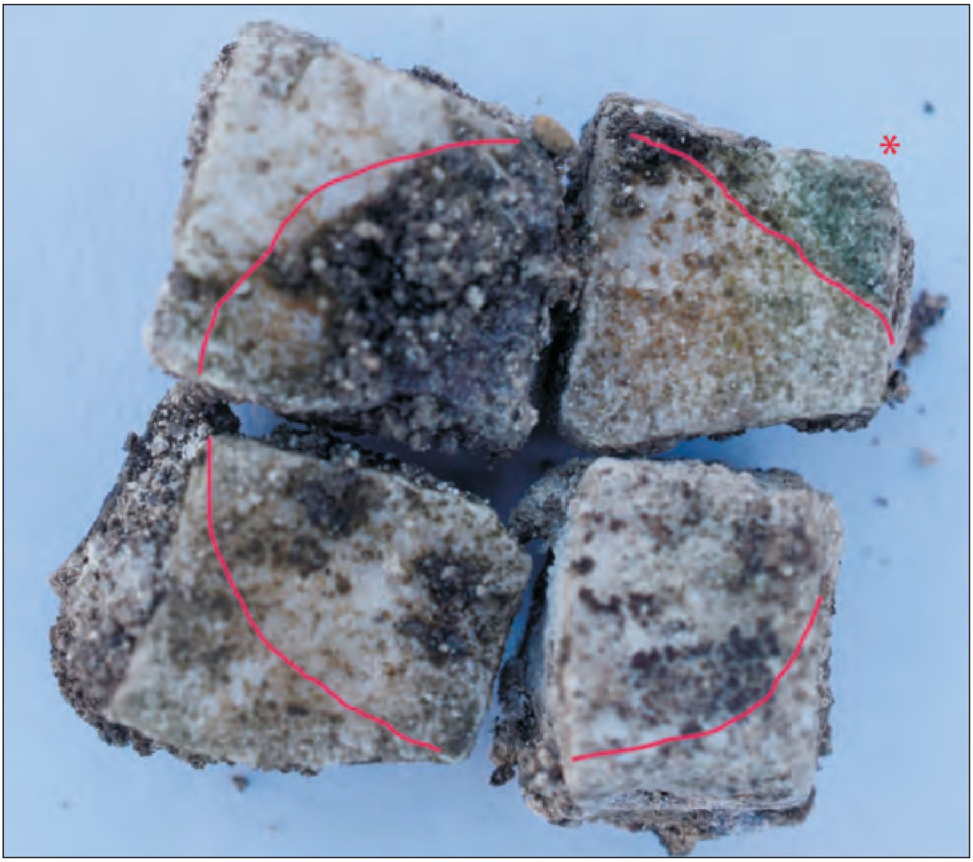


Fig. 12. *In situ* assays. Mosaic tesserae after treatment with 15% *Thyme* solution, concentrically diffused with respect to the injection point (highlighted as red line), a lost in pigmentation is clearly recognizable. A vital green colour is still present in the portion not reached (pointed by an asterisk).

logical remains (Kovacik 2000), as the mosaic tesserae of "Casa di Leda" - Greco - Roman Solunto archaeological site park, Sicily.

Particularly, a thick *biofilm* inducing a deep alteration of mortar and consequently the mosaic tesserae detachment has been identified during the restoration activities.

The *biofilm* has been characterized through optical microscopy, *in vitro* culture and molecular biology techniques, allowing the identification of microbial *taxa* as *Bacillus* sp., *Alternaria* sp., *Aspergillus* sp., as well as cyanobacteria, *Chroococcus* sp. and green algae, *Chlorella* sp. These microorganisms are considered biodeteriogens, able to induce precipitation of mineral crystals or promoting pH changes, causing damage on stonework surface (Sanchez-Moral & al. 2003; Albertano & al. 2003).

In this study new biocompatible products to control *biofilm* growth have been also assessed, evaluating the antimicrobial activity of two commercial essential oils, *Origanum vulgare* and *Thymus vulgari*s.

Table 1. *Agar disc diffusion* method. Average inhibition halo diameter (mm) of EOs (*O. vulgare*, *T. vulgaris*) Antimicrobial activity: Positive ≥ 9 mm; Moderate: 6 - 9 mm; Negative ≤ 6mm; *total growth inhibition. Benzalkonium chloride + chlorhexidine and Ethanol solutions were the controls.

Essential olis	Conc. (%)	*Bacillus* sp. pl.	*Alternaria* sp.	*Aspergillus* sp.
Origanum vulgare	100	*	60	50
	50.0	42	49	45
	25.0	40	48	46
	12.5	39	38	35
	6.25	28	16	16
Thymus vulgaris	100	*	*	*
	50.0	*	*	*
	25.0	*	*	*
	12.5	48	*	*
	6.25	30	36	32
Benzalkonium chloride + chloroexidine	0.2% (vol/vol)	12	6	8
Ethanol	70%	3	1	1

The results of *agar disc diffusion* assays are summarized in Table 1, showing a strong antimicrobial activity of both essential oils against bacterial and fungal colonies, consistent with the dedicated literature (Reichling & al. 2009; Stupar & al. 2014; Casiglia & al. 2015), although little is known about the permanence and application methods of EOs (Salem & al. 2014; Noshyutta & al. 2016).

In this case study *Origanum vulgare* and *Thymus vulgari*s EOs solution (100, 50, 15 %) have been tested *in situ*, on mosaic tesserae of “Casa di Leda”, after seven days of application.

Particularly, *Thymus vulgari*s 15% EO solution has proven to be the best diffused, strongly influencing the *biofilm* liveliness (Fig. 12).

Although further studies are needed to set up a standard protocol, according to these and previously result (Rotolo & al. 2016, 2017), we hypothesize the use of OEs to contrast microbial colonization, representing valid alternatives to traditional biocides, without negative environmental impacts and respecting the human health, in accordance with modern restoration strategies.

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Ignazio Camarda

Phytotoponymy and Flora of Nuraghes monuments (Sardinia)

Abstract

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Nuraghes are megalithic structures with a truncated conic tower, even more than twenty metres tall, with a circular plan and a central chamber covered by a faux vault. Some of these towers were fortified with turreted ramparts, often bordered by large walls to create imposing structures. Built from the sixteenth to the twelfth century BC, with over 7,000 monuments, they characterise the whole of Sardinia. These structures, which have been reused for various purposes up to this very day, feature a very diverse flora ranging from lichens to bryophytes and from small herbs to large trees. There are 385 nuraghes with plant names belonging to 80 different species. The analysis of the flora at 21 sites, located in the various parts of the island, ranging from sea level up to a maximum altitude of 1200 m, has led to the identification of 220 species living on the walls of the towers, on the ramparts and walls and on the roofs. The various components of the life-forms and the role that plants play in the broader ecological and landscape context are highlighted.

Key words: archaeology, floristic analysis, landscape.

Introduction

*a - Nuraghes**

Sardinia is characterised by the presence of stone edifices without cementing material known by the local name of *nuraghe or nurake*, built from about the year 1,600 to 1,000 BC, when a new culture developed in Sardinia - the nuragic "civilization" - which takes its name from the nuraghes, the most representative and original form of architecture of the new times (Lilliu 1963, 2006; Contu 1985,1990; Moravetti & al. 2015). The nuraghes, in fact, spread throughout the island, particularly in the central and northern parts. Numbering at least seven thousand (Fig. 1), they would go on to become the salient feature of Sardinia's ancient, historical and current landscape (Moravetti 2018). Their importance is such that they are already remembered in the ancient world in an engraving of the third century BC by a Pseudo-Aristotle (in *On Marvellous Things Heard*, 100) from the Siceliot world. It read: "They say that on the island of Sardinia there are buildings built according to the ancient Greek custom, and many other beautiful complexes and in particular tholoi with a magnificent balance of proportions." It is common opinion that reference is made here to

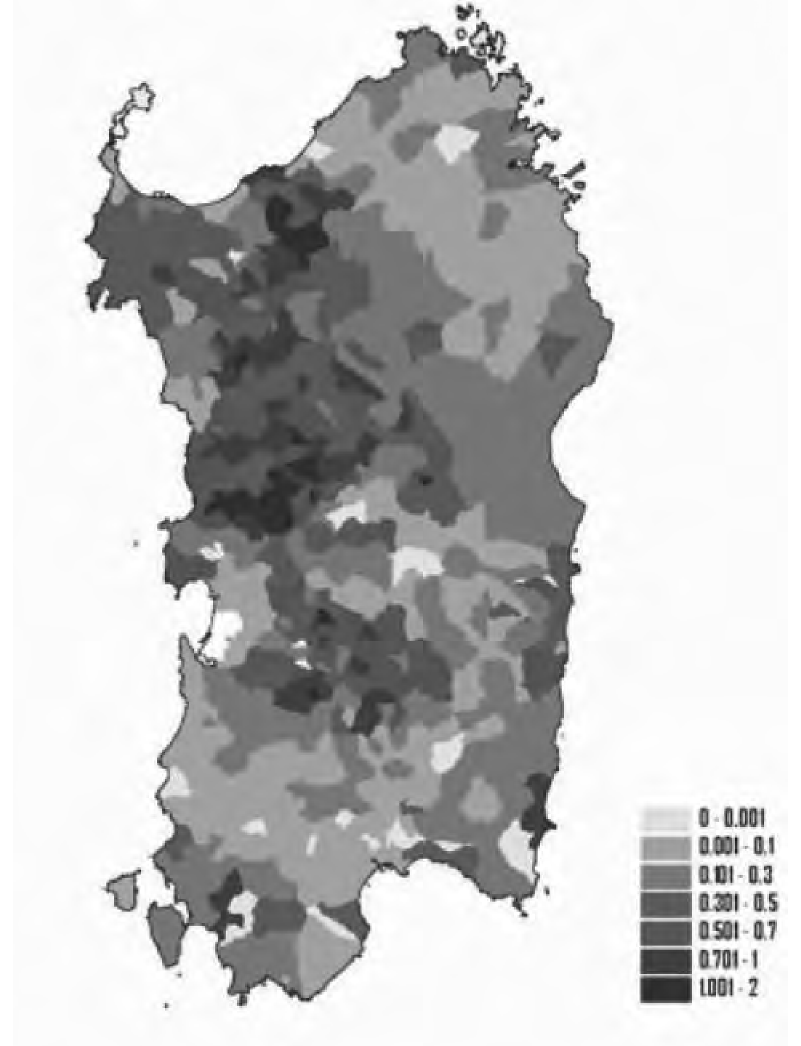

Fig. 1. Map of Sardinia with the spread of the nuraghes, density per sq. km (Melis 2017).

the nuraghes. However, on the island of towers there are also countless villages, megalithic tombs, temples and sanctuaries, and sculptural artefacts, as well as a rich production of metalwork and earthenware.

There are two types of nuraghes, identical in terms of the dry construction technique but different in the form and organisation of the interior spaces: the proto-nuraghe - or archaic nuraghe - and the classic tholos nuraghe.

The former, counting about 500 tower constructions to date, with rather simplified architectural style, feature a variety of shapes and rough masonry and are no more than ten metres tall.

The interior is articulated into corridors, small rooms, niches and stairs to reach the terrace.

The latter, the tholos nuraghe, of which more than 7,000 are known (Contu 1994; Melis 2017; Scanu, 2003; Scanu & Podda 2015), are a natural evolution of the former and respond to a standardised construction module: a truncated conic tower over twenty metres tall, circular plan, with central chamber - up to 11 metres tall - covered with false vaults. The tower could have up to three superimposed chambers, connected by a helical staircase ending on the terrace, which protruded on corbels not unlike medieval towers. The stone corbels found at the base of the buildings and the discovery of numerous models of nuraghe - in bronze, stone and clay - allow us to know something about that part of the building that is no longer extant. The tower could also have turreted ramparts, often bordered by large walls to create grandiose fortified structures.

The function of the nuraghes, which has always aroused interest and curiosity, has always been the subject of bizarre and extravagant hypotheses over time. At present, it is believed that they were multi-functional buildings designed to watch over the surrounding territory and its resources. At times they were simple “farms” of family groups, but in some cases, they were real fortresses, thus indicating a hierarchy of settlements in a land organised into cantons, within a tribal system with competitive communities and growing social differences.

The settlement was centred - but this was not always the case - around the nuraghe, and consisted, at least in the early stages, of mostly circular, single-cell huts with stone base and cover made of wood and branches. Later on, the tendency began to spread to aggregate several huts, in contact with one another, around a central space, thus creating blocks.

Some of these buildings, whether simple or complex, are almost entirely preserved, while others have left less important traces. In all of them though, it is possible to find many plants that often characterise the physiognomy of the landscape.

The nuraghes are spread throughout Sardinia, on all substrates, from sea level up to 1200 m above sea level, using the stone material present on site, but the constructions in basalt or trachyte are undoubtedly more common and are also those with more complex structures (Fig. 2). Su Nuraxi of Barumini, one of the most important nuragic sites in the island, was declared a World Heritage Site in 1997, as a representative of an architecture of particular originality in the dry stone construction of the Mediterranean basin in protohistoric times. Nuragic towers spread in the whole island and with high landscape value and identity for the Sardinians. The nuraghes, together with other architectural manifestations of the nuragic world (well temples and giants tombs), constitute an important tourist attraction for tens of thousands of people, and for this reason a particularly careful management is essential for their protection.

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b - Flora in archaeological studies on nuragic sites

There are numerous studies on the archaeology of the nuraghes, either of a general nature or regarding specific sites and individual monuments, and on the flora and vegetation of Sardinia, as well as studies on the presence of flora on these monuments. In archaeological research, flora has been given little attention in the past. Wetterstrom (1987) cited a number of seeds, including *Prunus avium* and several ruderal nitrophilous species, found in the excavations of the Toscono and Urpes nuraghes (Borore, central Sardinia). But there is no doubt that, at present, in archaeological excavations greater importance is being

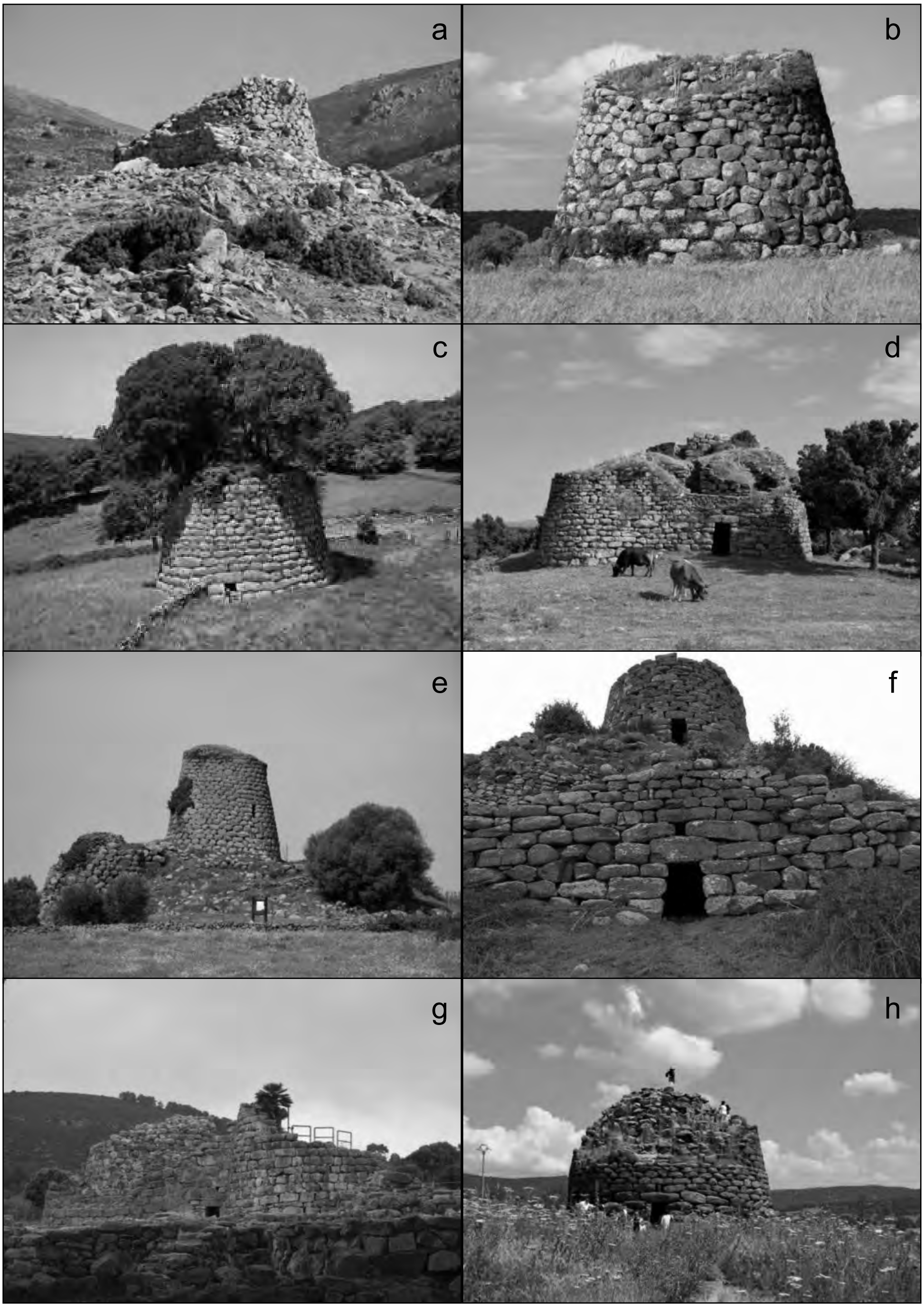

Fig. 2. a) Nuraghe Orruinas; b) Nuraghe Sa Jua; c) Nuraghe Erismanzanu; d) Nuraghe Loelle; e) Nuraghe Nuraddeo; f) Nuraghe Orolo; g) Nuraghe Palmavera; h) Nuraghe Ola.

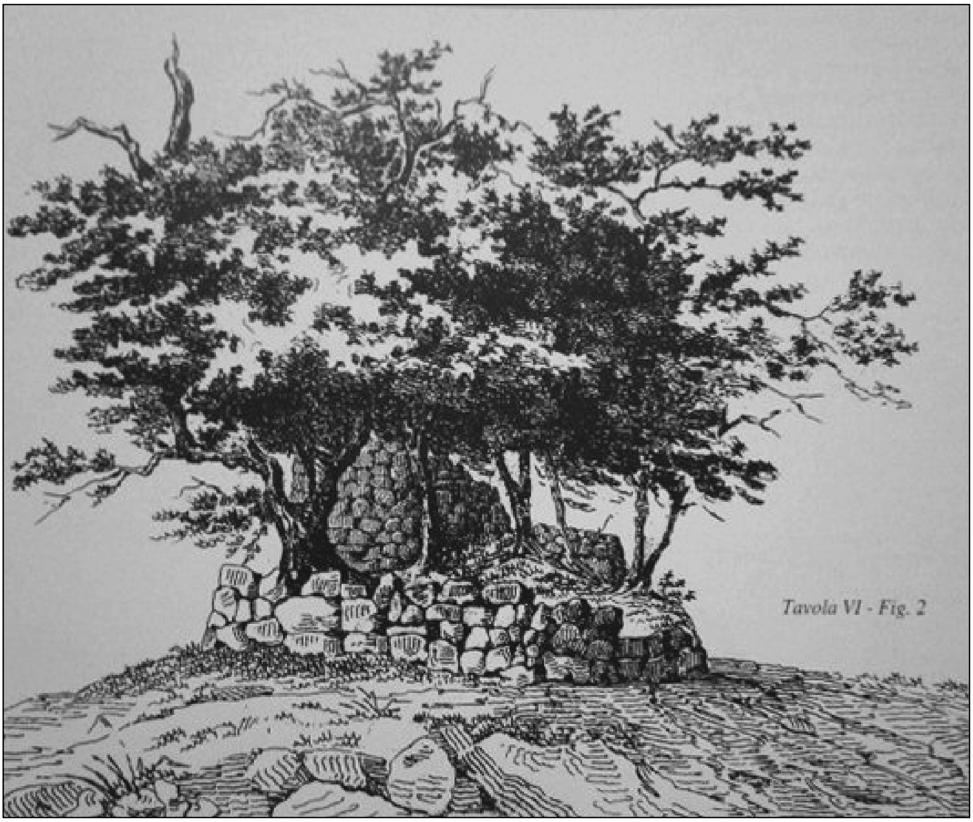

Fig. 3. Nuraghe Adoni in the picture by Alberto Della Marmora (1826).

attached to the identification of botanical finds thanks to the collaboration of experts in the field of botany. In particular, excavations in the nuragic areas of Sa Osa, in Sinis, (Sabato 2014; Usai & al. 2016) have revealed significant deposits of seeds and remains of tree species (including *Pinus pinea, Pinus halepensis, Myrtus communis*), *Pistacia lentiscus, Juniperus oxycedrus, Triticum aestivum/durum, Olea europaea, Vicia faba, Prunus* sp.*, Rubus ulmifolius, Rubus ulmifolius*, *Malva* sp. *Linum* sp.*, Vitis vinifera, Ficus carica* subsp. *carica* and *Cucumis melo,* which are also of great interest from a historical, cultural and phytogeographical point of view. This seems to demonstrate the presence of some species cultivated before the island's colonization by the Phoenicians (tenth century BC), a period that also marked the end of the construction of the nuraghes (Barreca 1988; Mastino 2005). In the past, the presence of nuraghes has interested scholars mainly from the archaeological and historical point of view (Angius 1843; Spano 1867) and only in some cases, with the notable exception of Della Marmora (1826), has it been possible to find references to the presence of plants, if only in the illustration of the nuraghes.

Table 1. Nuraghes studied, flora survey points, geographical coordinates and altitude in meters.

Nuraghe	Sites of releve	Coordinate	Altitude m a.s.l.	Municipality	Substrate
1- Santa Sabina	1a-Tower Walls, 1b-Cover	40°16’30.17"N 8°53’0.80”E	382	Silanus	Basalt
2 -Nuraghe Loelle	2a-Tower Walls, 2b Cover	40°34'7.16"N 9°18'55.14"E	796	Buddusò	Granite
3 - Nuraghe Orruinas	3a-Walls ramparts, 3b-Walls ramparts and cover	39°56’13.57”N 9°19’52.97”E	1200	Arzana	Porphyry
4 - Nuraghe Palmavera	4a-Tower Walls, 4b-Walls ramparts	40°35’42.06"N 8°14’33.96”E	50	Alghero	Limestone
5 - Nuraghe Losa	1a-Tower Walls	40° 7’0.78"N 8°47’24.86”E	315 ,	Abbasanta	Basalt
6 - Nuraghe Bainzu	6a-Tower Walls, 6b-Cover	40°13’1.79"N 8°50’1.99”E	384	Borore	Basalt
7 - Nuraghe Tolinu	7a-Tower Walls	40°12’43.57"N 8°56’0.09”E	282	Noragugumene	Basalt
8 - Nuraghe Miuddu	8a-Walls ramparts	40°15'59.1"N 8°49’29.4”E	473	Birori	Basalt
9 - Nuraghe Ola	9a-Tower Walls, 9b-Cover	40°18'06.3"N 9°10’34.7”E	342	Oniferi	Basalt
10 - Nuraghe Santu Antine	10a-Tower Walls, 10b-Walls ramparts	40°29’11.59"N 8°46’10.93”E	360	Torralba	Basalt
11 - Nuraghe Sa Jua	11a-Tower Walls, 11b-Walls ramparts, 11c-Cover	40°10'15.90"N 8°51’9.96”E	320	Aidomaggiore	Basalt
12 - Nuraghe Ghispa	12b-Walls ramparts	440°28’45.18"N 9°14’53.74”E	698	Nule	Granite
13 -Nuraghe Adoni,	13b-Walls ramparts, 13c-Cover	39°47’8.82"N 9°10’23.51”E	800	Villanovatulo	Limestone
14 - Nuraghe Voes	14a-Tower Walls, 14b-Walls ramparts	440°28’45.18"N 9°14’53.74”E	698	Nule	Granite
15 - Nuraghe Ardasai	15a-Tower Walls, 15b-Walls ramparts, 15c-Rampants and tower cover	39°53'36.04"N 9°20’21.17”E	1002	Seui	Limestone
16 - Nuraghe Ruiu	16a-Tower Walls	40°45’14.48"N 8°50’44.36”E	316	Perfugas	Basalt
17 - Nuraghe Elighe	17a-Tower Walls, 17b-Cover	40°17'4.68"N 8°44’58.84”E	656	Macomer	Basalt
18 - Nuraghe Semestene	18a-Tower Walls	40°19'27.7"N 8°48’48.6”E	736	Bortigali	Basalt
19 - Nuraghe Santa Barbara	19a-Tower Walls, 19c-Walls ramparts	440°16'33.48"N 8°46'58.83"E	640	Macomer	Basalt
20 - Nuraghe Orolo	20a-Tower Walls	40°17'15.38"N 8°48’48.34”E	785	Bortigali	Basalt
21 - Nuraghe Erismanzanu	21a-Tower Walls, 21c- Cover	40°24’10.87”N 8°57’19.77”E	800	Esporlatu	Basalt

Materials and methods

Alongside lichens and bryophytes, also vascular plants, whether herbaceous or woody, are able to colonize any type of rock and can live in practically soil-free conditions, on walls, roofs and lithic artefacts of any nature. The presence of plants in these contexts is an important element to better identify the ecology of individual species that vegetate in other habitats as well and provide tangible evidence when identifying the initial stages of a plant succession.

With specific reference to the nuraghes, up to now the main focus has been on lichens in relation to the identification of hydrometric indices on the various lithic substrates (Tetriach & al. 1991a, 1991b). The lichen component has also been analysed on the prehistoric monument of Sa Covecada (Cossu & al. 2015).

Preliminarily, it was deemed necessary to analyse in detail the toponymy referring to the nuraghes, highlighting those related to plants. Phytoponyms are *per se* a first sign of the presence of a certain species on nuraghes and refer to both woody plants and mostly perennial herbaceous species. Camarda (1992) was the first to carry out a survey on lichens, which was considered important here to expand to vascular plants.

The research was mainly focused on the basaltic stone towers by taking into account the plants that live both on the walls (a-walls), on the ramparts (b-ramparts) and on the cover (c-cover) of the towers. Often the ramparts and walls are in a state of ruin, as well as the cover, so it was not possible, in many cases, to carry out the surveys on all three parts. The spontaneous flora on these stone monuments without mortar includes numerous ecological niches fertile for the growth of hundreds of different species, from small *Sedum* to large oak and holm oak trees.

The plants growing at the foot of the nuraghes are often ruderal and nitrophilous because strongly influenced by the presence of domestic animals, which often graze around or even inside them and were therefore not considered.

The lithic substrate consists mainly of basalt and effusive rocks, granite, porphyry or various kinds of limestone. The distribution in altitude was taken into account, from sea level (Nuraghe Palmavera at 50 m a.s.l.) to the highest altitude (Orruinas at 1200 m a.s.l.) in Gennargentu, in the centre of Sardinia (Table 1). The geographical coordinates and height of each monument are indicated, as well as the main types of lithic material (basalt, granite, limestone, porphyry) and the municipality in which it falls from an administrative point of view.

The nuraghes do not have cement material and the very thin layer of soil that forms on the interstices of the stone blocks and surfaces is solely due to the build-up of material carried by the wind and rainfall, especially when it is carried by wind from the Sahara. On the various levels, the dry plants favour the presence of a minimum layer of humus and therefore the formation of micro-pseudo-steppe also in the presence of total cover. The nuraghes are also a refuge for bats and other small mammals and are also often nesting sites for various bird species that release organic material on both the walls and cover.

The flora found in the individual nuraghes, differentiated where possible into the three ecologically significant parts, has been included, as well as in individual tables, in a summary table that highlights the different components of the life-forms that are considered particularly significant to explain their presence. The surveys were carried out in the period from April to June 2018 on 21 nuraghes and represent a first contribution to the research, which is intended to extend to a statistically more significant sample among the approximately 7,000 monuments surveyed.

Results

a - The phytoponomymy of the nuraghes.

The analysis of the toponyms related to the nuraghes, obtained from the information system of the Sardinia Region (www.sardegnageoportale.it), is reported in the Electronic

Supplementary File 1 (ESF1), which highlights the phytototoponyms related to lichens (*Nuraghe Arrubiu/Orrubiu/Rubiu/Ruiu*) for the abundance of *Xanthoria parietina,* which gives a typical yellow-reddish colour to the monument (of which 31 phytotoponyms are recorded here), and vascular plants.

Among the 384 phytoponyms of the nuraghes, taken from *I nomi di Luogo della Sardegna* (Paulis 1987) and from the official website of Sardinia www.GeoportaleSardegna.it, as many as 79 of them refer to different vascular species taking into account their variants in local dialects (*Nuraghe, Naracu, Nurache, Nuracheddu, Nuraxi, Nuraci, Nuragi, Nurasci, Nurachi, Nuraghi, Nuraxeu, Nurechi, Runache, Nurasci, Nurazze*). The most represented woody species are *Ficus carica* (25), *Quercus ilex* (17), *Pyrus communis* (15), *Olea sylvestris* (14), *Olea europaea* (7), *Arundo donax* (12), *Ruscus aculeatus* (12), *Myrtus communis* (11), *Prunus domestica* (11), *Quercus suber* (11), *Ferula communis* (9), *Malus domestica* (9), and *Ulmus minor* (9); while among the herbaceous species, *Typha latifolia, Asphodelus microcarpus,* and *Holschoensu australis* appear 3 times each, followed by all the others with 1 or 2 mentions each. As many as 30 nuraghe toponyms (*Nur. Arrubiu/Orrubiu//Rubiu/Ruiu*) refer to *Xanthoria parietina/ocroleuca* because of the prevailing reddish colour which it typically gives to basaltic rock (Camarda 1992). In relation to life-forms, the most represented categories are phanerophytes, hemicryptophytes and lichens.

These plants, besides giving the name to the toponym, were also present in the nuraghes under investigation, with some exceptions. Indeed, it is likely that *Nuraghe Uda* = Nuraghe of *Typha latifolia* indicates in this case the proximity and not the existence of the plant on the nuraghe, while other names (Piras, Chessa, Ligios) may also refer to anthroponyms. All 79 species were found in various nuraghes, regardless of the 21 species specifically surveyed. The most represented life-forms are phanerophytes in the scapose (*Quercus ilex, Olea sylvestris, Sambucus nigra*), cespitose (*Anagyris foetida*), and lianose (*Clematis cirrhosa, Hedera helix*) sub-forms, camephytes (*Helichrysum microphyllum*), bulbous and rhizomatous geophytes (in particular *Ruscus aculeatus*), and scapose hemicryptophytes (*Foeniculum vulgare* and *Ferula communis*). Therophytes (*Vicia villosa*) are quite rare. In addition to the species, the phytoponyms often indicate a type of vegetation: *Sinibridaxiu* (juniper), *Cannedu* (reed-bed), *Feruledu* (*Feruletum*), *Arridelaxiu* (*Phillyretum*), *Lavredu* (*Lauretum*), *Luargiu* (*Euphorbietum*), *Iscopalzu* (*Ericetum*) *Eligosu* (*Quercetum ilicis*), *Ortigosu* (*Quercetum suberis*), *Zippiriu* (*Rosmarinetum*) and so on.

b - The flora of the nuraghes

ESF2 and ESF3 illustrate the surveys that take into account the three fundamental microhabitats that can originate on the nuraghes, while ESF4 shows the overall list of flora found on the 20 nuraghes studied. The number of species per nuraghe varies from 20 to 52 species taking into account the different microhabitats (tower wall, rampart and cover), but in many cases, it is necessary to bear in mind, in addition to the period of the survey, also the difficulty to access the monuments for an exhaustive survey.

There is a total of 220 species, in alphabetical order and with their life-forms, in ESF4. The table shows a clear prevalence of terophytes, followed by hemicryptophytes and geophytes, while the number of camephytes and phanerophytes is more limited. The most represented species among the terophytes are *Avena barbata* (20), *Andryala integrifolia* (16), *Fumaria capreolata* (16), *Sedum coeruleum* and *Hordeum leporinum* (15), (*Raphanus raphanistrum* (14), *Sonchus tenerrimus* (13), *Vulpia myuros* (11), *Lamarckia aurea* (10), *Silene gallica* (10), *Hypochoeris achyrophorus* (9), *Vicia disperma* (9) *Bromus madritensis* (9), and *Sedum album* (8). Small therophytes that flourish in winter, such as *Arabis verna*, *Anagramma leptophylla*, *Erophila verna*, *Teessdalia coronopifolia*, and *Hornungia petraea*, which are mineralised in a short time in warmer areas, are probably underestimated. Among the hemicryptophytes, there is a prevalence of *Poa bulbosa* var. *vivipara* (8), *Scrophularia trifoliata* (7), *Ferula communis* (7), and *Parietaria giudaica* (7). The most represented geophytes are *Umbilicus rupestris* (20), *Silene vulgaris* (10), *Allium ampeloprasum* (8), *Convolvolvolus arvensis* (5) and among the ferns *A, Polypodium australe* (15) and *Asplenium obovatum* (7) and *Asplenium ceterach* (3) on limestone. The most common camephytes are *Helichrysum microphyllum*, *Phagnalon saxatile*, *Stachys glutinosa*, and *Teucrium marum*. The presence of phanerophytes is almost constant. *Quercus ilex* (6) is sporadic on the walls of the towers, but can give life to real wooded formations oon the most degraded monuments, especially when they are accompanied by the ruins of ancient villages (Nuraghe sa Ghispa), or on the covers as in the case of the Nuraghe Erismanzanu; *Quercus pubescens/congesta* and *Hedera helix* are present in 3 cases, while *Rubus ulmifolius* (2) is more common. The endemic component, both upland and rupestral (*Arrhenatherum sardoum*, *Scrophularia trifoliata*, *Herniaria litardieriiì*, *Ptilostemon casabonae*, *Santolina insularis*, *Sesleria barbaricina*, *Stachys glutinosa*, *Thymus catharinae*), is significant as well, including the nitrophile *Urtica atrovirens* and *Arum pictum*, whilst the exotic component is almost negligible, with the exception of the *Opuntia ficus-indica*, which may colonise the ramparts and covers entirely.

The list of species is probably incomplete, both because of the limited number of surveys, and because of the period (as demonstrated by the analysis of phytototoponyms that highlights rare species such as the *Euonymus europaeus*). However, this first contribution already shows the importance of the nuraghes for the presence of about 10% of the native flora of Sardinia. Moreover, these monuments are an important field of analysis of the phenomena of colonization of extreme environmental contexts in microclimatic and pedological terms, representing the succession that, from the initial stages of evolutionary processes, leads to the formation of grasslands and forest vegetation with most of the elements of the maquis and all the species constituting the island's forests.

Spontaneous flora also plays a role in containing the monument's state of ruin. In fact, the roots of the plants often penetrate between the stone blocks and help to maintain a balance that the weather conditions would tend to alter. The presence of a grove of holm oaks, certainly more than a hundred years old, on the cover of the nuraghe Erismanzanu does not seem to threaten its stability. There is no doubt that their degradation is often accelerated when the excavations reveal the precarious structures of the monument by removing the roots that constitute a sort of protective adhesive that secures stability. Other times, the elimination of the herbaceous cover and soil layer formed on the roof of the main tower in the Abbasanta nuraghe has favoured the penetration of rainwater into the main chamber. Finally, it should be noted that the elimination of lichens and herbaceous plants colonising the recesses of these imposing and rustic monuments does not cause any damage to them, while on the contrary it helps to remove a natural element lasting thousands of years and that at the same time gives the local landscape its unique charm.

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Cèsar Blanché

When Botany and Archaeology meet: the Ancient Catalan Flora Project

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Key words: Catalonia, archaeobotany, iconography.

During the last 25 years, archaeological activity dramatically increased in Catalonia where up to 12.000 sites have been inventoried (although not all fully excavated). The amount of data obtained gives useful information to build a Catalogue of Ancient Catalan Flora. Initial tests started in 2014 as pilot plans with BSc D projects and full development began in 2017.

For each taxon, information is collected from the following sources: (i) archaeobotanical data (presence of macroscopic and microscopic plant fragments, phytoliths, chemical traces, etc. recovered from sites), (ii) biological material (mainly pollen) from paleovegetation and paleoclimatic studies, (iii) archaeological objects with plant information: iconographic (representations and illusions) illustrations of plants in ceramics, paintings, sculptures, coins and all other objects of utilitarian, representation, religious, etc. uses, and (iv) epigraphic (inscriptions on all types of substrates) and written (from classical literary, scientific, technical, agronomical, etc. texts). The considered chronological period ranges from Protohistory to late Antiquity (roughly c. 500 BC – 500 AD), the territorial scope and the botanical thesaurus are those of *Flora dels Països Catalans*. The collected information, obtained from fieldwork, bibliographic sources, documentation repositories and museums, is stored in a database in Miscrosoft Access format.

At present, the database includes 1.189 documented citations and data obtained from 193 sources, from 255 taxa, mainly spermatophytes, although records of algae, fungi, bryophyte and pteridophyte have also been captured. Records come from 54 (= 63%) *comarques* (counties) and mainly from Iberian and Roman cultural contexts. 42 % are from archaeological objects, whereas 58 % are biological samples.

Examples of catalogued Orientalizing plant elements will be shown, including both artistic/religious illustrations and true plant remains documenting the presence of eastern plants in the W. Mediterranean Catalan Countries, mainly of Phoenician/Punic origin, dating back to VI-IV centuries BC.

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Neriman Özhatay & Engin Özhatay

Green Heritage of İstanbul

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Key words: Urban flora, endemism, Turkey.

To the South of Istanbul lays the Marmara Sea, and to its North the Black Sea. The watercourse that divides Istanbul is the Bosphorus. It is located at 41° N 29° E, on the Bosporus strait, and encompasses the natural harbor known as the Golden Horn, in the northwest of the country. It extends both on the European (Thrace) and on the Asian (Anatolia) side of the Bosporus.

The wide diversity of unusual habitats has allowed development of an astonishingly rich flora. The province cover just 5110 sq.km yet supports a remarkably high diversity of plant species with 2300 vascular plant taxa. This paper based on several years interested on İstanbul floristic richness of the authors and recently carried out the project titled ‘’Inventory and Monitoring Project of Istanbul that is part of the National Biodiversity Inventory and Monitoring of Turkey .Project supported by the Ministry of Forestry and Water Management 1. Regional Directory. This project report covers the natural heritage interests based on field works (105 days) collected 3500 specimens during February 2016 and November 2017 and related literature. Five habitats (grassland, forests, heatlands, sand dunes and other coastal habitats and wetlands) are of high national or even international importance to nature conservation. Of particular importance to nature conservation are the province‘s rarer species. Over 270 species that are regarded as nationally rare and /or threatened occur, of these 40 species abound here than anywhere else on earth. The checklist of Vascular flora of İstanbul have been updated with 62 endemic taxa .As result of the project, 13 new records are added to the İstanbul flora, 2 species have been reported as new record for Turkish flora. Finally a new autumnal allium, *Allium istanbulense* Özhatay, Koçyiğit, Brullo & Salmeri has been described as a new species for plant science.

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Saad Banamar

Plant heritage in Fez (Morocco): millenary richness to multi-aspects, botanic, scientific, architectural, cultural

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Key words: medicinal plants, aromatic plants, ethnobotany.

The historical city of Fez (Morocco) has been classified as "World Heritage" by UNESCO since 1981 in recognition of its twelve centuries of multidimensional civilizational influence: science, spirituality, architecture, crafts, art of living, gardening, etc. Its geography and bioclimatic conditions have provided to the city and its region a great botanical diversity, particularly in endemic plants such as the genus *Fezia* (*Brassicaceae*) and medicinal and aromatic plants (MAPs). The wild MAPs have been meaningfully used in culinary art and in traditional medicine that have flourished in the city through the centuries. In addition, architecture typical of the homes of Fez, with inner gardens, has permitted the development of the MAPs culture in indoor gardens and in terraces and of the flourishing of the art of gardening. The use of the MAP, beyond empiricism, was supervised by the scientific knowledge accumulated in the scientific environment of Fez provided by Al-Quaraouiyine, prestigious and oldest university in the world. A strong testimony of this scientific support is given to us by the important work of the illustrious doctor and botanist born in Fez in the 16th century, Al Wazir Al Ghassani. The study of one of his manuscripts, preserved in the library Al-Quaraouiyine, entitled "The garden of flowers for the description of herbs and simples" revealed us throughout its 166 pages, in addition to its medical scope, its innovative character in the Botany field. The work presents for each plant a detailed description of the terms of use as a medicinal, preceded by that of its botanical and ecological characteristics. Due to the methodology, the diversity and accuracy of terminology and the completeness of the inventory, this manuscript provides an undeniable step forward in the historical development process of description and classification of plants and represents the first thematic regional Flora of Morocco.

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The genus *Tamarix* (*Tamaricaceae*) from archaeological to contemporary landscape*

Abstract

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This review includes the data concerning the presence of *Tamarix* species in old and contemporary landscapes, and their presence in archaeological areas. Their role as wild and ornamental plants, their use in sacred places, and their depiction in old relief sculpture, old and more recent paintings is also reported. Notes on the presence of *Tamarix* species in current landscapes and their invasiveness are discussed.

Key words: *Tamarix,* archaeology, landscape, biological invasion, distribution.

Introduction

Since ancient times tamarisks (*Tamarix* sp. pl.), were used in different Babylonian rituals, to ward away evil influence, in celebrations, as act of gratitude, to commemorate the birth of children, to accompany the procuring of water rights, as ornamental, medicinal plant, windbreak, etc. (Calvin 1847). In addition, tamarisks were a component of oaths and they were utilized in purification and divination. As folk use, the tamarisks were also used to produce a resinous, sugar exudation and for making cakes when mixed with wheaten flour (Forster 1942).

As reported by Umbarger (2012), the Genesis 21:33 states that “Abraham planted a tamarisk tree in Be'er Sheva”. On the basis of subsequent interpretations, it seems likely that Abraham planted a tamarisk to delimit the area around his altar in Be'er Sheva wanting to depict a sanctuary in the open or as symbol of his hospitality.

The remains of Saul, the first king of the Kingdom of Israel, and Judah (1047-1007 B.C.), was buried under a tamarisk tree (Holman Bible Publishers 2010).

Tamarix species were sacred to Osiris, the God of Afterlife (Barguet 1967), and it is said that next to his tomb the branches of a tamarisk support his soul with the appearance of a bird (McIntosh 2005).

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The above examples highlight the knowledge and several uses of tamarisks by ancient populations. The documents consulted show how tamarisks have long been a constant component of the landscape of various territories and in particular of the Middle East.

In this work, an analysis of the role of tamarisks in the evolution of the plant landscape is reported through their representation in old and more recent paintings, in wooden sculptures, etc. In addition, the current problems related to their invasiveness and the effects on ecosystems are also analyzed.

***Tamarix* as a component of plant landscape in sacred places**

Tamarix nilotica (Ehrenb.) Bunge is a floristic element characterizing the plant landscape in sacred places. This tree still characterizes the flora of Israel, currently consisting of 13 *Tamarix* taxa according to reports by Danin & Fragman (2016) in Flora of Israel Online. This is a well adapted species to saline soils, it is free of thorns, and not succulent. The twigs are slender and the leaves are lanceolate. The racemes bring pentamerous, white or pink, flowers. In Israel, *T. nilotica* grows on soil “islands” at the main channel of Nahal Zin and in sites where soil stays wet even many days after the flood (Danin & Fragman 2016), and on alluvium on Mount Sinai.

Tamarix aphylla (L.) Karsten is a rare species in Israel, common only in the Arava Valley, usually planted near wells in the northern Negev, northern Sinai, west and northwest of Mishmar HaNegev, Shuval, and Bet Kama, including the well of Abraham in Be'er Sheva (south Israel), the remnants of the village Masmiya and Tel Nizzana. This species can be recognized by its purplish brown and smooth branches. The twigs are drooping, wiry or needle-like and the leaves are bluish-green, alternate, reduced to tiny scales. The flowers are numerous, tiny, whitish-pink. Old trees of *T. aphylla* from the Hamriyah area of the Emirate of Sharjah (United Arab Emirates) are considered by local population of cultural importance and a link beteween present, past, and future generations (Mahmoud & al. 2015).

In the Zarka River Valley (biblical Jabbok) along the Jordan river, there is a wide population of *Tamarix jordanis* Boiss. It is a small tree with slender stems, red when young, leaves alternate, scale-like. The racemes bring white or pink flowers, clustered on terminal spikes.

***Tamarix* in relief sculpture, old and more recent paintings**

Looking at some most important and prized old paintings in which *Tamarix* species are depicted, it is possible to recognize the habitat and morphological characters of each species.

In Guy Rose (1867–1925), “Tamarisk Trees”, Southern France it is possible to observe the twisted shape of the slender trunks and the scattered foliage as well as the sandy habitat of *T. aphylla.*

In “Pharonic Fantasies of a Foolish Old Man” by Stanza Widen, Canada, it can be recognized the habitus of *T. usneoides* E.Mey. ex Bunge with slender branches and an upright form.

The “Tamarisk Tree of Lake Como” by Sigismund Christian Hubert Goetze, hosted in The Fitzwilliam Museum (Cambridge, United Kingdom), is clearly referred to *T. gallica* L., and in particular to a still living plant occurring along the shores of the lake.

Finally, the Private Painting Holiday by Angela Corben (Majorca, June 2017), entitled “Plein Air under the tamarisk”, refers to a tree of *Tamarix africana* Poir., that grows on sand near the sea.

Most Egyptian timber consists of tamarisk, acacia and Sycamore figs (Liphschitz 1998). Tamarisk wood, most probably from *T. nilotica,* was used in combination with wood of *Ficus sycomorus* L. The timber of tamarisks is dense, hard, durable, and used to prepare throwing sticks, bows, pegs, walking sticks and, boxes. The wooden nail of wooden masks, dating back to the 18th, 19th and 20th dynasties and some nail of coffins (320–330 BC) from Museums in Israel are made with tamarisks. A stamp seal with a small ring on the back dating to the Egyptian Middle Kingdom, the Head of Osiris (26th Dinasty), the statuettes of Shabti (New Kingdom), Isis and the head of the statuette of Osiris Ptah-Sokar (Ptolemaic Period, 3rd-2nd century B.C) are made with tamarisk wood.

Current distribution of *Tamarix* species

The genus *Tamarix* L. is naturally and widely distributed from Mediterranean Area (including North Africa) to western Europe, northeastern China, Mongolia, India, and Japan (Baum 1978). Tamarisks are adapted to arid climates and grow into the wild in a wide range of habitats. Some species are cultivated as ornamental plants or marine windbreaks and for the sandy dune stabilisation (Mandracchia & al. 2017). Some other species are cultivated for their recognized ethnobotanical uses (Tuttolomondo & al. 2014). The halophytic character of *Tamarix* leaves and the presence of salt glands are also a common feature (Alaimo & al. 2013; Grisafi & al. 2016).

In Europe, thanks to the recent increase in floristic exploration, the number of known tamarisk species is gradually increasing. New tamarisks growing spontaneously and others, introduced for cultivation in Italy through nurseries or random events, have recently been described as casual alien plants (Venturella & al. 2012).

The fluctuation in the number of tamarisks species occurring in Italy is mainly due to difficulties in the correct identification. The analysis of some features (habitus, size of racemes, etc.) adopted in the past are not exhaustive since the type of flower disk is an important discriminant character.

Notes on invasiveness

Tamarisks are considered worst invasives across different countries and included among the top twelve America’s “least wanted” by Nature Conservancy (Stein & Flack 1996; Zavaleta 2000). *Tamarix* sp. pl. are reproductive, competitive, and tolerant (Brotherson & Field 1987). In fact, these species are characterized by continuous seed production during the growing season, a seed output of more than 500,000 per individual per year, a high seed viability, an adaptation for long distance dispersal by means of wind and water. In addition, tamarisks show a high vegetative reproductive capability. The deep and extensive root system makes it easy to compete with other plants and to tolerate a wide range of environmental conditions. *Tamarix* sp. pl. are also facilitated in their invasiveness for the ease with which it is possible to root out after a fire, flooding, cutting, and herbicide treatment.

Among the various examples reported in the literature, highlighting the role of tamarisks in the alteration of some habitats and in the composition of flora and fauna, we can mention that of *Tamarix ramosissima* Ledeb. which has been related to several environmental changes in North America, and it negatively affected avian communities and bird nests (MacGregor-Fors & al. 2013).

In recent times, *T. usneoides* has undergone biological control in the United States and South Africa (Marlin & al. 2017).

T. ramosissima and *T. chinensis,* introduced from Asia in the United States of America, have become common and invasive in many western riparian habitats (Gaskin & Kazmer 2009).

One of the most effective biological agents tested in arid and semi-arid ecosystems against the invasiveness of *Tamarix* is *Diorhabda carinulata* Desbrochers, 1870, also known as northern tamarisk beetle (Pattison & al. 2011).

In Italy, although there is some evidence that tamarisks introduced and escaped from cultivation are spreading in nature, there are still no specific studies on the invasiveness of this genus.

Conclusions

Tamarix species show interaction with four ecological factors, such as regional climate and local weather climate, hydrologic variables, fire dynamics, and the salinity of the soil and groundwater. Over the years, these interactions have contributed to create a different plant landscape than in the past.

The tamarisks have long characterized the plant landscape of the coastal dunes and hinterland and have been elected as symbolic plants in some rituals and sacred places. The tamarisks, moreover, are widely cultivated as ornamentals and as such have been depicted in many paintings and sculptures.

The correct identification of these species is still a problem, as well as the absence in the catalogues of nurseries of the exact origin of the cultivated species. The problems linked to the invasiveness of tamarisks that escape cultivation are known above all in the United States, while they are becoming increasingly evident in Europe, especially because tamarisks are ofteb introduced as ornamentals, but also used in some environmental restoration works.

It is therefore necessary to intensify taxonomic studies on this still critical genus and to monitor actions on species that are gradually becoming spontaneous in different territories.

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International legal and protection of the landscape and biodiversity: the architecture of the limit between natural cultivation and culture

Abstract

Modìca Donà dalle Rose, C.: International legal and protection of the landscape and biodiversity: the architecture of the limit between natural cultivation and culture. — Bocc. 28: 151-160. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

The growth and spreading of environmental law for scientific and health protection, - together with the landscape that responds to more historical, aesthetic and cultural principles, represent an evolution of living law directly proportional to the ability of right operators to share with the scientific community the multiple problems and reflections of development risks . The right balance between scientific and technological evolution and the management of its voluntary or involuntary, regulated or regulated introduction into nature are the main challenges of scale application of what has become one of the fundamental principles of international law and single Nations: the precautionary principle.
Sicily and the park of Selinunte tell us through the variety of its plants a part of history: the anthropological and zootechnical passage of the human and animal migratory flows that have characterized the testimony of the past. The environmental changes have been voluntary, responding to aesthetic decisions and in other cases occasional and voluntary.
The environmental and biodiversity protection, expressed in national and international law, are today the main tools to manage risks with prudence and potential forecasts.
The natural landscape, emblem of what is historically presumed to have been ab origine in comparison with the cultural landscape, i.e. the intertwining of the many human passages that have intervened over the centuries, offers an important starting point for study and reflection to refine the scientific and regulatory techniques of nature protection.

Key words: environmental law, Selinunte, cultural landscape, natural landascape.

Biodiversity is a scientific concept that has occupied, in recent decades, many branches of national, European and international law, favouring the promotion of an ever closer collaboration between science and law, between research and regulatory production, in an attempt to achieve a greater adherence of the right to the sociological and anthropological dynamics of the international community.

When jurists, botanists, agronomists, doctors, biologists, industrialists, anthropologists, philosophers, historians, archaeologists, geologists, architects, engineers and politicians participate in the same study table, the first bases of an approach aware of the necessity of a vision have already been created. overall, replacing a now anachronistic purely specialized and sectorial approach.

The responsibility of the scientific community and of the responses it is able to give, not only to its financiers and economic supporters but above all to the final consumers and to those who are called upon to keep watch over them, have been gradually standardized starting however from the assumption that science has all the attributes to be able - in a generalized time frame - to foresee a corolla of possible chains causes and effects, in order to avoid a dangerous irreversibility of the actions carried out by man.

In short, science is asked to evaluate a priori what is actually predictable, with the tools available at the same time, therefore at least in power, the effect generated by a new scientific phenomenon or a mere innovation or geographical incursion of animal or vegetable species, in places other than that in which they evolved and are presumed to have originated.

But because this dynamic is not a purely conceptual matrix of work that is detached from reality but is actually aimed at finding conditions to reach, at least, a state of primordial knowledge, we must never lose sight of the interests and aims of those who today finances research.

In fact, scientific research has justly high economic costs and, paradoxically, even though it is one of the interests and duties of the nations, to monitor the common interest, namely the health, protection and protection of the ecosystem, of the micro and macrosystem, as well as of biodiversity, today it is increasingly relegated to the margins or, in turn, not too veiled by those who carry out scientific research into economic productions.

Uniting the two great worlds of science and law, in the field of biodiversity protection means, first of all, abandoning self-referential positions, perched in the specificity of the peculiar language and used in each of the doctrines and individual scientific communities.

Looking at a landscape with the eyes of a geologist, an archaeologist, a jurist, an architect, a botanist or an industrial entrepreneur means crossing, converging and bringing together different perspectives on the same object. This convergence of looks gives rise to a much sharper and more concrete vision of the status quo ante analysis and of the imaginary status in a temporal perspective with respect to the possible consequences, cause and effect.

The result can always be surprising and never univocal, but above all the neglect by the scientific community, with the analysis of the legal one, one of the possible consequences is an act of responsibility or irresponsibility: it integrates a choice.

But at best, every perspective, while preserving its own cognitive dynamics and the main aims of its own science, when faced with an experimental crossroads, in choosing, risks putting a sort of contact lenses that reveal a vision before one’s eyes. not always compatible. Very similar to cultural relativism, there is the risk of developing a sectoral relativism, that is, a sort of involuntary reference to the matrices and to the call for the classical procedure of its own scientific methodology, leaving aside the integrated and intuitionistic one of an equal dialogue between different sciences, such as the agronomy, botany, law, anthropology, archaeology, geology, biology, medicine, zoology.

It is known that technological development and science cannot but be financed by the private and public economy, and when it responds to ever wider dynamics, daughters of globalization and the concept of a common heritage of humanity, they are indissolubly sealed. necessary relationships of sustainability of political choices, regardless of their absolute scrutiny and scholar attentive to every risk factor.

Managing government power how to manage the economic power of safeguarding and growing one’s own business also means choosing between the different benefits and evils, minor and worst, which in the relationship between research, experimentation, protection, protection and development do not always follow the same dictates .

In the last fifty years the word specialization seemed to be synonymous with perfect analysis, par excellence, of guaranteeing risk assessment and every factor. Specialization meant precision in the meticulous analysis of the case.

Yet, looking only at the human body, we learn that a skin problem can find its root cause in a deeper pathology that can nest in the pancreas, in the liver, in the psyche. The cause must be investigated and is often far from the visible effect with the naked eye.

And so the plants of land and sea that, nourishing themselves from the same subsoil, can be the main spies of a phenomenon invisible to our sight, in the horizon of our gaze, which lurks its causes deep within the bowels as well as in the historical chain in which it developed.

Insects and animals, with their behaviour, alert us well in advance of the unstoppable mutation of nature and the acceleration or deceleration (positivism or negative, harmful or healthy that it is) that human action can trigger.

But the events and the search for the triggering causes, the etiologic of a relevant phenomenon, what the ancient Greeks called *αἴτιον*, the cause of events and pathologies, is a long and laborious path that knows neither shortcuts, nor lightness whatsoever, but above all self-sufficient presumptions.

With the help of the etiological myth, the ancients explained the origin of many phenomena, from the cataclysm to the supernatural phenomenon, an object or an animal, thus leaving aside the logical analysis of the natural phenomenon.

Paradoxically, today, despite literacy, globalization, the internet age and access to all information in real time, we are witnessing a sort of modern neo mythology, where the mass acceptance of an assumption through a slogan , an image, an advertisement, a Facebook page suffocates reflection, destroys the human inquiring instinct and makes the acceptance of an assumption particularly digestible without having investigated its evolutionary path.

Consider the case of milk powder, in African countries, which was served and presented to the international community as a salvation for humanity, neglecting the fact that the production of mothers’ milk, even in a total state of poverty and malnutrition, was the only reliable source of sustenance, safe up to the fifth year of age, and that the interruption, even if only for a day of feeding the mother’s milk, would have caused its cessation. To these women there remained only to wait, as well as a difficult destiny of dry mouth and all that surrounded them, the charity of the same international community that would have had to give him, without any pause, the magic milk in powder.

Moving a tradition, a habit - be it food, agriculture or farming, how to uproot a plant from one place to another, export it to another ecosystem - is a phenomenon frequently experienced in human history, from one continent to another. , but it has not always had an improvement effect on the eco-hosting system.

Through plants and their relationship with the earth and human tissue, we can proceed and reconstruct an accurate historical geolocation of all these steps, ideally reconstructing the virginity of that space and the incursions gradually suffered over the centuries.

The study of the phenomenology of the sub-ecosystem and the sub-ecosystem is part of the great history of humanity, that is, of that space in which, over the centuries, human intervention has diverted and modified the normal evolution of nature. This study of history, from the scientific and historical point of view, can provide and provide solutions that are unthinkable and essential for the treatment of possible or already present diseases. But above all, according to the application of the precautionary principle, it can become a preventive factor, almost prescient, based on real risk factors, certainly not on the questioning of the stars or lines of the hand.

In the past, some imprudent choices and certainly not aware of the commercialization of palm trees from North Africa, have led to the release of new bacteria in a new environment and harmful foreign insects that - more proliferative and free from the game of a greedy bird not adaptable to that place - they multiplied and broke the balance of their normal birth and death, destroying millions of palms in Sicily and elsewhere. Also in this case it is not the plant that was transported but the ecosystem that had to be studied and evaluated around the plant. This ecosystem is composed first of all of the climatic factors of the place where the palm grew, the animals that lived it and cured, with their intervention, insects or birds, their life and their death, in the continuous and mobile flow of nature .

The plants, in the case of the red weevil, have been unaware vectors, of a killer insect that slowly and others, different, already present in the territory.

This is the case of the red weevil, *Rhynchophorus ferrugineus*, which through Spain and the imports of palm trees that contained it in southern Italy has gradually adapted to the palms, the new ecosystem offered to feed its larvae, decimating more from year to year fifteen years the *Phoenix canariensis*, massively disfiguring the historical landscape of Sicily, now denuded by the long streets of Palme that over the centuries have characterized it. But above all, today, the killer beetle has begun to attack types of palms that up to now were not exempt from its voracity.

From the point of view of safeguarding the ecosystem and biodiversity we are therefore witnessing a break of a very delicate balance between the plant and the reception ecosystem, devoid of those minimum factors that would have preserved the natural life cycle, in this case the periodic death of beetle food in turn favorite of the

If we look at the history of the curculionid beetle native to southern Asia and Melanesia, already in the 1990s it was very harmful to palm trees, already signaling serious damage in the Egyptian date palms and the Arabian peninsula, we realize how nature alerted the scientific and legal community of government that they could - working in synergy - avoid the destruction of palm trees and the landscape that since 1994 has devastated Europe and, starting from Spain.

It was discovered, in the aftermath, that the Indian reddish *dendrogazza Vagabunda parvula* and the common kestrel *Falco tinnunculus*, a species originally originating from Asia (exactly like the beetle), commonly feed on this invasive parasite. The *Rufous Treepie Dendrocitta vagabunda* is a Treepie, native to the Indian subcontinent and adjacent parts of Southeast Asia and is a member of the Corvidae, or crows. But these birds did not easily adapt to the sud European ecosystem and above all follow their migratory routes, therefore they were not able to stop the proliferation of these beetles and its larvae inside the palm trunks. The man has therefore remained only the support of chemistry with the help of strong pesticides throughout the palms.

However, the remarkable biotic potential of the beetle and the incessant trophic activity of its larvae actually make the chemical action almost as irrelevant as that of native predators such as the black rat *Rattus rattus*, lizards, magpies or pigeons. Therefore, at present, the fight against the red Awl must be conducted with the systematic and rational use of insecticides authorized for the purpose. Dead palms must be promptly eliminated, and the infested parts must be ground to prevent adults from colonizing other palms. In Sicily, the common wild mouse *Apodemus sylvaticus* is often present in the summit of Canary palm trees infested with the red weevil. Larger than the domestic mouse *Mus domesticus.* The weevil-infested palms provide abundant food for the rodent, as evidenced by the presence of erupted pupal chambers and adult females with gnawed abdomen. Certainly the predatory activity of the wild mouse eliminates numerous punches and we can imagine, in turn, a proliferation of such rodents ?!

In the slight survey of a sectoral and non-shared and confluent progress of the various scientific disciplines, including the right, the place of honour, in the last twenty years, OGM, genetically modified organs, have certainly had that before still being perfectly certified as to their non-dangerousness if placed in the environment and therefore in a virgin ecosystem, they were proclaimed, in the late 90s, as biologically predisposed plant beings to treat their bacterium and antibody in the same space of an atom it is possible to declare that the dangerous pesticides, dispersed in the air in the fields in previous years, would no longer have been necessary.

Too bad, not having heard the great philosophers of the past who had alerted us more than once of the circumstance that everything flows, that everything changes, and nothing abides unchanged, in nature in the matter and in the immaterial, from form to thought. Returning to the dynamics of the killer beetle, we can say today that the red weevil having exhausted the *Phoenix canariensis* today has attacked other species of Palms once indigestible. With its import into southern Europe we accelerated its natural mutation and increased the use of pesticide chemistry.

And so, little by little, between one label and another, between a slogan and another, the bacteria have become stronger, stronger and have become super bacteria, little Superman able to defeat the barrier of any possible pesticide or injectable antibody in the same space as an atom. From the cultivation of the traditional ordinary field, we have moved on to the biological, then apparently biological, then ogm and now, supported by a pesticide chemistry now necessary both to the traditional field, and to the field now no longer biological if not in the label and from that from glorious sensationalist OGM past.

How to tell a gullible community, a victim of *modern neo-mythology* that now those same plants need an avalanche of pesticides far more powerful, almost unimaginable, than they needed before the super atoms were injected with the alleged magic potion that would genetically due to make them stronger, compared to an entire ecosystem, to infinity.

Thus it was that the crops and the land became increasingly inert, to the point of becoming, in certain cases, extreme, even infertile. But the undernourished earth of its natural balance, fortunately, always finds the way to react by calling on animals of all species, including humans.

Beyond each case and story, what is relevant is that the reason and the cause of a phenomenon, to be known must first of all be investigated with a valid path that is able to rework the passages that preceded it, the facts.

The activity of the scientific researcher, as well as of the juridical one, in the moment in which the phenomenon has already been established, takes the form of a probabilistic investigation that aims to stage, backwards, every possible and probable passage that could have preceded it.

The legal investigation, differently from what many people believe, in the study of environmental law and the search for a legal responsibility, is far from a mnemonic and utilitarian application of normative data is pure creativity, it is a far-sighted vision of the application of law and the representation of future concrete cases. In a word, it is pure prevention that never means blind prejudice or obstructionism, but an attempt to systemize the least myopic view of what can happen in nature.

Even if in the modern era, as for all civilizations, ours too is subjugated by myths, with a fantastic and unreal approach. The etiological term derives from the Greek word Etios, which means for the note cause / origin.

The etiological myths therefore belong to the past but they are not so far from the often coincidental result, with the absence of a thorough and collateral search for a valid explanation for a phenomenon that actually happened or is in the process of evolution.

The protection of biodiversity, if I had to represent it figuratively, I would borrow the image of an upturned oak where the intertwined branches are the different branches of knowledge that flow towards a single central body, the trunk, from year to year gradually. bigger.

In the last thirty years there has been a great activity and the growth of an ever greater interest in international environmental law. Through normative and programmatic tools the international community has set rules to slow down the phenomenon of biodiversity loss in nature.

Unfortunately, the interventions carried out and the instruments adopted did not lead to the desired results and the objectives set have not yet been perfectly achieved. But a stronger and more meaningful conscience has been created in every discipline of confluence, research also towards this purpose.

The international community continues to question itself on the tools to be adopted, to set new goals for an increasingly concrete protection of biodiversity and its being a world heritage. The protection of biodiversity is still today a central and delicate issue in the international debate on the environment. Despite the fact that 2010 has not in fact reported the expected results, the initiatives implemented for the “international year of biodiversity” have, however, produced a greater sensitivity and attention of public opinion on the subject and have fuelled the spirit of national governments for the determination of new goals. Before going on to examine some of the main interventions of international significance in the field of biological diversity, it may still be useful to clarify the origins of this concept and the way in which it was established. The term biodiversity, or biological diversity, expresses a concept with a complex and multifaceted character.

There have been several juxtapositions of knowledge in growth and the spreading of environmental law - for the scientific and health protection together with the landscape that responds to more historical, aesthetic and cultural principles - represent an evolution of living law directly proportional to the capacity of the operators of the right to share with the representatives of the scientific world the many problems and reflections of development risk. The right balance between scientific and technological evolution and the management of its release into nature, whether voluntary or involuntary, regulated or adjustable, are the main challenges of the application on a scale of what has become one of the fundamental principles of international law and individual nations: the precautionary principle.

In its general aspects, the semantics of the precaution we have explored as an introduction identifies one of the essential elements of the ideal tension that feeds the contemporary debate on the relationship between law and technology, and it is to some reflections that emerged in the context of this debate that we need briefly look to begin to decline and develop this semantics in a completely juridical sense.

The myth of Prometheus and the figure of the sorcerer's apprentice identify two metaphors abused in the discourse on the relationship between law and science, between law and technology.

Moreover, the precautionary principle appears in the middle of the last century in Germany with the *vorsorgeprinzip*, authorization of the public power to take all necessary and reasonable measures to face any scientific and environmental risks even in the absence of proven scientific or necessary knowledge establish its actual existence. But in reality this principle had already taken the first steps in the philosophies of the German Hans Jones who, taking up the themes treated by his master Heidegger, outlined an ethical theory impregnated with general ecological principles and destined for the future technological civilization in contrast with the roots of the humanism. The first request formulated to the law is in fact linked to the assimilation of the idea of technological retaliation, of the associated harmful consequence and arising from the (purely beneficial) use of scientific discovery.

Therefore, the myth combined with the destiny of man the key with which society is called to come to terms, developing and refining the juridical concept, makes it possible to formulate the answer of responsibility.

The responsibility and the fear of unleashing uncontrollable and irreversible forces using technology are the revealing feeling that must necessarily be listened to before the action and that therefore sets the task of formulating and applying rules capable of capturing the increasing intensity of this fear, to try to guide the development and application of technological knowledge with a sure hand to the antechamber of antecedence.

By combining the inexhaustible ability to infinitely redefine the needs of its users, the technology ends up by avoiding any limit imposed by the respect of purposes other than its own, that is, precisely, that of making the capacity to achieve goals infinitely: the technology that one would expect to regulate thus becomes itself legislation or legislator, coming out of the control and purpose of true sustainable growth that was driving it.

This concern reflects an awareness that contemporary thought has developed since the first half of the last century and that today identifies a cornerstone of philosophical reflection on technology: the relationship between law and science, between law and technology.

The jurist has the possibility to reply by repositioning the axis of the problem within the discourse that best masters it, or rather the one that allows him to claim the autonomous normativity of the law, even admitting the occurrence weakening of politics, increasingly in difficulty in the attempt to chase and manage the power of technology

The value of the norm in its mere procedural adequacy, the idea that the juridical is axiologically neutral and is in a dusty shelf of a secular library, ready to receive any content is very far from reality.

The jurist, claiming his neutrality with respect to a contest destined to take place within the procedural rules that in a democracy, can determine the supremacy of a value or a will to power.

Then there is a second path that the jurist travels in parallel, setting aside the ambition to describe law in terms such as to erect it into a self-referential system, overcoming the simple allusion to the *giusrazionalista* rational law root or to the post-positivist nature of contemporary law by assigning to constitutional principles and to fundamental rights a space no longer revocable by the right in place, but in the opening of the juridical to the sentiment.

Feelings, rather than reflective intellect, are in fact the main component of public opinion. The feeling of threat felt by society that - in stressing the need for the right, even before identifying its requirements or applying its rules, is prepared to listen in advance to information on the risk and danger associated with technology - approaches the investigation of the relationship between law and technology to legal implications in terms of precaution.

A thought and intellectual matrixes of the precautionary principle were elaborated within a cultural tradition by a German philosopher and sociologist, to the conclusion of a reflection that meets a social feeling that matures and consolidates in Germany over the years Seventy, also in the wake of the ecological catastrophe of the acid rains that devastate the Black Forest the *Waldsterben*.

Reflecting on the juridical dynamics of the genesis of this principle, the work of the German philosopher makes explicit the programmatic will to proceed to construct an idea of responsibility that knows how to place itself on a further plane than the one traditionally presupposed by the legal perspective. The intent is to overcome what, in relation to one's ethical need, constitutes the insurmountable limit that this responsibility reveals both in its civil and criminal connotation, since both compensation and punishment share a common destiny: the reality of the human condition.

The underlying themes arising from this reality stand at the limits of tolerance of nature and are those, urgent and decisive, of nutrition, the finiteness of raw materials and energy resources.

To manage all these forces and needs, a new great mother science is required to deal with the enormous complexity of the interdependencies of the different branches of science.

Projections can never be secure, but caution, especially in the case of irreversibility of some processes started, is the best side of courage and in any case an imperative of responsibility.

On this point, insecurity can be our permanent but indispensable destiny.

The temporal perspective of legal responsibility has intrinsic constitutive limits that fall within the predictability, denouncing the inability to adequately compute the future effects of the decision and of the scientific and legislative choices.

The need for a superordinate principle thus becomes clear, forcing political, scientific, economic, entrepreneurial and legislative action to come to terms with the ability to reveal the feeling of fear, thus moving towards an ideal behaviour towards which to direct collective action.

But fear must not distract us from acting but lead to a feeling of anticipatory responsibility, before the final uncertainty of hope, or a condition of responsibility for action.

The global dimension of risk and the way in which the powers and competences that society uses to govern it must be reorganized in the light of this awareness.

The first step is therefore the recognition that scientific rationality, with its claim to rise to a single instrument capable of objectively measuring risk, must be combined with social rationality and with the latter's ability to summarize the values to be based on risk analysis, to admit and value the interdependence that links it to the regulatory management of risks and responsibilities.

Because not even economic and international inequalities allow the full delocalization of the risk. The risk can go back to where it is generated, just like pesticides, which, conveyed by agricultural products, return to the nations of origin of the producing companies that sell them to the developing countries.

The end of the antithesis between nature and society is aimed at claiming the importance of developing the social capacity to anticipate dangers, demonstrating how environmental problems and ecosystem threats take on the appearance of social problems even before they are completely discharged and sworn by scientific assessment.

The belief that scientific rationality holds the only word to identify and describe the risk, setting maximum permitted values or insisting on the need for rigorous causal explanations, is now definitively overcome.

The blindness of technical-scientific rationality therefore finds a first explanation in the economic unidirectionality that distinguishes it, and that pushes it to seek the possibilities of economic exploitation as a primary mission, to relegate the risk (and its evaluation) to the category of induced side effects from the pursuit of this goal.

The rigor of the causal demonstration, pursued by elevating the scientific parameters of this assessment to the extreme, even if it omits the representation of the single causal factor of a given damage, cannot prevent the proliferation of this damage and the accumulation and interaction of etiological factors.

Also, the preventive determination of the maximum values of harmful factors takes on the features of a trial to which man is permanently subjected, with the paradox governing the burden of proof of the alleged perpetrator, the failed failure of the experiment.

Sicily and the park of Selinunte tell us, through the variety of its plants, a part of history: the anthropological and zootechnic passage of human and animal migratory flows that have characterized it from the past. The environmental changes were wrapped up voluntarily, responding to aesthetic decisions and in other cases completely occasional and or voluntary. The biodiversity of this park is an embryo of the largest biodiversity present throughout the territory of Sicily, a reversible treasure as to its original consistency and constantly subjected to potential natural or human induced changes.

The protection and protection of biodiversity, expressed in the rules of national and international law, are today the main tools to manage risks with prudence and potential forecast.

The natural landscape, emblem of what is historically presumed to have been *ab origine* compared with the cultural landscape, ie the intertwining of the numerous human passages that have taken place over the centuries, offer an important starting point for study and reflection to refine the scientific and normative techniques of nature protection. Art that knows no linguistic or national boundaries, filled with the pollen of a flower interprets that universal language that can best explain the risks and the instruments of protection and enhancement of the environment and nature.

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The cultural heritage of Mediterranean botanic gardens*

Abstract

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Mediterranean botanic gardens represent a rich and diverse cultural heritage, both tangible and intangible. They include spectacular landscapes and the plantings include many important introductions of both ornamental and economically important species. The gardens also contain many buildings of great architectural merit, some historic, some modern. Also important are the historic glasshouses and shade houses. Many of these gardens contain important herbarium collections that have served a key role in the preparation of Floras and major botanical libraries containing historical works of great value as well as works of art, sculptures paintings, drawings, and other illustrations and invaluable historic archives. The intangible cultural heritage of these gardens is represented by the impact that they have had the inhabitants of the cities and towns in which they are located and on generations of visitors – students, professionals and the public. With the decline of teaching and research in botany as a university discipline, some of these collections are at risk of dispersal or an even worse fate. In the face of these uncertainties a series of proposals to help safeguard this invaluable heritage is given, including the compilation of an inventory of these historically important buildings, libraries, works of art and archives and the use of the latest scanning and imaging techniques so that a visual record is prepared.

Key words: landscapes; herbaria; museums; libraries; inventory.

Introduction

For nearly 700 years, Mediterranean botanic gardens in their various manifestations have not only been important centres of botanical knowledge and research but have also had a major influence on social and cultural life though the gardens themselves, their buildings, museums, libraries herbaria and collections, all of which represent a rich and important heritage (Heywood 2015).

Landscapes, trees and plantings

Although many of the older Mediterranean botanic gardens are small and located in towns and cities where space is at a premium, some of them are noted for their spectacular

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landscapes and vistas. This is especially true of gardens located on the coast offering views down to the sea, such as the Giardino botanico Hanbury, La Mortola, Italy (Fig. 1) with its spectacular views from the upper terraces and the New Vista walk interrupted at intervals by steps and fountains, leading all the way down to a short stretch of the Via Aurelia at the bottom of the Garden. Another example is the Jardin Exotique de Monaco (Fig. 2) where the views, are so outstanding that I once heard Prince Rainier remark that he envied the Director because the views from his office were the finest in the Principality.

As well as such vistas, some spectacular plantings can be fund, include the avenue of *Ceiba speciosa*, in the Orto Botanico, Palermo, the *Wisteria sinensis* covering the great iron gazebo in the Jardín Botánico-Histórico La Concepción, Malaga, Spain, the choreographed plantings and topiary in the Jardim Botánico da Madeira, the avenue of plane trees (*Platanus*) in the Jardín Botánico-Histórico La Concepción, Málaga, Spain, the vividly colourful Passeig [staircase] de Font y Quer in the Jardí Botànic Marimurtra, Blanes, Spain.

Mediterranean botanic gardens contain hundreds of examples of monumental trees both native and exotic such as the specimens of *Taxus baccata* planted in 1720 and of *Quercus suber* dating from 1805 in the Giardino dei Semplice, Firenze, the Sweet Gum (*Liquidambar styraciflua*, a swamp cypress (*Taxodium distichum*) and *Pistacia atlantica* in the Orto Botanico, Bologna, the Cedar of Lebanon (*Cedrus libani*) planted in 1734 in the Jardin des Plantes, Paris by the botanist Bernard de Jussieu, *Celtis australis* in the Jardin Botanique, Montpellier, to name but a few. Publications documenting such trees have been prepared by some of the Gardens as in the case of the Jardí botànic, Valencia, Spain (Costa & Plumed 2016).

Fig. 1. Giardino botanico Hanbury, La Mortola, Italy.

Fig. 2. Jardin Exotique, Monaco.

Buildings and architecture

Many of the buildings in historic botanic gardens are of considerable architectural merit, such as:

- The emblematic Pabellón de Villanueva in the Real Jardín Botánico de Madrid, which was originally constructed in the 18th century as an ‘invernáculo’ or glasshouse to shelter tender plants in the winter (in effect an orangery) and also housing the cátedra (professorial chair) where Antonio José Cavanilles taught his classes. A second floor was built in in the 1930s which later housed the herbarium and then removed in 1981. Today it is an exhibition centre.
- The Orangerie La Gardette, Jardin des Plantes, Montpellier built by the celebrated architect Claude Mathieu de la Gardette in 1801–06 to replace and in effect complete an earlier hothouse in 1759 (Verdier 1997);
- The iconic building of the Orto Botanico di Pisa is the shell-covered façade of the Palazzo delle Conchiglie, the old Fonderia (Foundry), a laboratory for the preparation of medicaments derived from the medicinal plants grown in the Garden, set up at the end of the 16th century. Current plans are to restore the Fonderia, and house in it an exhibition on the history of the garden;
- The trio of neo-classical buildings dating from 1789 of the Orto Botanico di Palermo, Sicily, designed by the French architect Léon Dufourny – the Gymnasium, which originally housed the Schola Regia Botanices (school of botany), the Herbarium, the library and the director’s office, and the Calidarium and Tepidarium which grew plants from warm and temperate zones respectively (Raimondo & Mazzola 1992);

- Il Castello, Real Orto Botanico di Napoli built between the sixteenth and seventeenth centuries. It has been restored and now houses administrative offices and the museum of Palaeobotany and Ethnobotany.

Glasshouses and shade houses

Although not usually comparable with the great palaces of glass that are a common feature in more northern countries, a wide diversity of glasshouses and shade houses are to be found in Mediterranean botanic gardens, including some architecturally important examples. In fact, the origin of the glasshouse is to be found in the *orangeries*, *stanzoni degli agrumi, arancieri* and *limonaie* that were introduced in the 16th century to protect citrus trees from the winter cold. Some of these original structures may still be found and some have been restored and adapted for new uses, while others have fallen into disrepair or have been demolished.

Notable examples are the Estufa de Graells, Real Jardín Botánico, Madrid (1856), the Serra Carolina (1823, rebuilt 1857), Orto Botanico di Palermo, Les Grandes serres (1877–82), Jardin botanique de Lyon, France, the Serra Merola, Real Orto Botanico di Napoli (1809/1820), L'Umbracle [shade house] (1897–1900), Jardí botànic, Valencia (Fig. 3), the Serre Scopoliane, Orto Botanico di Pavia, Italy, and more recent examples such as the

Fig. 3. L'Umbracle, Jardí botànic, Valencia, Spain.

Invernadero de Bordeaux Bastide, France, the Nuova Serra Biosfera dell'orto Botanico di Padova, Italy. Although not in a botanic garden as such but in a public park, mention should be made of what Santiago Castroviejo Bolivar in the Real Jardín Botánico, Madrid, les serres, Jardin botanique hat is probably the largest shade house known, the Estufa fria, located in the Parque Eduardo VII, Lisbon, Portugal. It was originally a temporary shelter in an old basalt quarry for delicate plants that were to be introduced into municipal gardens but the project was put on hold and the plants started taking root. In 1933 the architect Raul Carapinha, designed the space as the Estufa fria, later complemented in 1975 with the addition of the Estufa Quente (Hot Greenhouse) and the Estufa Doce (Sweet Greenhouse).

Herbaria and Museums

Since the first recorded herbaria (*hortus siccus* as opposed to the *hortus vivus*, the botanic garden) were created in the 16th century, over 200 herbaria have been established in the Mediterranean region (Heywood 2003a), many of them in botanic gardens, with the bulk of herbaria and specimens (some c.34 million) found in only three countries, France, Italy and Spain. Although the Italian botanist Luca Ghini reputedly created the first herbarium in Pisa in 1544, an English merchant and botanist John Falconer (fl. 1547) who lived for some time in Italy and an apprentice surgeon Jean Girault in Lyon, France, each formed one in the same period of time as Ghini and it is likely that other botanists did so as well. Probably the key factor was the availability of paper as a mounting material for plants following the development of simpler and cheaper methods for the manufacture of continuous sheets of paper after the invention of printing in the in the mid-15th century: it has been suggested that the appearance of herbaria coincides with the technological improvements which allowed the manufacture paper at a low price (Saint-Lager 1886)[1]. The herbarium of Girault is dated 1558 in his own hand and is reportedly preserved in the Musém nationale d'histoire naturelle in Paris. The oldest known extant herbaria are those of Gherardo Cibo (alias Ulisse da Cingoli) (1512-1600) which he began in 1532 and is preserved in Rome in the Biblioteca Angelica and those of Ulisse Aldrovandi (1552–1605) conserved in the University of Bologna and Andrea Caesalpino (1525–1603) in the Museo Botanico dell'Università di Firenze (Moggi 1986).

It should be noted that an earlier use of the term herbarium referred to botanical treatises with engravings facing the text and many examples are conserved in Mediterranean botanic gardens along with other examples of botanical iconography (Montaccchini 1986), especially those concerning medicinal plants known as Herbals.

Although botanists from outside the region have played a major role in writing Floras of some Mediterranean countries and many of their important herbarium collections (incIuding types) of Mediterranean plant specimens are located in countries such as Switzerland (Geneva), Austria (Vienna), Czech Republic (Prague),Hungary (Budapest), Germany (Berlin), Sweden (Lund), the UK (Edinburgh, Kew, Natural History Museum) and even in

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[1] This extensive if somewhat wordy review of the origin of herbaria by St-Lager is an important source of information. See also Anon. Bull. Torrey Bot. Club, 12(12): 129-131 (Dec. 1885) for a brief English summary.

the United States (Heywood 2003), the herbaria of Mediterranean botanic gardens, notably those of Bologna, Firenze, Madrid, Montpellier, Paris and Palermo, contain substantial collections and type material of vital importance for Mediterranean plant taxonomy.

Botanical museums, on the other hand, are usually no longer held in great esteem, and many have suffered a lack of funding and a loss of confidence in the value of the collections (Clifford & al. 1990). Nonetheless, many botanic garden museums still contain many important collections of artefacts of both historical significance and importance for research in ethnobotany which is currently undergoing a marked revival of interest and development of techniques.

Much of the material in these museums is documentary or artistic rather than museological although with new sampling and analytical techniques biocultural collections can now be used more effectively as source material for research in various disciplines (Salick & al. 2014). However, with changing fashions, many important objects and even whole collections have been disposed of or destroyed and many of the collections are at risk as many of the artefacts are, incorrectly, no longer considered relevant. As regards displaying the materials, the emphasis today is on thematic exhibitions and on the use of interactive media, both indoors in exhibits and in the garden itself. Some new museums have been created, for example the ethnobotanical museum in Córdoba and the Pabellón del Bioma Boreal Europeo Carlos Linneo in the Jardín Botánico Atlántico, Gijon.

Plant introductions

For over 500 years Mediterranean botanic gardens played an important role in role as introduction centres for both ornamental and economically useful plants, although they were created too late to play a role in the initial post-1492 introductions from the Americas. As Raimondo & Garbari (1986) comment one can say that all the botanic gardens, whether university or not, both public and private, ancient foundations or newer creations, have contributed effectively to the introductions acclimation and spread of exotic medicinal, food, forestry and ornamental plants which in many cases have given a boost to the economy as well as having a significant impact on the landscape. An enormous diversity of species has been brought into cultivation and introduced into the economy outside the gardens. Because of the benign climate of the Mediterranean region, the introductions included many tropical and subtropical species. In particular, there were many introductions of *Citrus* species and cultivars to botanic gardens such as Palermo, Florence, La Mortola as well as in many villa and palace gardens. Although much of the emphasis in the past has been on the introduction of exotic species, there is now an increasing focus on the potential of the native flora as a source of new energy crops and ornamentals (Heywood 2003b).

The records of these gardens are an important but neglected archive of information about plant introductions and may be of relevance today to research into the adaptation of plants to climate change. Many gardens published catalogues of the plants they cultivated which are an invaluable source of data on the time and pattern of introductions as are the seed lists (*Indices Seminum*) (Heywood 1976) which many Mediterranean botanic gardens have published, often annually. Seed Lists not only catalogued the species for which seed was available but often contained valuable information about the Garden concerned and in some cases articles on taxonomy, cultivation requirements, floristics and other topic (Heywood 1964). Many new species have been described in Seed Lists and an online searchable ‘Guide to the plant species descriptions published in seed lists from Botanic Gardens for the period 1800 – 1900’ has been produced by Lut (2017). Seed Lists were published in limited editions and were often not kept so that their availability in botanic garden and other libraries is poor – in fact many of them were retained by the curatorial staff and never reached the library. Because of their historical importance efforts should be made by botanic gardens to seek out and collate any seed lists that can be traced.

Acclimatization (acclimation) and trial gardens

The introduction and successful cultivation of exotic species to botanic gardens was often a difficult process, especially in the case of tropical plants, because of their particular climatic requirements. To face this challenge, many acclimatization gardens which aimed at attempting to adapt the species to the local conditions were developed in the 17th and 18th centuries in the Mediterranean region, especially in France, Italy and Spain and were aimed largely at plants of agricultural or other economic importance. Some of these were within, or associated with, botanic gardens while others were private, in gardens belonging to the nobility. Such acclimatization gardens and acclimatization societies were quite common in some regions such as Tuscany in Italy (Moggi 2013). Many acclimatization gardens were established in Spain to cater for the plants brought from various parts of the then Spanish colonial territories. Examples are those that existed in Cartagena, Cordoba (although short-lived), Barcelona, Aranjuez, Madrid, Malaga, Burgos, Sevilla, Carmona, Cádiz, and La Orotava (Tenerife), Valencia (Puerto Sarmiento 2002). In France, acclimatization of plants was widely practised in Provence and various gardens for this purpose were established (Potron 1995) and the Jardin botanique de la villa Thuret, France has been engaged in the introduction and acclimation of plants for over 150 years (Ducatillion & Blanc-Chabaud 2010).

A number of trial gardens were established in the Mediterranean region, especially in France, Italy, Portugal and North Africa to assess and introduce plants of economic interest from mainly tropical countries. When linked to colonial development, they were termed Colonial Gardens as in the case of the Giardino Coloniale di Palermo and Jardim Colonial in Lisbon (now the Jardim Botânico Tropical). In North Africa, the 16 ha Jardin d’Essais Botaniques (JEB), Rabat (Morocco) which opened officially in 1928 was an experimental garden that undertook trials on fruit trees and ornamental species. The gardens were created between 1914 and 1919, under a joint initiative of the sultan Moulay Hafid and the French Protectorate and were designed by Jean-Claude Nicolas Forestier. They fell into disrepair and have recently been restored and with a broader remit, including the conservation of Moroccan endemic species. The Jardin d’Essais was classified a national heritage site in 1992 and in 2012, it was recognized by UNESCO as a World Heritage Site. In Egypt, the experimental garden of El Saff about 50 km south of Cairo was of major importance for plant introductions as were the experimental gardens of Zohriya (today the Zohira Trial Gardens) Gezireh west of Cairo, in which Delchevalerie in 1870 established the first station for acclimatization of plants.

Today as we are facing the impacts that global and in particular climate change is having on all aspects of our life, the need for research into plant acclimation and adaptation has a new resonance. This will be essential if we are to be able to develop and grow crops adapted to the new climatic regimes and thereby safeguard our food supply. Mediterranean botanic gardens have played an important role in the past in introducing and disseminating new agricultural and horticultural crops, trees and ornamental plants and are well placed to resume such vital work to meet today's challenges.

Art and sculpture

Mediterranean botanic gardens contain a great wealth of paintings and drawings, some of which are displayed although the majority are in kept in storage or in the archives. When they are used in exhibitions, they attract considerable public interest. Also, a great diversity of sculptures, many of them hidden in the undergrowth, is found in the Mediterranean's botanic gardens (Fig. 4). A number of tombs are found in the gardens, usually of the founder of the garden as in the case of the Orto Botanico Hanbury in Las Mortola where Sir Thomas Hanbury is buried.

Libraries – books, journals, archives

The libraries and archives of Mediterranean botanic gardens are a treasure house of material about the history of botany, plant exploration and introduction, economic botany and taxonomy, which is not only of regional but of global importance. The libraries and

Fig. 4. Example of sculptures found in the Mediterranean's botanic gardens.

archives of the early Italian *Orti botanici* such as Pisa, Padova, Firenze and Bologna contain materials are essential resources for understanding the early development of botany and botanic gardens. The Library of the Real Jardín Botánico, Madrid contains 32,000 books, 2,084 journals, 2,545 maps, 30,000 pamphlets and reprints. Its general Archive contains 4,865 historic documents from 1762 to 1900 and 169 boxes of contemporary documents. It includes 4000 drawings and engravings (Papiol 2005). In addition, the Archive contains documents and graphic material from important expeditions such as those of Loefling to South America, José Celestino Mutis to New Granada, Sessé & Mociño to Mexico and Central America, and Ruíz & Pavón to Peru.

A serious problem is that with the decline in the teaching of botany and the closure of botany departments or their merger with other departments, the libraries of university botanic gardens are being transferred to the universities' main library or even dispersed and then lose the necessary dedicated curatorial attention.

History and historical figures

Many celebrated botanists were directors or worked in Mediterranean botanic gardens, such as Antonio José Cavanilles, Augustin Pyramus de Candolle, Andrea Cesalpino, Mariano Lagasca, Luca Ghini, Michele Tenore, Pierre Magnol, Joseph Pitton de Tournefort, Antoine Laurent de Jussieu, Agostino Todaro, Filippo Parlatore, Pietro Andrea Mattioli, Pier Andrea Saccardo, Gustave Thuret to name just a few. One of the most celebrated was Luca Ghini who instituted the first botanic gardens in Pisa and Florence between 1543 and 1545 at the behest of Cosimo I de' Medici. He also created the plant press and one of the first herbaria and instituted the formal teaching of medicinal botany and laid the foundations for modern pharmacognosy.

Social impacts

The intangible heritage of the Mediterranean's botanic gardens is of enormous and incalculable social and cultural importance and influence. The relationship between the gardens and their patrons, students and the general public is an important dimension of their social impact. This interaction has changed over the centuries as the gardens themselves have occupied different roles. The impact on the life of the citizens of the towns and cities where they are located has been major factors in the evolution of their civic, social, economic and cultural development. Although many botanic gardens today tend to emphasise their role in the conservation of plant diversity, most visitors are motivated more by the aesthetic and recreational opportunities they afford. This is especially true of the large number of Mediterranean botanic gardens that are located in an urban setting. Public attitudes and expectations of the services that botanic gardens should offer, have changed and have in many cases affected policy. As Rakow & Lee (2015) note '… many are finding that the plants themselves are not enough to attract the size or diversity of audiences that they need to survive. More and more, gardens are embracing entertainment options to attract young professionals, families, and members of specific ethnic groups'. Although the general public visiting the botanic garden can appreciate the plants collections, the landscapes and vistas, the displays in the greenhouses and shade houses, and the statues, fountains and other features they are unaware of the riches to be found in the museums, libraries and archives as they are not normally accessible. Many botanic gardens put some of this material on display in occasional exhibitions and perhaps more effort should be invested in such events if they are to obtain public support for their work: one cannot expect such much-needed support if the rich heritage material is kept hidden. Regular open days and guided tours allowing the pubic to visit the herbaria, museums, libraries and the scientific, technical and conservation activities should be considered.

Two botanic gardens in the region have been recognized by UNESCO as World Heritage Sites – the Orto Botanico di Padova and the Jardin d'Essais, Rabat. It is perhaps surprising that so few have achieved such a status.

Safeguarding the heritage

The Mediterranean botanic garden estate is one of the most important in the world. It has seen the origin and development of the dominant western model of the botanic garden as we know it today and collectively the gardens contain an invaluable store of irreplaceable materials both in the living collections and their records, in their rich libraries and archives and in their herbaria and museums. Yet, much of the material is not fully documented, catalogued or recorded, and a considerable part of it is still poorly studied if at all.

As we have noted above, as a consequence of changes in the perception of the value of botany by university administrators and even by other biological scientists, and with falling numbers of students, departments of botany or plant biology are being closed or merged and university botanic gardens also face reduction in funding or even closure. As a result, some of the important collections in Mediterranean botanic garden are at risk of neglect or dispersal. The tragic destruction by fire of the Brazilian National Museum in Rio de Janeiro which housed one of the richest collections of natural history artefacts in the world, most of which were lost[2] should serve as a wake-up call to all natural history museums and botanic gardens to review the security of their collections in terms of fire and water damage risk, sprinklers, insurance (or as in the case of the Brazilian museum, lack insurance), documentation, duplicates, etc. As Zamudio & al. (2018) comment, 'Museum collections are timeless national treasures that represent our histories, cultures, and scientific achievements. Every institution and government should reflect and take heed at this sad moment. We must invest in and safeguard our museums and collections for the benefit of science and society worldwide'. Indeed, it would be tragic, if the public were to learn of the treasures that a botanic garden contained only after they had been lost by fire, flood, neglect or ignorance. The time for action to avoid such tragedies is now.

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[2] Fortunately not the herbarium which had been removed to a separate building.

Conclusions

This brief overview of the diversity of the living, preserved and artistic collections contained in the botanic gardens of the Mediterranean region has highlighted the major contribution that they have made to our understanding not only of the origin and development of botanical science and related disciplines such as herbal medicine, ethnobotany and ethnopharmacology, but of many of the crops we grow, the food we eat and the trees, shrubs and herbs that adorn our streets, parks and gardens. There are few areas of human life and wellbeing that have not been impacted by botanic gardens: from medicine and pharmacology to health and nutrition, from gardening and horticulture to exhibitions, recreation and enjoyment and social gatherings. Yet, the rich diversity of resources in the Mediterranean's botanic gardens is generally poorly known and little studied. Unless prompt action is taken, many of these unique resources risk falling into neglect, dispersal or even loss as is already happening in some gardens.

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Gianniantonio Domina

The floristic research in Italian archaeological sites*

Abstract

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Italy is one of the richest countries in historical and artistic heritage. The occurrence of vascular plants on monuments has always been analysed with some concern about conservation issues of the buildings. In order to present a framework of floristic research done in Italy within the archaeological areas and monumental sites in the country, the list of the basic references is presented. These 97 contributions are divided by publication date, area, and main historical period or civilization to which the complex refers. The most studied archaeological areas belong to the Roman civilization and occur in Latium and Sicily.

Key words: Vascular flora, Mediterranean area, management, artistic heritage.

Introduction

The Mediterranean Basin was the cradle of several civilizations that not only have profoundly changed the landscape but left numerous remains. Italy is one of the richest countries in historical and artistic heritage. The Central Institute for Catalogue and documentation of Italy (Istituto Centrale per il Catalogo e la Cocumentazione) lists 781 archaeological areas or parks and 622 main monumental complexes (http://www.catalogo. beniculturali.it); the number of individual monuments would exceed several thousand. Natural flora in monumental areas is seen with some concern because plants can damage monuments with their roots, can give the appearance of neglect, obstruct site access for visitors or conceal the monuments (Kanellou & al. 2017). In some case, trees or shrubs grown on ancient monuments have to be prudentially kept in the site as they provide stability to the structures and their removal could be dangerous. In the past (Romantic era) or in some peculiar situations (archaeological area of Angkor, in Cambodia, or Tikal, in Guatemala), they are considered to characterize the archaeological excavation, giving the visitor the idea that the site is still unexplored.

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The interest on the flora of archaeological sites in Italy dates back to the XVII Century. Panaroli (1643) reports 337 different plants (identified at species or genus level) growing on the Flavian Amphitheatre in Rome. The scope of floristic inventories can more focus on biological features of the plants growing into archaeological areas (e.g. Ceschini & al. 2006) or the list can be accompanied by the indication of their dangerousness for the monument with the indications for their management (Signorini 1995).

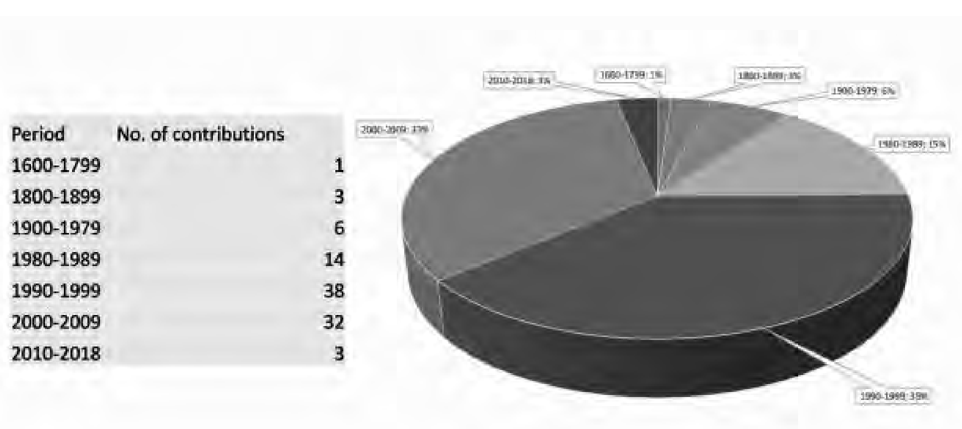
A first account of floristic references on archaeological areas is given in Caneva & Ceschin (2012). The aim of this paper is to present an updated framework of floristic research done in Italy within the archaeological areas and monumental sites in the country.

Material and Methods

The list of basic references concerning the flora (Higher plants, Bryophytes or Lichens) of archaeological sites located in Italy is presented as Electronic Supplementary File (ESF1). Each record includes authors, title, publication date, geographic area with geographical coordinates, main historical period or civilization to which the complex refers, the nature of the contribution (abstract, article, a chapter of Book or an entire book) and its editorial collocation (national or international). Thesis, doctoral thesis and unpublished research have been excluded. The main historical periods or civilizations considered are Greek (from 800 BC to 296 BC), Etruscan (from 800 BC to 396 BC), Punic (from 800 BC to 238 BC), Roman (from 753 BC to 476 AC), Medieval (from 476 to 1350), Renaissance (from 1351 to 1600), and Modern (from 1600 to today). Basic analysis is presented in figures 1-3.

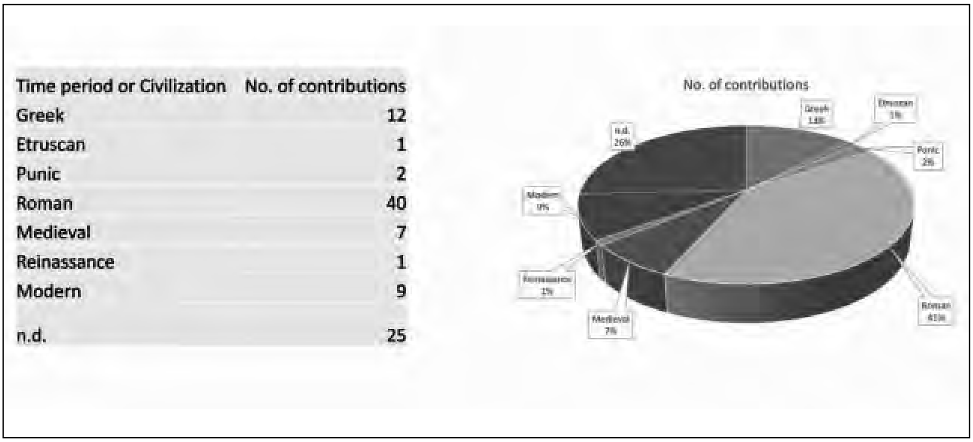
Results

Overall 97 references have been collected: 13 conference abstracts, 73 full articles, 10 book chapters and 1 complete book. The period in which the largest number of contribu-



Period	No. of contributions
1600-1799	1
1800-1899	3
1900-1979	6
1980-1989	14
1990-1999	38
2000-2009	32
2010-2018	3

Fig. 1. Chronological distribution of the considered publications.

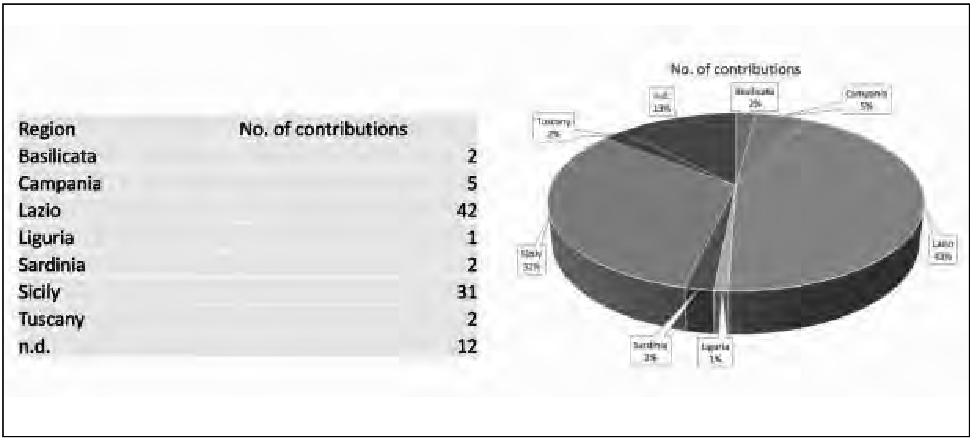


Time period or Civilization	No. of contributions
Greek	12
Etruscan	1
Punic	2
Roman	40
Medieval	7
Reinassance	1
Modern	9
n.d.	25

Fig. 2. The main historical periods or civilizations considered.

tions (38) was published was between 1990 and 1999. In the following decade (2000-2010) there was a slight decrease (32 contributions). In the last eight years (2011-2018) only 3 articles have been published. This is probably due to the limited interest by high ranked scientific journals in floristic research. Similar considerations can be deduced from the low number of contributions (only 21) published in international journals or international conference proceedings.

The most investigated regions are Lazio, with 42 contributions and Sicily with 31. However, in Sicily the studied sites are widespread in the region; in Latium the large part of contributions is focused on the area of Rome. Campania, Tuscany, Sardinia, Basilicata and Liguria have between one to five contributions. The resting 13 regions completely lack this kind of studies (Fig. 4).



Region	No. of contributions
Basilicata	2
Campania	5
Lazio	42
Liguria	1
Sardinia	2
Sicily	31
Tuscany	2
n.d.	12

Fig. 3. Geographical distribution of the considered publications.

Fig. 4. Map of the studied sites, in grey are marked the Italian administrative regions lacking of studies.

The most studied archaeological areas or single monuments belong to the Roman civilization. Even if, in many cases, it is not easy to attribute a monument to a precise historical epoch because different buildings, over time, have been re-adapted and used by the civilizations that have succeeded each other. A significant example is the castle of Milazzo in Sicily. It stands on a hill that, since 4000 AC, saw the flowering of different civilizations. The castle was built in 829 by the Arabs and was modified by the Swabians, the Angevins, the Aragonese, the Spanish, the Austrians, the British, the Bourbons, everyone has built or modified parts of the building that, over time, was used as noble residence, fortress or prison (Micale 1982). Hence the difficulty of considering the monumental complex belonging to one of the different civilizations that have followed.

With the exception of the single Flavian Amphitheatre in Rome (the Colosseum), which has become a case study with 8 published contributions from the XVII Century to nowadays, there are no studies published on most of the sites and monuments in Italy.

The floristic lists of species found in archaeological sites indicate that these florulas are subsets of the floras growing in the surroundings. There are few but interesting cases of species that spread from historical human settlements. *Poterium spinosum* L. (*Rosaceae*) occurs in Eastern and Central Mediterranean (Kurtto 2009). This species is widespread and abundant in East Mediterranean and occurs only near historical Greek settlements in Peninsular Italy, Sardinia, Sicily and Tunisia (Caruso 2013). This distribution and the traditional use as a medicinal plant (Bachrach 2007) would justify a deliberate spread of this plant that then naturalized in the areas close to human settlements. From the biological point of view, the florulas of archaeological areas are influenced by environmental factors and land use. The climate affects the archaeological areas in the same way as the surroundings, but the microclimate due to the buildings and the maintenance of the site can lead to variations on the biological spectrum. For example, by comparing the biological spectrum presented for the area of Neapolis in SE Sicily by Corbetta & al. (2002) with that of the whole Sicilian flora (Raimondo & Spadaro 2011) there is a higher percentage of therophytes than other forms. This can be explained with the periodical mowing in this area that favours the spread of plants typical of arid grasslands and of weeds of crops.

Discussion and conclusions

Knowledge and management of the flora on cultural heritage is a phenomenon affecting the entire globe. Botanical studies on archaeological areas should be not only limited to the protection of monuments but have to give the guidelines for the introduction of new plant elements to support the current fruition of the areas compatible with the original landscape (Caneva 1999). The study of flora occurring in the archaeological area and in its surroundings allow to select which species can be maintained or planted without excessive management costs.

This review can be a stimulus for scholars and managers in order to undertake targeted campaigns of prospecting of the biological component occurring in these areas and of deepening knowledge on its management in order to preserve this historical and artistic heritage. Researchers should send the results of their research to international journals with a large pool of readers. From what has been stated above it is evident that the botanical prospecting in archaeological areas is still very limited, lacking entirely in several regions. On the contrary, the botanical researches in archaeological sites including the analyses of pollen, palynomorphs, seeds/fruits, wood, charcoals and other plant remains may be used to deepen the history of past vegetation, land cover, land-uses; indeed, archaeobotany is a still growing field of research. As reported by Mariotti Lippi & al. (2018) all the Italian regions have recent studies in archaeobotany. Each year about 45 articles have been published on this field and their number has constantly grown from in the last decades.

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P. L. Nimis, S. Martellos & E. Pittao

Ecology and functional traits of lichens in the archaeological areas of Latium

Nimis, P. L., Martellos, S. & Pittao, E.: Ecology and functional traits of lichens in the archaeological areas of Latium. — Bocc. 28: 181. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: ITALIC, morpho-biological traits, management.

A matrix of the 263 species of saxicolous lichens known to occur in the archaeological areas of Latium and ecological data plus morpho-biological traits, retrieved from ITALIC (the Information System of Italian Lichens), was submitted to multivariate analysis (classification and ordination). The species are ordered along a complex gradient whose main drivers are increasing aridity (paralleled by increasing light intensity) and pH of the substrates. The occurrence of endolithic lichens (mainly on limestone) and of sorediate lichens (mainly in shaded and/or eutrophicated situations) requires special attention whenever their removal is attempted. The use of biocides in the presence of endolithic lichens may cause irreversible damage to the rock surfaces, while mechanical removal of sorediate lichens may increase their further spreading. Heat shock treatments may prove to be the most effective and less harmful strategy for the removal of lichens from monuments, but their growth rates should be always taken into consideration when attempting such measures, which often prove to be ineffective within short time-spans. However, the high lichen diversity of archaeological areas, mainly due to the presence of widely different allochtonous substrata, should be considered as a value in itself. Removal of the lichens should be attempted only when strictly necessary, and their diversity should be highlighted as an added value to the cultural interest of archaeological sites.

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Maria Letizia Gargano

Fungi in archaeological areas*

Abstract

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This review include the data concerning the presence of representations of fungi since prehistoric times. Particular attention is paid to their use in magical rituals, in nutrition and as a remedy for certain diseases. The work also examines some examples of megaliths whose shape recalls that of a mushroom, and the role of mushrooms in anthracological studies. Finally, data on the presence of mushrooms, some of them rare, of reforested areas and residual dune systems within the Archaeological Park of Selinunte are reported.

Key words: archaeology, anthracology, human diet, Selinunte, Sicily.

Introduction

Since prehistoric times, man has always been attracted to fungi (Karg & al. 2012), which he considered both magic elements of nature (Akers & al. 2011), a source of food (Cheung 2008) and, a remedy for various diseases (Wilford 1998).

Fungi has been also involved in ancient religious beliefs, sickness and health, religion and war. The Roman emperor Claudius was murdered, by his wife Agrippina, by poisonous mushrooms of the genus *Amanita* Pers. The fungi were also considered by some cultures as the rottenness of life while for others they were a delicious food (Bertelsen 2013). The ancient Egyptians as plants of immortality considered mushrooms, "a gift from the God Osiris" (Abdel-Azeem & al. 2016).

Many populations used mushrooms in rituals since they believed in their properties able to produce super human strength and to mitigate human fatigue (Geng & al. 2017) while Chinese culture has treasured mushrooms as a health food, an "elixir of life" (Valverde & al. 2015).

Even in the case of mushrooms, archaeological sites are an important reservoir of information (Santiago & al. 2016).

In this review paper is reported a summary of the information on the use of fungi in prehistory, anthracological research and, in ancient human diet. The presence of some interesting fungal cenosis in archaeological areas of Sicily (southern Italy) is also highlighted.

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Prehistoric use of mushrooms

Approximately 9000 years BC, the Saharan aboriginal tribes of North Africa used muhsrooms (possibly *Psilocybe mairei* Singer) in magic rituals (Samorini 1992). This is testified in stone paintings by mushroom head' depiction created by Sandawe indigenous ethnic group of Tanzania and the rock art of Bradshaw in Western Australia (Pettigrew 2011).

In northeastern Siberia, Dikov (1971) discovered fungoid petroglyphs referred to the hallucinogic *Amanita muscaria* (L.) Lam. on rocks in the Pegtymel River region.

The Spanish mural in the municipality of Villar del Humo (Spain) depict a mushroom with pileus and stipe very similar to those of *P. hispanica* Guzmán (Guzmán 2012).

The ancient Greek drink "Kykeon", usually refers to a psychoactive compounded brew, also containing *Psilocybe* species, used at the climax of the Eleusinian Mysteries to break a sacred fast (Naples 2013). In the town of Eleusis (West Attica, Greece) there is a stele on which Persephone appears to be passing to Demeter an hallucinogenic mushroom (Wasson & al. 1978).

The native American cultures (Olmec, Zapotec, Maya and, Aztec) had symbols, statues and paintings which indicate that they consumed "teonanácatl" (*P. mexicana* R. Heim), especially during religious rituals, as a way to communicate with deities (Carod-Artal 2015). Also the tribes of Nahua, Mazatec, Mixtec were involved in mushroom use for similar reasons (Camporesi 1998).

Mushroom megaliths

Megalithic natural rock formations with the shape of mushrooms can be observed in the former regions of Macedonia, Anatolia and, Thrace. In some cases, these structures have been modified by human intervention to increase their fungal likeness (Spasova 2015). Mushrooms rock formation are also reported from Cappadocia (Turkey) (Sarikaya & al. 2015). The "stem" is constructed by limestone and volcanic ash, while the cap is of lahar or ignimbrite. The rocks are usually ornamented with carvings, paintings and, folkloric motifs which indicate the psychoactive activity of mushrooms (Guzmán 2008).

In the archaeological site of Aryannoor (Kerala, India), the megalithic monuments known as kuda-kallu resemble mushrooms or have a parasol-shape (Samorini 1995). In modern times, these forms were taken up by the German architect Jürgen Mayer, who designed the Metropol Parasol in Seville (Spain).

Fungi in anthracological research

The remains of wood charcoals from archaeological excavations and natural deposits are very useful tools for anthracological studies in several regions (Ludemann & Nelle 2015). The fungal hyphae can be preserved within the wood charcoal after the burning process (Schweingruber 1982).

A huge number of fungi, mainly belonging to the class *Basidiomycetes*, are responsible for wood degradation (Stamets 2005). The *Basidiomycetes*, some *Ascomycetes* and Imperfect fungi, can attack both Angiosperms and Gymnosperms, and can even decompose the heartwood of living conifers (Moskal-del Hoyo 2010). Brown-rot, white-rot, and soft-rot fungi are responsible of wood decay and cause different types of morphological changes in branches (Xu & Goodell 2001), logs and, stumps (Karadelev & al. 2017a, 2017b; Venturella 2017).

The analysis of the type of decay of wood is generally possible on the basis of morphological parameters but some difficulties may occur in the case of mixed decayed patterns. This is primarily due to the interactions that occur, especially in the case of *Basidiomycetes*, between the different fungal species that colonize the wood (Boddy 2000).

A wide diversity of soil bacterial, archaeal and, fungal communities were isolated from archaeological layers in Monte Iato settlement in Sicily (Siles & al. 2018).

Fungi in ancient human diet

Dried mushrooms formed part of the human diet of archaeological populations (O'Regan & al. 2016) while Hamilton & al. (2009) reported a rare example of mushrooms-based diet in pigs during the Neolithic.

The use of mushrooms by Greek, Egyptian, Roman, Chinese, and, Mexican civilizations in diets and health has been documented throughout human history (Gargano & al. 2017). Egyptian pharaohs considered mushrooms to be food reserved only for royalty; common people were not allowed to touch them (Abdel-Azeem & al. 2016). There is clear evidence that mushrooms were used as food by hunter-gatherers in the Palaeolithic. Micro remains recognized as bolete mushrooms (*Boletus* sp. pl.) were found in a human dental calculus in the El Mirón cave in Spain (Power & al. 2015).

The well- preserved Iceman Ötzi or Similaun Mummy from the Chalcolithic Europe (3500 - 1700 BC) carried, among the numerous items of his equipment, a "Black Matter" prepared from *Fomes fomentarius* (L.) Fr. and two objects on the leather thongs as fragments of *Fomitopsis betulina* (Bull.) B.K. Cui, M.L. Han & Y.C. Dai (Peintner & al. 1998). Ötzi certainly benefited from the antibacterial, anti-parasitic, antiviral, anti-inflammatory, anticancer, neuroprotective, and immunomodulating properties of *F. betulina* (Pleszczyńska & al. 2017). In particular, Ötzi used the medicinal mushrooms against whipworm (*Trichuris trichiura* L., 1771) infections and to purge his bowels (Dickson & al. 2000). The use of *F. betulina* as a laxative by prehistoric peoples living in Northern Europe is also reported by Wilford (1998).

Fungi in the Archaeological Park of Selinunte

The Archaelogical Park of Selinunte (S.-W. Sicily) is included in the SIC (Sites of Community Interest) named "Dunal system Capo Granitola, Porto Palo e Foce del Belice" (code ITA010011) (La Rosa & al. 2007). The area is characterized by a dunal system, wetlands, reforestations with *Pinus halepensis* Mill. and *Eucalyptus camaldulensis* Dehnh, evergreen sclerophyllous vegetation with a prevalence of *Pistacia lentiscus* L. and maquis dominated by *Anagyris foetida* L. with scattered woods of *Quercus calliprinos* Webb.

In the conifers wood there is a prevalence of very common mycorrhizal species such as *Amanita ovoidea* (Bull.) Link, *Neoboletus erythropus* (Pers.) C. Hahn, *Suillellus queletii* (Schulzer) Vizzini, Simonini & Gelardi, *Suillus granulatus* (L.) Roussel and, *S. collinitus* (Fr.) Kuntze, saprotrophs [*Agaricus silvicolae-similis* Bohus & Locsmándi, *A. xanthodermus* var. *xanthodermus* Genev., *Clitopaxillus alexandri* (Gillet) G. Moreno, Vizzini, Consiglio & P. Alvarado, *Gymnopus dryophilus* (Bull.) Murrill], and parasitic [*Chroogomphus rutilus* (Schaeff.) O. K. Mill.].

The reafforestation of *E. camaldulensis* wood hosts a very interesting and infrequent species, *Lyophyllum buxeum* (Maire) Singer, which is located near the coast on sandy substrates.

As far as mycorrhizal species are concerned, as already noted by Venturella & Gargano (2008), the ecological characteristics of the Mediterranean area prevent eucalyptus plants from maintaining the same number of mycorrhizal species as those found in the coastal areas of Australia.

In the sandy coastal areas, where the Mediterranean scrub vegetation is present with a prevalence of *P. lentiscus*, we can observe *Battarrea phalloides* (Dicks.) Pers., a species typical of dry, sandy localities, sunny edges, and in clearings of different types of decidous, mixed, and coniferous woodlands (Lantieri & al. 2009) which is included in Armenia, Austria, Czech Republic, France, Germany, Hungary, FYR Macedonia, Poland, Serbia, Spain, and, UK Red Lists.

The presence of *B. phalloides* along the sandy coasts of southern Sicily confirms the mycological affinities between these areas and similar environments of the coasts of North Africa and Tunisia in particular (Ouali & al. 2018).

A few number of basidiomata of *Xerula mediterranea* (Pacioni & Lalli) Quadr. & Lunghini were collected in the rear dunes characterized by vegetation belonging to *Crucianelletalia maritimae* Sissing 1974.

Discussion and Conclusions

In conclusion, it can be said that mushrooms accompany man in his evolution. They contribute at various levels to the historical reconstruction of events that occurred in archaeological sites. Their presence on various substrates confirms the high diversity of these organisms, which represent the largest group present in nature after insects.

In the case of the Archaeological Park of Selinunte, since the mushrooms are mainly located near the residual dune systems, it is necessary to strengthen the actions of protection and conservation of these habitats in order to preserve their integrity and trying to put a stop to the progressive anthropization and erosion. The actions to be taken for the protection of the wooded areas inside the archaeological sites are also necessary because, although they are mainly represented by exotic species, they host a rich contingent of fungal species, some of which are infrequent.

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Plant morphology: outdated or advanced discipline in modern plant sciences?*

Abstract

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In the last decades, with the increase of molecular studies, the study of plant forms has gone through a steady decline in interest, and researches on this topic are often neglected and underestimated. Notwithstanding, comparative morphology as integrative discipline still assumes a pivotal role in modern sciences, remaining fundamentally relevant to nearly all fields of plant biology, such as systematics, evolutionary biology, ecology, physiology, genetics, molecular biology, not to mention also agriculture, bioengineering, and forensic botany. Contrary to common belief, plant morphology is not a conservative finished science, but, like other sciences, it is open to constant innovations involving both concepts and methods. This contribution aims to promote a reflective discourse on the role of plant morphology in modern sciences and provides some examples of significant supports from plant morphology to different botanical issues.

Key words: Systematics, plant micromorphology, seed coat sculpturing, leaf anatomy, ecomorphology, climate adaptation.

Introduction

Despite the increasing societal awareness and sensitivity about the knowledge of biological diversity and ecosystem functioning as pivotal matters for nature conservation on which human health and well-being fundamentally depend, studies in morphology-based classical taxonomy have increasingly become marginalized and considered less significant than other scientific methods in plant biology. This has led to a progressive decline in attention both at research institutions and funding allocation, and nowadays most scientists and academic students think of plant morphology as just a classical and largely outdated field of research.

Plant morphology is a biological discipline that aims at understanding the biology of plant organisms on the basis of their structural appearance, so it essentially consists in the scientific investigation on the plant forms and/or structures.

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As a discipline, plant morphology can be intended in either a narrow or a broad sense. In narrow sense, plant morphology is the science of external forms and their relationships expressed at the whole plant down to the organ level of organization. In broad sense, plant morphology includes forms and structures at each level of organization, that is whole plant, organs, tissues, cells, cell organelles, etc.; in this respect plant morphology also involves micromorphology, anatomy and cell ultrastructure (Sattler 1978; Sattler & Rutishauser 1997).

Traditionally, the study of plant morphology takes its origin in the history of botany. From early times, great importance was made in the geometrical appearance of plant organs and consequently many taxonomic groups (especially genera and species) were named accordingly to their morphological characters. Similarly, also several plant families have had their taxonomic name based on characteristics of the shape of flowers or other morphological features (Betz 2006; Cervantes & de Diego 2010). Since the introduction of the term intended as a scientific discipline by Goethe (1790), modern plant morphology has resulted from an eventful history (Kaplan 2001; Claβen-Bockhoff 2001).

Contrary to a widespread misconception of being conceived as the science of static forms, plant morphology has showed an intrinsic dynamic essence. Firstly, it deals with the topological and sequential changes of plant forms and structures throughout the time, during ontogeny and phylogeny. In addition, it has dynamically changed over time and improved its theoretical and analytical approaches embracing new technologies and tools, without neglecting traditional methods (Sattler 1990; Liem 1991; Ledford 2018).

Progresses in plant morphology have influenced research in various disciplines of plant biology which fundamentally use or imply morphological concepts, such as systematics, evolutionary biology, ecology, physiology, genetics, molecular biology. Even in the current times of genomics (plus many other "omics" topics) and functional ecology, when trait-based approaches are essential for studying and understanding plant functions and species relationships, it is clear that plant morphology, used as comparative and integrative approach, still assumes a pivotal role, remaining fundamentally relevant to nearly all fields of plant science (Sattler & Rutishauser 1997; Kaplan 2001; Scotland & al. 2003; Pochynok 2012; Schönenberger & von Balthazar 2012; Schönenberger & al. 2016; Bucksch & al. 2017).

Lots of studies have demonstrated how vegetative and reproductive characters, and their anatomical and/or micro-morphological structures, can be informative for phylogenetic studies and helpful to solve systematic problems at various levels. Most phenotypic traits show adaptive variation and different range of plasticity which have proved to be of great ecological and physiological significance and useful, for instance, in reconstructing plant adaptation to past climatic conditions or establishing defence mechanisms and structural changes in response to stress, climate changes and plant invasions, which all are basic information for nature conservation. Meanwhile, understanding patterns and origins of such morphological modifications and how plant traits connect to gene activity across species is crucial to address main evo-devo questions. Not to mention the basic role of plant morphology in other applied sciences, such as agriculture, bioengineering, and forensic botany.

Notwithstanding, plant morphology and the strictly related descriptive taxonomy are often considered a lower form of science, not fashionable and very far from the biggest challenges facing humanity. If not associated to molecular and phylogenetic data, they are in general underappreciated in many highly visible journals and inadequacy of research funding in these field is disproportionate relative to other disciplines in biology (Pyšek & al. 2013; Tahseen 2014; Coleman 2015), even though it seems that in the last decade taxonomic publications increased faster than those from other biological fields and reached high citation performances (Steiner & al. 2015).

This contribution intends to promote a reflective discourse aiming to change the current scientific culture towards a better acknowledgment and academic evaluation of research in plant morphology as the backbone of many other fields of plant biology and applied biosciences. Examples of fundamental interrelations between plant morphology and other biological disciplines are provided.

Material and Methods

Macromorphology

Studies on gross morphology were performed on both living wild plants collected from many localities of the Mediterranean area (exsiccates are preserved in CAT) and cultivated plants (10 to 30 individuals per species). Qualitative and quantitative morphological features were examined and recorded under a Zeiss Stemi SV11 Apo stereomicroscope at 6–66× magnification, on fresh samples when possible. Morphological comparison was also based on herbarium collections from various botanical museums and literature data. Both vegetative and reproductive characters were chosen according to their diagnostic value for discriminating among the investigated taxa and populations.

Micromorphology

Micromorphology was studied under a Zeiss EVO LS10 scanning electron microscope (SEM Zeiss, Oberkochen, Germany) using mature dehydrated samples set onto aluminium stubs with double adhesive tape and coated with gold prior to observation. Scanning electron micrographs were performed at an accelerating voltage of 10 kV and 18-1000× magnifications, depending on samples size. Terminology used for leaf surface and seed-coat sculpturing was based on Wilkinson (1979) and Barthlott (1981, 1984).

Leaf anatomy

Leaf blades of maximum size in their optimal vegetative development were used for the anatomical study. Cross sections 25 μm thick were made using a Leica CM 1900® cryostat (Leica, Wetzlar, Germany) at a temperature of -20 °C, then stained with 1% w/v aqueous Safranin. Vascular patterns were emphasized through leaf clarification based on the Fuchs' method (Fuchs 1963) modified by avoiding leaf tissue maceration in dried oven at 60◦C. Semipermanent slides were mounted with glycerol/water 1:1 and sealed with transparent nail polish. Photographs were taken under Zeiss Axioskope 2 light microscope equipped with digital camera.

Statistical analyses

Micro-morphological and anatomical characters were measured from five to ten different samples for each investigated species/population. Measurements were done using the Zeiss AxioVision Rel. 4.8.2 image analysis software.

Statistical analyses were computed on both quantitative and qualitative morpho-anatomical parameters and performed using XLSTAT 2018.1.1 software (Addinsoft) on Microsoft Excel platform. Simple descriptive statistics of the intra- and inter-phenetic diversity (mean, standard deviation, range, median, and so on) were calculated from the data. The statistical effect of climate conditions on leaf traits among different populations was estimated by simple and multiple linear regression models. Mean annual precipitation (MAP) and mean annual temperature (MAT), from each population site, were used as the explanatory variables. De Martonne Aridity index (expressed by the formula AI_{DM}= MAP/MAT + 10) was also calculated and tested as potential predictor for climate influence on leaf structure. Multivariate analyses were performed in order to assess the similarity or dissimilarity among populations and the degree of separation of different groups. A step-wise discriminant factorial analysis (DFA) was employed on measured data (using the method of inclusion and removal at each step) The determination of the most discriminating variables was carried out by means of Fisher's coefficient at the significant threshold value of 0.05. The posterior probability of classification of each sample (cross validation) and the Wilks' lambda value of each variable were also calculated. Principal coordinates analysis (PCoA) was carried out on general dissimilarity matrix from 23 qualitative morphological characters.

Results

Descriptive morphology and taxonomic issues

The comparative study of plant structures, at both macro- and micromorphological level, has always been the backbone of plant Systematics. There exist lots of review summarising the main role of structural aspects in systematic botany at different taxonomic levels, where the comparative morphology appear to be still necessary and helpful, and reliable determination keys based on morphological characters continue to be a major information source for species identification and distinction (e.g. Greuter 1973; Ronse & al. 2010; Endress 2011; Kendorff & al. 2015; Mannino & al. 2015; Nardi 2015; Brullo & Erben 2016; Iamonico 2016; Brullo & al. 2018; Colasante 2018). It may help in areas and at levels of the tree of life where molecular studies are difficult for some reason.

This is the case of wide complicated genera, such as the genus *Allium* whose systematic arrangement in subgenera and sections is largely based on specific combination of discriminant morphological features (Fritsch 2001; Khassanov & al. 2011; Govaerts & al. 2018; Brullo & al. 2019), which was in many cases confirmed by molecular approaches (Friesen & al. 2006; Nguien & al. 2008; Hirschegger & al. 2010; Li & al. 2010). The role of comparative morphology in *Allium* taxonomy was also essential to clarify the systematic positions and relationships within several species' complexes, many of which have proven to include cryptic species. This is, for example, the case with the *Allium cupanii* Raf. group where a distinctive combination of morphological diagnostic features, i.e. fibrous and more or less markedly reticulate outer bulb tunics, basally adherent or detached, filiform leaves, with cylindrical to semicylindrical outline, subglabrous to densely hairy leaf indumentum, persistent spathe, with 1 or 2 valves basally connate, partially sheathing the flower pedicels, few-flowered inflorescence, usually fastigiate and unilateral, arranged in

2 or 4 bostryces when the spathe is 1-valved or 2-valved respectively, perigon cylindrical to urceolate, white-pinkish to pink-purplish, simple stamen filaments included into the perigon, ovary with well-developed nectariferous pores, covered by a membranous plica, and capsule included into the perigon, suggested a more appropriate inclusion of this group in the autonomous sect. *Cupanioscordum* Chesm., also confirmed by molecular investigations; the intrinsic variability in these morphological traits allows to identify five distinct series and many new species whose populations were all formerly identified sub *A. cupanii* (bulb coats basally attached) or sub *A. hirtovaginatum* Kunth (bulb coats basally detached) (Brullo & al. 1995; Brullo & al. 2015; Salmeri & al. 2015). Another investigated critical group in the genus *Allium* was the *Allium paniculatum* L. complex. Based on literature and many herbarium collections, *A. paniculatum* was frequently conceived as having an extremely wide geographic distribution (from West to East Europe, North Africa and Asia), both in synanthropic and wild habitats, and a large morphological variability. Detailed surveys on herbarium collections, including the type specimen of the species, and on living plants from lots of different territories of the Euro-Mediterranean and Irano-Turanian regions, actually revealed that many different taxa of *A.* sect. *Codonoprasum* Rchb., all characterized by big size, diffuse and densely flowered umbrella, very long spathe valves, long pedicels, and cylindrical-campanulate perigon, have been wrongly attributed to *A. paniculatum*, thus affecting records on the geographic distribution and morphological characterization of this species. Thus, while the true *A. paniculatum* resulted to be native and circumscribed to the far eastern European territories (Ukraine and Russia), many other allied but distinct taxa (previously treated as *A. paniculatum*) have been described and well discriminated on the basis of the combination of a few relevant morphological traits (Brullo & al. 2001; Brullo & al. 2008; Salmeri & al. 2015).

Then again, comparative morphological analyses concerning vegetative and reproductive structures, such as bulbs, leaves, inflorescence and seed, were crucial to assess the current systematics of the complex genus *Scilla* L. *sensu lato*, leading to its splitting in different closely related, but taxonomically well-differentiated natural genera within the *Hyacinthaceae* family, largely confirmed by molecular data (Speta 1998; Pfosser & Speta 1999, 2004). Most of these features are easily detectable also in the field and have proven very useful in discriminating among the Italian squills (Fig. 1), for which identification keys to the existing genera and species were also implemented (Brullo & al. 2007).

Other useful examples come from leaf morphology and anatomy, which provided relevant elements for characterizing and discriminating species of the genus *Dittrichia* Greuter. This genus is represented by five distinct taxa, all distributed in the Mediterranean area, from West (*D. viscosa*, *D. revoluta*, *D. maritima*) to East (*D. orientalis*), and partly extended into the Irano-Turanian region (*D. graveolens*). Despite a certain intraspecific variability (Brullo & al. 2004), clear and stable interspecific differences were found in the leaves (but not only), regarding their shape and size, types of margin, apex, venation, and hairs, plus some anatomical aspects of palisade and spongy tissues, which can be considered valuable characters supporting the distinction at specific level (Fig. 2).

Insights from comparative micromorphology

Plant micromorphology is the study of finer details of external features, based on micro-level analyses of leaves, pollens, seeds, petals and other plant organs. The diversity of plant

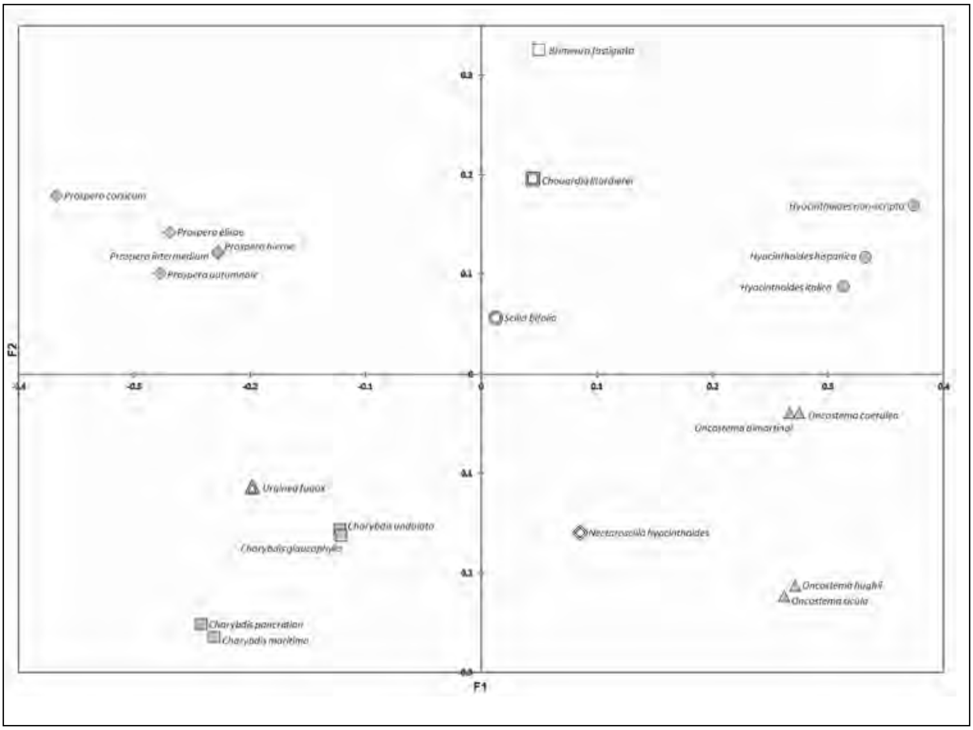

Fig. 1. Scatter plots resulting from principal coordinates analysis (PCoA) on *Scilla* s.l. species based on a data matrix of 23 morphological data.

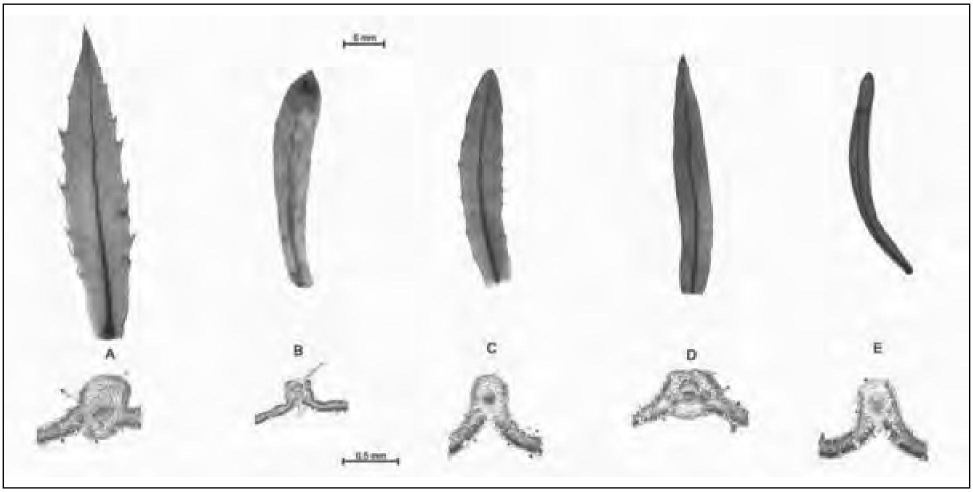

Fig. 2. Morpho-anatomical leaf variation in *Dittrichia* species: **a**, *D. viscosa*; **b**, *D. graveolens*; c, *D. maritima*; **d**, *D. orientalis*; **e**, *D. revoluta*.

surface structures arises from the variability of cell shape and size, and stratified microstructures of the cell surfaces, such as cuticle layers, epicuticular wax crystals, cuticular folds, hairs and glands. Almost unlimited different combinations of these cellular sculptures generate the high structural and functional diversity which characterizes land plants' surfaces (Barthlott & al. 2017).

The surface of plants is the critical interface for the interaction with the environment and fulfils many different functions (mechanical protection, attachment and particle adhesion, water loss reduction, light reflection, temperature control, air retention, wettability) related to ecological adaptation and/or reproductive strategies (Barthlott 1981, 1984; Bargel & al. 2004; Koch & Barthlott 2006). Furthermore, with exception of fossil pollens and spores, cuticles represent the most widespread unaltered fossil plant remains and are known from the Devonian to the recent times (Taylor & al. 1989). Thus, comparative studies of micromorphological features can provide significant insights into physiological properties and ecological responses of plants to environmental constraints and aid in systematic and evolutionary questions in extant and fossil plants, as highlighted by a vast existing literature (e.g. Stace 1965;, Jones 1986; Kessler & al. 2007; Ickert-Bond & Rydin 2010; Albert & Sharma 2013; Anil Kumar & Murugan 2015; Arabi & al. 2017; Ickert-Bond & al. 2018;, Sur & al. 2018; Scoppola & Magrini 2019).

Examples of micromorphological surveys include comparative analyses of seed coat sculpturing. The seed coat is the direct interface between embryo and external environment, acting as main modulator in the plant life cycle with key functions of regulation and protection. The taxonomic value of the macro-and micro-morphological characters of seeds and outer coats has been clearly demonstrated, being very conservative and stable features. In the genus *Brassica* L. sect. *Brassica*, with 20 taxa ten of which strictly endemic to Sicily, seed morphology and seed coat patterns provided useful information for discriminating among close taxa, especially those at subspecific level. Eighteen exomorphic parameters, including shape, size, color, surface texture, from 50 seeds for each accession (see Salmeri & al. 2011) were investigated. SEM analysis was carried out on 5-10 seeds from each sample, considering the arrangement and shape of epidermal cells, the architecture of anticlinal and periclinal cell walls (primary sculptures), their fine cuticular ornamentations (secondary sculptures).

Seed coat sculptures at low magnification (20×) showed a reticulate pattern, but higher magnifications (200-600×) revealed more complex networks, identifiable in 4 basic subtypes, i.e. simple reticulate, micro-reticulate, reticulate-foveate, reticulate-rugose, on account of their finer structuring. Significant differences were found in the overall cell shape (± polygonal or irregular) and the size, height and alignment of the meshes, which may be lax to compact, sharply angled to smooth, regular or irregular. Great variation among different taxa and populations was also observed in the anticlinal and periclinal cell walls and cell lumen, which can be straight to ± undulate, depressed, concave, flat or convex, smooth to ± markedly wrinkled, foveolate and / or papillose. Clear differences and very characteristic architectures were highlighted in most of the investigated species (Salmeri & al. 2011), with very close taxa such as the *B. villosa* and *B. rupestris* complexes (Fig. 3) characterized by well-defined sets of microsculptures valuable as discriminant features at specific and subspecific levels. In addition, seed coat microsculpturing can be helpful in the management of seed accessions in the seedbanks' collections.

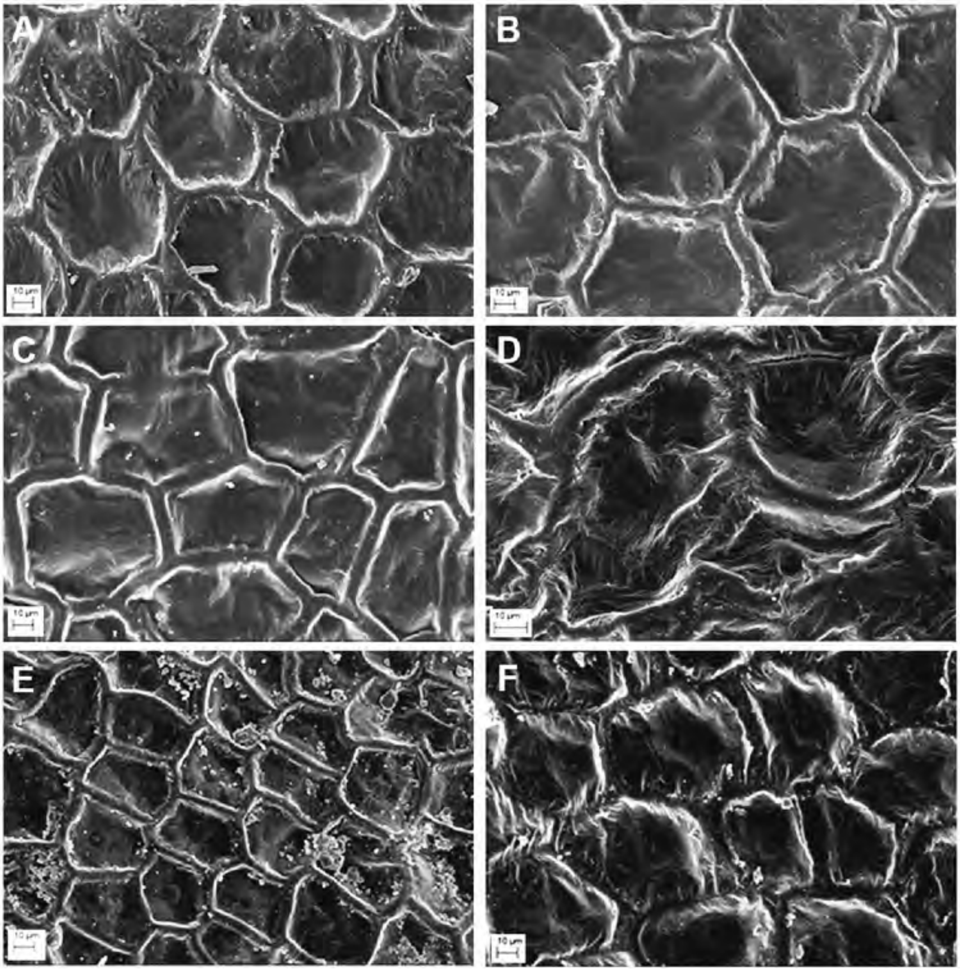

Fig. 3. Seed coat microsculpturing of some Sicilian taxa of *Brassica* sect. *Brassica* (500×): **a**, *B. villosa* subsp. *villosa*; **b**, *B. villosa* subsp. *bivoniana*; **c,** *B. villosa* subsp. *drepanensis*; **d**, *B. villosa* subsp. *tineoi*; **e**, *B. rupestris* subsp. *rupestris*; **f**, *B. rupestris* subsp. *hispida*

Comparative micromorphology of seed sculpturing is also relevant to assess dispersal strategies and infer potential and effective pathways of the gene flow within and among populations. A representative case is given by *Daucus carota* mericarps. Wild carrot fruits are oblong-ovoid schizocarps, 2-4 mm long, at maturity splitting into 2 small mericarps, with an outer convex surface provided with 5 primary short ciliate ridges and 4 secondary higher ridges with hooked prickles. Due to their shape, wild carrot diaspores can be transported by both wind and animals. Experiments revealed that especially spines decrease the fall of seeds in the air and that seeds were found to be scattered by wind over a distance on average not longer than 3 m (Lacey 1981; Manzano & Malo 2006), but they can reach longer distances (rarely up 100 m away from the original area), especially when whole dry umbels, curled into a ball, are detached from the host plants (tumbleweed effect). Actually, the post-fertilization contraction of the umbels due to hygroscopic responses to air humidity can also act as regulator of seed dispersal (through retention or release) in local microsites (Lacey 1980; Heywood 1983). However, the commonest means of dispersal is by attachment to animal fur or human clothing. Manzano & Malo (2006) demonstrated that wild carrot mericarps attached to sheep fleece could be transported 400 km by transhumant flocks, with about 7% remaining adherent for up to 6 months so that seed dispersal continues for a greater length of time. Thus, barbs and prickles undoubtedly favour seed dispersal and the number and the distance over which propagules are scattered can differ depending on scattering medium. A preliminary survey on different Sicilian populations of wild carrot from internal and coastal sites revealed a great variation in the mass of pericarps (both size and shape), but especially in the length and density of prickles along the ridges and in the number (1 to 4-5) and orientation (≤/≈/≥ 90°) of apical hooks (Fig. 4). These data, which still need further samplings, could provide useful information to interpret and predict gene flow among populations and hybridization patterns.

Ecomorphology and adaptive traits

Our current knowledge of biodiversity, adaptive strategies and ecosystem function is largely founded on descriptive comparative morphology, which enables our understanding of plant phenotypic plasticity and the related biological and ecological roles. The observation, description and documentation of variation in plasticity among and within populations allow to find adaptive explanations for specific forms and comprehend the ecological and evolutionary consequences of their diversity. Lots of publications discussed on the interaction of plant structures with environment or analysed how the environment conditions might modify the phenotypic expression of intrinsic features (Rotondi & al. 2003; Royer & al. 2005; Rozendaal 2003; Xu & al. 2009; Nicotra & al. 2010; Blonder & Enquist 2014; Angiolini & al. 2015; Yang & al. 2015; Mannino & Graziano 2016; Pilote & Donovan 2016; Saatkamp & al. 2018).

One investigated species showing significant levels of leaf morphometric variation across its populations was *Pancratium maritimum* L. In this widespread Mediterranean coastal species different combinations of some key leaf traits, such as thickness of epidermis components, blade tissues, features and size of stomata apparatus, and leaf venation, provide special morphological patterns which ensure populations to have a plastic ecophysiological adaptation to the local microclimatic conditions (Perrone & al. 2015). In fact, despite a main and rather stable morpho-anatomical structure, leaves in *P. maritimum* populations revealed significant differences in the size, number, and/or type of several micro-morphological and histological features. Single and multiple linear regression analyses, conducted to clarify the statistical effects of different climate parameters (mean annual precipitation, mean annual temperature, mean maximum temperature, aridity index) on leaf traits of *P. maritimum*, indicated the existence of significant correlations, positive or negative, between leaf plasticity and local climate. Thus, intra-specific variability in functional leaf traits of *P. maritimum*, especially those related to stress tolerance (thickness of cuticle and epidermis cells, cell size of palisade and spongy tissue, size and density of stomata, size and number of intercostal areas with aerenchyma or mucilage)

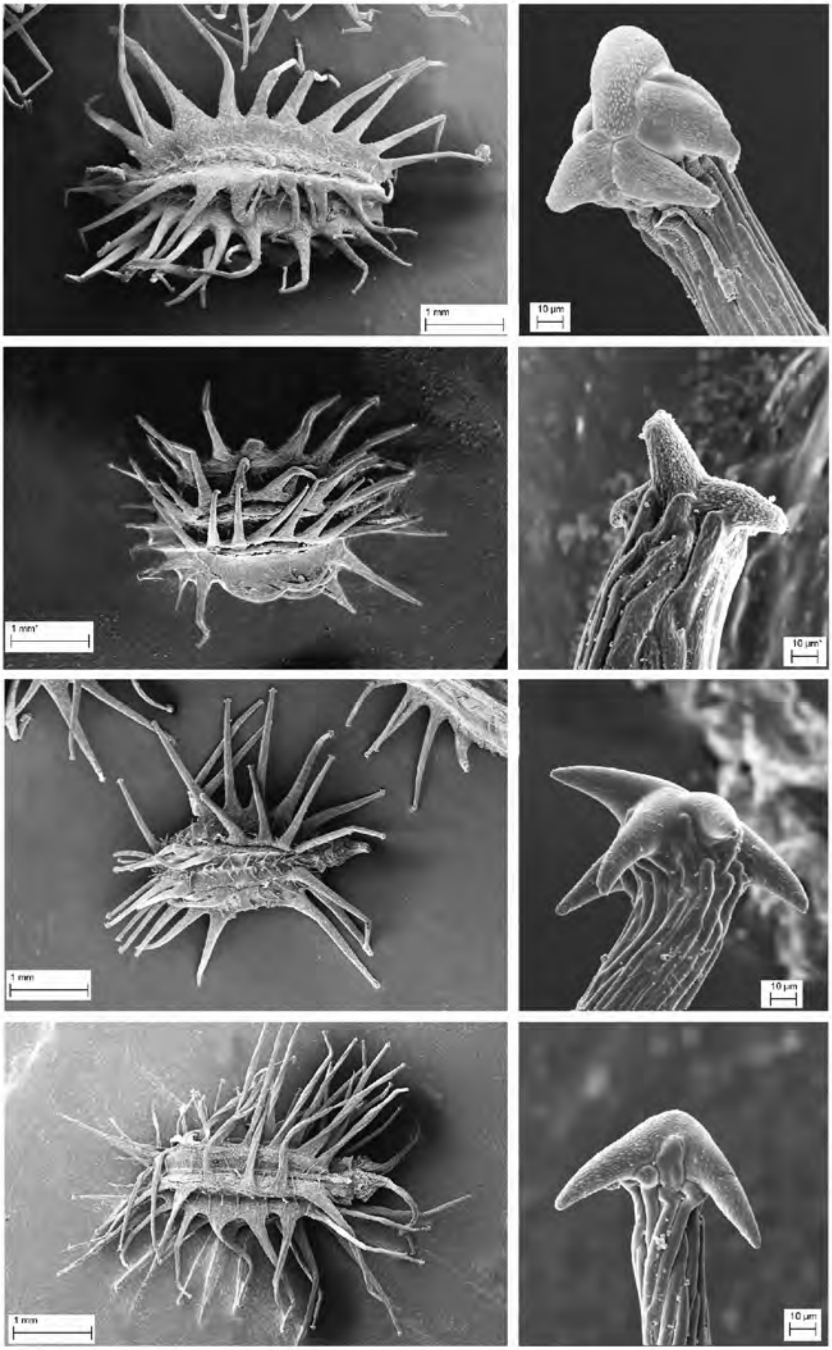

Fig. 4. Micromorphological fruit variation in some *Daucus carota* populations from Sicily: **a**, single mericarp with barbs and hooked hairs (18×); **b**, detail of the tip of hooked hairs (600×).

turned out to be a key aspect for long-term conservation, ensuring local adaptation to microsite conditions (insolation, drought, sandblasting) and increasing plant aptitude to adjust to climate changes.

Investigations on 6 different annual species of the genus *Salsola* sect. *Kali* Dumort, that is *S. kali* L., *S. tragus* L., *S. australis* R. Br., *S. squarrosa* Steven ex Moq. (formerly *S. tragus* L. subsp. *pontica* (Pall.) Rikle), and 2 taxa recently described within the genus *Kali* due to the previous taxonomic elevation of the homonymous section (i.e. *K. basalticum* Brullo & al. and *K. dodecanesicum* Brullo & al.), also revealed significant morpho-anatomical variations between species from maritime and inland areas, which clearly represent adaptations to survive under specific environmental conditions. Distinctive common features in this taxonomic group are stems rigid, not articulate, cortex green to greenish-red, with longitudinal chlorenchymatous striae, leaves linear-cylindrical, broadened at base, provided with apical spine, bracts similar to the leaves, but smaller, membranaceous perianth of 5 free segments, fruiting perianth usually winged, provided with unequal rudimentary abaxial appendices, membranaceous fruits, above flattened. Nevertheless, the species diverge in different combinations of morphological and anatomical characters, mainly related to the habit, stem, leaves and bracts, indumentum and salt glands, shape and size of flowers and fruits, which were proved to be directly involved in adaptive ecophysiological responses and/or reproductive strategies. As far as leaves are concerned, the investigated species show a cylindrical to semicylindrical outline, rather reflecting the same indumentum as the stem, no hypodermis, two concentric layers of chlorenchyma, typical of C4 Kranz anatomy, water storage tissue with mucilage in the central part, one central vascular bundle and 2 minor ones in the peripheral part, and 2 longitudinal collenchymatic ridges which interrupt palisade and Kranz cells. As showed in Fig. 5, main differences regarded the general leaf size (leaf area, leaf thickness), leaf indumentum, cell size and tissue thickness (complex cuticle-epidermis, palisade tissue, and collenchyma), which represent useful discriminant features among species (Fig. 6). Results from single and multiple linear regressions carried out on some leaf morphological characters (Fig. 7) suggested that climatic parameters have significant influence on leaf variability; in particular warming has positive relationships with leaf area and leaf thickness, while increased precipitations seem to affect negatively the leaf size. This can be explained by the fundamental role of a well-developed water storage tissue in drought conditions.

Discussion

The examples provided have demonstrated that plant morphology can and should contribute in a dynamic way to both basic and applied research, since today it has new and more opportunities than ever before, especially due to new techniques for structural research, such as SEM, confocal microscopy, microcomputer tomography and the modern morphometric analyses, which are opening possibilities for a better understanding of organisms' evolution and a further integration of comparative morphological studies and other biological disciplines.

Contrary to common belief, plant morphology is not a conservative finished science, but, like other sciences, it is open to constant innovations involving concepts and methods.

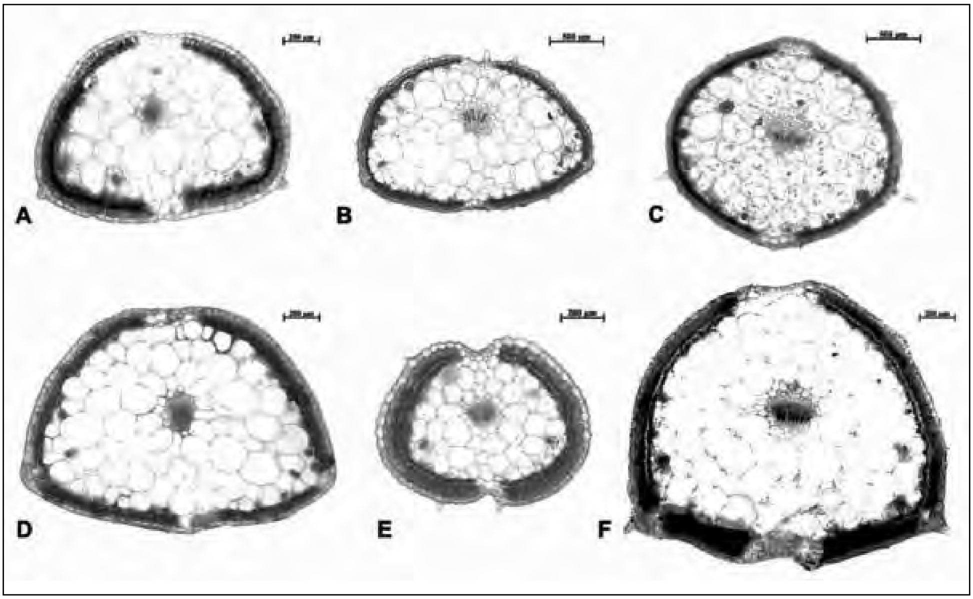

Fig. 5. Morpho-anatomical leaf variation in some annual *Salsola* species: **a**, *S. kali*; **b**, *S. tragus*; **c**, *S. dodecanesica* (*Kali dodecanesicum*); **d**, *S. squarrosa*; **e**, *S. basaltica* (*Kali basalticum*); **f**, *S. australis.*

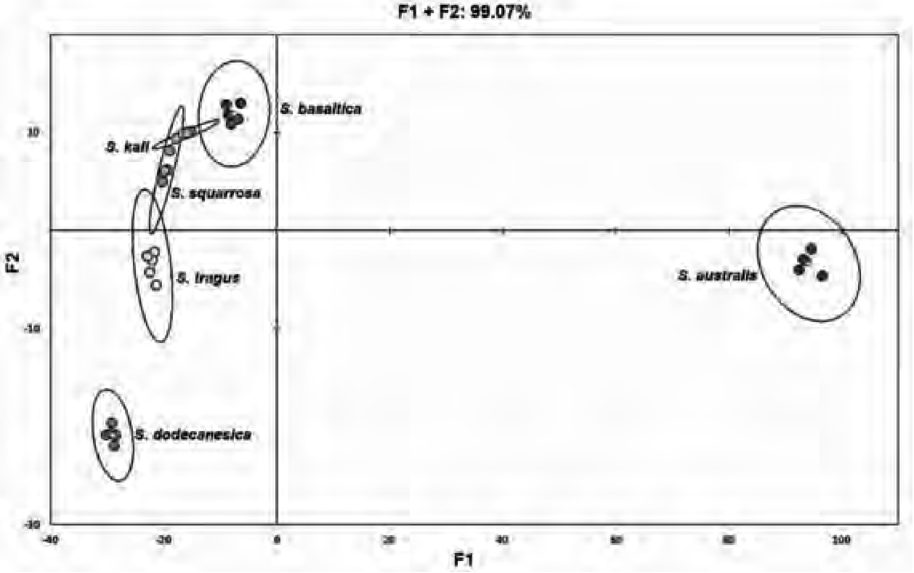

Fig. 6. Similarities among *Salsola* species resulting from discriminant factorial analysis among based on leaf parameters.

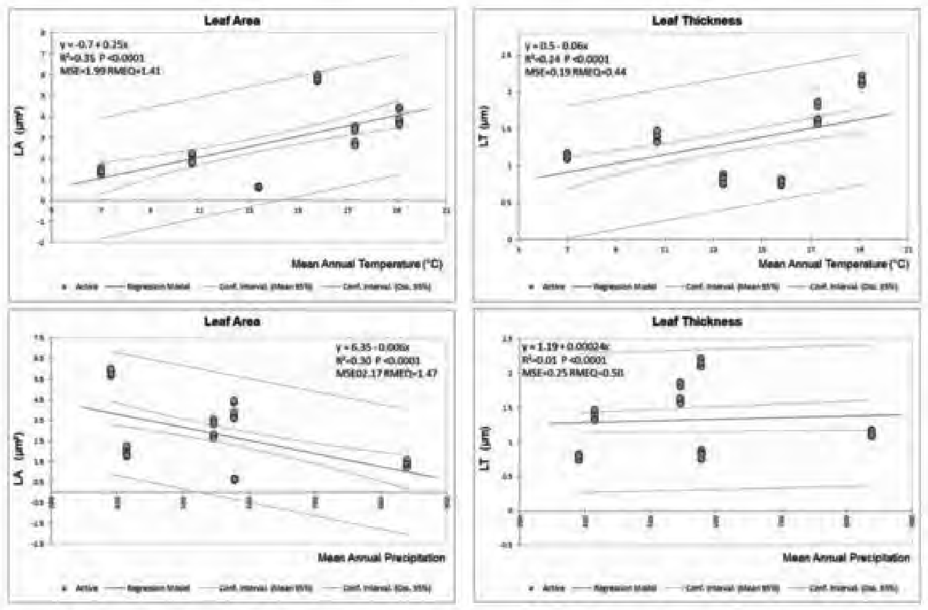

Fig. 7. Scatter plots and linear regressions indicating correlations between some leaf features and climatic parameters in *Salsola* species.

In fact, plant morphology has changed over time and improved its analytical approaches embracing new technologies and tools, without neglecting traditional methods.

Notwithstanding, morphological studies and their main related discipline, the classical alpha taxonomy, are still underestimated and somehow marginalized. Results from morphology-based research are often poorly cited in top-ranking journals, maybe because many authors tend to cite papers that support taxonomic treatments or reviews with molecular data, rather than papers only based on classical taxonomy (Pysek & al. 2013). The low number of specialists for particular limited groups further contribute to reducing the chances of plant morphology papers becoming highly cited (Krell 2002). This has progressively led to a worldwide decline in morphologists and taxonomists in general, which could have a broad impact on plant biology research and biodiversity conservation. Unfortunately, the simple assumption that biodiversity studies cannot advance without morphologists is unlikely to produce an adequate increase in public funding and broad support (Pearson & al. 2011). Thus, now it should be time to re-evaluate the contribution of plant morphology and contemporary plant morphologists at the level of modern botanical and evolutionary research in order to avoid the loss of a wide baseline expertise and favour the involvement of students and young researchers, especially through modern approaches and high technical tools, in this field of botany sciences.

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Potentilla greuteriana (*Rosaceae*), a new species from Mt. Taigetos (S Peloponnisos, Greece)*

Abstract

Kyriakopoulos, Ch., Kamari, G., Kofinas, I. & Phitos, D.: *Potentilla greuteriana* (*Rosaceae*), a new species from Mt. Taigetos (S Peloponnisos, Greece). — Bocconea 28: 207-220. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Potentilla greuteriana Kyriak., Kamari, Kofinas & Phitos is a new species of *P.* sect. *Plumosistylae,* known from two localities (summit Xerovouni and Langada gorge) on Mt. Taigetos (S Peloponnisos). The habitat of this *Potentilla* species is black bituminous, deeply karstified limestone. The closest relative of *P. greuteriana* is *P. arcadiensis,* which is distributed on the neighbouring Mt. Parnonas (E Peloponnisos), but belongs, to *P.* sect. *Crassinerviae.* The main morphological differences between the new species and its related taxa of *P.* sect. *Crassinerviae* (*P. ulrichii, P. nerimaniae, P. davisii*) and *P.* sect. *Plumosistylae* (*P. libanotica* and *P. isaurica*) are discussed. Additionally, the conservation status of this species is provided.

Key words: Greek flora, *Potentilla,* conservation, endemism, taxonomy.

Introduction

The high diversity of the flora of Greece, rich in endemic and rare plant species, is a consequence of the country's geological history, which has resulted in the formation of a multitude of isolated areas and habitats along the flora's migratory pathways, from Anatolia to central and northern Europe. Peloponnisos is the southern part of the Greek mainland and, at the same time, of the Balkan Peninsula. Mt. Taigetos is one of the main biodiversity hotspots of mainland Greece, with a high percentage of endemic and rare taxa (Phitos & al. 2009), having strong phytogeographical connections with other mountains of Peloponnisos (examples being the endemic monotypic genus *Phitosia crocifolia* (Boiss. & Heldr.) Kamari & Greuter, *Achillea taygetea* Boiss. & Heldr., *Crepis heldreichiana* (Kuntze) Greuter occurring also on Mt. Parnonas; *Globularia stygia* Orph. and *Teucrium aroanium* Boiss. occurring also on Mt. Chelmos, etc.) and of Crete (*Herniaria parnassica* subsp. *cretica* Chaudhri, *Ranunculus subhomophyllus* (Halácsy) Vierh., occurring also on the Lefka Ori range). The

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study of these connections is the subject of the first author's PhD thesis.

Several new taxa have recently been described from Mt. Taigetos and its surroundings, such as: *Allium orestis* Kalpoutz. & al. (Kalpoutzakis & al. 2012), *Campanula kamariana* Kyriak. & al. (Kyriakopoulos & al. 2017), *Geranium kikianum* Kit Tan & Vold (Tan & al. 2011) and also *Asperula lutea* subsp. *griseola* Greuter, *Ballota nigra* subsp. *anomala* Greuter, *Lolium scholzii* Greuter, *Nepeta hystrix* Greuter and *Trifolium michaelis* Greuter (Greuter 2012).

Potentilla L. is one of the largest *Rosaceae* genera, mostly Holarctic in distribution, though some of its representatives are also found on the mountains of southeast Asia (see Eriksson & al. 1998; Dobeš & Paule 2010; Dobeš & al. 2013). Wolf (1908), the monographer of the genus, recognized ca. 300 *Potentilla* species and divided the genus into two sections, based on the presence (*P.* sect. *Trichocarpae*) or absence (*P.* sect. *Gymnocarpae*) of hairs on the carpels, six subsections based on the shape of the pistils and the insertion of the styles, and several lower-ranking groups that are his main units of classification. Wolf's classification was adopted and modified by others, such as Juzepčuk (1941), who upgraded Wolf's subsections to subgenera and his groups to sections, and also Pawłowski (1965), who separated *P.* subg. *Fragariastrum* (Ser.) B. Pawł. into two sections (*P.* sect. *Fragariastrum* Ser. and *P.* sect. *Plumosistylae* B. Pawł.). Ball & al. (1968), in Flora Europaea, divided the genus *Potentilla* into 5 subgenera, among them the subg. *Fragariastrum* (Heister ex Fabr.) Reichenb., which was further divided into two sections, i.e. sect. *Fragariastrum* and sect. *Plumosistylae,* according to Pawłowski (1965). Later, Soják (1987) divided Wolfs' *Potentilla* sect. *Trichocarpae* Th. Wolf into 19 sections, based on flower and anther structure and style shape. Moreover, by using molecular phylogenetic methods, a better understanding of the origin of subfamily *Rosoideae* Arn. of *Rosaceae* Juss. and of *Potentilla* itself has been achieved (see Eriksson & al. 1998, 2003; Potter & al. 2007; Lundberg & al. 2009).

Recently, Soják (2008), while presenting a new genus-level classification of the *Potentilleae* Sweet, suggested its division into two subtribes, i.e. *Potentillinae* J. Presl and *Fragariinae* Torr. & A. Gray, based on morphological characters, which is consistent with the phylogenetic tree by Eriksson & al. (1998), who proposed that *Potentilla* contains ca. 485 species of annual, biennial and perennial herbs, several of hybridigenous origin. According to phylogenetic reconstructions (Dobeš & Paule 2010), *Potentilla* s. str. comprises mainly herbaceous species, representing 24 of the 31 series distinguished by Wolf (1908).

In Greece, there are 26 taxa of *Potentilla* (eight in Peloponnisos), three of which are endemic. These include the submontane *Potentilla arcadiensis* Iatroú (Iatroú 1985) from Mt. Parnonas, E Peloponnisos, and two mountain species, *P. kionaea* Halácsy (Halácsy 1888) from Mt. Giona, Sterea Hellas and *P. deorum* Boiss. & Heldr. (Boiss. & Heldr. 1856) from Mt. Olimbos, NC Greece (Strid 1986).

In July 2011, Ioannis Kofinas, during a visit to the Langada climbing area of Mt. Taigetos, noticed an interesting *Potentilla* chasmophyte with robust and richly leafy flowering stems, growing on vertical rocks. On August of the following year (Aug 5, 2012) during a field survey by the first author on N Taigetos, west of the Xerovouni peak (1523 m), an additional, larger population with the same characteristics was found. The substrate in the two above localities, where this species grows, is black bituminous, deeply karstified limestone. Macroscopically, it resembles *P. arcadiensis* (*P.* sect. *Crassinerviae*)*,* endemic to the neighbouring Mt. Parnonas (SE Peloponnisos), from which, however, it differs morphologically in several features, such as its strongly supine flowering stems and visibly compact inflorescences with short pedicels, attributes that rather point to representatives of *P.* sect. *Plumosistylae,* such as *P. libanotica* Boiss. and *P. isaurica* (P. H. Davis) Pawł. from S Anatolia.

In this paper we describe these *Potentilla* plants from Mt. Taigetos as a new species, which is related to the neighboring *P. arcadiensis* (*P.* sect. *Crassinerviae*) from Mt. Parnonas and also to the Anatolian taxa *P. libanotica* Boiss. (Boissier 1872) and *P. isaurica* B. Pawł. (Pawłowski 1965) of *P.* sect. *Plumosistylae.* We also clarify the relationships of the new species with other close relatives.

Materials and methods

For the description of the new species, both living and dried material of all related *Potentilla* taxa from Greece and S-SE Anatolia & E Mediterranean area was used. The herbarium material that we also used for comparisons is deposited in the following Herbaria: B, E, L, P, Herb. Phitos & Kamari (UPA) and UPA (acronyms follow Thiers 2018).

Morphological observations were carried out under a Zeiss stereomicroscope. For taxonomic identification, scientific papers and floras (Boissier 1872; Juzepčuk 1941; Pawłowski 1965; Ball & al. 1968; Schiman-Czeika 1969; Peşmen 1972; Iatroú 1985; Soják 1987, 2008; Duman & Mill 1999; Tan & Iatroú 2001; Parolly & Nordt 2002) were used. The collection localities for all species were georeferenced and the distributions were mapped using the freeware GIS software QGIS 2.18 (2017), and Image Editor GIMP 2.8.22.

A detailed comparison between the new species and other morphologically related taxa is given in Table 1.

Results

Potentilla greuteriana Kyriak., Kamari, Kofinas & Phitos in Fl. Medit. 28: 353. 2018. (Figs. 1 & 2).

Diagnosis: *Potentilla greuteriana* differs from its related Greek endemic *P. arcadiensis* by the absence of digitate leaves, longer petioles, different indumentum of 1.2-1.5 mm long glandular and 1.0-1.2 mm long simple hairs, larger leaflets, longer stipules and auricles of the basal leaves, dense inflorescences with much shorter pedicels (7-10 mm against 15-35 mm long), glabrous petals, and usually pubescent to almost plumose, rarely glabrous, persistent styles.

P. greuteriana is related to the members of *P.* sect. *Plumosistylae.* It differs from its closest relatives in that section, *P. libanotica* and *P. isaurica,* by its indumentum (long glandular and slightly shorter simple hairs), the longer leaflets, shorter epicalyx segments and petals, anther shape (ovate to obovate rather than globose) and smaller achenes. Additionally, it differs from *P. libanotica* by the number of leaflet teeth (5-6 rather than 6-9) and seed hairiness (apex pilose to pubescent) and from *P. isaurica* by the obtuse rather than acute teeth and the shape of the petals (obovate to ovate instead of elliptic).

Fig. 1. Individual of *Potentilla greuteriana* from its *locus classicus* on the summit Xerovouni of North Taigetos.

Type: Greece: S Peloponnisos: Nomos Arkadias: Mt. N Taigetos, W-SW of Xerovouni summit, 37° 09'N, 22° 13' E, alt. c.1150 m, with *Pinguicula cristallina* subsp. *hirtiflora, Campanula asperuloides, Teucrium aroanium* etc., on vertical karstified limestone rocks, 9 Jul 2017, Ch. Kyriakopoulos 2334 (Holotype: Herb. Phitos & Kamari, UPA!). Isotypes: ACA! and PAL-Gr!

Description: Perennial, densely tufted to pulvinate. Flowering stems several, decumbent-ascending, 8-24(-27) cm long, 1-2 mm in diameter, longer than basal leaves, densely clothed with 1.2-1.5 mm long, erect to erect-patent glandular hairs and equally numerous, up to 1.0-1.2 mm long, patent simple hairs. Leaves in rosettes, long-petiolate, trifoliolate, green to yellowish-green, concolorous, smooth, almost sericeous, with apressed long hairs along the nerves, and a mixture of short and long hairs to the rest of the surface, with scattered 2-4 celled, <0.5 mm long glandular hairs along the leaflet margins; leaflets obovate, cuneate at base, terminal: (20-)25-38(-44) × (10-)15-28 mm, lateral: (20-)22-35 × (10-)15-26 mm, terminal tooth of leaflets equalling or shorter than the first lateral teeth; margins crenate (-serrate), lateral teeth 4-6(-7) on either side; petiole 3-6(-7.2) cm long, with erect glandular hairs up to 2 mm long and patent-erect simple hairs up 1mm long (length ratio almost 1:2); stipules lanceolate-acuminate, 2.0-2.4 × 0.6-0.7 cm, with auricles 0.8-1.3 cm long, with simple apressed hairs, up to 0.8 mm long and shorter, scattered glandular along both margins, green, becoming yellowish-green at

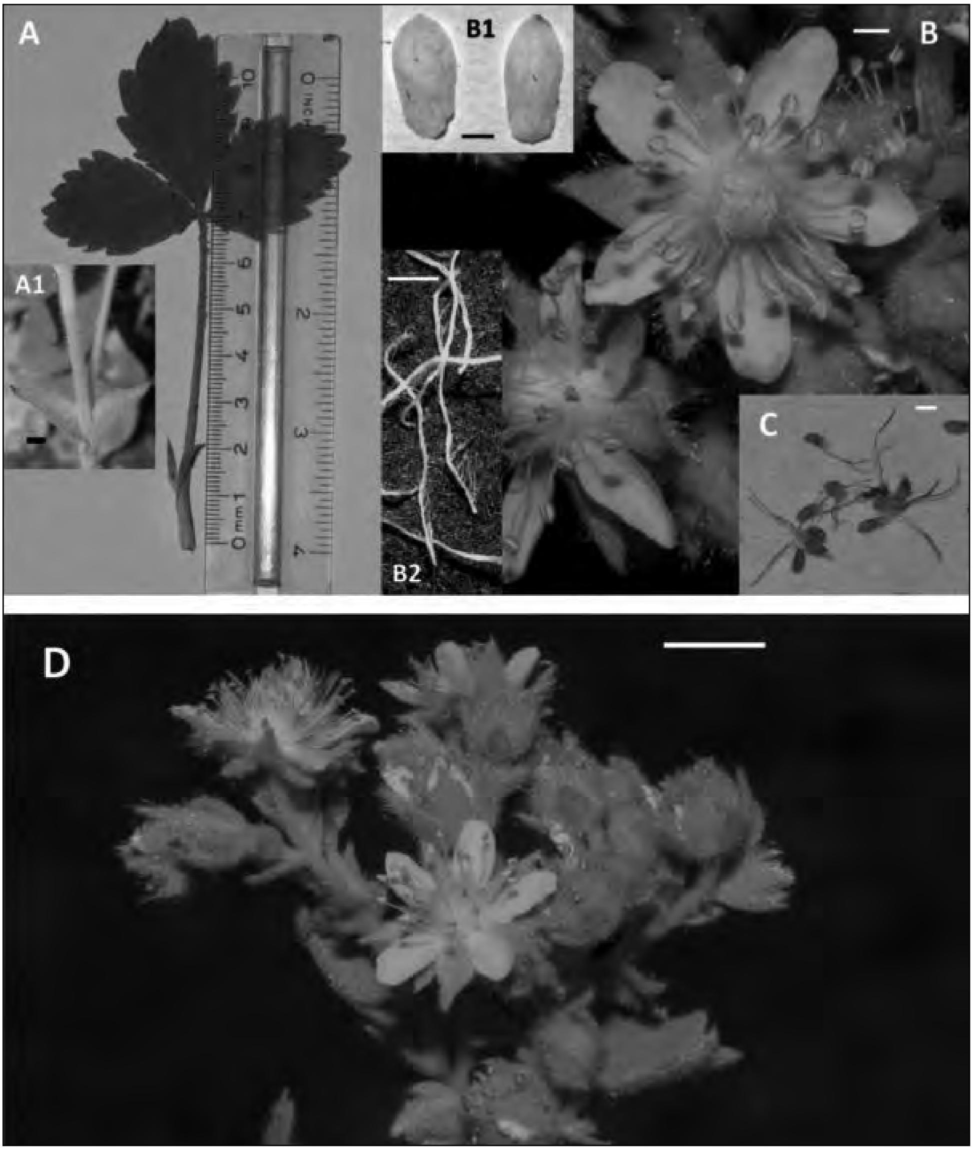

Fig. 2. *Potentilla greuteriana* sp. *nova:* **A,** basal leave, petiole, stipules; **A1,** stipules of cauline leaves; **B**, flower; **B1**, petals; **B2**, styles; **C**, achenes with persistent styles; **D**, inflorescense. – Scale bars A-C = 1 mm; D.= 5 mm.

the base. Cauline leaves similar but smaller, with green, broader stipules, leaflets with 4-5 teeth, the larger 27-32(-37) × 18-22(-26) mm, in the middle of the stems (4th-5th from the bracts), diminishing upwards. Inflorescence a compact, terminal, rather dense cyme, ca. 12-30(-40) flowered, densely to moderately villous with long (≤1.2 mm) patent simple hairs and erect glandular (≤1.2-1.5 mm long). Bracts foliaceous, usually less than 1.5-2.0 × 0.7-1.1 cm, with up to two teeth each side. Pedicels 7-10(-15) mm long, slender (diameter 0.5-0.8 mm). Flowers relatively small. Epicalyx segments 5, narrowly ovate-lanceolate, acute, ca. 3-3.5 × 1-1.5 mm, not visible in front view of the perianth, with patent simple and sparse, short glandular hairs. Calyx densely sericeous-villous, (7-)8-9(-11) mm in diam., moderately accrescent in fruit; divided into 5 sepals (4-4.5 × 1.5-2.0 mm), indumentum with long erecto-patent simple hairs chiefly on the abaxial face, slightly larger than the epicalyx segments, cuneate to truncate at base. Petals white, with an obovate to obovate-oblong, rounded to broadly obtuse apex and a rounded to cuneate base, slightly longer than the sepals, 3.2-4.5 × 2.5-3 mm, glabrous. Stamens ca. 30; filaments 2.5-3.5 mm long, pilose in proximal 5/6, more loosely so in the distal 1/2, anthers pale yellowish with reddish margins, ovate to obovate, 0.4-0.5 × 0.3 mm. Style subapical, usually pubescent (for 1/3-1/2 of its length) or rarely glabrous, ca. 3-4 mm long, filiform (nematostylous). Nutlets ivory, kidney-shaped, distinctly compressed, 0.9-1.3 × 0.9 mm, smooth, apex pilose, margin narrowly winged, with persistent style.

Phenology: *Potentilla greuteriana* flowering from mid-June to mid-August. Fruiting from late August to the end of September.

Distribution and Habitat: *Potentilla greuteriana* is a narrow endemic of Mt. Taigetos (S Peloponnisos). Based on current data, its area of occurrence (Fig. 4) is limited to two, disjunct areas, on the rocky systems of North Taigetos, west of the summit Xerovouni and at suitable habitats of Langada gorge, in Central Taigetos. *P. greuteriana* is a typical chasmophyte. It grows on shady or half-shaded places, on vertical rocks, which consist of gray to black bituminous (containing solid organic ingredients), karstified limestone, capable of providing the flora that grows on it with the needed water (Fig. 3). The species appears to have adapted to the particular features of that limestone substrate, its dense root network effectively penetrating and absorbing water and nutrients from it.

Potentilla individuals on the Xerovouni summit grow at an altitude of ca. 1150-1200 m in N-NE exposure, while those of the Langada climbing area grow at an altitude of 750-800 m in S-SE exposure (Fig. 3).

Together with *Potentilla greuteriana* on the summit of Xerovouni, N Taigetos, there also grows the carnivorous *Pinguicula crystallina* subsp. *hirtiflora* (Ten.) Strid (this is the first report of its presence on N Taigetos, which constitutes its southernmost known occurrence) and, additionally, some Peloponnese endemic taxa, e.g. *Globularia stygia*, *Teucrium aroanium*, *Campanula asperuloides* (Boiss. & Orph.) Engl., *Minuartia pichleri* Maire & Petitm, etc.

In Langada gorge, *Potentilla greuteriana* co-exists with the following endemic taxa: *Asperula boryana, Campanula asperuloides, Carum depressum* Hartvig & Kit Tan, *Inula verbascifolia* subsp. *methanaea* (Hausskn.) Tutin and *Stachys candida* Bory & Chaub., whereas the local endemic *Hypericum taygeteum* Quézel & Contandr. is found nearby.

Conservation status: *Potentilla greuteriana* is a narrow endemic with a very limited area of occurrence in specialized habitats. Based on in-situ observations, it appears that a necessary condition for the species survival is the uninterrupted supply of water through the capillaries of the calcareous rocks on which it occurs. Possible changes of

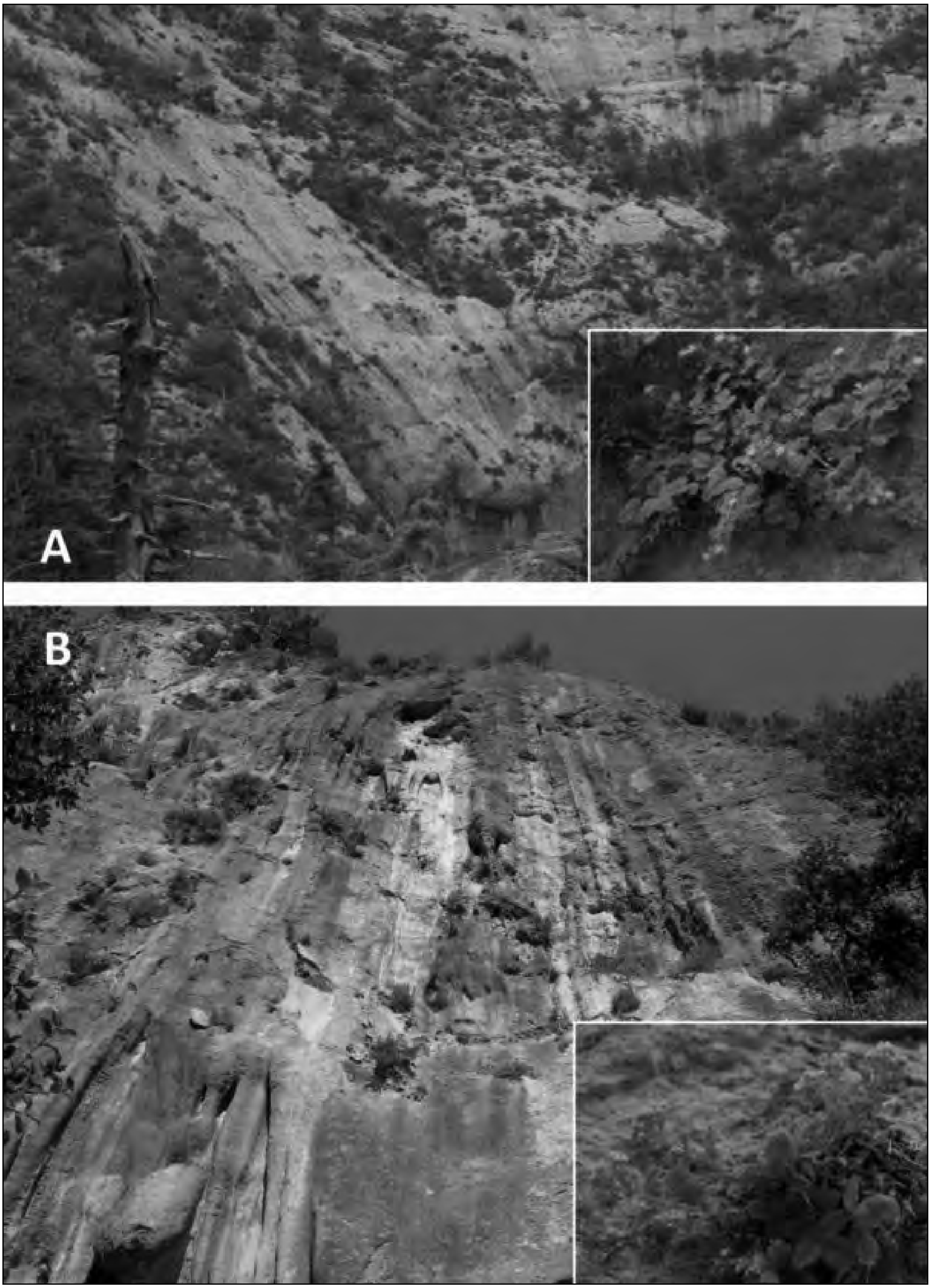

Fig. 3. Biotopes of the typical chasmophyte species *Potentilla greuteriana*: **A**, the summit area of Mt. Xerovouni (*locus classicus*) of the north Taigetos and **B**, the climbing area of Langada gorge in central Taigetos.

water potential of the karstified limestone systems, on which it grows, may cause a population decline. The subpopulation of the Langada area occupies an area of less than 300 × 50 m (< 1 km^2) and consists of 100-150 mature individuals, while the subpopulation of N Taigetos (Xerovouni) develops over an area of 250 × 30 m (< 1 km^2) and consists of 400-600 mature individuals. Moreover, the subpopulation of the former locality is potentially threatened by the fact that the area is used as a climbing field. Following the IUCN (2017) criteria, the taxon should be categorized as Endangered (EN), on the basis of its restricted distribution [restricted, extent of occurrence (EOO <100 km^2) and area of occupancy (AOO<100 km^2)], the fact that no more than 750 mature individuals were counted, and the high possibility of erosion of the substrate as a result of human activities (climbing) [B1ab(i,ii,iii,iv), B2ac(i,ii,iii,iv)].

Etymology: The species is named after Werner Greuter, Professor Emeritus of Plant Systematic, Nomenclature and Phytogeography of the world flora and especially expert of the Greek and Cretan flora, for his 80th birthday.

Discussion: *Potentilla greuteriana* is one more new stenoendemic taxon of Mt. Taigetos (S Peloponnisos). It is related to the Greek endemic *P.* (sect. *Crassinerviae*) *arcadiensis* from Mt. Parnonas (SE Peloponnisos), but also to the Anatolian endemics *P. isaurica* & *P. libanotica* (*P.* sect. *Plumosistylae*), which spread around S Turkey, Syria and Lebanon (see Fig. 4).

The only close relative of *Potentilla greuteriana* in Greece is *P. arcadiensis* (Fig. 5), which, however, according to Iatroú (1985), is a distinct and geographically isolated

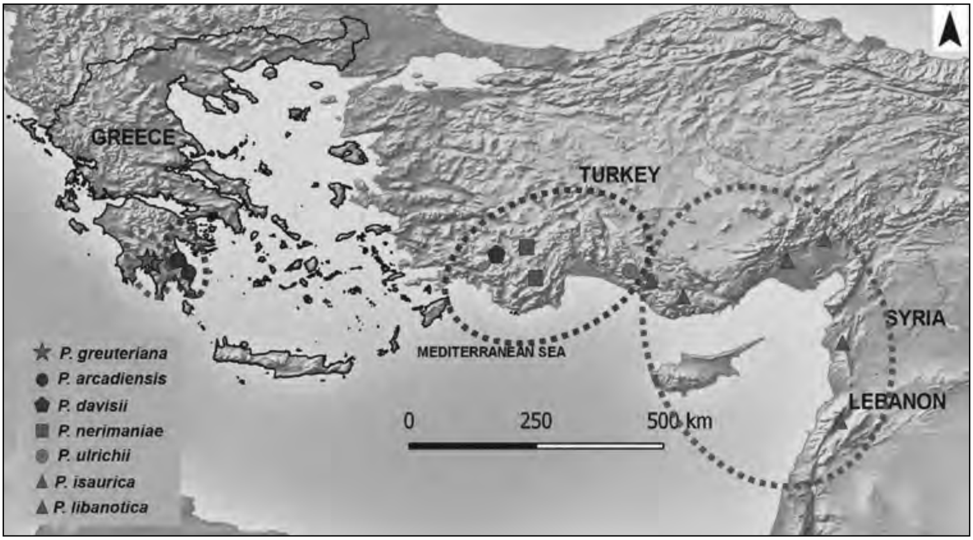

Fig. 4. Distribution map of the two *Potentilla* Greek endemic species and their related species in S & SW Anatolia, Syria and Lebanon.

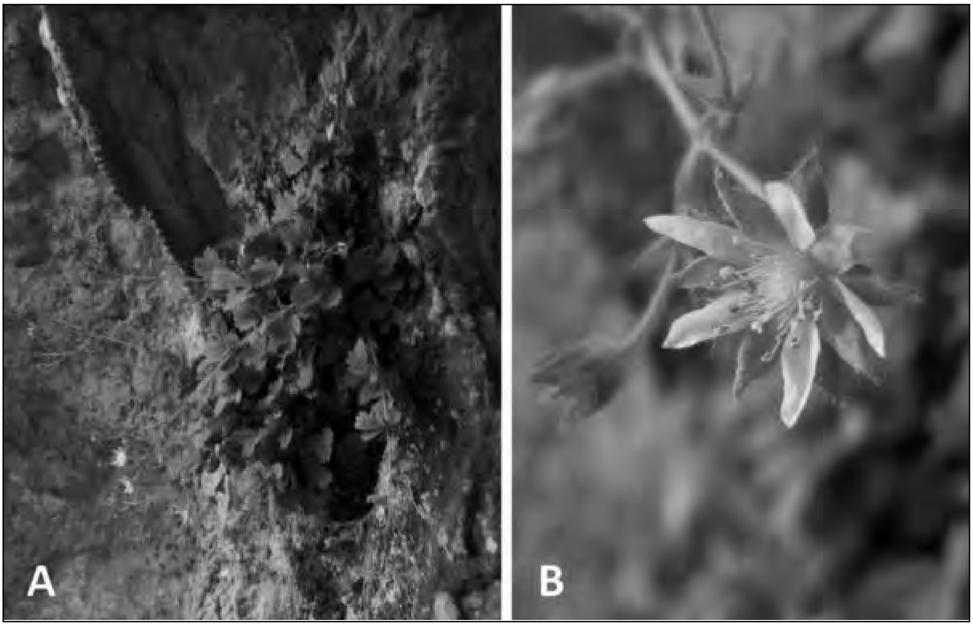

Fig. 5. *Potentilla arcadiensis* from its *locus classicus* at the Monastery of Elona, Mt. Parnonas: **A**, individual; **B**, infloresscense and flower.

species without any other close relatives in Greece. *P. arcadiensis,* in contrast to *P. greuteriana,* exhibits 1-2 digitate basal leaves, a feature that, according to Iatroú (1985), "suggests an intermediate position between the species of the E and W Mediterranean area". The diploid chromosome number of *P. arcadiensis*, 2*n* = 14, is an additional character of the representatives of the *Crassinerviae* group, such as *P. crassinervia* Viv., *P. valderia* L. and *P. haynaldiana* Janka (Contadriopoulos 1962; Baltisberger 2006). Based on this chromosome number, along with the hairlessness of styles and some other morphological features, Iatroú (1985) suggested that *P. arcadiensis* belongs to *P.* sect. *Fragariastrum* Ser., group *Crassinerviae.*

Additionally, *P. nerimaniae* Duman and *P. davisii* Mill & Duman, described by Duman & Mill (1999) from S & SW Anatolia, were also classified in *P.* (subg. *Fragariastrum*) sect. *Crassinerviae* (Th. Wolf) Juz. The taxa of *P.* sect. *Crassinerviae* differ from those of *P.* sect. *Plumostistylae* mainly by the predominant indumentum of simple hairs, ± hiding the much shorter glandular hairs, loose inflorescences, flowers with long pedicels, pilose filaments, achenes with scrobiculate-reticulate surface etc (see Table 1).

Potentilla ulrichii Parolly & Nordt, which was described more recently (Parolly & Nordt 2002), also from S Anatolia, was classified in *P.* sect. *Crassinerviae* and placed in the *P. nerimaniae* group, together with *P. davisii* and *P. arcadiensis.* This species is also considered a close relative of *P. libanotica* and *P. isaurica* (Table 1).

However, *P. libanotica* and *P. isaurica,* together with *P. saxifraga* De Not. (a taxon growing in the lowland and the middle altitudinal level of Mediterranean Alps) were clas-

Table 1. Morphological features of *Potentilla greuteriana* and its relatives (bold letters denotes the main differences of the Greek endemic species of Peloponnisos).

	Potentilla* sect. *Plumosistylae			*Potentilla* sect. *Crassinerviae* p.p. (*P. nerimaniae* group)			
Taxon	***P. greuteriana***	***P. libanotica***	***P. isaurica***	***P. arcadiensis***	***P. ulrichii***	***P. nerimaniae***	***P. davisii***
Stem (length in cm)	8-25(-27)	5-20	5-20	10-25(-30)	(5-)10-35, decumbent to ascending, rarely erect	5-15, decumbent to ascending, rarely erect	5-12
Stem leaves	numerous	numerous	numerous	numerous	sparse	sparse	sparse
Petioles (cm)	**4-7**, thin	5-7, stout	3-5, stout	**3-5**, thin	5-12, thin	1-7, thin	≤10, stout
Indumentum	simple hairs, longer glandular hairs	glandular hairs dominant, glutinous	glandular hairs dominant, glutinous	simple hairs, shorter glandular hairs	simple hairs dominant, ± hiding the much shorter glandular hairs	simple hairs dominant, ± hiding the much shorter glandular hairs	simple hairs dominant, ± hiding the much shorter glandular hairs
Leaves	ternate, not bicoloured	ternate, green, not bicoloured	ternate,green, not bicoloured	ternate **(1-2 basal digitate),** not bicoloured	ternate, (distinctly) bicoloured	ternate, (weakly) bicoloured	ternate, bicoloured
Leaflet size (mm)	25-38(-44) × 15-26(-28)	15-25 × 10-20	15-20 × 8-15	15-25 × 10-18	(20-)25-60(-70) × (15-)20-35(-45)	(7-)10-25 × (6)10-20	15-30 x 12-20
Leaflet margin	crenate-serrate	crenulate-serrate, rarely dentate	dentate to crenate-serrate	crenate-serrate	dentate	dentate	crenulate-serrate
Lateral teeth of leaflets	5-6	6-9	3-5(-6)	5-6(-7)	(6-)8-9(-10)	(3-)4(-5)	(4-)5-7(-10)
Tip of teeth	obtuse	± obtuse	± acute	obtuse	acute	acute	obtuse
Inflorescence	**compact cyme, 12-30(-40) flowers**	compact cyme	compact cyme	**loose cyme, 15-20(-30) flowers**	loose, ± corymbose cyme, (10-)15-30 flowers	loose, cymose	loose, cymose
Pedicels (length in mm)	**7-10(-15), stout**	≤12, stout	≤10, stout	**15-35, ± thin**	(10-)12-20(-35), thin	10-30, thin	10-30, thin
Epicalyx segments (mm)	**≤3.5 × 1.5,** **shorter than sepals**	4-6.5 × 1.5-2.2, equal to sepals	4-6.5, equal to sepals	**3.5-5.5, equal to sepals**	4-5 × 1-1.5(-2), equal or slightly smaller than sepals	2-4, shorter or as long as the sepals	6-10, equal to sepals
Petals length (mm)	**3.2-4.5 × 2.5-3**	5-7.5 × 2.6-4.1	6-8	**4.5-6 × 2-2.5**	4.5-6(-7)	5-5.5	6-10
Petals shape	**obovate to broadly oblong**	obovate to ovate	elliptic	**oblong to narrowly oblong**	obovate	obovate	obovate-orbicular
Petals apex	**rounded, glabrous**	rounded ± retuse, glabrous	± acute, apex glabrous	**usually acute, pubescent**	rounded to broadly obtuse, glabrous	obtuse or shallowly retuse, glabrous	obtuse, glabrous
Filaments	glabrous, **base not dilated**	glabrous, base not dilated	glabrous, base not dilated	glabrous, **base dilated**	pilose, base dilated	pilose, base dilated	pilose, base dilated
Anthers	**ovate to obovate often with base cordate,** yellowish with reddish margins	globose, yellow	globose, reddish	**oblong**, yellowish with reddish margins	oblong, yellowish	oblong, yellowish	oblong, yellowish
Style	**usually pubescent** or rarely glabrous, **persistent**	plumose, persistent	plumose, persistent	**glabrous, caducous**	glabrous, caducous,	glabrous, caducous	glabrous, caducous
Achenes (mm)	Smooth, 0.9-1.3, apex pilose, margin narrowly winged	Smooth, 1.2-1.8, pubescent	Smooth, apex loosely pilose	Smooth, 0.7-1.0, apex pilose, margin narrowly winged	Scrobiculate-reticulate, 1.6-1.8 × 0.9, glabrous, margin narrowly winged	Scrobiculate-reticulate 1.5-2.0, glabrous	Scrobiculate-reticulate, apex pilose
Altitudinal range (m)	**750-1200**	1450-2100	1100-1700	**450-650**	300-550	1350-1950	1370-1630

sified by Pawłovski (1965) in *P.* sect. *Plumosistylae* because of their main morphological features, which are the non-deciduous, persistent and plumose (for up to ¾) styles and the almost globose anthers. The same classification is also followed by Soják (1987), who added to the morphological features of *P.* sect. *Plumosistylae* the slender filaments not dilated at the base, and stems with numerous leaves. According to the above characters, *P. greuteriana* probably belongs to *P.* sect. *Plumosistylae.* The main morphological features commonly found in *P.* sect. *Plumosistylae,* are: numerous leaves on flowering stems (with 5-8 unequal leaves, the largest in the middle of the stems), short-pedicellate flowers [length 0.6-1.2(-1.5) cm], glabrous filaments, glabrous petals, subterminal, filiform, persistent styles pubescent for 2/3-3/4 of their length, and smooth achenes (Table 1).

Potentilla greuteriana also shows some similarities to *P. arcadiensis* of *P.* sect. *Crassinerviae,* from which, however, it differs mainly by the bigger size [(25-38(-44) × 15-26(-28) mm] of the always trifoliolate leaves; the indumentum of the flowering stems and pedicels, which consists of longer (12-15 mm) glandular and shorter (10-12 mm) englandular hairs; the longer [10-18(-24) mm] stipules of the basal leaves, with significantly longer (8-12 mm) auricles; the epicalyx segments significantly shorter than the sepals; the shorter, glabrous petals, the styles usually pubescent for 2/3-3/4 of their length, persistent on the achenes; and more significantly the shorter [7-10(-15) mm] pedicels and the compact inflorescences (see Table 1).

Kechaykin & Shmakov (2016) in their revision of *Potentillinae* J. Presl, using molecular data and based on morphological differences, classified *Fragariastrum* Heist. ex Fabr. and *Tormentilla* L. as separate genera and included in them several *Potentilla* species. For example, *P. arcadiensis* and some of its Anatolian relatives are included in *Fagariastrum* sect. *Plumosistylae* (Pawłowski) Kechaykin & Shmakov (*P.* sect. *Plumosistylae* Pawłowski). This new classification of *P. arcadiensis* is uncertain because it does not display any of the key characters of *F.* sect. *Plumosistylae,* such as: anthers globose; style persistent in fruit and plumose at least in its lower half etc. (see: Pawłowski 1965: 79; Ball & al. 1968: 47). Detailed molecular data from *P. arcadiensis* and *P. greuteriana,* as well as from taxa of both *P.* sect. *Plumosistylae* and *P.* sect. *Crassinerviae,* could help elucidate the relationships of the two Greek endemic *Potentilla* species and their relatives.

Identification key to the Greek and the S-SE Anatolian & E Mediterranean *Potentilla* species related to *P. greuteriana.*

1. Loose inflorescence 2
-. Compact inflorescence 5
2. Petals pilose, oblong, acute .... ***P. arcadiensis***
-. Petals glabrous, obovate, obtuse 3
3. Achenes pubescent, leaflet margins crenulate to serrate .... ***P. davisii***
-. Achenes glabrous, leaflet margins dentate 4
4. Lateral teeth of leaflets (3-)4(-5), epicalyx segments 2-4 mm long .... ***P. nerimaniae***
-. Lateral teeth of leaflets (6-)8-9(-10), epicalyx segments 4-5 mm .... ***P. ulrichii***
5. Petal shape elliptic, lateral teeth of leaflets 3-5(-6), acute .... ***P. isaurica***
-. Petal shape obovate to ovate, lateral teeth of leaflets 5-9, obtuse 6
6. Lateral teeth of leaflets 5-9, achenes pilose, styles plumose .... ***P. libanotica***
-. Lateral teeth of leaflets 5-6, achenes pilose only at the apex, styles usually pubescent or rarely glabrous .... ***P. greuteriana***

Specimens seen

Potentilla greuteriana

GREECE: S Peloponnisos: Prov. Arkadias: Mt. N Taigetos, W-SW of Xerovouni summit, 37° 09'N, 22° 13' E, 1150-1200 m, 5 Aug 2012, *Ch. Kyriakopoulos & Chr. Papagiannopoulos* 1300 (Herb. Phitos & Kamari, UPA); ibidem: 24 Jun 2013, *Ch. Kyriakopoulos* 1530 (Herb. Phitos & Kamari, UPA); ibidem: 23 Juy 2013, *Ch. Kyriakopoulos* 1697 (Herb. Phitos & Kamari, UPA); ibidem: 16 Jul 2015, *Ch. Kyriakopoulos* 2240 (Herb. Phitos & Kamari, UPA); ibidem: 24 Sept 2015, *Ch. Kyriakopoulos* 2249 (Herb. Phitos & Kamari, UPA); ibidem: 11 May 2016, *Ch. Kyriakopoulos* 2264 (Herb. Phitos & Kamari, UPA); ibidem: alt. c. 1150 m, with *Pinguicula cristallina* subsp. *hirtiflora, Campanula asperuloides, Teucrium aroanium* etc, on vertical karstified limestone rocks, 9 Jul 2017, *Ch. Kyriakopoulos* 2334 (Holotype: Herb. Phitos & Kamari, UPA; Isotypes: ACA and PAL-Gr).

GREECE: S Peloponnisos: Prov. Lakonias: Mt. Taigetos, Langada gorge, on vertical limestone cliffs, 37° 04' N, 22° 18' E, 750-800 m, 31 Jul 2011, *Ch. Kyriakopoulos* 895 (Herb. Phitos & Kamari, UPA); ibidem: 22 Jun 2012, *Ch. Kyriakopoulos & E. Kartsonas* 968b, (Herb. Phitos & Kamari, UPA); ibidem: 25 Jun 2012, *Ch. Kyriakopoulos* 1103 (Herb. Phitos & Kamari, UPA); ibidem: with *Campanula asperuloides*, 5 Aug 2012, *Ch. Kyriakopoulos & Chr. Papagiannopoulos* 1310 (Herb. Phitos & Kamari, UPA).

Potentilla arcadiensis

GREECE: E Peloponnisos: Arkadia: Mt. Parnonas, in declivibus orientalibus montis Parnon; ad Monasterium Elona, in rupestribus calc., alt. c. 550 m, 7 Jul 1983, *G. Iatrou* 1911 (Holotype: UPA); ibidem: the nunnery of Agios Nikolaos Sintzas, c. 6.4 km, SW the village of Leonidion, steep, calcareous rocks mostly to the N and SE of the nunnery, 37° 0.8' N, 22° 49' E, alt. 550-600 m, 30 May 2003, *Th. Constantinidis & E. Kalpoutzakis* 10677 (Herb. Phitos & Kamari, UPA); ibidem: monastery of Panagia Elona, vertical limestone cliffs after the monastery entrance, 37° 09' N, 22°45' E, alt. 500 m, 10 Jul 2016, *Ch. Kyriakopoulos* 2293 (Herb. Phitos & Kamari, UPA).

Potentilla davisii

TURKEY: C2 Denizli: Acipayam, Bozdag, Olukbaîi, above Geyran Yayla, 1450 m, rocks, 4 Aug 1997, Aytaç 7648 (Isotype E00075639); Bozdag, near Geyran Yayla, 4500 ft, rocks, 16 Jul 1947, Davis 13334 (Paratype E00146056); ibidem: 5000-5500 ft, Davis 13435 (Paratype E00146055).

Potentilla isaurica

TURKEY: C2 Antalya: Vil. Antalya (Isauria): Kargi Chai, between Durbanas and Derince valley, in cliffs, fl. white, 25 Aug 1947, *Davis* 14466 (Holotype E00010703, Paratype K000762317);
C4 Antalya: Alanya, Dimçayi vadisi, 1200 m, 10 Oct 1992, *Duman* 4677 & *Karaveliogullari* (E00077481).

Potentilla libanotica

LEBANON: Liban, in mount Libano, 1837, Aucher-Eloy 1457 (P03342030); In declivita Libani borealis occidentalibus, prope pagum Ehden, 1450-1700 m, 30 Jun-2 Jul 1910, *Bornmüller* 11766 (E00146058); Bcharré [sentier des Cèdres] (Liban), 1800 m, 14 August 1927, *Gombault* 17 (P03342020); Mt. Lebanon, Akoura, 2000 m, 30 Jul 1932, *Louis* [Frères Maristes d'Alep] s.n. (P04173512); ibidem: Aqoura, 31 Jul 1932, *Gombault* 1981 (P03342018, P03342019, P03342021, P03342018).

SYRIA: Hadret, 1822, *Ehrenberg* 322 (L.1901646); Syria, 1846, *Pinard* s.n. (E00409399).

TURKEY: C5 Içel: Kapudschi Dere, an Felsen, 1896, *Siehe* 643 (E00146059); Osmaniye: Amanus: Mont de Düldül, 1500-2000 m, 15 Aug 1911, *Haradjian* 3890 (E00409400).

Potentilla nerimaniae
TURKEY: C2 Antalya: Elmali, Çiglikara, 1900-1950 m, on calcareous rocks, 1 Aug 1995, *Duman*, *Ekici* & *Duran* (Duman 5978), (Isotype E00009314).

Potentilla ulrichii
TURKEY: C3 Antalya: Abzweig der Straße Manavgat - Akseki, nahe Ahmetler SW Muratiçi, 500 m, überhängende, schattige Kalkwand, Exp. E, 15 Oct 2000, *Ulrich* 121 (Holotype B100293986); Balme, nahe Ahmetler sudwest l. Murtiçi, 360 m, Exp. NW, 23 Apr 1997, *Ulrich* (paratype E00084587); near Ahmetler, crevices of limestone rocks, 330 m, Exp. N, 26 Aug 1998, *Ulrich* (Paratype E00077698).

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S. Samaropoulou, P. Bareka & G. Kamari

Biodiversity of the genus *Fritillaria* (*Liliaceae*) in Greece

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Key words: karyology, hybrodization, taxonomy.

Fritillaria L. is a genus of perennial bulbous plants, very important from a taxonomic, pharmaceutical, horticultural and karyological point of view. Greece has been characterized as an evolutionary centre of the subgenus *Fritillaria* L. since there are at least 31 taxa, most of them endemic to the country. Following both morphological and biogeographical data, Greek *Fritillaria* taxa can be classified into smaller groups.

The chromosome number $2n = 2x = 24$ is common among Greek representatives of the genus, except from *F. montana* ($2n = 2x = 18$). The karyotypes are asymmetrical, consisting of one metacentric and one submetacentric chromosome pair, while the rest are acrocentrics and subtelocentrics. In order to define the differences among the generally similar karyotypes, differentiations such as the presence and morphology of satellited chromosomes, secondary constrictions and B-chromosomes are always emphasized and chromosomes characterized as meta- and submetacentric, satellited or bearing secondary constrictions, are studied as markers. Moreover triploidy ($2n = 3x = 36$ and $2n = 3x = 27$) has been referred for a few Greek *Fritillaria* taxa.

Hybridization in the genus is reported as rare, however in Greece hybrids have been found at areas where two or more taxa co-exist. These hybrids are characterized by morphologically intermediate forms and karyologically different karyotype morphology, ploidy levels and number of B-chromosomes.

The morphological and karyological variety prove the genus is evolving. Hybridization is a very important key to evolution as it can lead to gene flow and consequently to many possible genotypes, sometimes more adaptable to the environment than their parents. In addition, B-chromosomes and polyploidy lead to important genome size variation and consequently to speciation. But what remains as a question is whether these procedures are responsible for the great number of *Fritillaria* taxa in Greece.

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Invasive alien species: potential cheap resources of plant substances for medicinal use*

Abstract

Kozuharova, E., Ionkova, I. & Raimondo, F. M.: Invasive alien species: potential cheap resources of plant substances for medicinal use. — Bocconea 28: 223-236. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

On the basis of the literature examined, the scientific acquisitions concerning the pharmacological properties and medicinal uses of *Ambrosia artemisiifolia* and *Erigeron canadensis* – two American vascular plants of Asteraceae family that have become invasive in Europe and others continents – are collected and discussed. The data reveal the potential of the invasive as cheap sources of compounds with valuable pharmacological activities. In addition to the two plants presented as a case study, there are hundreds of plant species at hand as potential assets to explore and make money.

Key words: *Ambrosia artemisiifolia*, *Erigeron canadensis*, *Asteraceae*, biologically active compounds, pharmacological activity, management, ecosystem services.

Introduction

Some alien plant species have high tolerance of various habitat conditions and elevated propagation ability. This promotes their aggressive invasive behaviour. Often they over compete the local vegetation. Additionally many of them suppress the seed germination and seedling development of local plants. In the newly invaded habitats they might not have suitable herbivores to control their populations (DAISIE 2009). The only effective enemy might be *Homo sapiens*. Humans are known with their destructive power once an object has become significant for industrial utilization. Due to the fact that these are aggressive invasive species, they can provide abundant and cheap resources of plant bioactive compounds which can be used for medicinal purposes. Additionally, excessive harvesting for medicinal use might contribute to decrease their populations and reduce the destructive impact of these species on natural habitats.

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The good practice in the traditional use of plants for remedial purposes is a precondition for successful phyto-therapeutic application. On these basis a modern scientific approach such as phytochemical and pharmacological investigations affirms the therapeutic effect.

Echinacea purpurea (L.) Moench. is an example of a plant with growing modern popularity based on good practices in Native Americans' traditional medicine (Austin 2004, Wilkes 2012).

The aim of this contribution is to review research data and reveal the potential of two invasive plants of *Asteraceae* family as cheap sources of compounds with valuable pharmacological activities.

Material and metods

On the basis of the literature examined, the scientific acquisitions concerning the pharmacological properties and uses of *Ambrosia artemisiifolia* L. and *Erigeron canadensis* L., two American species that have become invasive on different continents, are collected and discussed. Some brief botanical, distributive and ecological indications on these two species are given below.

Ambrosia artemisiifolia is an annual plant native to North America across Canada, the eastern and central United States, the Great Plains, and in Alaska; the Caribbean on Cuba, Hispaniola, and Jamaica; and South America in the southern bioregion (Argentina, Chile, Paraguay, Uruguay), the western bioregion (Bolivia, Peru), and Brazil. This species has been introduced in Europe at the end of 19th century in seed crops at various independent geographical points and at various times since its introduction in natural habitats. Recently, the number of naturalized populations increased considerably fast and it is considered to be the one of the most dangerous invasive alien species of Europe (Chauvel & al. 2006; Kazinczi & al 2008; Essl & al. 2009; DAISIE 2009; Hodgins & al. 2013).

Erigeron canadensis [= *Conyza canadensis* (L.) Cronquist] is an erect, annual plant. It is native throughout most of North America and Central America and invasive in Europe. It was introduced into Europe in the mid 17th century, likely along with Canadian furs shipped to France (Tilley 2012). This plant is associated with disturbed, open and unshaded habitats, such as cultivated land, abandoned fields, roadsides, ruderal places, and other open habitats. Canadian horseweed can reduce crop yields through direct competition for resources. (Tilley 2012). It also contains allelopathic chemicals which can inhibit germination and reduce seedling growth in several species (Shaukat & al. 2003).

On the two plants chosen as a case study (*Ambrosia artemisiifolia* and *Erigeron canadensis*), here we present: 1) traditional ethnobotanical data from their native habitats; 2) modern investigations of pharmacological activity and essential secondary compounds.

The case studies

Ambrosia artemisiifolia (Fig.1).

This species contains phytotoxins and shows significant inhibitory effects on the seed germination and primary growth of crops (Ritter & Coble 1981; Wang & Zhu 1995;

Fig. 1. Drawing of *Ambrosia artemisiifolia* from Bulgarian population (by E. Kozuharova).

Brückner & al. 2003; Vidotto & al. 2013). High levels of naturally occurring variation in the ALS gene sequence have been found in *A. artemisiifolia* allowing rapid and widespread selection for resistance when ALS-inhibiting herbicides are used (Tranel & al. 2004). The main problem is that its pollen is well known as noxious allergen (Mirone & al. 2004; D'Amato & al. 2007; Léonard & al. 2010).

There are different therapeutic effects known to the Native Americans, which are well documented (Gilmore 1913; Speck 1941; Tantaquidgeon 1972; Hamel & al. 1975; Herrick 1977; Shemluck 1982; Anderson & al 1988; Austin 2004, Table 1).

Table 1. Ethnobotanical data and therapeutic effects of *Ambrosia artemisiifolia* known to the Native Americans.

Tribe	Therapeuti effect	Method of application	References
Cherokee	Dermatological Aid	Crushed leaves rubbed on insect sting and infusion of leaf rubbed on hives.	Hamel & al. 1975, Moerman 1998
	Disinfectant	Juice of wilted leaves applied to infected toes.	Hamel & al. 1975 Moerman 1998
	Febrifuge	Infusion of leaf taken for fever.	Hamel & al. 1975 Moerman 1998
	Pulmonary Aid	Infusion taken for pneumonia.	Hamel & al. 1975 Moerman 1998
Dakota	Antidiarrheal	Infusion of leaves and plant tops taken for bloody flux.	Gilmore 1913 Moerman 1998
	Antiemetic	Infusion of leaves and plant tops taken for vomiting.	Gilmore 1913 Moerman 1998
Delaware	Blood Medicine	Poultice of plant used to prevent blood poisoning.	Tantaquidgeon 1972, Moerman 1998
Houma	Gynecological Aid	Decoction of root taken for menstrual troubles.	Speck 1941, Moerman 1998
Iroquois	Antidiarrheal	Compound decoction of plants taken for diarrhea with bleeding.	Herrick 1977, Moerman 1998
	Heart Medicine	Infusion of roots taken for stroke.	Herrick 1977, Moerman 1998
	Orthopedic Aid	Decoction of plants taken for cramps from picking berries.	Herrick 1977, Moerman 1998
Lakota	Antirheumatic (External)	Infusion of leaves applied to swellings.	Rogers 1980, Moerman 1998
		Plant used for toilet paper.	Rogers 1980, Austin 2004, Moerman 1998
Luiseno	Emetic	Plant used as an emetic.	Sparkman 1908, Moerman 1998
Mahuna	Dermatological Aid	Infusion of plant used as a wash for minor skin eruptions and scalp diseases.	Romero1954, Moerman 1998
Oto	Antiemetic	Bruised leaves laid on scarified abdomen for nausea.	Gilmore 1919, Moerman 1998

It contains sesquiterpenoids-sesquiterpene lactones, etc. (Bianchi & al. 1968; David & al. 1999; Sturgeon & al. 2005; Taglialatela-Scafati & al. 2012; Huang & al. 2014; Ding & al. 2015; Kiss & al. 2017) as well as polyphenols and flavonoids (Parkhomenko & al. 2005, 2006; Maksimovic 2008) or other constituents (Georgiev & al. 2007).

Pharmacological tests revealed that *Ambrosia artemisiifolia* possess numerous activities such as cytotoxic, antimalarial, antimicrobial, anti-inflammatory, pronounced hepatoprotective and hypolipemic-lowers the concentration of fats in the blood (Table 2).

Principal constituents of the essential oil obtained by steam destilation are germacrene D (24.1%), limonene (16.83%), α-pinene (8.0%) and myrcene (7.4%) with significant bactericidal and fungicidal activity (Chalchat & al. 2004, Table 2).

Table 2. Pharmacological activities of *Ambrosia artemisiifolia*.

Activity of the plant extracts	Reference
Antioxidant	Maksimovic 2008
Hypolipemic	Parkhomenko & al. 2005, 2006
Hepatoprotective	Parkhomenko & al. 2005, 2006
Cytotoxic	Bianchi & al. 1968; David & al. 1999; Sturgeon & al. 2005; Huang & al. 2014; Kiss & al. 2017
Antimalarial	David & al. 1999
Antimicrobial: antifungal, antibacterial, antiviral	Georgiev 2007; Solujić & al. 2008
Anti-inflammatory	Pérez 1996
Activity of the essential oil	
Significant bactericidal and fungicidal activity	Chalchat & al. 2004

Erigeron canadensis (Fig. 2).

Ethnobotanical investigations reveal that there are number of therapeutic effects known to the Native Americans (Moerman 1998, 2009; Pennacio & al. 2010; Austin 2010, Table 3). It is claimed that in folk medicine this plant is used in diarrhea, dysentery uterine hemorrhages, dropsy, gravel, cystitis, calculus, bronchial catarrh, and hemoptysis (Yan & al. 2010, Shakirullah & al. 2011) but there is no indication for original native American tradition Phytochemical studies revealed that *Erigeron canadensis* contained saponins, diterpenoids, terpenoids, glycosides, tannin, anthraquinone, steroids and flavonoids (quercetin-7-O-beta-D-galacto pyranoside,quercetin, luteolin, apigenin, 5,7,4'- trihydroxy-3'-methoxy flavone, quercetin-3-alpharhamnopyranoside, quercetin-3-O-beta-Dglucopyranoside, apigenin-7-O-beta-D-gluco pyranoside, luteolin-7-O-beta-D-glucuronide methyl ester,4'-hydroxy baicalein-7-O-beta-Dglucopyranoside, baicalein and rutin). Also conyzolide; conyzoflavone; conyzapyranone A; conyzapyranone B; 4 Z,8 Z-matricaria- γ-lactone; 4 E,8 Z-matricaria- γ-lactone; 9,12,13-trihydroxy10(E)-octadecenoic acid; epifriedelanol; friedeline; taraxerol; simiarenol; spinasterol; stigmasterol; β- sitosterol; C10 acetylenes; sesqui-

Table 3. Ethnobotanical data and therapeutic effects of *Erigeron canadensis* known to the Native Americans.

Tribe	Method of application	Therapeutic effect	References
Native Americans	smoke the flowers and leaves	for pleasure or to relive head colds.	Pennacio & al. 2010
Native Americans		gastointestinal aid	Moerman 2009
Chumash	grind the plant tea	relive pain kidney problems	Austin 2010
Navajo	crush leaves to	treat skin problems	Austin 2010

Table 4. Pharmacological activities of *Erigeron canadensis*.

Activity of the plant extracts	Reference
Antioxidant (potent radical scavenging activity)	Olas & al. 2006; Saluk-Juszczak & al. 2010; Shah & al. 2012; Park & al. 2013
Anti-platelet and anticoagulant	Olas & al. 2006; Saluk-Juszczak & al. 2010; Pawlaczyk & al. 2011
Antiinflammatory	Lenfeld & al. 1986, Sung & al. 2014
Antiproliferative	Réthy 2007; Réthy & al. 2007; Csupor-Löffler & al. 2009, 2011
Anti-gastric ulcer	Park & al. 2013
De-pigmentation	Hong & al. 2008
Antibacterial	Biswas & Sinha 2014
Reduce blood glucose level in vitro	Aslam & al. 2018
Activity of the essential oil	
Anti-inflammatory	Guenter 1976
Haemostatic	Guenter 1976
Stimulant	Guenter 1976
Carminative	Guenter 1976
Antiproliferative	Choi 2008,
Antifungal - evaluated to weak	Curini & al. 2003
Antifungal - evaluated to moderate or strong activity against *Candida, Cryptococcus, Trichophyton, Rhodotorula* but no antibacterial activity	Veres & al. 2012
Anti-melanoma B16 activity	Yan & al. 2010

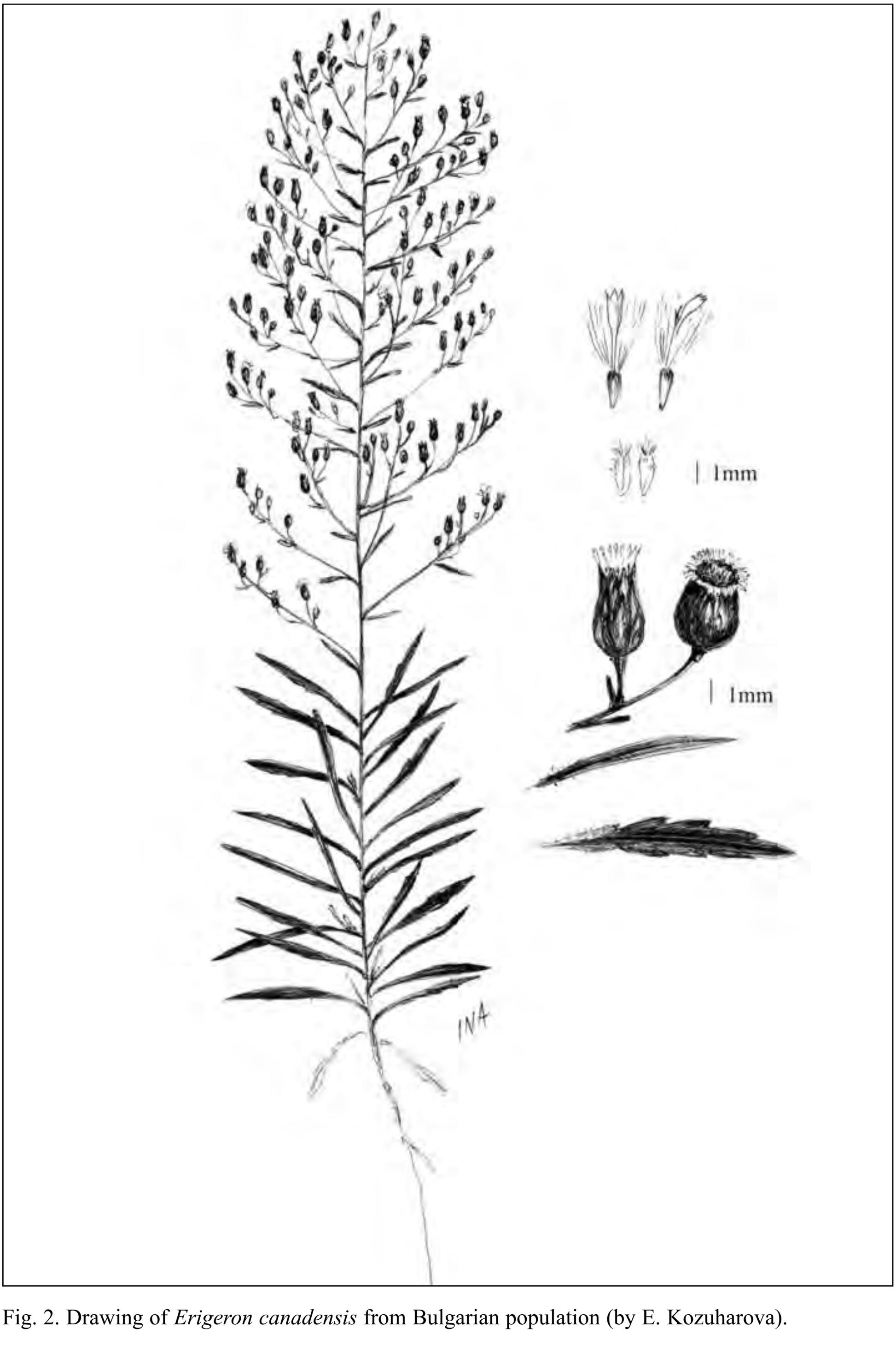

Fig. 2. Drawing of *Erigeron canadensis* from Bulgarian population (by E. Kozuharova).

terpene hydrocarbons, beta-santalene, beta-himachalene, cuparene, alpha-curcumene, gamma-cadinene, sphingolipids 1,3,5-trihydroxy-2-hexadecanoyl amino-(6E,9E)-heptacosdiene; 1,3,5-trihydroxy-2- hexadecanoylamino-(6E,9E)-heptacosdiene-1-Oglucopyranoside; 1,3-dihydroxy-2-hexanoylamino- (4E)-heptadecene; p-hydroxybenzoic acid, 3,5- dihydroxybenzoic acid, 3,5-dimethoxybenzoic acid; 3beta-hydroxyolean-12-en-28-oic acid; 3beta-erythrodiol; beta-sitosterol; stigmasterol; beta-sitosterol 3-O-beta-D-glucoside and harmine were isolated from different parts of the plant (Bohlmann & Jakupovic 1979; Lenfeld & al. 1986; Czeczot & al. 1990; Mukhtar & al. 2002a, 2002b; Wei & al. 2007; Shakirullah & al. 2011; Csupor-Löffler & al. 2011; Shao 2012; Shah & al. 2012; Veres & al. 2012; Biswas & Sinha 2014).

Extracts of *Erigeron canadensis* were reported to have anti-inflammatory and anti-proliferative activity as well as gastric ulcer protective effect. Also anti-inflammatory, de-pigmentation, anti-coagulant, anti-platelet and anti-oxidant effects are reported (Table 4).

Health risks or side effects following the proper administration of designated therapeutic dosages were not recorded (Anonymous 2000).

The essential oil contains more than 30 constituents but is mainly composed of monoterpenoids-limomene, camphene, α and β-pinenes etc., and sesquiterpenoids – caryophyllene, germacrene D and α-curcumene etc. (Miyazawa & al. 1992; Lis & Góra 2000; Rustaiyan & al. 2004; Tzakou & al. 2005; Lis & al. 2005; Unnithan & al. 2014, Ayaz & al. 2017). A few non-terpenoid acetylenic compounds were also detected (Unnithan & al. 2014). The compounds isolated from essential oils differ among different locations which may be attributed to the different environmental and climatic conditions (Unnithan & al. 2014).

The essential oil of *Erigeron canadensis* possess anti-inflammatory, haemostatic, stimulant, carminative and antifungal activity (Table 4).

Discussion and conclusion

Ethnobotanical data from their habitats reveal promising medicinal potential. A growing body of scientific literature points to their therapeutic properties. Valuable chemical constituents of these alien invasive species are sesquiterpene lactones, essential oils etc. They posses different activities such as anticancer activity, as well as antitussive, antifungal, antiinflammatory, antinociceptive, hypoglycaemic, antimitotic, antioxidant, antitrypanosomal, CNS depressant activity, diuretic effects, contact dermatitis, insecticidal and herbicidal activities, hepatoprotective and hypolipemic activities etc.

Due to the fact that these are aggressive invasive species, they can provide abundant and cheap resources reach of plant chemical constituents which can be utilized for therapeutic purposes. Additionally, exploitation of the biomass for medicinal use might contribute to relieving the destructive impact of these species on natural habitats.

The invasive plant species considered in this contribution deserve further investigations as they have valuable pharmacological activities. Harvesting of the plants for their medicinal value may reduce the populations due to decreased seed production and propagation. This way additionally the risk of allergy caused by *Ambrosia artemisiifolia* pollen will decrease.

There are many studies conducted on the two species here examined and there is good reason to believe that there are prospects of study that can still provide other products that can contribute to give further value to negatively evaluated biological resources, since they are seen as harmful and competitive agents and not as a resource. Therefore, unexplored fields remain to which new research can be directed. In addition to the plants presented as a case study, there are hundreds of species at hand as potential assets to explore and make money.

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Ali Said Faqi

Botanical Pharmaceuticals: from Bench to Market

Faqi, A. S.: Botanical Pharmaceuticals: from Bench to Market. — Bocc. 28: 237. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: botanical drug, drug development, drug regulatory submission.

Plants have a long history of use in Medicine and have been used by all cultures or ethnic groups throughout history of humanity. They have always been a common source of medicine either in the form of traditional preparations or as pure active principles. Their use is similar to the way modern pharmaceutical are used today. Many botanical medicines contain curative principal active substances, which have proven to be valuable as primary or supplemental therapies when carefully applied. Plants are an essential source for the discovery of novel pharmacologically active compounds, with many blockbuster drugs being directly or indirectly extracted from plants. Medicinal plant drug discovery continues to provide new and important leads against various pharmacological targets including cancer, HIV/AIDS, Alzheimer's, Malaria and Pain. Approximately 75% of the new chemical entities (NCE's) reported between 1981 and 2006 resulted from studies of natural products.

Botanical drug development is challenging as the inherent nature of these products is that they are generally, extracts of plants rather than chemically pure compounds. The objective of this presentation is to discuss botanical drug development from lead identification, optimization and development to Nonclinical and Clinical Drug Development and regulatory submission and review to marketing approval.

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Effect of combination of *Citrus bergamia* (*Rutacae*) and *Cynara cardunculus* (*Compositae*) derivatives in liver dysfunction

Ragusa, S., Gliozzi, M., Musolino, V. & Mollace, V.: Effect of combination of *Citrus bergamia* (*Rutacae*) and *Cynara cardunculus* (*Compositae*) derivatives in liver dysfunction. — Bocc. 28: 239. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: bergamot, artichoke, metabolic disorders.

Non-alcoholic fatty liver disease (NAFLD) is a metabolic disorder which is considered the hepatic manifestation of the metabolic syndrome, being often related with diabetes and obesity. The development and the progression of NAFLD represents a continuum of events characterised by excessive hepatic fat accumulation (steatosis) in the absence of significant alcohol consumption, which can progress to nonalcoholic steatohepatitis (NASH); fibrosis, cirrhosis, and in some severe cases hepatocellular carcinoma (HCC). Although the evolution of NAFLD have been widely described, to date the molecular mechanisms triggered by an impaired lipid metabolism have not well understood and, as a consequence no approved therapy for NASH currently exists. Bergamot (*Citrus bergamia* Risso & Poiteau) has a particular composition of flavonoids and glycosides in its juice and albedo and it has been shown to have anti-oxidative and anti-inflammatory properties in patients suffering from metabolic syndrome. Moreover, Cynaropicrin, a sesquiterpene lactone of a guaianolide type isolated from artichoke (*Cynara cardunculus* L.) is a potent antioxidant and hence it can play a supportive role for liver in different hepatic diseases. Here, to investigate the protective effect of an innovative and unique combination of Bergamot polyphenol fraction (BPF) and *Cynara cardunculus* extract, known as Bergacyn, against pathological features of NASH, we used the better defined animal model of diet-induced non-alcoholic fatty liver disease (DIAMOND) that mimics the key physiological, cell-signalling, transcriptomic, metabolic and histologic modifications observed in humans suffering from progressive NASH.

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A. Attanzio, L. Tesoriere, M. Allegra & M. A. Livrea

Phytochemicals and Nutraceuticals: the biochemical core of the Mediterranean plants

Abstract

Attanzio, A., Tesoriere, L., Allegra, M. & Livrea, M. A.: Phytochemicals and Nutraceuticals: the biochemical core of the Mediterranean plants. — Bocc. 28: 241-247. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

The Mediterranean lands are ideal sites for providing any kind of green food. In this scenery Sicily may really be considered a Treasure Island. The known benefits from Mediterranean diet, and the ever-increasing awareness of the benefits from consumption of fruits and vegetables, generated a great input in researching about typical Sicilian species and their impact on human health. We first investigated properties and bioactivity of cactus pear fruits [*Opuntia ficus-indica* (L.) Mill.] and its characteristic phytochemicals, betanin and indicaxanthin. The latter, only occurring in the cactus pear among the edible fruits, has been the object of most of our research. Chemical, physico-chemical, antioxidant and reducing properties, as well as bioactivities, from anti-inflammatory to anti-proliferative, have been described in various systems, cell cultures and animal models. Moreover, we ascertained that indicaxanthin is highly bioavailable in man, making a real link between experimental set-ups and potential activity in the body.

In other studies on bioactive polymeric proanthocyanidin components of Sicilian pistachio (*Pistacia vera* L.), we observed inhibition of the inflammatory response triggered by cytokine IL-1B in human intestinal epithelial cells, suggesting beneficial effects for the gastro-intestinal pathophysiology.

Other investigations on extracts of caper (*Capparis spinosa* L.) showed antioxidative activity of caper, including the capacity of reducing the highly reactive hypervalent-iron heme, a radical formed in red meat during cooking. In addition, the extract components from a serving size (8.6 g capers), prevented the autoxidation of meat in a simulated gastric digestion.

Finally we are studying composition, reducing power, antioxidant potential, anti-inflammatory and anti-proliferative activity of manna, the product of spontaneous solidification of the sap pouring from appropriate incisions on the bark of the trunk and main branches of two different native species of ash (*Fraxinus ornus* L. and *F. angustifolia* Vahl) cultivated in North Sicily (Madonie). In addition, we patented a method to purify, and then re-qualify the waste matter from manna remaining adherent to the bark of the tree.

Key words: Mediterranean diet, Antioxidant activity, *Opuntia*, *Pistacia*, *Capparis*, *Fraxinus*, Manna.

The known benefits from Mediterranean diet, and the ever-increasing awareness of the benefits from consumption of fruits and vegetables, generated a great input in researching about typical Sicilian species and their impact on human health.

Our Lab has been one of the first to carry out systematic investigations on properties and bioactivity of cactus pear fruits [*Opuntia ficus-indica* (L.) Mill.] and its characteristic phytochemicals, betanin and indicaxanthin. The latter, only occurring in the cactus pear among the edible fruits, has been the object of most of our research. Chemical, physicochemical, antioxidant and reducing properties, as well as bioactivities, from anti-inflammatory to anti-proliferative, have been described in various systems, cell cultures and animal models. Moreover, we ascertained that indicaxanthin is highly bioavailable in man, making a real link between experimental set-ups and potential activity in the body (Livrea & Tesoriere 2015).

Discovering the activity of dietary phytochemicals at the level of intracellular signal transduction pathways is now considered the basis to suggest their eventual health effects. The bioactivity of these molecules is generally ascribed to redox and antioxidant properties, with a growing body of evidence indicating that most compounds are to be considered for their roles as modulators of redox-mediated signaling cascades, including those relevant to either survival or cell death. Betalains are nitrogen-containing pigments occurring in the *Cariophyllales* order of plants, including beetroot and cactus pear, and in some fungal genera. Indicaxanthin (Ind, Fig.1), the yellow betalain characterising the *Opuntia ficus-indica,* has recently emerged as a radical scavenger and antioxidant with peculiar physicochemical characteristics, allowing the molecule to interact with and locate in membranes and the potential to act at the level of body cells and tissues.

Anti-inflammatory and protective effects of Ind have been shown *in vitro*, in endothelial cell cultures, in either healthy or pathological erythrocytes, and in inflammatory rat model when administered at concentrations comparable with the amounts reached in man after a dietary supplementation with cactus pear fruits. Other studies showed modulatory activity of Ind on the contractility of isolated mouse ileal muscle. Differently from the majority of

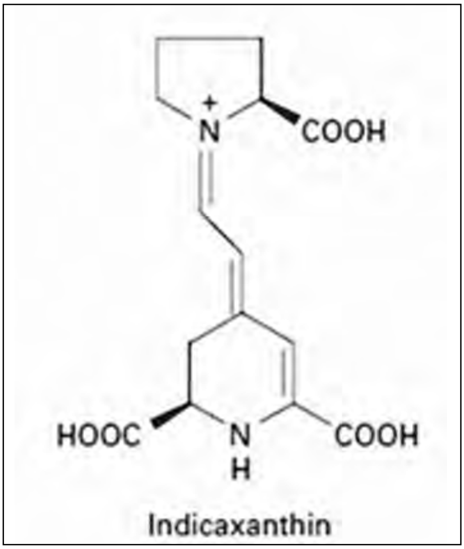

Fig. 1 Molecular structure of indicaxanthin.

dietary phytochemicals, Ind has appeared to be quite stable in absorptive gastrointestinal conditions, is not metabolized by human enterocytes or hepatocytes and is bioavailable, reaching plasma micromolar concentrations after ingestion of four fruits (Tesoriere & al. 2013).

A strong, reciprocal crosstalk between inflammation and melanoma has rigorously been demonstrated in recent years, showing how crucial is a pro-inflammatory microenvironment to drive therapy resistance and metastasis. We investigated on the effects of Indicaxanthin against human melanoma both *in vitro* and *in vivo*. The effects of indicaxanthin were evaluated against the proliferation of A375 human melanoma cell line and in a mice model of cutaneous melanoma. Cell proliferation was assessed by MTT assay, apoptosis by Annexin V-Fluorescein Isothiocyanate/Propidium Iodide staining, protein expression by western blotting. Melanoma lesions were subcutaneously injected in mice with B16/F10 cells, chemokine release was quantified by ELISA. We found that indicaxanthin effectively inhibits the proliferation of the highly metastatic and invasive A375 cells as shown by growth inhibition, apoptosis induction and cell invasiveness reduction. More interestingly, the *in vitro* data were paralleled by those *in vivo* showing that indicaxanthin significantly reduced tumor development when orally administered to mice. The results of our study also clarify the molecular mechanisms underlying the antiproliferative effect of indicaxanthin, individuating the inhibition of NF-kB pathway as predominant. In conclusion, we demonstrated that indicaxanthin represents a novel phytochemical able to significantly inhibit human melanoma cell proliferation *in vitro* and to impair tumor progression *in vivo*. When considering the resistance of melanoma to the current therapeutical approach and the very limited number of phytochemicals able to partially counteract it, our findings may be of interest to explore indicaxanthin potential in further and more complex melanoma studies in combo therapy, i.e. where different check points of melanoma development are targeted (Allegra & al. 2019).

In other studies on bioactive polymeric proanthocyanidin components of Sicilian pistachio (*Pistacia vera* L.), we observed inhibition of the inflammatory response triggered by cytokine IL-1β in human intestinal epithelial cells, suggesting beneficial effects for the gastro-intestinal pathophysiology. Intestinal epithelial cells (IECs) have a strategic position at the interface between the antigenic luminal environment and the internal milieu, and play an important role in the enteric immune system by establishing bidirectional interaction with the underlying immune cells. As a real physical barrier, IECs can modulate a direct exposure of immune cells to antigens and can initiate a transient inflammatory response with the secretion of inflammatory mediators. Inflammation of IECs to a moderate extent is normal and crucial to maintain gut structural integrity and function. On the other hand, alteration and dysregulation of inflammatory pathways can increase the number and activity of inflammatory cells in the gut mucosa, and substantially contribute to the pathogenesis of IBD. As the therapeutic approaches to IBD are not entirely satisfactory, the importance of prevention cannot be overlooked. In this context, the influence of dietary components on the mucosal inflammatory processes may be relevant. Plant polyphenols, in particular flavonoids, are one example of these compounds, and proanthocyanidins are a subgroup of flavonoids exhibiting potential biological actions, including anti-inflammatory activity. Data from human subjects show that high molecular weight proanthocyanidins - with more than three subunits - do not undergo intestinal absorption. However, beneficial effects of these dietary components on the digestive tract may not require efficient absorption through the gut. Rather, due to their high digestive stability and their poor intestinal absorption, these compounds could achieve high luminal concentrations thus meeting the potential conditions to participate in reactions relevant to digestive tract health through direct interaction with the IECs. In this context, plant extracts with high proanthocyanidin content have shown anti-inflammatory and protective effects in animal models of chronic intestinal inflammation, such as ulcerative colitis and inflammation-associated colorectal cancer. The genus *Pistacia* contains only 11 species among which *Pistacia vera* L. is the sole producing edible nuts. Experimental data show that the pistachio nut consumption has positive effects on human serum lipid profile and cardiovascular disease (CVD) risk factors and significantly improves oxidative status and reduces circulating inflammatory biomarkers. On the other hand, anti-inflammatory effects of pistachio nut are still poorly characterized from a molecular point of view.

Previous research from our group provided evidence that a hydrophilic extract from Sicilian pistachio nuts (HPE) contains substantial amounts of polyphenols, including proanthocyanidins, and possesses radical-scavenging and anti-oxidative properties. Moreover, we also demonstrated that HPE has anti-inflammatory activities in LPS activated macrophages, interfering with the NF-kB activation, and that its high molecular weight proanthocyanidins can play a major role as bioactive component of HPE. Dietary approaches to control inflammatory bowel diseases (IBD) may include proanthocyanidin-rich foods. We then studied the effects of HPE and of its polymeric proanthocyanidin fraction (PPF) in a cell model that simulated some conditions of IBD, consisting of interleukin (IL)-1β-stimulated Caco-2 cells. HPE was prepared by *Pistacia vera* L. nuts, and PPF was isolated from HPE by adsorbance chromatography. Proanthocyanidins were quantified as anthocyanidins after acidic hydrolysis. Differentiated Caco-2 cells were pre-incubated with HPE or PPF and then were exposed to IL-1β. Cell viability and parameters associated with nuclear factor-kB (NF-kB) activation were assayed. Adsorption of polymeric proanthocyanidins to the cell membrane was investigated by transepithelial electrical resistance (TEER) measurements. HPE decreased prostaglandin (PG)E_2 production, IL-6 and IL-8 release, and cyclooxygenase (COX)-2 expression. HPE also inhibited the increase in paracellular permeability and reduced NF-kB activation. Polymeric proanthocyanidins, tested at a concentration comparable with their content in HPE, produced effects comparable to HPE. Finally, cell exposure to PPF increases TEER of the epithelial monolayers. Our results provide evidence that pistachio nut components inhibit inflammatory response of intestinal epithelial cells *in vitro* and indicate polymeric proanthocyanidins as the major bioactive nut components. The protection implies inhibition of NF-kB activation and occurs in parallel with the adsorption of polymeric proanthocyanidins to cell membrane. Our findings suggest that intake of small amounts of pistachio nut can exert beneficial effects to gastrointestinal pathophysiology (Gentile & al. 2012, 2014).

Other investigations on extracts of caper (*Capparis spinosa* L.) showed antioxidative activity of caper, including the capacity of reducing the highly reactive hypervalent-iron heme, a radical formed in red meat during cooking. In addition, the extract components from a serving size (8,6 g capers), prevented the autoxidation of meat in a simulated gastric digestion.

Capparis spinosa L. is one of the most common aromatic plants growing wild in the dry regions around the Mediterranean basin. In Italy, this blue-gray spiny plant is intensively cultivated, particularly on small islands around Sicily, such as Pantelleria and the Eolian Salina, which provide 95% of the national product. Capers are appreciated for their pungent and bitter flavor and are used as an appetizer with olives, cheese, and nuts or as a complement to meat, salads, pasta, and other foods. The aromatic floral buds are gathered just before blooming and stabilized either in brine or in salt. During this processing the plant glucosinolates are converted to their cognate isothiocyanates, responsible for the characteristic flavor of the caper, in a concomitant fermentation process. The fermentation is completed within 30 days, and edible capers are usually marketed after 2–3 months. Apart from its use as flavoring, the caper has been known for centuries in traditional phytomedicine, which exploited its properties for several purposes. The aqueous extract from total aerial parts of the plant has been used for its antifungal, anti-inflammatory, antidiabetic, and antihyperlipidemic activities and is among the constituents of polyherbal formulations to treat liver ailments. Other investigations showed that raw floral buds contain lipids, alkaloids, glucocapperin as major glucosinolate, and a number of antioxidant phytochemicals such as flavonoids and other polyphenols. Quercetin-3-rutinoside (rutin) has appeared to be the most abundant flavonoid in *C. spinosa*.

Floral buds of *Capparis spinosa* L. are commonly used in the Mediterranean cuisine as flavoring for meat and other foods. We evaluated bioactive components and antioxidant activity of Sicilian capers from Pantelleria (Sicily) stabilized in salt. Whereas R-tocopherol was absent, low levels of γ-tocopherol and vitamin C were measured. With reference to one serving size (8.6 g of capers), rutin was 13.76 mg, isothiocyanates, recently acknowledged as anticarcinogen phytochemicals, were 42.14 μmol, total phenols were 4.19 mg of gallic acid equivalents (GAE), and the total antioxidant potential measured using the [2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)] diammonium salt (ABTS) cation radical decolorization assay was 25.8 μmol of Trolox equivalents. The antioxidative activity of a caper hydrophilic extract was assessed in a number of assays. The extract at 3.5 and 7.0 μM GAE exhibited a dose-dependent peroxyl radical scavenging activity in a methyl linoleate methanol solution oxidized by azo initiator, and reduced hypervalent iron myoglobin species formed from met-Mb and H_2O_2, at 180 μM GAE. The hydrophilic extract, at 70–280 μM GAE, caused a dose-dependent inhibition of lipid autoxidation in heated red meat, incubated with simulated gastric fluid for 180 min. In the same model rutin tested at a concentration corresponding to its content in the extract was ineffective, and R-tocopherol at 25 μM was poorly effective. The hydrophilic extract (70 μM GAE) prevented the consumption of the co-incubated R-tocopherol, whereas lipid oxidation was inhibited for the experimental time, suggesting cooperative interactions between extract components and the vitamin. The findings encourage the use of caper with foods that contribute oxidizable lipids in view of the association between dietary oxidized lipids and risk of oxidative stress-based diseases (Tesoriere & al. 2007).

Finally we are studying composition, reducing power, antioxidant potential, anti-inflammatory and anti-proliferative activity of the manna.

Known for centuries within the ethnobotanical field, the Sicilian *manna* is a very singular vegetable product. It is obtained during summertime, by the spontaneous solidification of the sap pouring from incisions done, according to traditional methods, on bark and main branches of some species of the genus *Fraxinus*. The production of manna requires a number of special conditions. The trees need to be grown in areas characterized by high temperatures, low humidity and low temperature range. Some areas of the Madonie Mountains in Northern Sicily are ideal pedoclimatic niches for the cultivation of the *Fraxinus* species, from which the sap is extracted and gathered using traditional methods. The manna from *Fraxinus* is available in thin cylindrical forms of whitish color (the "cannolo" manna) with a sweet and pleasant taste. In addition, we patented a method to purify, and then re-qualify the waste matter from manna remaining adherent to the bark of the tree.

The invention consists in a procedure allowing a total purification of waste matter from manna, in order to re-qualify this now neglected and undervalued material and obtain a final product with a high market price (10-15-fold the current one). The product so obtained contains all components of pure manna, and results further enriched with phenol bio-compounds known for health-promoting properties. The purified product may be utilized in the alimentary industry, and applied in pharmaceutical and cosmetic preparations.

Sugars, mono- and oligo- saccharides make up more than 80% of the dry weight of the *Fraxinus* manna. Among them mannitol is the main constituent, representing 50% of the total sugars. Therefore, health benefits of manna have mostly been ascribed to, and are consistent with, the properties of mannitol, a polyol involved in a wide range of physiological processes in plants as regulator of the pool of cellular reductants, as a cryoprotectant, osmotically active solute and as a hydroxyl radical scavenger. On the other hand, recent phytochemical characterization of the *Fraxinus* manna has revealed a fatty acid and phenol compounds profile comparable to that of most extra-virgin olive oils (Caligiani & al. 2013), which is consistent with the chemotaxonomic closeness between *Fraxinus* and *Olea* genera. The chemistry of these components suggests that, beyond the well known physiological effects due to the presence of mannitol, the manna may provide a reducing and antioxidant potential contributing to the redox homeostasis.

Despite the widespread use of the manna in the folk medicine, little or no scientific study addressed a systematic investigation on the reducing and antioxidant properties of the manna. We used two solvents, methanol and ethyl acetate, to extract and carry out a quali-quantitative analysis of phytochemical components of manna from *Fraxinus* ssp. grown in the Madonie mountains and investigated reducing and antioxidant properties of the extracts utilizing well established chemical and biological screening methods (manuscript in preparation).

The Mediterranean is one of the ideal places for providing any kind of green food. In particular Sicily may really be considered a Treasure Island. Sicilian fruits and vegetables, and their bioactive phytochemicals, are currently studied intensely for basic science and applied research. Understanding how these compounds exert physiological effects when ingested with food and exploiting the properties of the nutraceutical components is the key goal of our study of molecular nutrition.

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Elena Conti

Macro- and micro-evolutionary perspectives on diversification: linking pattern with process

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Key words: angiosperm, evolution, phylogeny.

Recent reviews have addressed the state of our knowledge on angiosperm evolution, focusing primarily on macroevolutionary patterns. What is still largely missing is the link between macroevolutionary outcomes (in other words, the patterns that we can observe in the distribution of diversity across lineages) and the processes that generate these outcomes. For example, once we identify a genomic, morphological, ecological, or distributional change that appears to be correlated with a shift of diversification rates in a phylogeny, can we discover how the change affected processes of speciation and extinction? What are the likely intrinsic and extrinsic drivers that shape biological variation and species divergence in sympatry vs. allopatry? What is the relationship between species integrity and gene flow at that most challenging of hierarchical levels, where microevolution meets macroevolution? In this talk, I argue that one way of linking macro- and microevolution is by combining studies at multiple hierarchical scales in focal taxa, de facto turning them into model lineages for evolutionary biology. I will refer primarily, but not exclusively, to my work on primroses, where I try to accomplish the goal of relating macroevolutionary patterns to microevolutionary processes. The interconnections between these hierarchical levels can best be elucidated by investigating target taxa and integrating evidence from a range of methodological approaches, including phylogenetics, population genetics, comparative genomics, experimental and functional studies, and morphological and modeling analyses. I will conclude by highlighting current challenges to a more holistic understanding of evolution before suggesting possible ways forward.

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C. Oberprieler, F. Wagner, U. Lautenschlager, T. Ott, S. Tomasello & R. Vogt

Phylogeny, biogeography and species delimitation in the *Compositae-Anthemideae*

Oberprieler, C., Wagner, F., Lautenschlager, U., Ott, T., Tomasello, S. & Vogt, R.: Phylogeny, biogeography and species delimitation in the *Compositae-Anthemideae*. — Bocc. 28: 251. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: hybrid detection, polyploidy, reticulate evolution.

The chamomile tribe of the sunflower family (*Compositae*, *Anthemideae*) provides a plethora of examples for Biology´s Second Law, which complements Biology´s First Law (´In the absence of selection and constraint, complexity – in the sense of differentiation among parts – will tend to increase.´) by adding that ´Complexity does not increase through differentiation but also through (re)combination, reticulation, and exchange´. Especially hybridisation and homoploid and polyploid hybrid speciation are very common phenomena in the tribe that support the importance of reticulations in plant evolution and the growth of biodiversity. The present contribution will summarise studies of the last years dealing with reticulate evolution in *Anthemis*, *Leptinella*, *Leucanthemopsis*, and *Leucanthemum*. It will also present novel methodological approaches towards hybrid detection, species tree reconstruction in hybridising species complexes, and species network reconstruction in polyploid genera. Methodological progress in species delimitation based on next-generation-sequencing (NGS) will be exemplified in the heavily hybridising, diploid genus *Rhodanthemum* from NW Africa and the polyploid complex of the S European genus *Leucanthemum.*

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K. Marhold, M. Šlenker, H. Kudoh, T. Mandáková & J. Zozomová-Lihová

Discovery and introduction of *Cardamine occulta* (*Brassicaceae*) into Europe

Marhold, K., Šlenker, M., Kudoh, H., Mandáková, T. & Zozomová-Lihová J.: Discovery and introduction of *Cardamine occulta* (*Brassicaceae*) into Europe. — Bocc. 28: 253-254. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: karyology, xenophytes, *Cardamine*.

Schulz in 1903, in his monograph of *Cardamine* (*Brassicaceae*), treated *C. flexuosa* in a wide sense with a number of subspecies, varieties and forms. Out of the infraspecific taxa recognised by him, only *C. scutata* Thunb., *C. fallax* (O.E. Schulz) Nakai and *C. pennsylvanica* Willd. are now generally recognised as separate species. The remaining part of *C. flexuosa* had until recently been treated as a single species without recognising any infraspecific taxa. In 2006, however, Lihová et al. showed that Eastern Asian weedy populations assigned to *C. flexuosa* represent a separate cytotype and genetic lineage. Recently, the name *C. occulta* Hornem. was determined for these Asian populations. While an octoploid level was ascertained for *C. occulta*, the tetraploid level was confirmed for *C. flexuosa*, as well as for their close relatives from Asia, *C. scutata* and the recently described *C. kokaiensis* Yahara & al. The relative monoploid genome sizes were found to be strikingly different between these species. Variation in genome size agrees with different polyploid origins suggested based on genomic *in situ* hybridisation and comparative chromosome painting. These data indicate an autopolyploid origin of *C. kokaiensis* from a parental genome related to *C. parviflora* L. By contrast, an allopolyploid origin has been shown for the other species: *C. scutata* most likely originated via crossing of *C. amara* L. with *C. parviflora*, and *C. flexuosa* from *C. amara* and *C. hirsuta* L. Interestingly, *C. occulta* most probably originated through allopolyploid hybridisation of *C. scutata* and *C. kokaiensis*. While *C. occulta* is widespread in Asia and has been recorded in other continents for a long time, in Europe it was discovered only recently: in 1977 it was collected at Vercelli (Italy) and in 1993 in the province of Alicante (Spain). Nevertheless, currently it is present throughout most of the European countries, its spreading being supported mostly by horticulture.

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P. Campisi, M. G. Dia & M. L. Marino

An analysis of the bryophyte flora in Sicilian archaeological areas*

Abstract

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An analysis of the bryophyte diversity in the studied Sicilian archaeological areas was conducted, highlighting which species are more common and potentially harmful on the ruins.
The floras are much diversified and the presence of some rare taxa highlights the role of refuge carried out by these areas, especially for the species of strongly threatened coastal habitats. Attention on the complexity of the relationships between restoration interventions on lithic structures and conservation needs of the rare and interesting taxa is point out.

Key words: Mediterranean area, biodeterioration, rare bryophyte taxa.

Introduction

Among Italian regions, Sicily is certainly one of those that boasts a particularly rich archaeological heritage, consisting of over 50 sites distributed throughout the territory, in many cases subjected to specific protections (Grella & al. 1997).

As evidenced by several studies, the archaeological areas are of considerable interest also from the naturalistic point of view as they represent refuge areas for numerous species threatened by urban expansion and generally host a high floristic diversity (Celesti Grapow & al. 1993-1994; Lucchese & Pignatti Wikus 1995; Ceschin & al. 2006; Minissale & al. 2015).

In Italy the studies on the flora of the archaeological sites started in the Nineties and Sicily is one of the regions most concerned by this research activity (Domina 2018).

In addition to the vascular component, also the cryptogamic one was investigated in Sicily, in order to improve the knowledge of the main biodeteriogens on the remains of the ancient human-made structures (Raimondo & al. 2008). Several researches have focused in particular on bryophyte floras, starting from the Nineties, as was pointed out by Gueli & al. (2005). Some of these studies have highlighted the presence in Sicilian archaeological areas of very rare taxa and therefore of conservation interest (Dia & al. 2003; Campisi & Provenzano 2004; Dia & Campisi 2006;Campisi & al. 2008; Dia & Campisi 2009),

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drawing attention to the need to clarify the deteriogenic role of bryophytes to evaluate in some cases the hypothesis of their maintenance on the ruins.

Here we analyze so far studied bryophyte floras in some archaeological areas of Sicily with the aim of evaluating the bryophyte diversity of the areas and highlighting which species are more common and potentially harmful on the ruins as well as wich species are worthy of conservation.

Materials and methods

The Archaeological Parks of Solunto and of Mount Iato in Palermo province, those of Segesta and Selinunte e Cave di Cusa in Trapani province, the Neapolis Archaeological Park of Syracuse town, the Temple of Cerere in Enna province and the Greco-Roman Theatre and the Roman Amphitheatre inside Catania town have been taken into consideration in this analysis (Table 1). In view of their naturalistic interest, some of these areas, in particular Mount Iato Archaeological Park, Selinunte and Cave di Cusa Archaeological Park and Solunto Archaeological Park, are included in the list of Sites of Community Interest (ITA020027 Monte Iato, Kumeta, Maganoce e Pizzo Parrino; ITA010011 Sistema dunale Capo Granitola, Porto Palo e Foce del Belice; ITA020019 Rupi di Catalfano e Capo Zafferano).The present study was based on bibliographic and unpublished data. In particular, we have considered the papers of Privitera & al. (1996), Lo Giudice & Cristaudo (1998), Di Benedetto & Grillo (1998), Puglisi (1999), Guglielmo & al. (2003) and Aiello & al. (2003). Furthermore, the data concerning bryophyte material collected by the authors in the Sicilian archaeological areas of Selinunte and Mount Iato were also taken into consideration.

The archeological areas of Selinunte, Syracuse, Catania, Solunto and Segesta are located at lowland or hilly altitudes (10-415 m a.s.l.) on the contrary Mount Iato and Enna are located at sub-mountain altitudes (850-970 m a.s.l.). Vegetation is mostly represented by xerophilous or mesophilous grasslands and garrigues; only at Selinunte psammophilous, wetlands communities and Mediterranean maquis also occur (Table 1).

The relevant samples are kept at the *Herbarium Mediterraneum Panormitanum* (PAL).

The nomenclature of the species comply with Söderström & al. (2016) for liverworts

Table 1. Studied areas and relatives data of surface, altitude and vegetation types.

Archaeological area	Abbreviation	Altitude (m a.s.l.)	Area size (ha)	Vegetation type
Mount Iato Archaeological Park (Palermo)	Ia	850	40	Mesophilous grasslands, garrigues
Segesta Archaeological Park (Trapani)	Sg	415	30	Xerophilous grasslands, garrigues
Selinunte and Cave di Cusa Archaeological Park (Trapani)	Sl	10	215	Psammophilous communities, Mediterranean maquis, wetlands communities, crops
Neapolis Archaeological Park (Syracuse)	Si	25	22	Xerophilous grasslands, crops
Solunto Archaeological Park (Palermo)	So	215	20	Xerophilous grasslands, garrigues
Greco-Roman Theatre and the Roman Amphitheatre (Catania)	Ca	25	0,6	Sinantropic communities
Temple of Ceres (Enna)	En	970	0.4	Subnitrofilous xerophilous grasslands

and hornworts and Ros & al. (2013) for mosses, with the exception of *Didymodon tophaceus* complex for which Kučera & al. (2018) is followed .

In order to characterize the floras of Sicilian archaeological areas, chorological and ecological features were compared. Chorotypes were taken from Düll (1983, 1984, 1985, 1992), where almost all taxa of studied sites are reported, with same abbreviations and for the construction of the chorological histogram they were after joined in five groups: temperate (temp, s.temp, temp-mont, subkont); oceanic-Mediterranean (oc-med, oc-submed, suboc-med, suboc-submed); Mediterranean (med, med-oc, submed, submed-oc, submed-suboc, submed-suboc-mont submed-mont); boreal (subbor, subbor-mont); oceanic (suboc).

Ellenberg's indicator values relating to light, temperature, moisture and substrate reaction, were taken from Düll (1991).

All available data were assembled in a Microsoft Access database, where for each taxon ecological indicator values, chorotypes, and occurrence in the Sicilian archaeological areas were recorded.

For each site, the ecological indicator mean values were calculated to draw radar diagram. In order to measure the level of similarity of the floras, a hierarchical cluster analysis using Jaccard's similarity index (Jaccard 1908), applied on a data matrix including presence–absence of moss and liverwort taxa, was performed with the Biodiversity Professional program (McAleece & al. 1997).

The bioclimatic thermotypes were derived from the thermotypes map provided by Pesaresi & al. (2014).

Moreover, with the aim of identifying the potentially most dangerous species for the integrity of the ruins, in the sites of Selinunte, Segesta and Solunto the following data were recorded by the authors in the field and analized:

1) frequency of taxa in five classes based on percentage occurrence in the total collection points of every archaeological area (I: 0–20%, II: 21-40%, III: 41-60%, IV: 61-80%, V: 81-100%); 2) percentage cover in five classes based on percentage cover of each species on the total surface colonized by the bryophytes in 30 ×30 cm areas, in every archaeological area (I: 0–20%, II: 21-40%, III: 41-60%, IV: 61-80%, V: 81-100%); 3) sporophyte or propagule production (production was considered high (+) when their occurrence was recorded in more than 30% of plants in the collected specimens, low (-) if in 30% of plants or less).

Life strategies were taken from Dierβen (2001) with same abbreviations.

In all figures and tabular material studied sites were indicated with following abbreviations: Ca: Greco-Roman Theatre and the Roman Amphitheatre in Catania town; En: Temple of Ceres in Enna town; Ia: Mount Iato Archaeological Park; Sg: Segesta Archeological Park: Si: Neapolis Archaeological Park in Syracuse town; Sl: Selinunte and Cave di Cusa Archeological Park; So: Solunto Archaeological Park.

Results and Discussion

Overall, the bryophyte flora of the Sicilian archaeological areas studied so far includes 88 taxa (75 mosses and 13 liverworts). They are listed in Table 2, where the presence in each area, ecological indicators and chorotypes are reported.

Table 2. List of taxa of studied archaeological areas and their ecological indicators (from Düll 1991) and chorotypes (from Düll 1983, 1984, 1985, 1992). L: light; T: temperature; M: moisture; R: substrate reaction. The abbreviations of archeological areas are given in Table 1.
Temp: temperate; s.temp: south-temperate; temp-mont: temperate-montane; subkont: subcontinental; oc-med: oceanic-Mediterranean; oc-submed: oceanic-submediterranean; suboc-med: suboceanic-Mediterranean; suboc-submed: suboceanic-submediterranean; med: Mediterranean; submed: submediterranean; submed-oc: submediterranean-oceanic; submed-suboc: submediterranean-suboceanic; submed-suboc-mont: submediterranean-suboceanic-montane; submed-mont: submediterranean-montane; med-oc: Mediterranean-oceanic; subbor: subboreal; subbor-mont: subboreal-montane; suboc: suboceanic.

	Archaeological areas							**Ecological indicators**				**Chorotypes**
Taxa	**Ca**	**En**	**Ia**	**Sg**	**Sl**	**Si**	**So**	**L**	**T**	**M**	**R**	
Cephaloziella baumgartneri Schiffn.	●	x	●	●	●	x	x	5	7	5	●	oc-med
Conocephalum conicum (L.) Dumort.	●	●	●	●	●	x	●	7	3	7	7	subbor-mont
Fossombronia caespitiformis (Raddi) De Not.	●	●	●	x	x	x	x	7	9	5	8	oc-med
Fossombronia pusilla (L.) Nees	●	●	●	●	●	x	●	7	7	7	3	suboc-submed
Lunularia cruciata (L.) Dumort. ex Lindb.	x	●	●	●	x	x	●	7	8	6	6	oc-med
Pellia endiviifolia (Dicks.) Dumort.	●	●	●	●	●	x	●	●	4	8	9	s.temp
Riccia atromarginata Levier	●	●	●	●	●	●	x	●	●	●	●	med-oc
Riccia glauca L.	●	●	●	●	x	●	●	8	5	7	5	submed
Riccia lamellosa Raddi	●	●	●	●	x	●	x	8	9	5	●	med
Riccia sorocarpa Bisch.	●	●	●	●	x	●	●	9	●	5	5	temp
Southbya tophacea (Spruce) Spruce	●	x	●	●	●	●	●	●	●	●	●	oc-med
Sphaerocarpos michelii Bellardi	●	●	●	x	x	●	●	7	8	6	6	suboc-submed
Targionia hypophylla L.	●	●	●	●	x	●	●	6	7	4	5	oc-submed
Aloina aloides (Koch ex Schultz) Kindb.	●	●	x	x	●	x	x	7	6	4	9	temp
Aloina ambigua (Bruch & Schimp.) Limpr.	●	●	●	●	x	x	x	7	6	4	8	submed
Aloina rigida (Hedw.) Limpr	●	●	x	●	x	●	●	7	4	5	6	temp
Barbula bolleana (Müll.Hal.) Broth.	●	●	●	●	●	x	●	8	9	8	8	submed
Barbula convoluta Hedw.	●	●	x	●	x	x	x	8	●	3	6	temp
Barbula unguiculata Hedw.	x	●	x	x	x	x	x	7	●	2	7	temp
Bryum argenteum Hedw.	●	●	x	●	x	x	x	7	●	4	6	temp
Bryum canariense Brid.	x	●	●	x	●	●	●	●	●	●	●	submed
Bryum dichotomum Hedw.	●	●	●	x	x	x	x	8	6	6	5	submed
Bryum radiculosum Brid.	●	●	●	x	●	●	x	9	6	2	7	suboc-med
Crossidium crassinervium (De Not.) Jur.	●	●	●	●	x	●	x	9	8	2	8	submed

Table 2. continued.

Crossidium laxefilamentosum W.Frey & Kürschner	●	●	●	●	●	●	x	●	●	●	●	●
Crossidium squamiferum (Viv.)Jur.	●	●	●	●	x	●	x	9	8	x	8	submed
Dicranella howei Renauld & Cardot	●	●	●	x	x	●	●	9	8	5	8	oc-med
Didymodon acutus (Brid.) K.Saito	●	●	x	●	x	x	x	9	5	●	8	submed
Didymodon luridus Hornsch.	●	x	x	●	x	x	x	9	6	2	8	submed
Didymodon rigidulus Hedw.	●	x	●	●	●	●	x	5	3	4	7	temp
Didymodon tophaceus (Brid.) Lisa	●	x	x	●	●	●	●	7	●	7	7	temp
Didymodon tophaceus subsp. *sicculus* (M.J.Cano, Ros, García-Zam. & J.Guerra) Jan Kučera	●	●	●	x	●	●	x	●	●	●	●	med
Didymodon vinealis (Brid.) R.H.Zander	x		x	x	x	x	x	9	6	2	7	submed
Entosthodon muhlenbergii (Turner) Fife	●	●	●	●	x	●	●	9	6	5	8	submed-suboc-mont
Entosthodon pulchellus (H.Philib.) Brugués	●	●	●	x	x	●	●	8	8	5	8	submed-suboc
Eucladium verticillatum (With.) Bruch & Schimp.						x		5	7	7	9	submed
Fissidens crassipes Wilson ex Bruch & Schimp.	●	●	●	●	●	x	●	●	6	8	8	suboc-submed
Fissidens gracilifolius Brugg.-Nann. & Nyholm	●	●	●	●	●	x	●	3	4	6	9	temp-mont
Fissidens pusillus (Wilson) Milde	●	●	●	●	x	●	●	3	4	6	6	temp-mont
Fissidens viridulus (Sw. ex anon.) Wahlenb var. *viridulus*	●	●	●	●	x	x	x	7	5	6	8	submed
Fontinalis antipyretica Hedw.	●	●	●	●	●	x	●	8	5	9	●	subbor
Funaria hygrometrica Hedw.	●	●	x	x	x	●	●	8	●	6	6	temp
Funariella curviseta (Schwägr.) Sérgio	●	●	●	x	x	●	●	5	8	5	7	med
Gigaspermum mouretii Corb.	●	●	●	●	x	●	●	●	●	●	●	oc-med
Grimmia crinita Brid.	●	x	●	●	●	●	●	9	8	●	8	submed
Grimmia orbicularis Bruch ex Wilson	●	x	●	●	x	●	●	9	7	●	8	submed-mont
Grimmia pulvinata (Hedw.) Sm	●	x	●	●	●	●	x	9	5	●	7	temp
Gymnostomum calcareum Nees & Hornsch.	●	x	x	●	●	x	●	4	7	5	9	submed-mont
Gymnostomum viridulum Brid.	●	●	●	●	x	●	x	4	8	4	9	suboc-med
Homalothecium aureum (Spruce) H.Rob.	●	●	●	●	x	●	●	8	9	2	7	med
Homalothecium lutescens (Hedw.) H.Rob. var. *lutescens*	●	●	x	●	x	●	●	9	4	2	8	temp
Homalothecium sericeum (Hedw.) Schimp.	●	x	●	●	●	x	●	8	3	2	7	temp
Hygroamblystegium varium (Hedw.) Mönk. *var. humile* (P.Beauv.)	●	●	●	●	●	x	●	5	5	6	4	temp
Kindbergia praelonga (Hedw.) Ochyra						x		6	4	6	5	temp
Microbryum davallianum (Sm.) R.H.Zander	●	●	●	x	x	●	●	8	5	6	6	submed

Table 2. continued.

Microbryum starckeanum (Hedw.) R.H.Zander	●	●	x	x	x	●	●	9	6	7	5	submed
Orthotrichum diaphanum Schrad. ex Brid	●	●	●	●	x	●	●	8	6	2	6	temp
Oxyrrhynchium speciosum Nees var. *speciosum*	●	●	●	●	●	x	●	5	7	7	6	subkont
Pleuridium acuminatum Lindb.	●	●	●	●	●	x	●	7	5	5	4	suboc
Pohlia wahlenbergii (F.Weber & D.Mohr) A.L.Andrews var. *wahlenbergii*	●	x	●	●	x	●	●	6	●	7	6	subbor
Pseudocrossidium hornschuchianum (Schultz) R.H.Zander	x	●	x	●	x	x	x	9	5	2	7	submed-suboc
Pseudocrossidium obtusulum (Lindb.) H.A.Crum & L.E.Anderson	●	●	●	●	●	●	x	●	●	●	●	●
Pseudocrossidium replicatum (Taylor) R.H.Zander	●	●	●	●	●	●	x	7	7	3	8	temp
Pseudocrossidium revolutum (Brid.) R.H.Zander	●	●	●	●	x	●	x	7	6	3	8	oc-submed
Ptychostomum capillare (Hedw.) Holyoak & N. Pedersen	●	x	x	●	x	x	●	5	●	5	6	temp
Ptychostomum imbricatulum (Müll.Hal.) Holyoak & N.Pedersen	x		x	x	●	x	x	8	●	5	6	temp
Rhynchostegiella littorea (De Not.) Limpr.	●	●	●	●	x	●	x	4 -	5	5	8	oc-med
Rhynchostegiella tenella (Dicks.) Limpr.	●	●	●	●	x	●	●	4	5	3	8	submed-suboc
Rhynchostegium riparioides (Hedw.) Cardot	●	●	●	●	●	x	●	●	3	8	6	temp
Scleropodium touretii (Brid.) L.F.Koch.	●	●	●	●	●	x	●	8	7	3	6	oc-submed
Scorpiurium circinatum (Bruch) M.Fleisch. & Loeske	●	x	●	x	x	x	x	6	7	3	5	oc-med
Syntrichia montana Nees	●	x	●	●	●	●	●	9	6	●	8	submed-mont
Syntrichia ruralis (Hedw.) F.Weber & D.Mohr	●	●	●	●	●	x	●	9	●	2	6	temp
Timmiella anomala (Bruch & Schimp.) Limpr.	x	●	●	●	●	x	●	5	9	5	5	med
Timmiella barbuloides (Brid.) Mönk.	●	●	●	x	x	x	x	5	9	5	8	med
Tortella flavovirens (Bruch) Broth.	●	●	●	●	x	●	●	8	5	2	8	suboc-submed
Tortella inflexa (Bruch) Broth.	●	●	●	●	x	x	●	4	8	3	9	oc-med
Tortella nitida (Lindb.) Broth.	●	●	x	●	x	x	x	8	8	2	7	oc-med
Tortella squarrosa (Brid.) Limpr.	●	●	●	●	x	x	●	9	8	2	6	submed
Tortula acaulon (With.) R.H.Zander var. *pilifera* (Hedw.) R.H.Zander	●	●	●	●	x	●	●	9	6	2	7	temp
Tortula marginata (Bruch & Schimp.) Spruce	●	●	●	x	x	x	●	3	8	5	9	oc-med
Tortula muralis Hedw.	●	●	x	x	x	x	x	8	5	●	●	temp
Tortula vahliana (Schultz) Mont	●	●	●	●	x	●	●	●	●	●	●	oc-med
Trichostomum brachydontium Bruch	●	●	●	●	x	x	●	8	6	2	8	submed-mont

Table 2. continued.

Trichostomum crispulum Bruch	●	●	●	●	x	x	●	6	4	6	9	temp
Weissia condensa (Voit) Lindb. var. *condensa*	●	●	●	●	●	●	x	9	7	●	9	submed
Weissia controversa Hedw. var. *controversa*	●	x	●	●	●	x	●	7	4	4	6	temp
Weissia controversa var. *crispata* (Nees & Hornsch.) Nyholm	●	●	●	●	●	●	x	9	4	●	7	submed-mont

As shown in Table 3, bryophyte species numerosity of the studied archaeological areas is very variable and does not exclusively depend on the size of the areas. The archaeological park of Selinunte, which is also by far the largest of those studied, hosts the highest number of bryophytes (51 taxa); however, in relation to the size of the areas the species richness of the Syracuse and Solunto parks is remarkable (38 and 33 taxa respectively).

From the chorological point of view, the floras are quite diversified since the Mediterranean taxa prevail in the floras of Selinunte (43.1%), Segesta (50%) and Solunto (43,8%) parks and Catania site, while the temperate taxa are the most represented in Enna site (40%) and in Mount Iato (55.6%) and Syracuse parks (36.4%) (Fig. 1). The high incidence of the latter type in the first two archaeological areas is likely to be related to their mountain altitudes, while in Syracuse park could be due to the significant presence of wet microhabitats in it.

An analysis of the average values of the Ellenberg index (Fig. 2) shows a relative uniformity of the floras with reference to the behaviour of the species with respect to the various factors, since the average values show variations of at most 1 and 1.5 units. Some significant differences may, however, be noted such as particularly high xerophily of the Solunto and Catania floras (average values of the moisture factor 3.7), the relatively low values concerning the temperature factor at the Enna site and in Mount Iato park (average value less than 6), the low value related to the reaction of the substrate in the area of Catania (6.3 average value).

A qualitative comparison of the floras, conducted through a cluster analysis, highlighted an accentuated diversification of the floras, as demonstrated by the low levels of link in the dendrogram of Fig. 3. Furthermore, it is observed that the clusters reflect the thermoclimatic conditions of the sites. The greatest similarity is found, in fact, among the floras of

Table 3. Number of bryophyte taxa in the archaeological areas. For abbreviations see Table 1.

	Sl	Ia	Sg	Si	So	Ca	En
Mosses	44	18	18	36	28	6	13
Liverworts	7	0	2	6	4	1	2
Total bryophyte taxa	51	18	20	42	32	7	15

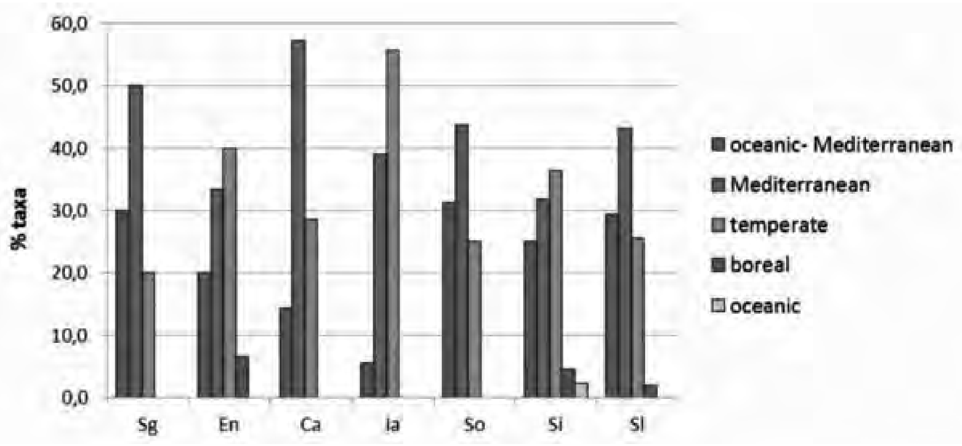

Fig. 1. Chorological Spectrum of bryofloras of studied areas. Chorological data are taken from Düll (1983, 1984, 1985, 1992). For abbreviations of archeological areas see Table 1.

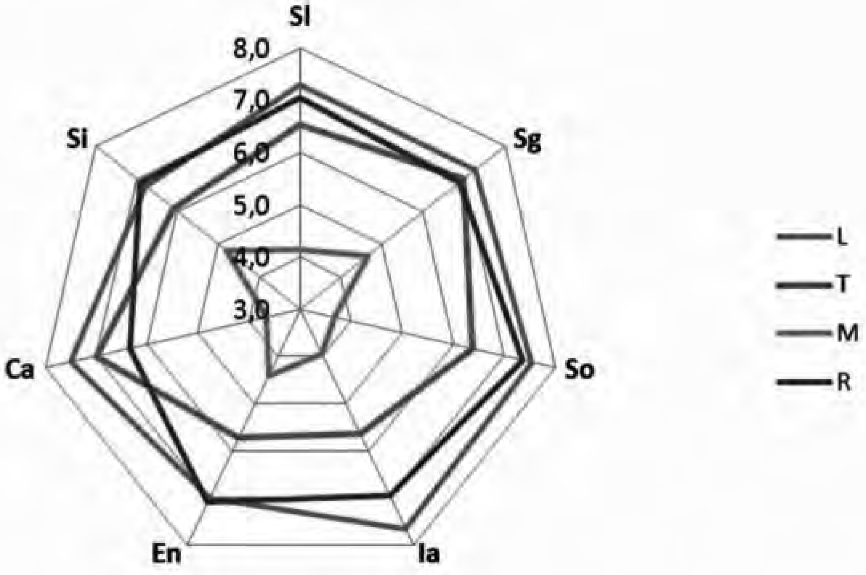

Fig. 2. Radar graph of average Ellenberg's indicator values (from Düll 1991) for taxa of studied bryofloras. The abbreviations of archeological areas are given in Table 1.

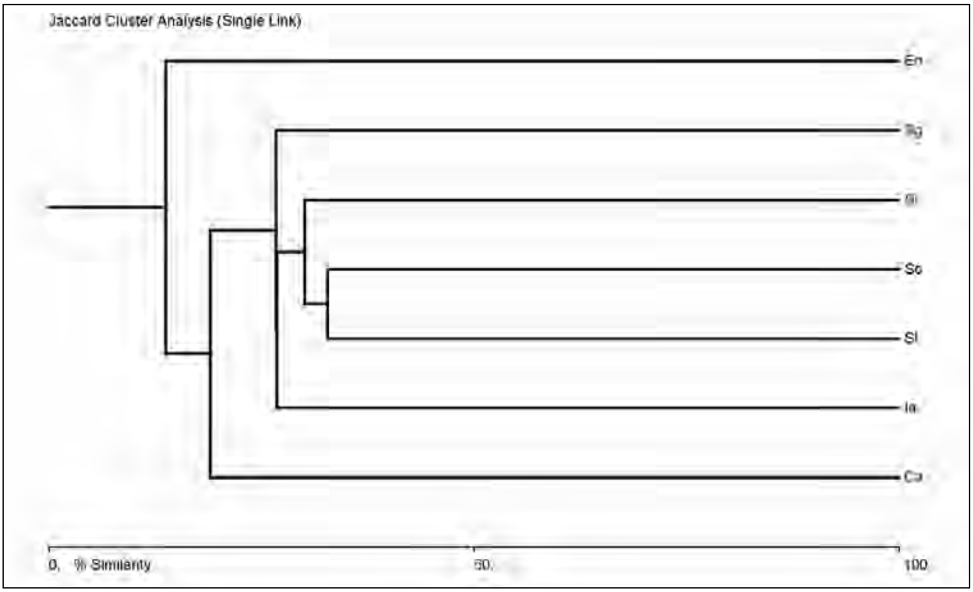

Fig. 3. Dendrogram of Jaccard's similarity (Jaccard 1908) among studied bryofloras.

Selinunte, Solunto and Syracuse, characterized by a lower thermomediterranean climate thermotype and to this cluster the floras of Mount Iato and Segesta (lower mesomediterranean climate thermotype), the flora of Catania (upper thermomediterranean climate thermotype) and, lastly, the one of Enna (upper mesomediterranean climate thermotype) are sequentially linked.

In addition to the high dissimilarity, the peculiarity of the floras of the Sicilian archaeological areas is due to the presence of taxa that be able to live almost exclusively in coastal areas with little disturbance. Among them four taxa, *Crossidium laxefilamentosum* W. Frey & Kürschner, *Gigaspermum mouretii* Corb., *Pseudocrossidium obtusulum* (Lindb.) H.A. Crum & L.E. Anderson and *P. replicatum* (Taylor) R. H. Zander., are of notable interest as they are very rare in Italy and candidates to inclusion in the European Red Data Book (Hodgetts 2015).

Pseudocrossidium replicatum was reported in Europe and Mediterranean basin only in Sicily (Solunto and Linosa) and Calabria (Dia & al. 2003; Privitera & Puglisi 2000; Ros & al. 2013; Hodgetts 2015). Elsewhere it is distributed in Central and South Africa, South-West Arabia and America (Zander 1981; Menzel 1986; Frey & Kürschner 1988a 1988b). In the archeological park of Solunto it lives on basic soil in interstices between quartz mosaic tesserae of the houses floors.

Pseudocrossidium obtusulum was reported from North America Europe, Asia and Africa, (Fedosov & Ignatova 2006; Khalil & Farag Abu-Elhamd Ali 2018). It is very rare in the Mediterranean basin, where it is only known from Andorra, Egypt, Sicily, Spain and Turkey (Ros & al. 2013; Khalil & Farag Abu-Elhamd Ali 2018). In Sicily, it was only recorded in Solunto and Linosa (Dia & Campisi 2006; Privitera & Puglisi 2009). At Solunto it lives together with *Pseudocrossidium replicatum* in interstices between quartz mosaic tesserae of the houses floors in the archaeological park.

Gigaspermum mouretii is an oceanic-Mediterranean species scattered in Syria, Israel, Cyprus, Turkey, Crete, Sicily, Morocco, Canary Islands, Spain, and Balearic Islands (Ros & al. 2013). In Italy it was reported only from two locality of Sicily (Selinunte and Capaci) (Campisi & al. 2008). At Selinunte it grows on calcarenite plinth of the temples E and F.

Crossidium laxefilamentosum was reported from Europe , Asia (Arabian peninsula) and Africa. In the Mediterranean basin it is known from Egypt, Serbia, Sicily, Tunisia and Turkey (Ros & al. 2013). In Sicily it was recorded only in two archaeological areas (Solunto and Molino a Vento near Gela) (Dia & Campisi 2009; Puglisi & al. 2013). At Solunto it lives on exposed soil among ruins of the archaeological park.

On the basis of coverage, frequency, abundance of sporophytes and propagules data as well as the life strategies of taxa living in the Segesta, Selinunte and Solunto archaeological parks, some species of mosses were identified as a potentially great threat to the state of conservation of the ruins in consideration of the direct correlation between species diffusion and coverage on the one hand and their possible biodeteriogenic action on the other. In particular, they are *Tortula muralis* Hedw., *Scorpiurium circinatum* (Bruch) M. Fleisch. & Loeske and *Didymodon vinealis* (Brid.) R. H. Zander, which are present in all three areas, always reaching cover class II or higher. Furthermore, *Aloina ambigua* (Bruch & Schimp.) Limpr., *Barbula convoluta* Hedw., *Bryum dichotomum* Hedw., *Didymodon luridus* Hornsch., *Funariella curviseta* (Schwägr.) Sérgio, *Pseudocrossidium hornschuchianum* (Schultz) R. H. Zander and *Tortella nitida* (Lindb.) Broth. occure in at least 2 areas with high frequency or coverage class (III or more) at least in one area. All these species, with the exception of the pleurocarp moss *Scorpiurium circinatum*, are annual or colonists, biological strategies that according to Dierßen (2001) are characterized by short-lived (<1 year-few years) with more or less high reproductive effort. They present a high production of sporophytes already in the first year of growth or after 2-3 years or form also propagules in the first years of life and, therefore, tend to expand more and more on the stone substrates, continuously creating new colonies. On the contrary, the perennial species *Scorpiurium circinatum*, shows reproductive effort low and begin to form sporophytes only after several years. It forms very wide moss mats that extend above all on horizontal surfaces of archaeological structures in the studied areas.

The liverworts also show a high reproductive capacity both through the sporification and with different modality of vegetative propagation (propagules production in *Lunularia cruciata* (L.) Lindb. and y-shaped growth form in *Riccia* species). Five out of seven species (*Fossombronia caespitiformis* De Not. ex Rabenh., *Riccia glauca* L., *R. lamellosa* Raddi, *R. sorocarpa* Bisch., and *Sphaerocarpos michelii* Bellardi) present an "annual" strategy, being characterized by a very rapid growth of the vegetative body (few months) and very high formation of spores (Dierßen 2001). However, these species spread more widely on soils and, therefore, do not reach high frequency values on the ruins, where, except for *Fossombronia caespitiformis*, they have a low degree of coverage due to their small size.

Regarding the periods of maximum sporification, it is observed that most bryophytes release the spores in the spring (Table 4). In some cases the maturation of the sporophytes is a little early and occurs already in later winter (February and March), in others it is pro-

Table 4. Frequency and cover classes, sporophyte or propagule presence, time of sporophyte production and life strategies (from Dierßen 2001) of taxa growing in the sites of Segesta (Sg), Selinunte (Sl) and Solunto (So). a: annual; c: colonist; ec: ephemeral colonist; l: long-lived shuttle p: perennial; pc: competitive perennial; s: short-lived shuttle; sp: stress tolerant perennial. For abbreviations of archeological areas see Table 1.

Taxa	**Frequency classes**			**Cover classes**			**Sporophyte or propagule**			**Sporification period**	**Life strategies**
	Sg	Sl	So	Sg	Sl	So	Sg	Sl	So		
Hepaticae											
Cephaloziella baumgartneri	●	●	I	●	●	I	●	●	+	Late winter-early	c
Fossombronia caespitiformis	I	II	I	IV	II	II-III	+	+	+	Winter	a
Lunularia cruciata	●	I	●	●	I	●	●	+	●	●	p
Riccia atromarginata	●	●	I	●	●	II	−	●	−	Late winter-early	a
Riccia glauca	●	I	●	●	I	●	−	+	−	Late winter-early	a
Riccia lamellosa	●	I	I	●	I	II	−	+	+	Late winter-early	a
Riccia sorocarpa	●	I	●	●	I	●	−	+	−	Late winter-early	a, s
Sphaerocarpos michelii	I	I	●	I	I	●	+	+	−	Late winter-early	a
Targionia hypophylla	●	I	●	●	I	●	+	+	+	Spring-summer	l
Musci											
Aloina aloides	I	●	I	I	●	I	−	●	●	Winter-spring	c
Aloina ambigua	●	III	I	●	III	I	●	+	−	Winter-spring	c
Aloina rigida	●	I	●	●	I	●	●	●	●	Winter-spring	c
Barbula convoluta	●	III	I	●	I	I	●	●	−	●	c
Barbula unguiculata	I	I	I	I	I	I	●	●	●	Spring	●
Bryum argenteum	●	I	I	●	I	I	●	●	+	Winter-spring	c
Bryum canariense	I	●	●	II	●	●	●	●	●	●	
Bryum dichotomum	I	III	I	II	III	I	●	+	+	Spring	cp
Bryum radiculosum	I	●	I	II	●	I	+	●	+	●	ce
Crossidium crassinerve	●	I	I	●	I	II	●	●	+	Spring	c
Crossidium laxefilamentosum	●	●	I	●	●	I	●	●	●	●	c
Crossidium squamiferum	●	I	I	●	I	I	●	●	+	Spring	c
Dicranella howei	I	II	●	I	I	●	●	●	●	Winter-spring	c
Didymodon acutus	●	I	II	●	I	I-II	●	●	●	Spring	c
Didymodon luridus	●	IV	II	●	III	I-II	●	●	●	Spring	c
Didymodon rigidulus	●	●	I	●	●	I	●	●	+	●	c
Didymodon tophaceous subsp. *sicculus*	II	●	I	II	●	I	●	●	●	●	c
Didymodon tophaceus	●	I	●	●	I	●	●	●	●	Spring	●
Didymodon vinealis	II	III	II	I-II	III	I-II	●	●	●	Spring-summer	c
Entosthodon muhlenbergiii	●	I	●	●	I	●	●	●	●	Spring	a
Entosthodon pulchellus	I	I	●	I	I	●	+	+	●	Spring	a
Fissidens viridulus	●	I	I	●	I	II	●	●	+	Spring-summer	ec
Funaria hygrometrica	I	I	●	I	II	●	+	+	●	Spring-summer	f
Funariella curviseta	III	I	●	I-IV	II	●	+	+	●	Spring	a
Gigaspermum mouretii	●	I	●	●	I	●	●	●	●	Autumn	c
Grimmia orbicularis	●	I	●	●	I	●	●	+	●	Spring	c
Grimmia pulvinata	●	●	I	●	●	I	●	●	+	Winter-spring	c
Gymnostomum viridulum	●	II	I	●	II	II	●	●	+	Spring-summer	c
Homalothecium aureum	●	I	●	●	I	●	●	●	●	Spring	p
Homalothecium lutescens	●	I	●	●	I	●	●	●	●	Spring	p
Microbryum davallianum	II	I	●	I	I	●	+	+	●	Winter-spring	a
Microbryum starckeanum	I	I	●	I	I	●	+	+	●	Winter-spring	a
Orthotrichum diaphanum	●	I	●	●	I	●	●	+	●	Spring	c
Pohlia wahlenbergii	●	I	●	●	I	●	●	●	●	Spring-summer	pc
Pseudocrossidium	●	II	I	●	III	I	●	●	●	Spring	c
Pseudocrossidium replicatum	●	●	II	●	●	II	●	●	●	●	c
Pseudocrossidium revolutum	●	I	II	●	II	I	●	●	+	Spring	c
Ptychostomum capillare	●	II	●	●	I	●	●		●	Spring-summer	c
Ptychostomum imbricatulum	II	●	I	I-II	●	II	●	●	●	Spring-summer	c
Rhynchostegiella littorea	●	I	I	●	I	I	●	●	●	Spring	sp
Rhynchostegiella tenella	●	I	●	●	I	●	●	●	●	Autumn	sp
Scorpiurium circinatum	I	III	I	V	V	II-V	●	●	●	Spring	p
Timmiella barbuloides	I	I	I	V	II	III	+	●	●	Spring-summer	s
Tortella flavovirens	●	I	●	●	I	●	●	●	●	Spring	c
Tortella inflexa	●	I	●	●	I	●	●	●	●	Spring	c
Tortella nitida	●	IV	III	●	V	II-V	●	+	+	Autumn	sp
Tortella squarrosa	●	I	●	●	I	●	●	●	●	Spring	pc

Table 4. continued.

Tortula acaulon var. *pilifera*	•	I	•	•	I	•	•	•	•	Autumn-spring	a
Tortula marginata	I	I	•	I	I	•	+	−	•	Spring	c
Tortula muralis	IV	IV	IV	II-IV	III	II-IV	+	+	+	Spring-summer	c
Tortula vahliana	•	I	•	•	I	•	•	•	•	Spring	c
Trichostomum brachydontium	•	II	•	•	I	•	•	•	•	Spring	p, s
Trichostomum crispulum	•	I	•	•	I	•	•	•	•	Spring	c
Weissia condensa	•	•	I	•	•	I	•	•	−	Winter-spring	c
Weissia controversa var. *crispata*	•	•	I	•	•	I	•	•	•	Winter-spring	c

longed in the summer. Few species have autumnal sporification. Therefore, the analysis of these data suggests that the winter is the most suitable season to guarantee the effectiveness of the interventions on the ruins.

Conclusive considerations

Overall, this analysis confirms the naturalistic interest of archaeological areas for their significant floristic diversity and species richness, whose values are comparable to those recorded in Sicily in some natural areas (Campisi & al. 2006). The importance of these areas is also increased by the presence of some rare taxa in Europe for which specific attention would be required during the necessary, periodic, restorative interventions on remains of architectural structures.

These cleaning interventions should primarily be aimed at the removal of widespread bryophytes with numerous or extensive colonies, considering that the action of biodeterioration is certainly related to the degree of bryophyte coverage. Furthermore, the possibility of diffusion of spores and propaguls due to colony detachment operations should not be underestimated.

Nevertheless, it should be emphasized that further research is desirable to better clarify the biodeteriogenic role of different bryophyte taxa, so far ascertained only in some epilithic moss species (Hughes 1982; Altieri & Ricci 1994; Altieri & al. 1997). Many species on lithic structures, indeed, are not true saxicolous but they settle only in small accumulations of soil in grooves and fractures caused by the alteration usually due to other deteriogenic agents; hence, the possibility that they, like other terricolous bryophytes, can exercise, instead, a protective action on substrates cannot be excluded with certainty at least in some cases. The important role of moss coverings against soil erosion is, in fact, well known both in forest ecosystems and in arid habitats where they contribute to the formation of the biological soil crusts, very effective to counteract the action of atmospheric agents (Weber & al. 2016).

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Eckhard von Raab-Straube, with editors and authors of the Euro+Med PlantBase

From Flora Europaea and Med-Checklist to Euro+Med PlantBase: the never-ending task for a happy Sisyphos

Raab-Straube von, E. with the editors and authors of the Euro+Med PlantBase: From Flora Europaea and Med-Checklist to Euro+Med PlantBase: the never-ending task for a happy Sisyphos. — Bocc. 28: 271-272. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: Mediterranean flora, European flora, databasing.

As of 1st of February 2018, 18 years after the project has begun, the Euro+Med PlantBase (E+M) has finally reached full coverage of vascular plant taxa. E+M now provides free access to a complete checklist of the European and the Mediterranean Flora, including also the Macaronesian Islands and the Caucasus. E+M is the most comprehensive taxonomic information system on plant biodiversity of the region, designed as a dynamic, permanently updated and critically evaluated on-line checklist. However, due to the limited number of active contributors, data quality is still heterogeneous. The bulk of the data originates from the merge of Flora Europaea, Med-Checklist, the Flora of Macaronesia plus ongoing additions from more than one hundred recent standard floras, checklists, taxonomic monographs and floristic publications. Still, ca. 15 % of the taxa had to be taken from external sources, namely from the World Checklist of Selected Plant Families, Kew, and from the International Legume Database and Information Service (ILDIS) for the *Fabaceae*. Work is currently in progress to replace those external data with original, amended and updated E+M data. E+M now contains 224 families with 2409 genera and a total of 44437 taxa (32760 species and 11677 subspecies), including those genera with very large numbers of apomictic microspecies. The database provides 47620 accepted names and 94310 synonyms with standardized nomenclatural citations, misapplied names, orthographic variants, 147804 common names in 53 different languages, 375810 source-referenced distribution records for 46644 taxa, and literature-based distribution maps. Suprageneric classification has been updated and now largely follows the APG IV system. The forthcoming migration of the database to the Common Data Model will allow for easier editing, immediate on-line publication of additions and corrections, easier connection with other data resources, and direct publications of selected datasets for defined regions or taxonomic groups.

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Mohamed Fennane & Mohamed Rejdali

Moroccan vascular plant Red Data Book: A basic tool for plant conservation*

Abstract

Fennane, M. & Rejdali, M.: Moroccan vascular plant Red Data Book: A basic tool for plant conservation. — Bocconea 28: 273-284. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Morocco's ecosystems, like the ones of the other southern and eastern Mediterranean countries, have been for decades undergoing very harsh anthropo-zoogenic pressure. Threats of regression or even extinction of plant (and animal) species are real and serious. Researchers and decision makers are all encouraged to work hard for the conservation of the national biodiversity. In order to achieve this goal with full knowledge, an inventory of the situation seemed essential. This is how the idea of a Red Data Book emerged.

The project "Red Data Book of the vascular flora of Morocco" is currently very well advanced. A first version was published, between November 2016 and November 2018, in ten fascicles, via the website of the Tela-Botanica Association, in order to collect suggestions, comments and complements from the botanical community.

The Red Data Book deals with all the existing or doubtful plant species in Morocco, whatever their status: natural, naturalized or adventitious. They are classified according to the IUCN Red List Categories (World Union for Nature), slightly amended. For Categories VU (Vulnerable), EN (Endangered) and CR (Critically Endangered) species, the following information is provided: biological type, world distribution and distribution in Morocco.

The Red Data book also provides an updated national floristic inventory, with updated nomenclature and taxonomy.

Key words: vascular flora, inventory, Morocco, IUCN Red List.

Introduction

For decades, the IUCN Red List has provided a global assessment of the threat status of species and their extinction risk and has played a major role in influencing conservation strategies. Many countries have used it as a basis for the preparation of National Red Lists and Books.

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The first known list of Morocco, by Sauvage (unpulished list) was distributed by IUCN in 1970s. This list of nearly 500 species, almost all national endemics, remained for a long time the one adopted by the IUCN with very slight modifications.

In 1998 was published a catalog of more than 1600 species, endemics, rare or very rare in Morocco (Fennane & Ibn Tattou 1988). This work has remained up to now the main source of information of threatened flora.

In 2015, were published more details on endemic monocotyledons (Rankou & al. 2015). As research and knowledge advance, the "official" Red List of Morocco is regularly enriched and improved by IUCN on its web page "iucnredlist.org".

The project "Red Data book of the vascular flora of Morocco", object of this article, is also the occasion to draw up an inventory of the national vascular flora at a time when the pressure and the threats on the whole of the biodiversity are more and more intense and a source of major concern.

Alarming context

It is worth noting that Morocco, with a population exceeding 35 millions (Haut Commissariat au Plan 2018), depends heavily on agriculture and livestock. Such dependence combined with the irrational management of plant communities and species, has caused several degradation problems. Over grazing in forests, *Stipa tenacissima* L. steppes and alpine vegetation has led to the vulnerability of many species some of which have become rare and threatened with extinction. It was reported by Ellatifi (2012) that Morocco forest domain was losing about 10.000 hectares per year. As for plant species, preliminary studies showed that over one thousand plant species are either rare or threatened of extinction (Fennane & Ibn Tattou 1998).

The green heritage is subject to strong pressure because of the various ways humans use plants for their survival and wellbeing. For centuries, it has been customary to use plants as a major source for therapy and folk medicine. It is also common to use plants for timber, industrial purposes and as fuel wood and energy as well as utensils in daily life. This wide reliance on plants threatens their sustainability and requires special care and particular attention to make the best and sustainable use of them.

Governance and planning policies and management

The over exploitation of Morocco's natural resources is exacerbated by dubious and unfortunate modes of governance and management. The main ones are:
- Inappropriate modes of exploitation;
- Lack of rigour and firmness in monitoring operating markets;
- Difficulty in controlling and regularizing pastoral activities;
- Predominance of the economic component over the ecological one;
- Absence or low adoption of the ecosystem approach.

Legislation vs Protection and Conservation

Despite the many legislative efforts made during the last decades, overall, legislation for the protection and conservation of national biodiversity remains far behind the quick changing patterns of use and rate of exploitation.

The current state can be summarized as follows:

- Laws in force mainly concern: water, forest estates, agricultural domains, rangelands, hunting and fishing;
- A unique law on protected areas (Loi 19-07, 2010);
- CITES law: national list of protected species (Loi 29-05, 2015), comprising only nine species;
- Absence of regional lists of protected species;
- Absence of national lists of threatened ecosystems and habitats;
- Administrative and executive staff with little or no qualification in floristic competence.

Material and method

The present paper is a summary of a presentation of the finding of a research work leading to the production of a "Red data Book of the Moroccan vascular flora".

New updated data on the Moroccan flora are provided and discussed, especially on endemic, rare or endangered species. They all come from the analysis of ten fascicles prepared in the framework of this project and distributed in digital format by the Tela-Botanica association on its website "tela-botanica.org" between November 2016 and November 2018 (Fig. 1).

Red data Book of the Vascular Flora of Morocco

The main features of the projected book are the following:

- All Moroccan vascular flora (indigenous + naturalized + adventitious), including species of doubtful presence covered;
- Updated Nomenclature and Taxonomy;
- IUCN Red List category (IUCN 2012), slightly adapted to the proposals of Fennane & Montmollin (2015); the categories are: EX (Extinct), RE (Regionally Extinct), CR (Critically Endangered), EN (Endangered), VU (Vulnerable), NT (Not Threatened), LC (Least Concern), DD (Data Deficient), NA (Not Applicable);
- Biological type, World distribution and distribution in Morocco for threatened categories (VU, EN and CR);
- Detailed bibliography, especially about geographical distribution.

Quantitative and qualitative analysis

a. Total flora (Figs. 2 & 3, Tables 1 & 2)

The total Moroccan vascular flora is about 4,800 species, including:

- 90 hybrids;
- 298 naturalized or adventitious;
- 482 of doubtful presence;
- 144 of dubious taxonomic status;

The eight richest families (more than 100 species) (Table 2), are the same as those designated in the work of Fennane & Ibn Tattou (2012), namely: *Asteraceae, Fabaceae,*

CARYOPHYLLACEAE Juss.

Agrostemma L.

Agrostemma githago L. **LC**

Arenaria L.

Arenaria aggregata (L.) Loisel. B2ab(ii,iii) **EN**$_{(e)}$
Gypsophila aggregata L. ; *Arenaria capitata* Lam.

Ch. Méditerranée occidentale. Au Maroc et en Algérie, ***subsp. mauritanica*** (Batt.) Maire **(•A)** : signalé par [Maire 1916:263] [CPM:207] [FAN9:158] [Quézel & Santa 1962:334] dans 3 localités dont deux frontalières : jbel Doug sur l'Atlas saharien et Ghar Rouban au sud de Oujda ; la $3^{ème}$ localité, Djelfa, se situe au Centre nord de l'Algérie.

Arenaria armerina Bory **(•I)** **NT**

Ch. Péninsule Ibérique méridionale. HA-4-5 MA R-2-3.

Arenaria cerastioides Poir. **LC**

Arenaria dyris Humbert **(•)** B2ab(ii,iii) **VU**$_{(e)}$

Ch. HA-5 (Ayachi ; Mâasker) [CPM:208, 982] [FAN9:164]. Cette endémique est encore relativement bien présente [Taleb & Fennane 2008:132] grâce à ses habitats assez difficilement accessibles : fissures des rochers de hautes montagnes. Principales menaces actuelles : stress climatique ? et dégradation anthropique.

Arenaria emarginata Brot. **LC**

Arenaria grandiflora L. B2ab(ii,iii) **VU**$_{(e)}$

Ch. Méditerranée occidentale.

Fig. 1. Extract from "Eléments pour un Livre rouge de la flore vasculaire du Maroc, Fasc. 5". Edit. Tela-Botanica, january 2018.

Table 1. Number of species* by IUCN Red List Category (* incl. adventitious, naturalized and hybrids).

	NA	DD	LC	NT	VU	EN	CR	RE/EX	Total
Pteridophyta	18	3	29	5	1	8	7	2	73
Gymnospermae	1	-	9	2	3	2	1	-	18
Dicotyledonae	802	284	1536	345	238	266	284	17	3772
Monocotyledonae	262	116	337	62	43	49	67	1	937
Total	1083	403	1911	414	285	325	359	20	4800

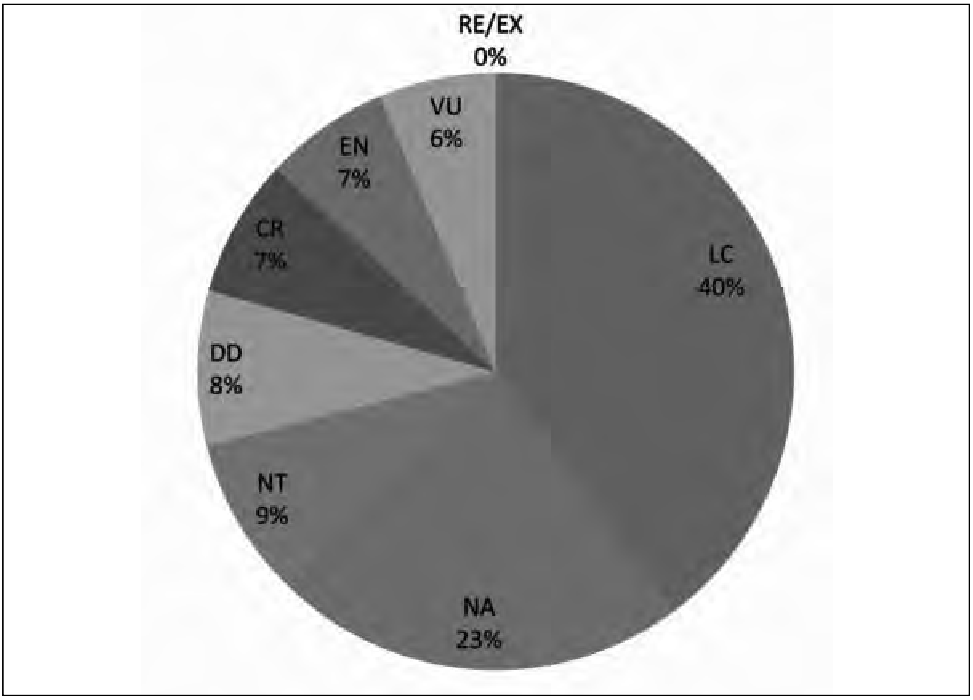


Fig. 2. Percentage of different IUCN Red List Categories.

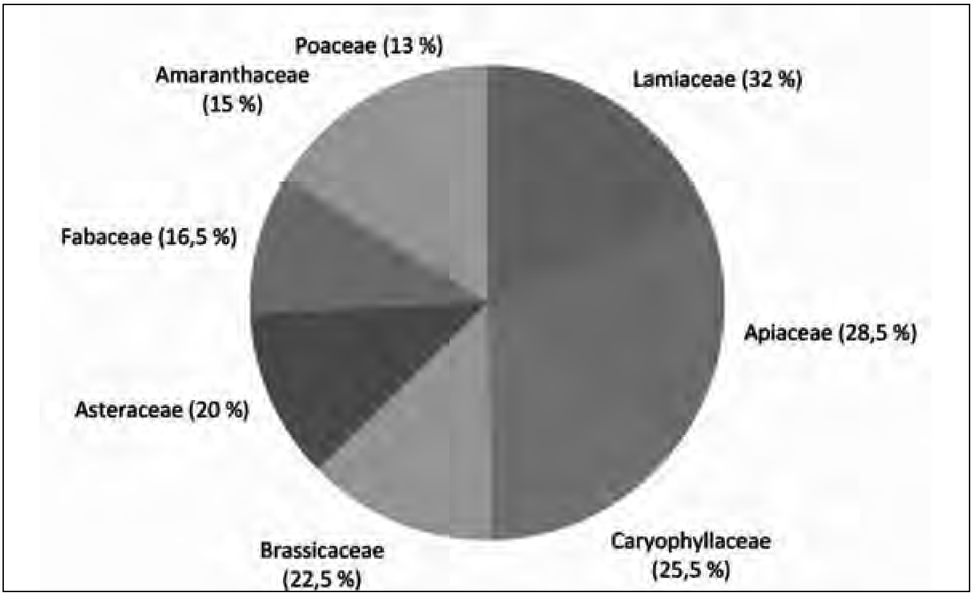


Fig. 3. Percentage of threatened species (VU, EN, CR) in the main families (> 100 sp).

Table 2. Number of species* in the main families (> 100 sp) by IUCN Red List Category (* incl. adventitious, naturalized et hybrids).

	NA	DD	LC	NT	VU	EN	CR	RE/EX	Total
Asteraceae	124	48	276	58	32	53	44	5	640
Fabaceae	107	40	220	41	25	35	21	3	492
Poaceae	136	59	184	29	16	15	31	0	470
Lamiaceae	58	24	59	23	21	26	30	1	242
Brassicaceae	44	13	104	24	24	21	9	1	240
Caryophyllaceae	23	8	115	20	19	18	20	0	223
Apiaceae	30	15	78	10	12	15	26	1	187
Amaranthaceae (incl. Chenopodiaceae)	26	15	53	0	3	7	7	1	112

Table 3. Biological types / IUCN Red List Categories.

	NA	DD	LC	NT	VU	EN	CR	RE	Total
Phanerophytes /Nanophaneroph.	79	20	152	56	35	28	19	1	390
Chamephytes	63	39	162	65	55	59	70	0	513
Hémicryptoph.	177	92	330	106	74	70	113	1	963
Geophytes	79	49	152	29	35	39	36	5	424
Therophytes /Th-bisannuals	248	127	817	93	46	68	60	8	1467
Hydrophytes	19	18	26	10	6	6	7	0	92

Table 4. Number of endemics / IUCN Red List Categories.

Endemics	NA	DD	LC	NT	VU	EN	CR	RE/EX	Total
Moroccco	117	35	56	113	100	141	163	4	729
Morocco + Algeria	35	32	44	37	24	30	29	3	234
Morocco + Iberian Peninsula	61	24	27	36	34	39	43	2	266
Morocco + Algeria + Iberian Peninsula	10	15	78	16	11	11	0	1	142

Poaceae, Lamiaceae, Brassicaceae, Caryophyllaceae, Apiaceae and Amaranthaceae (incl. Chenopodiaceae).

23 % of the species are in the Category NA (Not Applicable): hybrids + adventitious + naturalized + species of dubious presence + species of dubious taxonomic status (Fig. 2).

20 % of native species are threatened (categories VU, EN, CR) (Fig. 2). The *Lamiaceae* are more threatened (32 % the species) (Fig. 3). Members of the *Poaceae* appear to be the least threatened (13 % of species) (Fig. 3).

b. Biological types (Table 3)

The main observations are:
55.7% of therophytes are in the LC category;
35.8% of chamaephytes are threatened (VU, EN, CR);
19.5% of the hydrophytes are insufficiently known (DD).

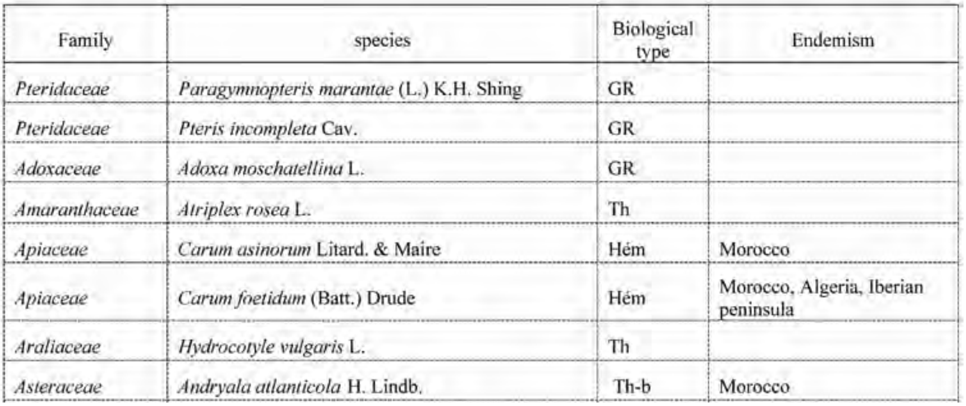
c. Endemism (Table 4, Figs. 4 to 9)

The main observations are:
55.3% of Moroccan endemic are threatened (VU, EN, CR);
43.6% of Moroccan-Iberian endemics are threatened (VU, EN, CR);
35.4% of Moroccan-Algerian endemics are threatened (VU, EN, CR).

d. Species extincted or presumed extincted (Table 5)

49 species are extincted or presumed extinct:
13 Moroccan endemics;
7 Moroccan-Iberian endemics;
5 Moroccan-Algerian endemics;
12 woody species (Ch, Nph, Ph);
9 geophytes;
28 herbaceous species (Th, Th-b, Hém).

Table 5. Extinct or presumed extinct species.

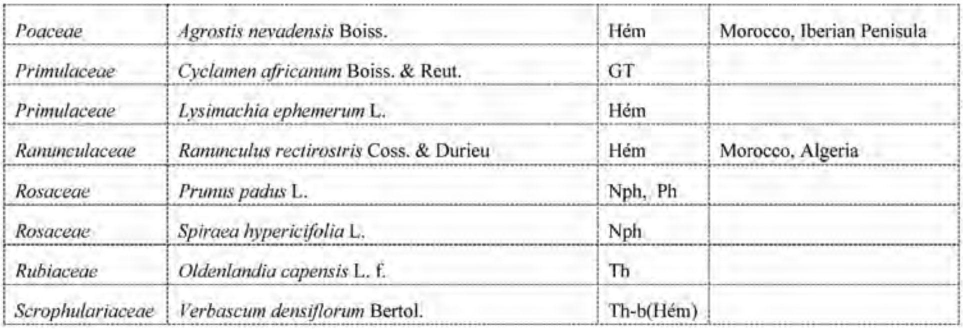


Family	species	Biological type	Endemism
Pteridaceae	*Paragymnopteris marantae* (L.) K.H. Shing	GR	
Pteridaceae	*Pteris incompleta* Cav.	GR	
Adoxaceae	*Adoxa moschatellina* L.	GR	
Amaranthaceae	*Atriplex rosea* L.	Th	
Apiaceae	*Carum asinorum* Litard. & Maire	Hém	Morocco
Apiaceae	*Carum foetidum* (Batt.) Drude	Hém	Morocco, Algeria, Iberian peninsula
Araliaceae	*Hydrocotyle vulgaris* L.	Th	
Asteraceae	*Andryala atlanticola* H. Lindb.	Th-b	Morocco

Table 5. continued.

Asteraceae	*Andryala maroccana* (Caball.) Maire	Ch	Morocco, Algeria
Asteraceae	*Centaurea ducellieri* Batt. & Trab.	Hém?	Morocco
Asteraceae	*Crepis salzmannii* Babc.	Hém	Morocco, Algeria
Asteraceae	*Cynara tournefortii* Boiss. & Reut.	G	Morocco, Iberian Peninsula
Asteraceae	*Rhaponticum longifolium* (Hoffm. & Link) Soskov	Hém	Morocco, Iberian Peninsula
Boraginaceae	*Echium arenarium* Guss.	Th (Th-b)	
Boraginaceae	*Heliotropium antiatlanticum* Emb.	Ch	Morocco
Brassicaceae	*Maresia nana* (DC.) Batt.	Th	
Caryophyllaceae	*Moehringia glochidisperma* J.M. Monts.-Marti	Hém (GR)	Morocco
Cistaceae	*Halimium ocymoides* (Lam.) Willk	Ch	Morocco, Iberian Peninsule
Cistaceae	*Helianthemum pomeridianum* Dunal	Ch	Morocco, Algeria
Convolvulaceae	*Ipomoea sagittata* Poir.	GR?	
Fabaceae	*Ononis tridentata* L.	Nph	Morocco, Iberian Peninsula
Fabaceae	*Ononis villosissima* Desf.	Th	Morocco, Algeria
Fabaceae	*Trifolium acutiflorum* Murb.	Th	Morocco
Fabaceae	*Trifolium sylvaticum* Gérard	Th	
Fabaceae	*Vicia fairchildiana* Maire	Th	Morocco
Fabaceae	*Vicia leucantha* Biv.	Th	
Gentianaceae	*Centaurium barrelieroides* Pau	Th	Morocco
Hypericaceae	*Hypericum australe* Ten.	Ch	
Lamiaceae	*Clinopodium acinos* (L.) Kuntze	Th Th-b	
Lamiaceae	*Galeopsis angustifolia* Hoffm.	Th	
Lamiaceae	*Glechoma hederacea* L.	Hém	
Lamiaceae	*Marrubium atlanticum* Batt.	Ch	Morocco
Lamiaceae	*Marrubium werneri* Maire	Ch	Morocco
Lamiaceae	*Micromeria brivesii* Batt.	Ch	Morocco
Lamiaceae	*Phlomis italica* L.	Ch, Nph	Morocco, Iberian Peninsula
Lamiaceae	*Sideritis imbricata* H. Lindb. f.	Ch	Morocco
Lamiaceae	*Stachys brachyclada* Noĕ ex Coss.	Th	
Malvaceae	*Malva microphylla* (E. G. Baker) J. Molero & J.M. Monts.	Th?	Morocco
Menyanthaceae	*Menyanthes trifoliata* L.	HyF (GR)	
Orchidaceae	*Orchis palustris* Jacq.	G	
Poaceae	*Agrostis nebulosa* Boiss. & Reut.	Th	Morocco, Iberian peninsula

Table 5. continued.



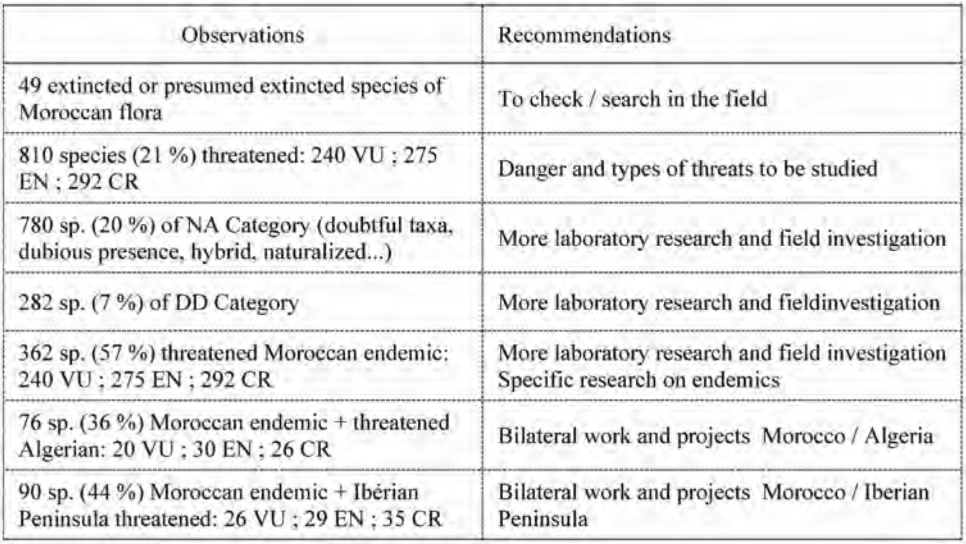
Poaceae	*Agrostis nevadensis* Boiss.	Hém	Morocco, Iberian Penisula
Primulaceae	*Cyclamen africanum* Boiss. & Reut.	GT	
Primulaceae	*Lysimachia ephemerum* L.	Hém	
Ranunculaceae	*Ranunculus rectirostris* Coss. & Durieu	Hém	Morocco, Algeria
Rosaceae	*Prunus padus* L.	Nph, Ph	
Rosaceae	*Spiraea hypericifolia* L.	Nph	
Rubiaceae	*Oldenlandia capensis* L. f.	Th	
Scrophulariaceae	*Verbascum densiflorum* Bertol.	Th-b(Hém)	

Practical interest

The analysis of the data of the Red Book of the Moroccan vascular flora presented above, although concise, shows interesting features, that can provide guidance to researchers and decision-makers for the good of the national phytodiversity.

We give here (Tables 6, 7 and 8) those that seem most important to us, with concrete and practical proposals and recommendations for each of the three following levels: Knowledge (Table 6), Exploitation / Valorization (Table 7) and Protection / Conservation (Table 8).

Table 6. Observations and recommendations concerning Knowledge.



Observations	Recommendations
49 extincted or presumed extincted species of Moroccan flora	To check / search in the field
810 species (21 %) threatened: 240 VU ; 275 EN ; 292 CR	Danger and types of threats to be studied
780 sp. (20 %) of NA Category (doubtful taxa, dubious presence, hybrid, naturalized...)	More laboratory research and field investigation
282 sp. (7 %) of DD Category	More laboratory research and fieldinvestigation
362 sp. (57 %) threatened Moroccan endemic: 240 VU ; 275 EN ; 292 CR	More laboratory research and field investigation Specific research on endemics
76 sp. (36 %) Moroccan endemic + threatened Algerian: 20 VU ; 30 EN ; 26 CR	Bilateral work and projects Morocco / Algeria
90 sp. (44 %) Moroccan endemic + Ibérian Peninsula threatened: 26 VU ; 29 EN ; 35 CR	Bilateral work and projects Morocco / Iberian Peninsula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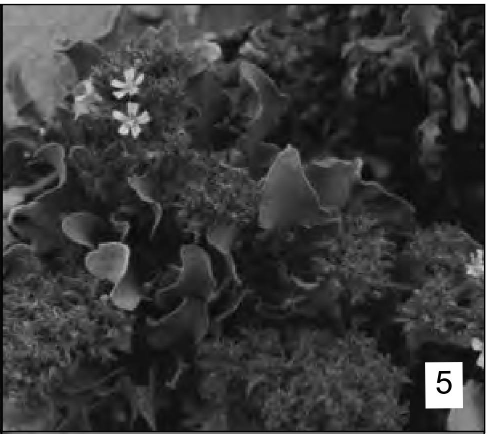
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Fig. 4. *Adenocarpus artemisifolius*, Moroccan endemic [CR] (Ph. Msanda).
Fig. 5. *Limoniastrum weygandiorum*, Moroccan endemic [CR] (Ph. Thiaudière).
Fig. 6. *Caralluma joannis*, Moroccan endemic [CR] (Ph. Sébastien).
Fig. 7. *Echiochilon simonneaui*, Moroccan endemic [CR] (Ph. Garcin).
Fig. 8. *Helianthemum grosii*, Moroccan endemic [CR] (Ph. Dobignard).
Fig. 9. *Euphorbia mazicum*, Moroccan endemic [CR] (Ph. Chatelain).

Table 7. Observations and recommendations concerning Exploitation / Valorisation.

Observations	Recommendations
1574 species (41 %) of LC category	Expand exploitation / valorisation operations to LC taxa to ease the pressure on those threatened
362 sp. (57 %) threatened Moroccan endemics	Maximum precaution , rigor and restrictions for exploitation
77 sp. (32 %) of threatened *Lamiaceae* (mainly Aromatic and medicinal plants)	Rigor, organization and control of exploitation ofthe aromatic and medicinal plants

Table 8. Observations and recommendations concerning Protection / Conservation.

Observations	Recommendations
Large number of endangered species (810, i.e. 21%) of all biological types and thus diverse environments Insufficient knowledge of threats dangers and species responses	Ecosystem approach for : - Maximum protection of species - Protect habitats Approach centered around ‘key’ species, patrimonial, emblematic…
57 % of threatened Moroccan endemics : 292 CR ; 275 EN ; 240 VU.	Priority species for *in situ* and *ex-situ* conservation programs and actions

Conclusion

The Red Data Book of Morocco’s vascular flora provides an update of information on the vascular flora of the country in terms of inventory, taxonomy and nomenclature. From this point of view, it is a basic reference for researchers to focus and prioritize their studies.

In terms of management, protection and conservation of biodiversity, this book is a tool at the service of decision-makers for the choice of species and the target regions of programmes and practical actions.

This first version of the Red Data Book could be subject to corrections, additions and modifications. In all cases, this is a work that needs to be regularly reviewed and updated according to the progress of research on the flora, on the one hand, and the evolution of the ranges of the species on the other hand. This cannot be achieved without the support of a large number of motivated and committed researchers in the laboratory and in the field.

Acknowledgment

We are grateful to professors F. M. Raimondo and G. Domina, as well as to all the organizers of the International Symposium “Botany at the intersection of Nature, Culture, Art and Sciences” who have given us the opportunity to attend the Symposium and to give the oral presentation which is subject of the present publication. We thank warmly the anonymous reviewers for their valuable comments.

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The Carob tree: biogeography, ecology and cultural history of a neglected Mediterranean tree

Médail, F., Baumel, A., Bou Dagher Kharrat, M., Diadema, K., Juin, M., Legalliot, N., La Malfa, S., Mirleau, F., Nieto Feliner, G., Ouahmane, L., Pironon, S., Suc, J.-P., Viruel, J., & Sanguin, H.: The Carob tree: biogeography, ecology and cultural history of a neglected Mediterranean tree. — Bocc. 28: 285-286. 2019. — ISSN: 1120-4060 printed, 2280-3882

Key words: *Ceratonia siliqua*, *Fabaceae*, plant domestication.

The Mediterranean thermophilous woodlands were very early impacted by human activities, and are still highly threatened by the destruction and the alteration of their habitats. For forage and fruit trees, the recurring exchanges between natural populations and cultivated agroecosystems constituted a pivotal aspect in the process of Mediterranean fruit tree domestication. Nowadays determining the native status of Mediterranean fruit tree populations represents a major but difficult task for phylogeography because early human influences began just after post glacial migrations. Here we applied geographical genetic methods to tackle this issue for a neglected thermophilous tree, the Carob tree (*Ceratonia siliqua* L., *Fabaceae*) aiming at providing the first genetic diversity report across its entire distribution range. Carob tree is widely exploited for food and forage since Antiquity and currently for industrial, agricultural and soil restoration purposes. The origin of carob tree populations throughout the Mediterranean basin is supposed to be dependent of an historical process of dissemination by humans since its domestication in the Middle-East around 6,000-4,000 BC. However, previous palaeobotanical and vegetation studies stated that the carob is a widespread component of thermophilous forest vegetation and opened a debate about the native or feral status of its populations. The patterns of genetic diversity were compared for populations growing in natural, semi-natural or cultivated habitats. We examined the relative contribution to genetic differentiation of geographical distance, current and past environments and the role of human dissemination routes. Genetic diversity and differentiation analyses revealed unexpected geographical patterns calling for a new appraisal of the domestication pattern of the carob tree in the Mediterranean basin. This research was investigated in the framework of the DYNAMIC (*Deciphering sYmbiotic Networks in cArob-based MedIterranean agro-eCosystems*) French ANR-project.

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Svetlana Bancheva

Diversity and conservation of subfam. *Carduoideae* (Asteraceae) in Bulgaria

Bancheva, S.: Diversity and conservation of subfam. *Carduoideae* (*Asteraceae*) in Bulgaria. — Bocc. 28: 287. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: *Centaurea*, endemism, medicinal plants.

Depth floristic and taxonomic studies on Bulgarian flora began in the late XIX century. As a result several editions of Floras have been published. In 1963 a long-term project to develop a critical Flora of Bulgaria was started, which is still in place. Up to now, 11 volumes have been published and the last 12 volumes are currently being developed by a team of scientists under the framework of the project ‘Flora of the Republic of Bulgaria, vol. 12: Biological Diversity in *Asteraceae* subfam. *Carduoideae* and *Cichorioideae*’ (ДН-01/7/16.12.2016), financed by the Bulgarian National Fund for Scientific Research. All species included in vol. 12 of the Flora of the Republic of Bulgaria are illustrated by professional artists. The main part of the volume is devoted to the diversity of subfam. *Carduoideae*. This sub-family includes 20 genera and 145 species that represent annuals, biennials and herbaceous perennials, distributed throughout the country from the sea shore to the highest mountain peaks. More than 25% of the species are of conservation significance being Bulgarian or Balkan endemics. The percentage of endangered species is not small. The richest genus is *Centaurea*, with 75 species and 12 subspecies. It is also the richest in species with conservation status: 10 species are Bulgarian endemics; other are Balkan endemics (18 species); 18 species are of conservation significance and are included in the Bulgarian Biodiversity Act. The state of the populations of some of these is quite worrying and action plans have been developed for its improvement. There have been detected 21 medicinal and aromatic species from subfam. *Carduoideae* which are subject to collection by the local people and are included in the National Law on Medicinal Plants.

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A. Papini, M. Viola, V. Maggini, C. Tani, F. Firenzuoli, S. Schiff & R. Fani

Relationship between the cypsela of *Echinacea* and its endophyte symbionts

Papini, A., Viola, M., Maggini, V., Tani, C., Firenzuoli, F., Schiff, S. & Fani, R.: Relationship between the cypsela of *Echinacea* and its endophyte symbionts. — Bocc. 28: 289-290. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: micromorphology, fruit, bacteria, fungi.

Cypselas are fruits derived from an inferior ovary, forming a further layer (perianth) outside the fruit pericarp. We investigated the three most frequently cultivated *Echinacea* species (*Asteraceae*) to observe the presence and localization of endophytic microorganisms. Bacteria were observed exclusively within cells of the cotyledons parenchyma. The bacteria were enclosed in membrane structure similarly to the situation observed in other endocellular bacteria such as mycobacteria.

Moreover, the presence of fungi was recorded in the perianth, that is the most external component of the cypsela. This modified residual of the flower is woody and porous in the cypsela and hosts numerous hyphae, that are able to cross the walls between one cell to the other. This presence was never recorded before. The presence of fungi in the cypsela is apparently arrested at the level of the pericarp, containing phytomelanin.

A last microorganisms component is that represented by bacteria strictly adhering to the external side of the perianth.

In conclusion, the observation of the cypselas of three different species of *Echinacea* showed that three different components of microorganisms are carried by the fruit during dispersal. One endocellular bacterial component in the cotyledon; another more generic component adhering to the external side of the perianth, and a fungal component contained inside the porous layer of the perianth, whose remarkable structure may be considered as an adaptation for fungal transport. The endophytic bacteria are reported as possible producers of substances of pharmaceutical interest, while the fungi in the perianth may be important to block the entrance of pathogenic fungi by production of alkaloids. The presence of endophytic bacteria was observed also in the shoot, leaves and roots of the adult plant and we may suggest that these endosymbiont bacteria are carried also at the seed stage.

The cypsela can therefore be described as a unit of dispersal composed by more symbionts.

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Benito Valdés

Progenitors of cultivated plants in the Iberian Peninsula

Valdés, B.: Progenitors of cultivated plants in the Iberian Peninsula. — Bocc. 28: 291. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: agriculture, Crop Wild Relatives, Wild Harvested Plants.

In the Mediterranean area agriculture began in the Neolithic with the introduction into cultivation in the Middle East of a group of cereals, legumes and other crops, which cultivation expanded latter to Europe and the rest of the Mediterranean at a speed not higher than one km per year. None of these crops reached the Iberian Peninsula before the Bronze Era, and during the Paleolithic, Mesolithic and Neolithic, primitive inhabitants survived by hunting, fishing and by gathering fruits, seeds, leaves, roots, etc. of a high number of native plants, of which Evergreen Oak (*Quercus ilex* subsp. *ballota* (Desf.) Samp.) played a basic role, but also Hazel (*Corylus avellana* L.), Stone Pine (*Pinus pinea* L.), Wild Olive (*Olea europaea* var. *sylvestris* (Mill.) Lehr.), White Beam (*Sorbus aria* (L.) Crantz), Rowan (*S. aucuparia* L.), Wiode Service Tree (*S. torminalis* (L.) Crantz), etc, whose use has never been abandoned. Some new crops are being obtained in the Iberian Peninsula by domestication from their native progenitors. Indications are given on the introduction into cultivation of Borage (*Borago officinalis* L.), Golden Thistle (Spanish Oyste Plant; *Scolymus hispanicus* L.) and Bladder Campion (*Silene vulgaris* (Moench) Garke)..

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Franco Pedrotti

The vegetation around dry-wall stone huts on the Macereto plateau (Sibillini Mountains, Central Apennines)

Abstract

Pedrotti, F.: The vegetation around dry-wall stone huts on the Macereto plateau (Sibillini Mountains, Central Apennines). — Bocc. 28: 293-306. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

On the Macereto plateau (Monti Sibillini, Central Apennines), at elevation between 800 and 1150 m, there is a settlement of round, dry-wall stone huts with conical rooves, similar to huts existing in other towns of the south-central Apennines. The huts served as shelter for shepherds and peasants during the period 1700-1940. All the huts of Macereto have collapsed, and the remaining stones from the walls and vault favor secondary succession by species of the following vegetation classes: *Asplenietea rupestris*, *Sedo-Scleranthetea*, *Thlaspietea rotundifolii*, *Rhamno-Prunetea* and *Querco-Fagetea*. In particular, three shrub associations develop on the remaining piles of stones: *Milio vernalis-Aceretum campestris*, *Galio aparine-Prunetum mahaleb* and *Cytisophyllo sessilifolii-Prunetum spinosae*, which are typical of the meso-temperate altitudinal belt. Also present is *Atadinus alpinus* (*Rhamnus alpina*), a species of the supra-temperate belt, but which grows at lower altitudes where it is favored by the piles of stones, giving rise to these subassociations: *Milio venalis-Aceretum campestris atadinetosum alpini*, *Galio aparine-Prunetum mahaleb atadinetosum alpini* and *Cytisophyllo sessilifolii-Prunetum spinosae atadinetosum alpini*.

Key words: Vegetation of dry-stone huts, *Milio vernalis -Aceretum campestris*, *Atadinus alpinus*.

Introduction

On the plateau of Macereto (Sibillini Mountains, central Apennines), at elevations of 800-1200 m, there is a settlement of round, dry-wall stone huts with conical rooves, similar to huts existing in other towns of the south-central Apennines (e.g. the *trulli* of Puglia). These "dry-wall" huts were constructed without mortar and will hereafter be called simply 'dry-stone' huts. These served as shelter for shepherds and farmers during the summer. The huts are located on some plains and slopes at the base of the western slope of Monte la Banditella (1583 m).

Almost at the center of the plateau is the sanctuary of Macereto (998 m), built in the years 1528-1556 and surrounded by a vast area destined for sheep farming since very ancient times. Macereto is considered the "center of the pastoral life of the Sibillini Mountains" (Venanzangeli 1996).

Near a knoll on Monte Grotagna (or Rotagna), called the Poggio of Macereto, there was a castle with annexed possessions over a large surrounding area. Possession of this castle was subject to various struggles until 1521, when a decree by Giovanni Maria Varano settled the dispute for many years (Pirri 1916). In the documents of the time, many references are made to the pastoral agro-silvo activities that took place on the Macereto Plateau, but no mention is made of the stone huts.

According to the Statutes of the ancient Municipality of Visso (1461), as reported by Venanzoni (1960), there were at that time four inhabited localities on the Macereto Plateau, including one called Macereto, which was located on the Colle di San Giovanni (see Fig. 1). In another part of his contribution, these places are called “villages”, and he says they were formed of “houses” and not of “huts”. On the Colle di San Giovanni today, there are the remains of a village of dry-stone huts.

Such huts are present in south-central Italy from Basilicata to the Marche; in the Marche Region they are found on the Montagna dei Fiori and on the Sibillini Mountains, where they constituted their northernmost town. The huts on the Montagna dei Fiori are generally well preserved (Cappelli 2007), but the huts of the Sibillini Mountains have almost all collapsed, and only some still retain their perimeter walls.

Various species of herbaceous and woody plants have become established on the hut remains. The purpose of this note is to describe how the colonization of the Altipiano of Macereto hut remains occurs and the plant associations that develop on them.

The dry-stone huts of the Apennines

The dry-stone huts of the Apennines are round, with rooves made by a pseudo-vault technique. These are called *thòlos* by archaeologists, and their archaic architecture was brought northward from Puglia (where they were called *trulli*) with the seasonally migrating shepherds. On the Apennines they are found from Basilicata to the southern Marche, on the Montagna dei Fiori (Nanni & Properzi 1975; Paone 1987; Micati 2001; Gisotti 2003; Cappelli 2007; Miosi 2013), as was shown clearly in a paper by Miosi (2012). Dry-stone huts comparable to those of the Appenines are the *thòlos* – called also with the local name “cùbburo” – from the territories of the Nebrodi, Peloritani and Iblei, in Sicily (Imbornone 1994).

A little further north of the Montagna dei Fiori, on the Macereto Plateau (Monti Sibillini), there is another, previously unknown complex with over 150 huts. A dry-stone hut with a square plan is also present in the Val di Bove, at about 1500 m (G. De Rosa, Camerino, *in litt.*).

The huts now present in the central Apennines, also called “caselle”, are all of recent construction. According to Redi (2009) they were not built before 1600-1700, and most date from the 1800s. The construction technique, however, is very ancient and has remained intact over the millennia.

The dates of the Macereto huts are not known, but by analogy with the Abruzzo huts one can think of the same years, even though the Sanctuary of Macereto, which is much earlier (mid-1500s), could make one think of more ancient times.

The types of huts are quite different, especially the shape of the dome (Gisotti 2003; Miosi 2012), which was difficult to establish for the Macereto huts because the vaults have collapsed and only the perimeter walls remain. The huts were abandoned in different years, but some were still in use until just before the Second World War.

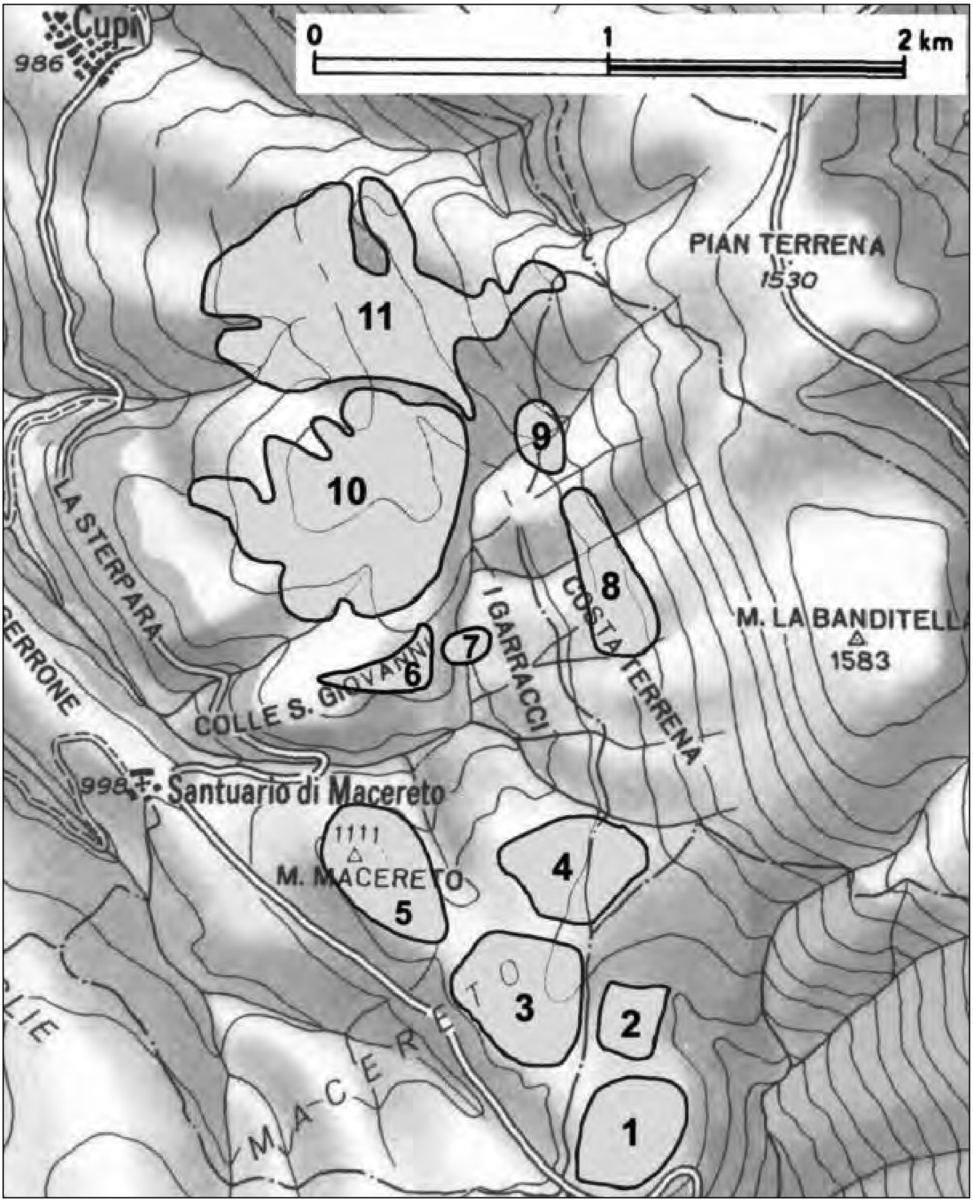

Fig. 1. The dry-stone hut villages of the Macereto Plateau; 1-7 villages with many huts; 8-9 villages with few huts; 10-11 areas used in the past for agriculture, with few isolated huts, not united in villages (topographic map from the Associazione Valorizzazione Monti Sibillini, 1977).

Study area

The dry-stone huts of the Altipiano of Macereto are distributed in 9 adjoining groups, separated by small valleys and hills, on slope exposed partly to the west and partly to the southwest of Monte la Banditella, at altitudes between 800 and 1200 m (Fig. 1). The toponyms that recur on topographical maps are those of Monte Macereto, Colle di S. Giovanni, the Arette, the Garracci, Costa Terrena, the Piane, the Piannellucci and the Fienili.

The substrate is exclusively calcareous, and all the Monte la Banditella and its slopes, including Colle S.Giovanni, is formed of *scaglia rossa*, a red scaly Cretaceous limestone. In some areas *scaglia variegata* and *scaglia cinerea* also emerge (Pierantoni 2013). The huts are built with stones made from *cinerea* and *variegata* chips.

The area has been subjected for centuries to two types of very intense human activity, namely agriculture and mountain pasturing, which led to complete deforestation with strong soil erosion, with the exception of some valleys that retained residual coppice forests of a S*cutellario columnae-Ostryetum carpinifoliae*.

The cultivation areas are still easily recognizable today due to the presence of piles of stones, the *maceras*, locally called "moregghini", representing the stones that were removed over the years. There are frequent traces of terraces and other geometric shapes, due to the ancient parceling (Fig. 2). Cereals were cultivated there and also 'cicerchia' (*Lathyrus sativus*), 'moco' (*Vicia ervilia*) and 'roviglio' (*Pisum sativum* subsp. *elatius*) (Rosi 2005). The vegetation of these areas, in the past cultivated but today only sparse xeric meadows, is undergoing the processes of regression and secondary succession.

The areas intended for the summer stay of the shepherds and grazing animals are recognizable by the presence of the huts, which preferably occupied flat or only slightly sloping areas. The most favorable areas around the huts were designated for cultivation. Here there were low xeric meadows used for grazing, with cover degree varying from 80 to 100% (since sometimes there are rocky outcrops and scattered stones that interrupt the continuity of the turf). These meadows are partly undergoing regression, partly secondary succession, and partly fluctuation of anthropic origin in the periods when they are still partially subjected to sheep grazing.

It is possible to distinguish 11 complexes of huts as follows: 7 temporary villages formed by many huts (40-50) (Fig. 3); 2 temporary villages with few huts (8-9); and 2 areas destined in the past for agriculture, with few isolated huts not united in villages (10-11, Fig. 1). The areas corresponding to the villages 1-7 were mainly destined for cattle breeding, because in them there are few traces of cultivation and they are today undergoing secondary succession. Areas 8-9 were mainly dedicated to agriculture. Here one can see terraces, geometric shapes and many 'maceras'; on the outer edge there are few isolated huts, not gathered in villages. Outside of these there are other areas, sometimes very large, that in the past had been cultivated, such as the slopes of Costa Terrena and Pian Terrena, on which the parcels of the old properties are still visible, mainly in rectangular shapes.

In the area under study, there are the following types of man-made structures: *caciare*, huts gathered in villages and sometimes isolated; dry-stone walls along some roads and also near the huts, presumably used to delimit the pens; *arette*, threshing floors for the beating of wheat and other cereals obtained by placing flat stones on the ground to form a floor, recognizable today only with difficulty; salt licks for the sheep; flattened stones (in

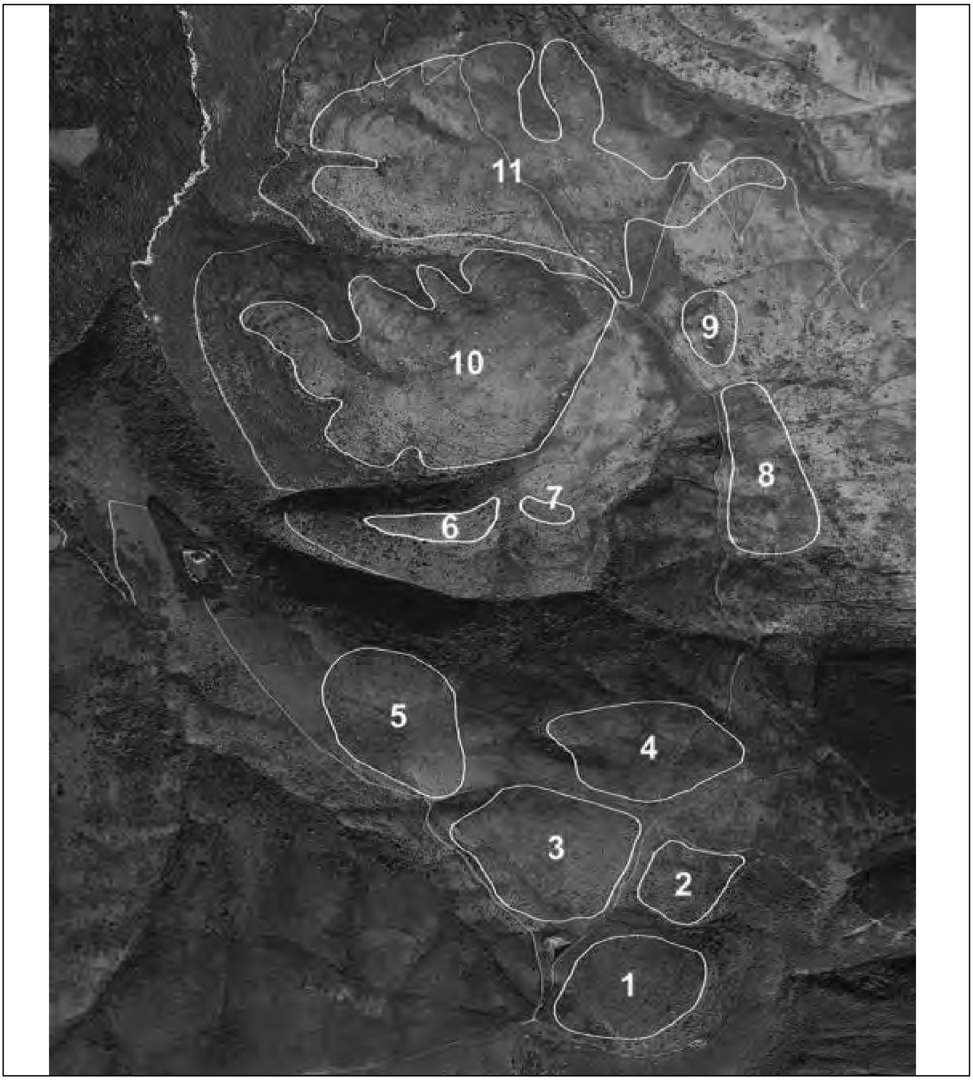

Fig. 2. The dry-stone hut villages of the Macereto Plateau; the meaning of the numbers is the same as in the previous figure (satellite image).

the Marche called “spianche”) placed in the grass where the salt was spread; and *macere*, heaps of stones that had been removed. The *arette* are the same as those found on Monte Cardosa, not far from Macereto (Rosi 2005), where some are still well preserved. The *spianche* are similar to those found at the Pian Grande of Castelluccio di Norcia and on the Montagna di Torricchio (Cortini Pedrotti & al. 1973; Pedrotti 1981).

The vegetation developed on the huts and the other structures mentioned earlier can be summarized as follows. On the *arette* and the *spianche* there are some species with ruderal

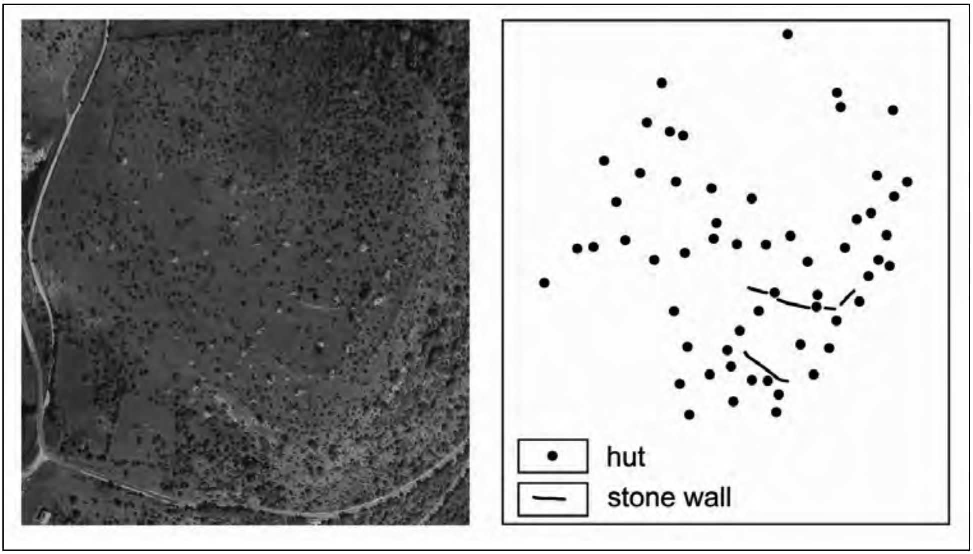

Fig. 3. The distribution of the huts in the village no. 1.

behavior, such as *Capsella bursa-pastoris, Lolium perenne, Poa infirma, Medicago lupulina,* and *Plantago major,* with a very low cover degree and with isolated individuals. These do not form a definite plant association.

Along the dry-stone walls there are hedges of the *Cytisophyllo sessilifolii-Prunetum spinosae* and sometimes alignments of *Quercus pubescens* saplings.

On the heaps of stones (*macère*), some species of the *Festuco-Brometea* class (order *Phleo-Brometalia*) and of the class *Sedo-Scleranthetea* can become established, with a very low coverage (10-15%); establishment along the outer margins of the stone piles was possible for some rare species of the group *Cytisophyllo sessilifolii-Prunetum spinosae.*

On the remains of the stone huts, species of the *Rhamno-Prunetea* class have settled and constitute three shrub associations: *Milio vernalis-Aceretum campestris, Galio aparine-Prunetum mahaleb* and *Cytisophyllo sessilifolii-Prunetum spinosae*. There are also herbaceous species with a very low cover (10-20%), which belong to different classes of vegetation, including the *Sedo-Scleranthetea*, *Thlaspietea rotundifolii* and *Festuco-Brometea.*

The xeric grasslands belong to the order *Phleo-Brometalia* and to the *Phleo ambigui-Bromion* alliance, with the following main species: *Bromus erectus*, *Phleum ambiguum*, *Festuca center-apennina*, *Orchis morio*, *Neotinea tridentata*, *Poterium sanguisorba*, *Muscari atlanticum, Saxifraga granulata*, *Asperula purpurea*, *Anthyllis vulneraria*, *Valeriana tuberosa*, *Eryngium amethystinum*, *Helianthemum grandifolium*. These can be traced partly to the association *Asperulo purpureae-Brometum erecti*. In some of the prairie areas, there are groups of individual plants of *Helichrysum italicum*, the last remnants of the ancient crops then abandoned.

The secondary succession is due mainly to a single species, *Juniperus deltoides*, which is spread massively by birds. Juniper shrubs also foster seed germination by tree species such as *Ostrya carpinifolia*, *Quercus pubescens*, *Sorbus aria* and others, and therefore function as a development center for the biogroups.

The next step, which should involve progressive development of the woody species up to the formation of the pre-forest stage, has not yet become established.

The dry-stone huts of the Macereto Plateau

The dry-stone huts of the plateau of Macereto are called "*caciare*" and take this name from "cacio" (cheese). They are all round in shape, except for some rectangular *caciara*. They are concentrated in agro-pastoral complexes, as they are defined by Colecchia (2015), which, seen anthropogeographically, can be considered mountain villages inhabited only in the summer months for the mountain pastures and partly for agriculture. These settlements correspond to temporary villages of the mid-coast and are quite similar to those in some mountain areas of the Alps, as on the Lombard side of the Ortles-Cevedale Group, where they were illustrated by Albertini (1955). The architecture in the two cases, however, is evidently very different.

The vaults of the Altipiano of Macereto huts have all fallen in and at best only the perimeter walls remain (Fig. 4). The fallen remains form heaps of stones of various sizes, with the flattened stones of the walls and the vault predominating. Often these remains are still delimited by the lower part of the perimeter walls, just 30-40 cm high, which formed the walls of the hut. The size of the huts is variable, from diameters of 5, 8, 10 meters and a little more, up to 11 meters.

The settlement system constituted by the villages of the *caciare* of Macereto is very characteristic but is not mentioned in the specific literature of the Sibillini Mountains that deals with human settlements, or even in hiking guides (see, for example, Bittarelli 1985; Alesi & Calibani 1992; Vitalini Sacconi 1998; Sargolini 2000; Masè & Brunelli 2002).

The vegetation of the *caciare*

On the remains of the *caciare* some herbaceous and woody plant species have settled and, as a whole, give rise to a rather heterogeneous vegetation situation, which nevertheless can be assigned to some very specific phytosociological units. The species found belong to the following vegetation classes: *Asplenietea rupestris*, *Thlaspietea rotundifolii*, *Sedo-Scleranthetea*, *Festuco-Brometea*, *Rhamno-Prunetea* and *Querco-Fagetea*.

The class *Asplenietea rupestris* is limited to the sporadic presence of some rare clumps of *Asplenium trichomanes*, *A. ruta-muraria* and *Ceterach officinarum* on the outer perimeter walls of the huts.

Of the class *Thlaspietea rotundifolii*, only *Drypis spinosa* is present, on the thin debris of a few collapsed huts.

The *Sedo-Scleranthetea* class occupies the same type of substrate as the previous class, but with a soil layer of 1-2 cm; it is present everywhere, at all the huts. The species are *Sedum album* and *Sedum sexangulare*, accompanied by a group of pterophytes, namely

Fig. 4. Hut with a circular plan, remains of the perimeter walls (Photo F. Pedrotti, 2018).

Saxifraga tridactylites, Draba verna, Alyssum minus, Arenaria serpyllifolia, Thlaspi praecox and *Cerastium brachypetalum.*

The species of the *Festuco-Brometea* class, coming from the xeric prairies, are present in the open spaces (ie not covered by shrubby species) of the debris of the collapsed huts, with sparse and isolated individuals, with a degree of covering that rarely exceeds 10-15% (*Festuca centro-apenninica, Bromus erectus, Poterium sanguisorba, Cerastium arvense* and a few others). Only on the external edge can one speak, sometimes, of a band (one meter wide or slightly less) of grassland with a brometo covering 90% and up to 100%, but it is a very variable grouping.

The species of the *Rhamno-Prunetea* class are numerous: *Clematis vitalba, Cornus mas, Crataegus laevigata, Cytisophyllum sessilifolius, Evonymus europaeus, Juniperus deltoides, Malus sylvestris, Prunus mahaleb, Prunus spinosa, Atadinus alpinus* (*Rhamnus alpina*), *Rosa canina, Rubus ulmifolius*; and also *Daphne laureola, Ribes alpinum* and *Viburnum lantana*.

These are all species of the meso-temperate belt, plus *Atadinus alpinus* from the supra-temperate belt. This species is reported on the Sibillini Mountains between 1200 and 1800 m, with a location also at lower altitudes, 700-750 m, in the Rio Terro Valley (Sarnano) in a rocky gorge (Ballelli & al. 2005). It occurs therefore from the meso-temperate belt to the supra-temperate and oro-temperate belts.

The location of the study is between 800 and 1150 m, so it is a station that can be considered heterotopic, considering the presence of *Atadinus alpinus*, found more commonly at 1500-1800 m. The remains of stone huts have allowed *Atadinus alpinus*, transported there by birds, to settle about 400 m lower than the altitudinal range normally occupied by this species.

On the stone huts, the species listed above form the following shrub associations: *Milio vernalis-Aceretum campestris* Pedrotti 1982, *Galio aparine-Prunetum mahaleb* Pedrotti 1994 and *Cytisophyllo sessilifolii-Prunetum spinosae* Cianfaglione and Pedrotti 2016.

The species of the *Querco-Fagetea* class are *Acer monspessulanum, Acer obtusatum, Acer campestre, Fraxinus ornus, Quercus pubescens, Lonicera xylosteum*, and *Sorbus aria*; these always grow as isolated individuals, favored by other species, especially by *Juniperus deltoides*. There are, however, two exceptions, namely *Acer campestre*, which forms very dense thickets on some huts; and *Quercus pubescens*, which sometimes grows along dry stone walls, forming an alignment of saplings.

Ostrya carpinifolia has never been observed on the huts, while it is quite easy to observe it as a component of the biogroups.

Milio vernalis-Aceretum campestris

The *Milio vernalis-Aceretum campestris* is a shrub association attributed to the alliance *Berberidion* (Poldini & al. 2002), which is frequent in the Umbria-Marche Apennines, where it forms hedges at the edge of the parcels and along walls, as well as patches of limited extent. When the hedges are no longer pruned periodically, some species quickly take on an arborescent habit, especially *Acer campestre*, and tend to evolve towards forest associations, as happens in the hedges of the Torricchio Nature Reserve (Pedrotti 2010). On Monte Fiegni (Camerino), the *Milio vernalis-Aceretum campestris* forms hedges along the terraces, but in a flat summit area it has colonized a heap of stones removed from the cultivated areas (Pedrotti 1982).

Fig. 5. Remains of a collapsed hut on which the association *Milio vernalis-Aceretum campestris* has developed; on the right a plant of *Juniperus deltoides* (Photo F. Pedrotti, 2018).

Table. 1. Associations of *Rhamno-Prunetea* class.

Relevé number	1	2	3	4	5	6	7	8	9*	10	11	12	13+	14	15	16	17	18	19	20	21°	Occurr. rel. 1-10	Occurr. rel. 11-14	Occurr. rel. 15-21
Altitude (m a.s.l.)	1050	1100	1000	900	950	1100	1100	980	900	1050	900	950	920	880	1000	1100	1100	1200	1050	980	900			
Aspect	-	-	-	-	W	S-W	-	-	-	S	W	S-W	W	S-S-W	-	-	-	S	S-W	W	W			
Slope (°)	-	-	-	-	5	10	-	-	-	5	5	10	5	5	-	-	-	10	10	5	10			
Cover (%)	100	100	100	90	90	100	90	100	90	90	100	100	100	100	90	90	90	90	90	90	90			
Relevé area (m^2)																								
Diagnotic specie of *Milio vernalis - Aceretum campestris*																								
Acer campestre	5.5	3.4	5.5	3.3	2.3	4.4	1.1	1.1	1.1	1.1	.	.	.	.	1.1	1.1	1.1	.	+	.	.	10	.	4
Milium vernale	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Diagnostic species of *Galio aparine-Prunetum mahaleb*																								
Prunus mahaleb	.	+	+	.	.	+	.	+	1.1	1.1	3.3	1.1	4.4	1.1	.	.	.	.	.	+	+	6	4	2
Galium aparine	1.1	.	1.1	+	.	+	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	5	2	.
Diagnostic specie of *Cytis. sessilifolii-Prunetum spinosae*																								
Prunus spinosa	+	.	+	+	+	.	.	+	+	.	1.1	1.1	+	+	1.1	1.1	2.2	3.3	1.1	2.2	2.2	6	4	7
Cytisophyllum sessilifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	1
Differential species of subassociations *Milio vernalis-Acer. camp. atadinetosum alpini* , *Galio aparine-Prunet. mahaleb atadinetosum alpini* , *Cytis. sess.-Prunetum spinosae atadinetosum alpini*																								
Atadinus alpinus	.	.	.	.	1.1	1.1	2.2	3.3	3.3	3.3	.	2.2	1.1	1.1	.	.	+	+	+	+	1.1	6	3	5
Characteristic sp. of all. (*Berberidion* and *Cytision sess.*) ●, ord. (P*runetalia spinosae*) and cl. (*Rhamno-Prunetea*)																								
Juniperus deltoides	+	+	+	.	1.1	+	.	+	1.1	1.1	+	+	+	2.3	3.3	3.3	+	1.1	3.3	1.1	3.3	8	4	7
Rosa canina	+	+	+	.	+	.	+	.	+	.	1.1	.	+	+	+	+	.	1.1	1.1	.	+	6	3	5
Rubus fruticosus	.	+	+	.	.	.	.	+	.	.	+	+	+	.	+	.	.	.	.	+	.	3	3	2
Crataegus laevigata	.	.	+	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	2	1	1
Evonymus europaeus	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Corylus avellana	.	.	.	2.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Clematis vitalba	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Cornus mas	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1
Other species																								
Geranium lucidum	1.1	2.3	2.2	1.2	1.1	1.2	1.2	.	.	+	2.2	2.3	.	+	.	+	.	.	.	.	.	8	3	1
Rumex acetosa	+	+	+	+	+	.	.	+	.	.	+	+	+	.	.	.	.	.	.	.	.	6	3	.
Silene cucubalus	+	+	.	.	.	.	.	+	+	+	.	+	1.1	.	.	.	.	.	.	.	.	5	2	.
Lonicera xylosteum	.	+	.	+	.	+	.	.	+	+	.	.	+	+	+	1.1	1.1	.	+	.	.	5	2	4

Table. 1. continued.

Geum urbanum	+	1.2	+	1.1	.	.	.	+	1.1	.	.	.	.	.	.	.	.	.	.	.	.	6	.	.
Dactylis glomerata	.	.	+	+	.	.	.	.	+	.	.	.	+	+	.	.	.	.	.	.	.	3	2	.
Malus sylvestris	.	+	.	1.1	.	.	+	.	.	.	+	.	+	.	.	.	.	.	+	.	.	3	2	1
Galium mollugo	.	2.2	1.1	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	3	1	.
Poterium sanguisorba	.	.	.	.	.	.	+	.	.	+	.	.	.	+	.	.	.	.	.	.	.	2	1	.
Geranium purpureum	+	.	.	.	.	.	+	.	.	.	.	.	+	+	.	.	.	.	.	.	.	2	2	.
Silene italica	.	.	.	+	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	+	.	3	1	1
Urtica dioica	.	+	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	2	1	.
Quercus pubescens	.	.	.	.	.	.	2.2	+	.	.	.	.	.	+	.	.	+	.	.	.	.	2	1	1
Helleborus bocconei	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.
Acer monspessulanum	.	.	.	.	1.1	.	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	3	.	1
Teucrium chamaedrys	.	.	.	+	.	1.2	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	3	1	.
Muscari atlanticum	+	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.
Geranium pyrenaicum	.	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.
Poa nemoralis	.	+	.	.	.	.	.	.	.	,	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Lathyrus aphaca	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Draba muralis	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Cruciata glabra	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Viola dehnhardtii	.	.	+	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Daphne laureola	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Fraxinus ornus	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	1	.	1
Bunium bulbocastanum	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	1	.
Ribes alpinum	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1	1	.
Festuca heterophylla	1.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Sorbus aria	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Anchusa azurea	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Tragopogon crocifolius	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Lotus corniculatus	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Hypericum perforatum	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Ranunculus ficaria	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Saxifraga granulata	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Bellis perennis	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Digitalis ferruginea	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Trifolium ochroleucum	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Bromus erectus	.	.	.	.	.	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	1	.
Number of sp. per relevé	14	15	22	16	10	10	12	19	20	9	11	11	16	11	6	6	6	5	7	9	6			

- ● Milio vernalis-Aceretum campestris (Berberidion)
- ● Galio aparine-Prunetum mahaleb (Cytision sessilifolii)
- ● Cytisofilo sessilifolii-Prunetum spinosae (Cytision sessilifolii)

* Holotypus of Milio vernalis-Aceretum campestris atadinetosum alpini subass. nova hoc loco
+ Holotypus of Galio aparine-Prunetum mahaleb atadinetosum alpini subass. nova hoc loco
° Holotypus of Cytisophyllo sessilifolii-Prunetum spinosae atadinetosum alpini subass. nova hoc loco

On the remains of the huts of Monte la Banditella, this association is very frequent and presents itself with two different aspects: that of scrub of limited extent that occupies only part of the collapsed hut, and that of a round grove that occupies the whole area, corresponding to the perimeter of the fallen huts (Fig. 5). In both cases one can certainly recognize the association *Milio vernalis-Aceretum campestris*, which however has a less rich floristic composition than that of the hedges. The findings of 0. 1 can be distinguished in two groups: relevés 1-4 are similar to those described for hedges, while relevés 5-10 differ from the previous by having also *Atadinus alpinus*. This permits describing a new sub-association, the *Milio vernalis-Aceretum campestris atadinetosum alpini*, subass. nova hoc loco (holotypus no. 9, Tab. 1).

In the meso-temperate belt (1100-1150 m) *Atadinus alpinus* participates in the formation of the sub-association *atadinetosum alpini* of the *Milio vernalis-Aceretum campestris*. In the supra-temperate belt (1400-1600 m) *Atadinus alpinus* becomes a component of the *Rhamno alpinae-Amelanchieretum ovalis* association, reported in various locations in the Sibillini Mountains (Pedrotti 1994). In the oro-temperate belt there are isolated shrubs, and Marchesoni (Ballelli & al. 2005) notes that on Monte Castelmanardo at 1700 m *Atadinus alpinus* forms the last shrub vegetation. In the National Park of Abruzzo, Lazio and Molise this species was observed up to 1900 m (Scuriello & al. 2014).

Galio aparine-Prunetum mahaleb

The *Galio aparine-Prunetum mahaleb* is an association of the *Cytision sessilifolii* alliance (Poldini & al. 2002) that develops in conditions quite different from those of the abandoned crop terraces and in the form of hedges along the country roads. In Macereto, this settled on the sloping huts facing west, thermally more favored than those on the plain. There are only 11 species in the relevé, as opposed to 28 in the relevés reported in Pedrotti (1994), which represented an early stage of the association. Similar associations are *Lonicero etruscae-Prunetum mahaleb* Biondi & al. 1988 and *Cytiso sessilifolii-Prunetum mahaleb* Pedrotti 1994 (Biondi & al. 1988; Pedrotti 1994; Poldini & al. 2002).

Also in this case one can distinguish a subassociation characterized by *Atadinus alpinus*, *Galio aparine-Prunetum mahaleb atadinetosum alpini* subass. nova hoc loco (holotypus no. 14, Tab. 1).

Cytiso sessilifolii-Prunetum spinosae

This association, also belonging to the *Cytision sessilifolii* alliance, is developed on the calcareous debris of the outermost parts of the collapsed huts, in much more xeric conditions than in the central part. It is very poor in species (Tab. 1), with only 6 to 9 species per relevé. The surveys carried out in the Pié Vettore locality (Monti Sibillini) are much richer in species, from 13 to 29 species per relevé (Cianfaglione & Pedrotti 2016). This case was also an initial stage of the association.

Atadinus alpinus is also present in this association, but with a very low degree of cover and with small plants. Similar to the two previous associations, here too it is possible to distinguish a sub-association with *Atadinus alpinus*, *Cytiso sessilifolii-Prunetum spinosae atadinetosum alpini*, subass. nova hoc loco (holotyus no. 20 Tab. 1).

Discussion

The stone huts of the Altipiano of Macereto (Monti Sibillini) are environments that favor the process of secondary succession, which occurs through colonization by herbaceous species (*Sedo-Scleranthetea* and *Festuco-Brometea* classes), then shrubs (class *Rhamno-Prunetea)* and sometimes trees (*Querco-Fagetea* class). The large stones of the perimeter walls and the vaulted ceilings, accumulated on the ground, and the small cavities between them, favor the condensation of atmospheric moisture. This is one of the factors that allows settlement by shrub species of the *Milio vernalis-Aceretum campestr*is and *Galio aparine-Prunetum mahaleb* associations. On smaller stones, this phenomenon is less marked, and in fact on them there develops the third shrubby association, the *Citysophyllo sessilifolii-Prunetum spinosae,* which is less demanding than the other two. On the collapsed huts these three associations of the meso-temperate belt are enriched with *Atadinus alpinus*, a species normally present in the supra-temperate belt. In this way each modification forms a peculiar subassociation, *atadinetosum alpini,* which is the most characteristic vegetation of the dry-stone huts of Macereto.

In the xeric prairies surrounding the huts, secondary succession is also in progress, but takes place much more slowly. In fact until today it has produced only the spread of isolated plants or groups of *Juniperus deltoides* and a few other species, such as *Rosa canina,* and the formation of biogroups, each of which consists of very few species, 4-5 species at most (in addition to *J. deltoides, Fraxinus ornus, Sorbus aria, Acer obtusatum, Rosa canina, Clematis vitalba, Cytisophyllum sessilifolium, Viburnum lantana, Lonicera xylosteum*, with very low levels of cover, from 1 to 10%). We cannot yet speak of associations, as is the case on huts.

Lastly, one should also remember the process of primary succession, with the development of groups of *Drypis spinosa* plants. This is a typical species of the Sibillini screes, from the meso-temperated belt to the oro-temperate.

Relevés locations (Tab. 1, rel. 1-21): Altipiano of Macereto (Sibillini Mountains, Central Apennines), VI-2018.

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Ernst Vitek

Gundelia (*Compositae*), from one to many species – an ignored diversity*

Abstract

Vitek, E.: *Gundelia* (*Compositae*), from one to many species - an ignored diversity. — Bocconea 28: 307-313. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

For long time in scientific botany the genus *Gundelia* (*Compositae*) was treated with only one polymorphic species *Gundelia tournefortii* L. When finding new populations in Armenia it was realized, that several species are hidden in the variety. At the moment 15 species are accepted as distinct taxa. The genus can be found from Turkey eastwards to Afghanistan, southwards to Israel and Iraq. The centre of diversity is in Eastern Turkey.

Key Words: Mediterranean Flora, systematics.

Introduction

Linnaeus (1753) described *Gundelia tournefortii*, all later described species and varieties have been put back into synonymy by later authors (e.g. Kupicha 1975; Rechinger 1989). Therefore during the OPTIMA excursion in Armenia in 2002 plants of this genus have been presented to the participants as *"Gundelia tournefortii"*. In 2005 two new localities of *Gundelia* have been found in Armenia, and comparing these populations it became clear that there is more than one species in the genus. After finding the important characters to distinguish the species, step by step all published names of whatever rank have been checked, typified and – as far as possible – the type localities visited. The plants of the genus *Gundelia* are called „Kenger" in Turkish, „Akub" in Arabic and „Kuub" in Farsi language, with some local dialectic variations. Young shoots are used as vegetables or as food for animals. The latex of the cut shoots can be dried and used as chewing gum. The roasted fruits can be used to replace coffee beans.

Results

At the moment 15 species are accepted (Vitek & Jarvis 2007; Vitek & al. 2010; Vitek & al. 2014; Nersesyan 2014; Armağan 2016; Fırat 2016, 2017a; Vitek & al. 2017a, 2017b; Vitek & Noroozi 2017a, 2017b; Fırat 2017b; Çakılcıoğlu & al. 2018; Vitek 2018). They can be distinguished by size of the plant, colour of flowers (Fig. 1), number of flowers in one partial synflorescence, indumentum, shape and size of fruits, climatic and ecological requirements (Table 1).

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Table 1. Gundelia species and their characters.

Taxon	**Plant size (cm)**	**Synflorescences per plant**	**Flower colour (inside)**	**Number of flowers**	**Indumentum (in synflorescence)**	**Distribution (countries)**
G. anatolica	30–60	10–15	yellowish green to green	6	young shoots with dense arachnoid hairs	Turkey
G. aragatsii subsp. *aragatsii*	50–80	5–15	brown	3 (–5)	arachnoid hairs when young	Armenia, Azerbaidjan
G. aragatsii subsp. *steineri*	50–80	5–15	brown	3	arachnoid hairs when young	Armenia
G. armeniaca	50–80	5–15	violet	6	glabrous	Armenia, (Turkey?)
G. asperrima	20–50	5–10	blackish brown	3 (–5)	very dense arachnoid hairs	Turkey
G. cilicica	30–70	5–10	golden yellow	(5–) 6	arachnoid hairs when young	Turkey
G. colemerikensis	50–80	15–30	reddish maroon to pinkish–maroon	5–6	glabrous or arachnoid hairs when young	Turkey
G. dersim	60–100	5–15	brown to reddish–brown	6–7	densely covered with tomentose (and arachnoid) hairs	Turkey
G. glabra	30–60	5–10	brown	3–4	glabrous	Turkey
G. komagenensis	30–60	1–5	golden yellow	3 (–5)	glabrous or sparsely arachnoid hairs	Turkey
G. mesopotamica	50–80	5–20	whitish to pale yellowish	6–7	glabrous to tomentosely hairy	Turkey
G. microcephala	20–60	3–10	yellow	6–7	young state covered with hairs	Iran, Iraq
G. munzuriensis	30–80	5–10	bright pink to pink	3–6	sparsely hairy with arachnoid hairs	Turkey
G. rosea	40–120	10–60	pale violet	(7–) 8 (–10)	arachnoid hairs when young	Iran, Iraq, Turkey
G. tehranica	40–120	10–60	yellow	(7–) 8	glabrous, rarely few arachnoid hairs on young shoots	Iran
G. tournefortii	40–100	5–10	bright yellowish to yellow	5–7	hairy to densely hairy	Cyprus, Israel, Syria, Lebanon, Turkey, (Iran?, Iraq?)
G. vitekii	40–60	1–5	dark pink to red	3 (–5)	arachnoid hairs when young	Turkey

Accepted taxa:

Gundelia L., Sp. Pl. 2: 814 (1753), type species: *G. tournefortii.*

G. anatolica Fırat, *Gundelia* Spec. Anatolia: 23–24 (2016). – Fig. 1c.
Type: Turkey, B4, Kırıkkale, Delice province, Tuzkayası region, 700 m, 39°58'20" N, 34°04'12" E, 2. 5. 2015, M. Fırat 32645 [holotype VANF, isotypes ANK, Herb. Yıldırımlı, Herb. Fırat].

G. armeniaca Nersesyan, Ann. Naturhist. Mus. Wien, B 116: 192 (2014). – Fig. 1f.
Type: Абовянский район, окр. с. Гехадир, 10. 06. 1988, А. Нерсесян, [Abovian region, surroundings of Geghadir village, 10. 06. 1988, A. Nersesyan] [holotype ERE 137773, isotypes ERE 137772, ERE 149115, ERE 149116, ERE 149117, W 2006-0005938, W 2006-0005939].

G. aragatsi Vitek, Fayvush, Tamanyan & Gemeinholzer subsp. *aragatsi*, Ann. Naturhist. Mus. Wien, B 111: 92 (2010).
Type: Armenia, Aragatsotn province, Mt. Aragats SW-slope, track between Avtona water reservoir and Kakavadzor, 1880 m s. m., 40°22'5"N/44°2'49"E, 23. 6. 2007 G. Fayvush, K. Tamanyan, H. Ter-Voskanyan, E. Vitek 07-1373 [holotype ERE, isotypes W (four sheets) 2009-18514–2009-18517, B, BC, BM, BRNU, E,MO, MSB, NY, WU].

G. aragatsi subsp. *steineri* Vitek, Fayvush, Tamanyan & Gemeinholzer, Ann. Naturhist. Mus. Wien, B 111: 96 (2010).
Type: Armenia, Vayots Dzor province, mainroad to south Armenia,Wof Yeghegnadzor, SE of crossroad to Erechgnadzor, slope S of river, 1050 m. s. m, dry rocky slope, 39°44'21"N/45°15'3"E, 2009-06-01 G. Fayvush, K. Tamanyan, E. Vitek 09-0700 [holotype ERE, isotypes W2009-18513, B, BC, E, MO, MSB, NY, WU].

G. asperrima (Trautv.) Fırat, Ot Sist. Bot. Dergisi 24(2): 62 (2017) [31 Dec 2017?]
≡ *G. asperrima* (Trautv.) Çakılcıoğlu, Yüce & Vitek, Ann. Naturhist. Mus. Wien, B, 120: 240 (2018). [Jan 2018, isonym]
Type: "In Turciae districtu Erzerum, in montibus Palänteken, altit. 6300' [1920 m], Radde" [TB n. v.].

G. colemerikensis Fırat, Gundelia Spec. Anatolia: 15–16 (2016). – Fig. 1b.
Type: Turkey, C9, Hakkâri Province (Colemerîk) from Karadağ hill to Berçelan plateau, 2284 m, 37°36'39" N, 43°44'44" E, 11. 6. 2015, M. Fırat 32465 [holotype VANF, isotypes ANK, Herb. Yıldırımlı, Herb. Fırat].

G. dersim Vitek, Yüce & Ergin, Phytotaxa 161: 131 (2014).
Type: Turkey, Province Tunceli (Dersim), Ovacık, c. 11. 7 km WWSW Ovacık, 1. 9 km ENE Ziyaret (fountains of river Munzur), 1300 m s. m., 39°20'16" N / 39°4'57" E, 12. 06. 2013, E. Vitek, E. Yüce, C. Ergin & H. H. Makal 13-0030 [holotype W 2013-0006146, isotypes Tunceli University, HUB, ISTE, E, G, US].

G. glabra Mill., Gard. Dict., ed. 8. n. 2 (1768). – Fig. 1a.
Type: Turkey, province Bayburt, c. 4.4 km SSE Bayburt, road to Gümüşsu, c. 100 m from main road, 1595 m s.m., 40°13'37"N 40°15'43"E, 14.6.2013 E. Vitek, E. Yüce, C. Ergin & H. H. Makal 13-0173 [neotype W 2013-0006162, iso-neotypes Tunceli University, B, E, G, HUB, INU, ISTE, NY, US].

G. komagenensis Fırat, Gundelia Spec. Anatolia: 6–7 (2016). – Fig. 1g.
Type: Turkey, C7, Adlyaman: Kahta Province, Nemrut mountain, 1445 m, 31'57'01" N,

38°45'38" E, 26. 5. 2015, M. Fırat 32494 [holotype VANF, isotypes ANK, E, Herb. Yıldırımlı, Herb. Fırat].

G. mesopotamica Fırat, Acta Biol. Turc. 30: 65 (2017).
Type: Turkey. C8 Mardin: 2–3 km from Mardin to Nusaybin (Nisêbîn), eroded slopes, aride steppe, 807 m, 37°17'36"N, 40°46'20"E, 8. 5. 2017, M. Fırat 33725 [holotype VANF, isotypes ANK, Herb. M. Fırat].

G. microcephala (Bornm.) Vitek, Ann. Naturhist. Mus. Wien, B, 120: 235 (2018).
Type: Inter Kermandschahan et Bagdad, prope Khanegyn [Chanekin, Chanaqin] ad fines Persiae, Grenzstation, 3. 4. 1894, Strauss s. n. [JE 00015288].

G. munzuriensis Vitek, Yüce & Ergin, Phytotaxa 161: 135 (2014).
Type: Turkey, Province Tunceli (Dersim), Ovacık, c. 2 km WWSW Ovacık, 1275 m s. m., 39°21'19" N / 39°11'29" E′, 12. 6. 2013, E. Vitek, E. Yüce, C. Ergin & H. H. Makal 13-0025 [holotype W 2013-0006270 (inflorescence) and 2013-0006269 (additional leaf), isotypes Tunceli University, HUB, INU, ISTE, B, E, G, L, US].

G. rosea M. Hossain & Al-Taey, Notes Roy. Bot. Gard. Edinburgh 42 (1): 41 (1984). – Fig. 1d–e.
Type: Iraq, c. 60 km. N. E. of Mosul, 10. 5. 1978, Hossain s. n. [holotype MSUH, isotypes BAG, E00385310, K000797235]

G. tehranica Vitek & Noroozi, Ann. Naturhist. Mus. Wien, B, 119: 246 (2017).
Type: Iran, Tehran, Tuchal Mt., above Velenjak, 2200-2300 m, 35°49'26"N, 51°23'30"E, 6. 5. 2016, J. Noroozi [holotype W 2016-0011195, isotypes E, G, IRAN, NY, TARI, W 2016-0011196].

G. tournefortii L., Sp. Pl. 2: 814 (1753).
Lectotype: [Aleppo,] Rauwolf 1583, t. 74. Epitype: [Aleppo,] Rauwolf, hort. sicc. 81 [L].
= *G. cilicica* Fırat, *Gundelia* Spec. Anatolia: 19–20 (2016).
Type: Turkey, C5, Mersin, Erdemli province, Tozlu village, 1460 m, 36°48'12" N, 34°07‘09" E, 5. 5. 2016, M. Fırat 32705 [holotype VANF, isotypes ANK, Herb. Yıldırımlı, Herb. Fırat].

G. vitekii Armağan, Ann. Naturhist. Mus. Wien, B, 118: 130 (2016).
Type: Turkey, province Tunceli (Dersim), Tunceli Merkez, c. 8 km N of Tunceli, mountain slope NW of Tüllük Bucaği, 39°10'32"N 39°32'04"E, 1745 m s. m., 31. 5. 2015, E. Vitek, M. Armağan & M. Özel 15-0042 [holotype VANF, isotype W 2015-11168].

Names still needing clarification:
Gundelia tenuisecta Freyn & Sint., Oesterr. Bot. Z. 42: 168 (1892).
G. tournefortii var. [β] *araneosa* DC., Prodr. Syst. Nat., 5: 88 (1836).
G. tournefortii var. *armata* Freyn & Sint, Österr. Bot. Z. 42: 168 (1892).
G. tournefortii var *tenuisecta* Boiss., Fl. Orient. 3: 421 (1875).

Discussion

It is a surprising fact, that the diversity in the genus has been ignored for long time. Probably this is partly due to the difficulties in collecting these often rather big, spiny and badly drying plants. In the herbarium specimens some characters as the flower colour can-

Fig. 1. *Gundelia,* synflorescence. a) *G. glabra,* b) *G. colemerikensis,* c) *G. anatolica,* d–e) *G. rosea,* f) *G. armeniaca,* g) *G. komagenensis.* – a, d, e, g © Vitek, b, c, f © Armağan.

not be seen and in most cases there is no information on the habitat. Some authors (e.g. Bornmüller 1906; Trautvetter 1876) found the important differencing characters, but described the taxa as varieties.

All species are clearly differentiated in their characters (Table 1), but also well defined in their ecological needs. E.g. *G. glabra* has been found in the province Elaziğ, near Sivrice growing on a dry slope (Vitek & al. 14-0189 [W 2014-0014879]; Vitek & al. 2017: Fig. 4c), and *G. dersim* in about 30 m distance in a grassy humid ditch (Vitek & al. 14-188 [W 2014-0014881], new record for the province Elaziğ). No plants could be found in between showing the strict limitation to the required habitat. In Armenia *G. aragatsi* subsp. *aragatsi* is found in mountain (steppe) meadows (1700-1900 m), *G. aragatsi* subsp. *steineri* on a stony slope with Shibljak vegetation (1000-1100 m) and *G. armeniaca* in semi-humid to dry meadows in lower altitude (1300-1600 m).

Gundelia has its centre of diversity in Turkey with 12 (-13) species, reaching Afghanistan in the East, Israel in the South and Cyprus. Based on photos and information found in the internet there are still some species to describe. There is insufficient information on the variability in Iran and Iraq with 3 (-4) species at the moment. For other countries from which *Gundelia "tournefortii"* is reported, e.g. Azerbaijan or Turkmenistan, there is no reliable information to assign a species, but with high certainty this is not *G. tournefortii.* The same is valid for Afghanistan - the photo in Breckle & Rafiqpoor (2010: 271) shows some similarity to *G. tehranica*, but does not allow a clear assignment. Anyway the total number of species could go up to 20-25 species in future.

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The National Herbarium of Georgia at the Institute of Botany, Ilia State University, Georgia

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Key words: Caucasus, virtual herbarium, databasing.

The National Herbarium of Georgia at the Institute of Botany of Ilia State University, Tbilisi, is one of the oldest (1845) herbaria in the Caucasus. It is included in Index Herbariorum under the code "TBI".

The Herbarium contains collections of nomenclature types, the Caucasian, Middle Asian, Iranian-Turkish, European, Paleotropical, Grossheim's collections as well as collections of plants of Tbilisi environments, introduced plants (at Batumi, Sokhumi, Tbilisi Botanical Gardens), and the duplicate fund.

The total number of the herbarium specimens exceeds one million, while the number of nomenclatural types exceeds 1000. An important direction in the work of the Herbarium in 2014-2018 has been a survey of the monocot specimens stored at the Herbarium and their arrangement in compliance with modern taxonomy and nomenclature on the basis of electronic databases and relevant monographies. Other important directions include creation of a virtual herbarium of target collections, establishment of a Georgian-English database, herbarium specimen barcoding and promotion of their use at the international level. An exchange program for duplicate material with various leading world centers will become active, promoting, in its turn, replenishment of the herbarium fund.

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A. Bisio, L. Pessa, F. Pedrelli, N. De Tommasi & M. Giacomini

From the experience of “PLANT” and “PYRGY” EU Projects onwards: interdisciplinary link of medicinal plant science with history and art

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Key words: ethnobotany, medicinal plants, aromatic plants.

The iconography of medicinal and aromatic plant in art masterpieces can be an interesting contribution to the ethnobotanical knowledge related to the historic period when the artefact was produced. Along herbarium specimens, sometimes misrepresenting the morphological characters, the images inside artistic expressions not meant for scientific purposes, and often related to complex symbolic meanings, are of interest also from the botanical and the pharmaceutical point of view. Within the work of the EU project “Plants in European Masterpieces (PLANT)” we considered 100 species of ethnobotanical interest into 25 paintings and frescoes of XVI century in the Genoese museums or in other museums but having Genoa as a subject. Part of the dissemination activities of the EU project “Strategia d’impresa in settori di nicchia per l’economia agroindustriale del Mediterraneo (PYRGI)”were devoted to the comparative study of a Genoese collection of pharmacy jars, pharmacy recipes of pharmacopoeias used in the past in Liguria, and aromatic and medicinal plants of the Ligurian area. For both projects a relational database ad hoc developed, having specific tables for all the three main sections of study (art, botany and pharmaceutical and ethnobotanical knowledge), was produced. These databases were the backbones of the PLANT desktop application and of the web site for PYRGI respectively. The hyperlink trees allow the user to navigate among reconstructions of ancient recipes, the botanical information and the related masterpiece. The ongoing research is focused on other paintings of the Genoese collections of the Musei di Strada Nuova. The painting *I santi Sebastiano, Giovanni Battista e Francesco*; *Madonna con il Bambino e Angeli* (1502-1503) by Filippino Lippi, is of particular relevance, with 43 entities; 36 of which are herbaceous species. 18 taxa are clearly identifiable, belonging to Pteridophtyes (2 taxa) and Angiosperm Dicotyledons (16 taxa).

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A. R. Burgaz, R. Pino-Bodas & B. Gutiérrez-Larruga

Cladonia subturgida a very little known Mediterranean lichen

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Key words: *Cladoniaceae*, morphology, chemotaxonomy.

Cladonia subturgida Samp. is a species that for a long time was known only from a single locality in Beira Alta (NW Portugal). After a morphological, chemical and molecular study of similar species it was concluded that *C. subturgida* is a morphologically and chemically polymorphic species that should include *C. iberica* Burgaz & Ahti, but is not related with *C. corsicana* (Rondon & Vězda) Pino-Bodas, Burgaz & M. P. Martín (*C. turgida* var. *corsicana* Rondon & Vězda), and its distribution was enlarged to SW of the Iberian Peninsula.

As result from new collections, this species is much more frequent in other countries of the Mediterranean Region. It has been found in South France, Sardinia (Italy) and Greece (continental areas and Crete).

This species has a persistent primary thallus with long squamules (6-16 × 5-4 mm), upper surface light green to olivaceous and lower surface white to greyish colour. Podetia are not very often encountered, not scyphose, branched, 5.5-15 × 1-2.3 mm, corticated and with open axils. Apothecia are common, dark brown. Pycnidia are very common, on the squamules surface, pedunculated, black. The chemistry is variable with six different chemotypes,but atranorin and protolichesterinic acid are the most frequent substances.

It grows on bare soils or earth bank, preferably acidic or subneutrophilous. The dominant vegetation is *Cistus* shrubs, heathlands, Pinus or oak formations. The altitude ranges from 25 to 1225 m.

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Roberta Calvo

Thermal insulation role and possible exploitation of *Posidonia oceanica* detritus in the Mediterranean area*

Abstract

Calvo, R.: Thermal insulation role and possible exploitation of *Posidonia oceanica* detritus in the Mediterranean area. — Bocconea 28: 321-327. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

The paleoendemic seagrass *Posidonia oceanica* (L.) Delile represents a key species of the most important and productive ecosystem in subtidal habitats of the Mediterranean Sea. This species is the most common seagrass in Sicily where it forms dense and extensive beds, which are characterized by high coverage and primary production values. The beaching of *P. oceanica* detritus (banquette) can be an environmental, economic and social problem, if it comes into conflict with a number of activities (tourism, bathing establishments, etc.). Even though seagrasses play a fundamental ecological role in limiting coastal erosion and promoting the origin of the coastal dunes, the presence of *P. oceanica* detritus along the coasts can negatively decrease the tourism value of beaches. As a result, according to national and regional laws and guidelines, local authorities are required to remove banquette and to accumulate it in landfills. In this survey, the ancient exploitation and current uses of *P. oceanica* detritus are reported according to literature data. Moreover *P. oceanica* detritus were used to replace soil in an experimental installation located at the University of Palermo. Meanwhile, continuous temperature values measurements by using hobo data logger sensors were carried out. The results confirm the thermal insulation role of this material and highlight potential applications in the field of Soil Bioengineering.

Key words: seagrasses, soil bioengineering, circular economy, Sicily.

Introduction

The world population is expanding incessantly, and economic and demographic growth are leading to the exploitation of the environment and the reduction of natural resources, with potentially important impacts on global climate change (Vörösmarty & al. 2000).Therefore, more efficient management of resources is necessary, based on the modification of sustainable objectives of environmental policies and strategies and lower consumption of resources. Actions are needed to promote the transition from a linear economy

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model to a circular one, consisting of a continuous positive development cycle that preserves and improves natural capital, optimizing the use of resources (MacArthur 2013).

P. oceanica (L.) Delile is an endemic seagrass found in the Mediterranean Sea, where it forms extensive meadows in the marine infralittoral zone (Duarte 1991). This species is the most common seagrass in Sicily, covering a surface of about 76,000 ha and growing at a depth of 0-50 m (Calvo & al. 2010). In particular, along the western coasts of Sicily *P. oceanica* meadows form dense and extensive beds, which are characterized by high coverage and primary production values.The seagrass plays a fundamental ecological role in limiting coastal erosion and promoting the establishment of the coastal dune system (Boudouresque & Meinesz 1982; Simeone & De Falco 2012; Boudouresque & al. 2016). As a consequence of phenological process, the beached detritus of *P. oceanica* (banquette) are widely considered a problem by local inhabitants, conflicting with many economic activities such as coastal tourism, bathing, etc. As a result, local authorities are required to remove *banquette* and dispose them in landfills. In fact, Italian legislation considers these plant biomasses as a special kind of solid waste material to be disposed to landfills, thus resulting in an enormous loss of organic materials, nutrients and useful biomolecules (Saidi & al. 2009), with additional problems associated with their transport to landfills.

Circular no. 35792/2009, issued by the Sicilian Regional Administration, proposes a management option that consists in the reuse of biomass in landscape reconstruction, as a compost in agriculture or as environmental restoration workin coastal areas (Legislative Decree 75/2010 reforming and revision of the fertiliser guidelines, pursuant to Article 13 of Law no 88 of 7 July 2009).

In this regard, Soil and Water Bioengineering uses plants as living building material in environmental and landscape development works. Such works with low environmental impact promote biodiversity and, in addition, offer a promising strategy for mitigation and adaptation to climate change (Duarte & al. 2013). Thus, the use of adequate, sustainable, easy to find and low-cost materials is essential for the achievement of these objectives. From the viewpoint of the circular economy, the reuse of *P. oceanica* detritus has a double beneficial effect. It constitutes a solution to the problem of waste disposal and an opportunity for the creation of local and low-cost new products.

Considering the great availability of detritus resulting from the annual cleaning of beaches from the leaves of *P. oceanica* in Sicily, the aim of present work is to test if this detritus could exert a thermal insulation role with potential applications in the field of Soil Bioengineering. For this pourpose an experimental installation located at the University of Palermo were set up, where different treatments consisting of mixtures of *P. oceanica* detritus-soil composed were assembled in modular structures.

State of art of multiple-uses of *P. oceanica* detritus

The uses of beached *P. oceanica* detritus date back to prehistoric history. In fact, the occurrence of vegetable biomass was detected in the Lazaret's Cave (Nice), where dissected *P. oceanica* detritus were used to build beds (De Lumeley & al. 1969). The ancient Egyptians made seaball to make shoes (Tackolom & Drar 1954). Along the coasts of North Africa, in Spain and Balearic Islands (Terrados & Borum 2004), the beached leaves of *P.*

oceanica were used for the construction of roofs and bricks for the construction of walls and shafts (Trotter 1915). A rich macrofauna (gastropods, crustaceans, annelids and insects) inhabits the banquettes (Deidun & al. 2009). Whatever the role of the *P. oceanica* debris in the diet of the harboured fauna, banquettes are very important as a physical structure that provides detritivorous and predatory species with refuge from environmentally stressful conditions (Colombini & al. 2009) and top predators such as sea birds (Bartoli & Prévot 1978; Bartoli & Holmes 1997). *P. oceanica*, because of the high content of cellulose, may be suitable for the production of paper (McRoy & Helfferich 1980). The detritus of *P. oceanica* have found a greater field of application in agriculture as organic substance to increase the fertility of soil (Cocozza & al. 2009; Parente & al. 2009; Montesano & al. 2014; Mininni & al. 2015; Pirrera & al. 2017; Calvo 2018). The thermo-absorbent properties of *P. oceanica* leaves, combined with their low density and high porosity (Milchakova 2014), allowed its use as thermal insulator in Greece (Sordina 1951).

Some uses in traditional medicine were confirmed as well as antibacterial and antifungal activity of leaves extracts. Gokce and Haznedaroglu (2008) have conducted a study on diabetic rats, which showed how the oral intake of the extracts of *P. oceanica*, reduces blood glucose and induces blood vessel protection.

Researches on the possible use of *P. oceanica* in cosmetics were introduced by the Company Egadi Natural Cosmetics which defined a protocol of green collection on *P.oceanica* beached and has obtained an extract with excellent antioxidant properties for a new line of treatment cream.

Finally, several projects have provided for the use of *P. oceanica* detritus. In the whole Mediterranean area there are different experiences of composting, thanks to the high presence of beached detritus of *P. oceanica* along the coasts. In Tunisia, for example, the compost was used as substrate for the cultivation of vegetables and, in particular, tomato (Verlodt & al. 1983). In Italy, experimental activities of composting and the use of the compost were carried out by serveral authors (Cocozza & al. 2011; Mininni & al. 2015; Montesano & al. 2014). *P. oceanica* detritus were also recently used in a Soil Bioengineering project to the Municipality of Custonaci (province of Trapani, Sicily) (Pirrera & al. 2017).

Materials and Methods

The construction of modular structures was made with organic waste materials, namely detritus of *P. oceanica* and vine pruning (vine shoots). In this regards, vine shoots were assembled in the form of fascines to constitute the basic element used to create a fascinate module, a linear Soil and Water Bioengineering work with anti-erosive, consolidation and stabilization functions, while the detritus of *P. oceanica* were used as a growing medium, to permit it, after planting with native species, an evolution toward a more natural substrate. Finally continuous temperature values measurements using hobo data logger sensorswere carried out whitin different mixtures.

A small prototype of fascinate has been set up in experimental fields at the University of Palermo. (38°06'27.73 "N; 13°20'59.48" E). The work 20 m long, is structured in 12

fascines.The fascines were subsequently filled with 30 liters of substrate composed of several mixtures of detritus of *P. oceanica*-soil according to the scheme:
– no. 3 fascine filled with 100% of *P. oceanica* detritus;
– no. 3 fascine filled with 80% soil - 20% of *P. oceanica* detritus;
– no. 3 fascine filled with 100% soil;
– no. 3 fascine as control.

Temperature values inside the fascines was measured from July to November 2017 by using hobo data logger sensors. The data were recorded continuously every 30 minutes only in a) the external environment, b) inside the *P. oceanica* detritus (5 cm depth) contained in fascines and c) in the soil (5 cm depth) next to the installation. On the whole, 18.603 temperature values were acquired.

Results

During summer, temperature values ranging between 36.6°C in *P. oceanica* detritus and 55.1°C in the external environment. Instead, in autumn the minimum temperature values measured were 5.6°C in the external environment and 9.7°C in the detritus of *P. oceanica*. Moreover, maximum and minimum temperature values registered in the soil were 43.2 °C and 11.9°C (Fig. 1).

Lowest average temperature values were recorded in *P. oceanica* detritus inside fascines, both in the summer period (25.7±3.6) and throughout the measurement period (21.8±5.2) (Table 1).

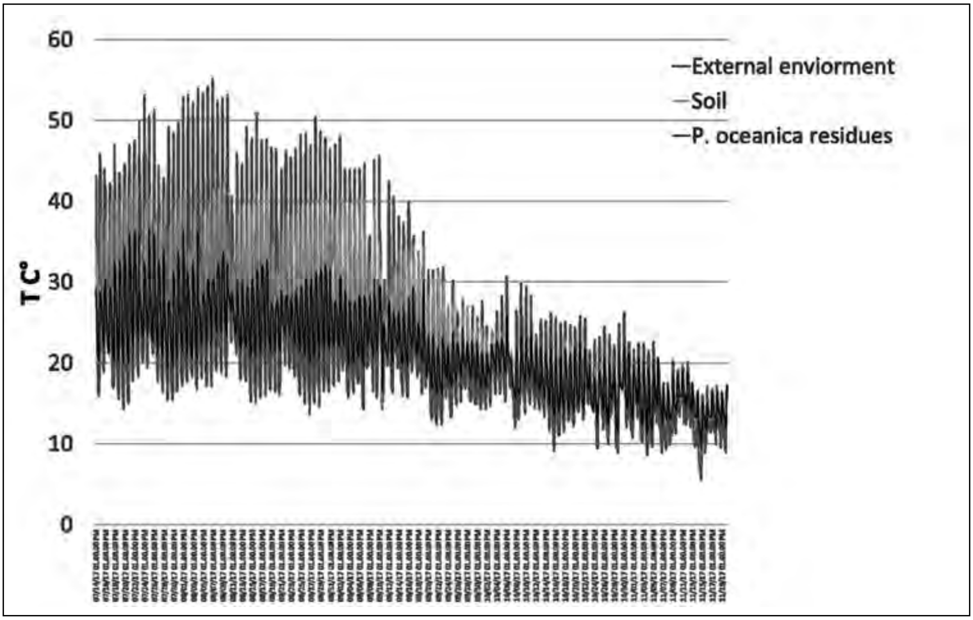

Fig. 1. Temperature values recorded from July to Sempember 2017 during the experiment.

Table 1. Average temperature values (±SD) recorded in the experimental installation.

Dates	External temperature (mean±SD)	P. oceanica detritus (mean±SD)	Soil (mean±SD)
14-31 July 2017	29.6±10.2	26.4±4.2	31.2 ±5.1
01-31 August 2017	29.1±10.9	26.4±3.2	30.7±5.0
01-30 September2017	23.1±7.2	25.5±3.1	25.5±5.0
01-31 October 2017	17.8±4.2	18.3±2.6	19.0±2.0
01-20November 2017	13.7±3.2	15.2±2.2	15.8±1.6
14 July - 21 September2017 (Summer)	28.0±10.0	25.7±3.6	29.8±5.2
22 September – 20 November 2017 (Autumn)	16.8±4.6	17.5±3.0	18.5±3.0
14 July - 20 November 2017	22.7±9.7	21.8±5.2	24.5±7.1

Discussion and Conclusions

In the framework of an efficient use of resources and a good waste management, this study underlines the high insulating capacity and the value of *P. oceanica* detritus as a replacement for the plant substrate. In fact, using *P. oceanica* detritus a significant attenuation of maximum and minimum daily temperature values was observed at level of root system, comparing with soil and external environment (Figure 1). Hence, this study suggests that beached of *P. oceanica* detritus, in addition to finding application as thermal insulation in buildings (Sordina 1951; Milchakova 2014), can also be used to promote the rooting and growth of plants that find application for their biotechnical characteristics in the field of Soil Bioengineering (Tuttolomondo & al. 2017).

Moreover, the use of *P. oceanica* detritus, widely detectable in Sicily and in the Mediterranean basin, represents a valuable example of low cost, sustainable use, energy efficiency and complete respect of the environment. In this context it is also necessary to consider the opportunity to raise public awareness of the importance of seagrass and the beached detritus for the preservation of coastal ecosystems.

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Plant landscape and phytodiversity in the ancient town of Erice (NW Sicily)

Di Gristina, E., Pedone, P. & Raimondo, F. M.: Plant landscape and phytodiversity in the ancient town of Erice (NW Sicily). — Bocc. 28: 329-330. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: native flora, ornamental flora, biodiversity.

The town of Erice, in the province of Trapani, is an environmental unicum in the context of the ancient settlements of western Sicily. Its history, substrates, and particular climate, generated by its geo-orographic position, make it a particular hot spot of natural and cultural biodiversity. Located on the top of Mount San Giuliano, in addition to natural habitats with their specific florulas, the town shows small gardens and among the few inhabitants there is a widespread green culture. A tourist destination by its various architectural and landscape historical peculiarities, Erice presents a residential center made up by small stone buildings, with small courtyards or "bagli" often used to house pergolas, decorative or fruit plants placed in pots or in the ground. Protected from the wind - thanks to the special microclimatic conditions that occur at the top of the relief exposed to moist sea breeze- they find the optimal environment to grow and preserve.

The Giardino del Balio, Villa Pepoli and the remains of the park around the town, as well as the Castello di Venere and the various rocky relieves within the town, the old walls of protection of the city, are ideal habitats for many native and cultivated species. Among the former we remember the endemic and very rare *Centaurea erycina*, *Silene nefelites*, and *Brassica villosa* subsp. *drepanensis* Other endemic species find the best habitat in emerging cliffs and in architectural artefacts; they are *Silene fruticosa*, *Dianthus rupicola* subsp. *rupicola*, *Seseli bocconei*, etc. In the same contexts other chasmophytes are also frequent among which *Athamantha sicula* emerges. On the margin of Villa Pepoli, awesome trees of *Prunus mahaleb* subsp. *mahaleb* testify to the ancient settlement of native tree species - rare on the island - then locally cultivated. In the Giardino del Balio, in addition to the ancient borders of *Buxus sempervirens*, luxuriant specimens of *B. balearica* remarks the sub-oceanic character of the climate at the top of Mt. San Giuliano. The presence of a rich contingent of pteridophytes and bryophytes also depends on such climate, including the rare epiphytic moss *Cryphaea heteromalla*, common right on the branches of the two *Buxus* species.

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P. Minissale, V. Magro & F. M. Raimondo

Why did *Acanthus mollis*, native to West Mediterranean, become a so relevant artistic and symbolic element arising from ancient Greece?*

Abstract

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In classical antiquity many plant species were a source of inspiration in art and architecture. An emblematic case is *Acanthus mollis*, a Western Mediterranean species, although many Mediterranean countries Floras are in contradiction with respect to its native distribution. Two subspecies are known: *A. mollis* subsp. *mollis* distributed in Italy, France and Croatia, and *A. mollis* subsp. *platyphyllus* growing in Morocco, Algeria and Tunisia. In other Mediterranean countries it should be an introduced taxon, such as in Greece and Turkey where the native species is *A. spinosus*. Although the maximum spread of the *Acanthus* leaf in architecture occurred in Roman times, the Corinthian capital was born in Greece, portraying *A. mollis*. Among the earliest examples we remember the Doric Temple of Apollo Epicurius at Bassae in Peloponnese, built in 450-425 BC. probably by Ictino, the Tholos at Epidaurus (360-330 BC.), characterized by Doric columns in the exterior, while the inner colonnade consists of 14 Corinthian columns. The leaf carved in the stone is unequivocally *A. mollis*. The invention of the Corinthian capital is attributed, without certain proof, both to Callimaco and Ictino, which operated in Athens and in the Peloponnese. As this species was not present as native in Greece at that time, it was seen and designed taking inspiration from some place in Sicily or Magna Greece or from cultivated plants originating in those areas. The first examples of this capital fall into areas of Doric ethnicity. A city founded by this ethnic group that had intense cultural exchanges with the mother country was Syracuse, where *A. mollis* is widespread. This city seems to have played an important role in the the genesis of this architectural element, which is an evidence of cultural influences implemented in the motherland starting from the colonies become autonomous.

Key words: botany and art, cultural heritage, Mediterranean plants.

Introduction

In classical antiquity many plant species were a source of inspiration in art and architecture (Caneva & Kumbaric 2010). An emblematic case is *Acanthus mollis* L. and to a

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lesser extent *A. spinosus* L., both Mediterranean species used in antiquity by Greeks and Romans and later by other Mediterranean peoples above all as architectural frieze carved on capitals. *A. mollis* also has a remarkable ornamental value and therefore since ancient times it has probably been the object of cultivation and diffusion in other Mediterranean regions, today in the world (GISD 2018).

The aim of the present research is to understand with a biogeographical approach, combined with historical data, which could be the motivations that led to stylize the acanthus shape for the first time in areas where *A. mollis,* the most represented species of the genus, was not present in the native flora.

For this purpose, it is necessary to reconstruct the native distribution of the Mediterranean species of the genus *Acanthus* L. This genus is composed of 20 species distributed in Africa, southern Europe, southern Asia, and Australasia (McDade & al. 2005; Iamonico & Peruzzi 2018); in the Mediterranean area there are *A. mollis* subsp. *mollis* (Fig. 1), *A. mollis* subsp. *platyphyllus* Murb., *A. spinosus* (Fig. 2) and *A. balcanicus* Heywood & I. B. K. Richardson (Fig. 3).

Materials and methods

The research on the distribution of *Acanthus* species is based on literature material such as floras and checklists of all European and Mediterranean countries, herbarium consultations and personal distribution data. The distributive data are compared with the ancient historical sources related to key moments of displacements of peoples, in particular the Greeks and the Romans.

Historical framework

Although the maximum spread of the *Acanthus* leaf in architecture occurred in Roman times, the Corinthian capital seems to be born in Greece (Billot 1993), but through a long process concerning its stylization on the carved stone. Among the earliest examples many authors (Billot 1993, Kelly 1995, Loth 2014, Thodis 2018) remember the Doric Temple of Apollo Epicurius at Bassae in Peloponnese, built in 450-425 BC. probably by Ictino. Gros (1993) is very critical about this interpretation. As this author reminds us, the architectural formalization of the Corinthian capital takes place through the work of *Vitruvius De Architectura*. This author, lived in the second half of the first century BC, indicated in Callimachus (sculptor and architect operating during Vth century BC) the creator of the aforementioned capital; but probably his affirmation, inserted in a legendary context, only wants to ennoble its origins Inspiration would be drawn by a basket covered by a roof tile and layng on a Corintihian girl's grave by her nurse. Being placed on an acanthus root it got leaves wrapping the basket (Locatelli 2016). Anyway, Gros (1993) believes that the first, supposedly, Corinthian capital of Bassae has nothing to do with those of later centuries as the acanthus leaf is very different from the typical one and barely recognizable as such (Fig. 4). It should also be kept in mind that of this single capital, which had a particular meaning with regard to its location inside the temple (Thodis 2018), there remain only

Fig.1. *Acanthus mollis* in flower to Mount Erice (N.W. Sicily). (Photo F.M. Raimondo, June 2018).

Fig. 2. *A. spinosus* in flower, from his natural habitat in Albania (Photo F.M. Raimondo, June 2016).

Fig. 3. *Acanthus balcanicus*: particular of leaves (from Wikimedia Commons, the free media repository).

fragments, now in National Archaeological Museum of Athens, and a drawing made at the time of the discovery in 1811 (Loth 2014). This first appearance at Bassae of the acanthus leaf as decoration not only occurs on a capital but also on other architectural elements of the temple, such as simas and acroteria. Similar ornaments occur also in the temple of Poseidon at Sounion built about 440 BC. Billot (1993), recognizes at Sounion the form of *A. spinosus* but she admits that the shape is very stylized so it could also be other real or imaginary plant. The decoration with acanthus on the acroteria appears to the Parthenon of Athens and here the leaves are much more similar to those of *A. mollis* (Fig. 5a). Similar friezes are reported to the Heraion of Argos (Fig. 5b) and in Magna Graecia to Caulonia and Crotone temple of Hera Lacinia, at the Tholos of Epidaurus and at the Tholos of Delphi (Billot 1993), here with very realistic *A. mollis* friezes (Fig. 5c). The Tholos of Epidaurus, monument built in 360-330 BC., is also characterized by Doric columns in the exterior, while the inner colonnade consists of 14 Corinthian columns. The leaf carved in the stone is unequivocally *A. mollis* as you can see in the Archaeological Museum of Epidaurus where is showed a Corinthian capital unearthed below the foundations of the Tholos temple (Fig. 6).

The maximum development of the use of acanthus will take place in Roman times but always in connection with the Greek civilization; it must be remembered that since the end of the third century BC the Roman civilization undergoes a profound Hellenization especially with the fall in the Roman hands of the great cities of Magna Graecia and Sicily such as Taranto and Syracuse.

The decorative aspects of the Greek world were much appreciated and contacts with Athens were established. Artistic studios of this city were also installed in Rome (Sauron 1993) starting from 150 BC. In the same period and following, in the age of Augustus, the acanthus leaf will be a fundamental decorative element both for the Corinthian capital that will be formalized by Vitruvius and in other decorations as the extraordinary example of the Ara Pacis (13-9 BC) in Rome (Caneva 2010; Rossi 2016; Sauron 2018), where acanthus supports the architrave and it, in all its variations, will always be recognizable as *Acanthus mollis* species. Roman Art used acanthus not only in the decoration of the Corinthian capital but in the creation of friezes and pilaster strips, too. Because of its great decorative effect it was preferred in the decoration of the great columned streets ("cardus maximus" in Palmira, Syria, III century BC, "cardus maximus" in Gerasa, Jordan, III century BC) (Rossi 2016).

Results and Discussion

Defining the native distribution of *Acanthus mollis* is problematic as, probably, since ancient times it has been diffused from the original sites in other localities of the Mediterranean basin. The indications of the Mediterranean countries Floras and the databases are sometimes inaccurate and in contradiction with respect to its native distribution. Two subspecies are known: *A. mollis* L. subsp. *mollis* distributed in Italy (Pignatti 1982, 2018), but in the northernmost regions and Sardinia it is considered an alien species (Ballelli & Pedrotti 2009; Puddu & al. 2016); south France and Corse, and *A. mollis* subsp. *platyphyllus* Murb. growing in Morocco (Fennane & Ibn Tattou 2005), Algeria (Quézel &

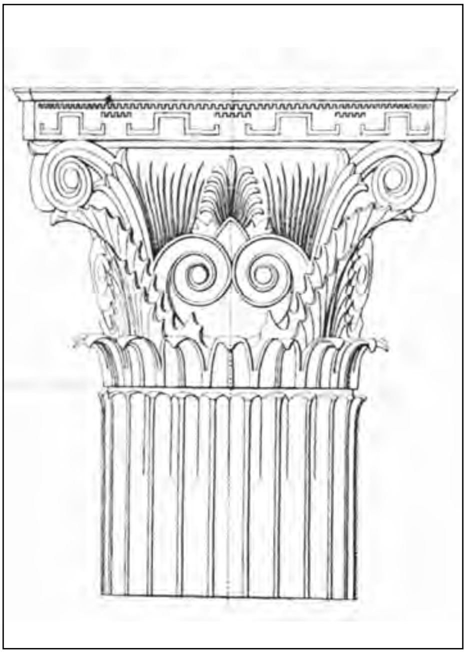

Fig. 4. Drawing of the Corinthian Capital of the Temple of Apollo Epicurius made by J.M. von Mauch for the German edition of the original work by Charles Normand (1819). The drawing is based on field notes and sketches of fragments by the archaeologist Haller von Hallerstein, highlighted during his excavation campaign carried out in Greece, at the site of Bassae (Peloponnese), between 1811 and 1812.

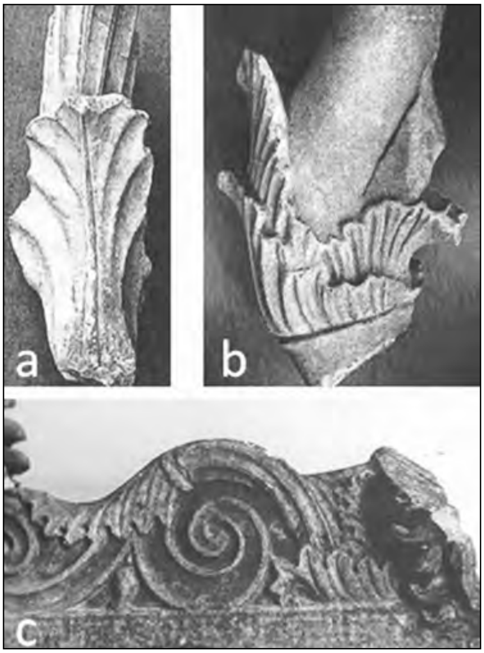

Fig. 5. *Acanthus* leaves in some ancient Greek monuments (from Billot 1993).
a. Athens; Parthenon , basal fragment of the central acroteria (Acropolis Museum – Athens).
b. Argos Heraion, classic temple, basal fragment of the central acroteria (National Museum – Athens).
c. Delphi, Tholos little sima (Archaeological Museum – Delphi.

Santa 1963), Tunisia (Pottier-Alapetite1981), Lybia (El Gadhi 1983) and south Spain (Valdés Castrillón & al. 1987). In other Mediterranean countries it should be an introduced taxon (Malcuit 1939; Barcelò 1980; Della & Iatrou 1995; Castroviejo 2001), such as in Greece (Arianoutsou & al. 2010; Dimopoulos & al. 2013, 2016) and Turkey (Davis 1984) where the native species is *A. spinosus* L. Also for these species is difficult to know the original distribution. *A. spinosus* is known in the Mediterranean and in south-eastern Europe (Italy, Croatia, Albania, Greece, Bulgaria, Crete, East Aegean islands), the Asiatic Turkey as well as in Algeria, but it is native probably only in East Mediterranean.

As this species was not present as native in Greece at that time, it was seen and designed taking inspiration from some place in Sicily or *Magna Graecia* or from cultivated plants originating in those areas. The first examples of this capital fall into areas of Doric ethnicity. A city founded by this ethnic group that had intense cultural exchanges with the mother country was Syracuse, where *A. mollis* is widespread (Minissale & al. 2015). From this city, probably, the acanthus was brought to Dalmatia. Today it is in fact present almost

Fig. 6. Corinthian capital from the tholos of Epidaurus (Argolis, Greece) clearly inspired by *Acanthus mollis* [380-375 BC. Archaeological site of Epidaurus] (from Wikimedia Commons, the free media repository).

exclusively in the Adriatic islands (Nikolić 2015) which were Syracusan colonies or in very close areas. In particular, they were Issa (today Vis Island) and the subcolonies of Lumbarda near Korkyra Melaina (Korčula Island), Tragyrion (Trogir), Epetion (Stobreč) founded from third to second century BC (Lombardo 1993). It also occurs in the nearby Pharos (Hvar Island) founded in 386 BC by Greek settlers from Island of Paros, but allied to Issa. It is surprising the overlap of the presence of the acanthus which in Dalmatia is rare, with the islands affected by the Greek colonization coming from Syracuse (Fig. 7). This circumstance proves, or at least the clue is highly realistic, that acanthus was a relevant species, perhaps also ornamental. It should be noted that Lissa is also the only Dalmatian locality of another species present in Greece and Syracuse surroundings, *Salvia fruticosa* Mill. (Radosavljević & al. 2015, 2019), also this probably was transported by the Greeks of Syracuse.

There are no clues so clear for other places, for example of Greece, but it is possible that from Syracuse or from other Greek colonies the acanthus has been made known in the motherland and, representing a much more appreciable species of the native *A. spinosus*, has become a source of artistic inspiration.

Fig. 7. *Acanthus mollis* distribution in Croatia (black dots) from Flora Croatica Database (http://hirc.botanic.hr/fcd) and the colonies founded by Syracuse. Issa (today Vis, Lissa in Italian) was the first in 390 B.C., the others are sub-colonies founded by Issa (Tragyrion, Epetion, Lumbarda) or other Greek colonies interacting with Issa (Pharos, Korkyra Melaina).

Fig. 8. Corinthian capital – probably inspired by *Acanthus spinosus* or by *A. dalmaticus* – from Ephesus (Smyrne, Turkey) [I-II Century a.C.] (from Wikimedia Commons, the free media repository).

But why was the acanthus in particular chosen? Was it just for the peculiar leaf morphology or for the plant symbolism in classical antiquity? In this regard, the acanthus symbolizes both resurrection and regeneration; in addition, as a perennial herbaceous plant – cyclically subject to dry in the summer season and come back to vegetate since the next winter starting a new cycle – it is ideally suited for being interpreted in art and architecture. Therefore, the biological form (hemicriptophyte) of the *Acanthus* species is the basis of its symbolism and its stylistic success.

But the frenetic activity of the Greek navigators remains fundamental and the consequent contaminations and cultural exchanges between colonies and motherland, contaminations that will then be absorbed and greatly developed later by the Roman civilization.

Conclusion

Contrary to common interpretations on the possibility that the Corinthian capital may be inspired by several Mediterranean species of *Acanthus,* what is just discussed opens the way in excluding or minimizing this possibility. The historical, biological and phytogeographic considerations reported, the symbolism of the plant and in particular the cultural exchanges between motherland and Magna Graecia, on the one hand, constitute the cause and effect of the anthropogenic spread of *A. mollis* in the rest of the Mediterranean area of Greek and Roman influence, on the other, of its own decorative and artistic value. All these elements allow us to affirm that the Corinthian capital, originally inspired by *A. mollis* (Fig. 1) – an easily propagated and cultivated plant and among the most decorative species – may have been inspired, subsequently, also by *A. spinosus* (Fig. 2) or ever more by *A. balcanicus* (Fig. 3); the latter – native to the Balkan peninsula, up to Dalmatia – is now also cultivated in many European and American gardens. In this different view, the cases of the capitals of the Greek Temple of Apollo Epicurius (Fig. 5) and of the columned street ("cardus maximus") of Ephesus (Fig. 8) appear very expressive and would support the thesis of the congeneric multi-specificity, of the inspirational model of the Corinthian capital.

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The Botanical Record of Archaeobotany Italian Network - BRAIN: a cooperative network, database and website*

Abstract

Mariotti Lippi, M., Florenzano, A., Rinaldi, R., Allevato, E., Arobba, D., Bacchetta, G., Bal, M. C., Bandini Mazzanti, M., Benatti, A., Beneš, J., Bosi, G., Buonincontri, M., Caramiello, R., Castelletti, L., Castiglioni, E., Celant, A., Clò, E., Costantini, L., Di Pasquale, G., Di Rita, F., Fiorentino, G., Furlanetto, G., Giardini, M., Grillo, O., Guido, M., Herchenbach, M., Magri, D., Marchesini, M., Maritan, M., Marvelli, S., Masi, A., Miola, A., Montanari, C., Montecchi, M. C., Motella, S., Nisbet, R., Orrù, M., Peña-Chocarro, L., Pepe, C., Perego, R., Rattighieri, E., Ravazzi, C., Rottoli, M., Rowan, E., Sabato, D., Sadori, L., Sarigu, M., Torri, P., Ucchesu M. & Mercuri, A.M.: The Botanical Record of Archaeobotany Italian Network - BRAIN: a cooperative network, database and website. — Bocconea 28: 341-352. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

The BRAIN (Botanical Records of Archaeobotany Italian Network) database and network was developed by the cooperation of archaeobotanists working on Italian archaeological sites. Examples of recent research including pollen or other plant remains in analytical and synthetic papers are reported as an exemplar reference list. This paper retraces the main steps of the creation of BRAIN, from the scientific need for the first research cooperation to the website which has a free online access since 2015.

Key words: archaeobotany, network, database, Italy, Mediterranean.

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Introduction

Italy is an extraordinary cradle of cultural heritage located at the centre of the Mediterranean basin, hotspot of biodiversity, rich of habitats (Blasi 2010; Bartolucci & al. 2018) and scenery for incessant migrations and trade over the last millennia. Scholars from every side of the world come to this country to study the long-term coexistence between Culture and Nature, an interaction that has resulted in an uncountable number of archaeological sites.

Therefore, it is not a surprise that an interdisciplinary research field like archaeobotany, joining archaeology and botany, is so well developed that the study of pollen and other plant remains is more and more introduced in the archaeological projects planned in Italian sites (e.g. Roman Peasant Project: Bowes & al. 2015; SicTransit: www.sicilyintrasition.org) or considered in the vegetation history of the Mediterranean area (e.g. Mercuri & Sadori 2014; Fyfe & al. 2018). The archaeobotanical approach has been especially developed for the understanding of the relationships between people and environment, genesis and developing of cultural landscapes (De Pascale & al. 2006; Perego & al. 2011; Di Rita & Melis 2013; Di Rita & al. 2018), features and spread of cultivated species (Orrù & al. 2013; Sabato & al. 2015, 2017; Ucchesu & al. 2016, 2017; Bosi & al. 2017), links between plant processing and the religious value of food (Celant & Fiorentino 2017; Primavera & al. 2018), uses in medicinal preparations (Giachi & al. 2013), understanding of particular practices like metallurgy (Toffolo & al. 2018). The study of economic transformations under environmental/climate changes is investigated by considering plant exploitation and managing in prehistoric periods (de Marinis & al. 2005; Di Rita & al. 2010; Fiorentino & al. 2013; Cremaschi & al. 2016; Melis & al. 2018; Sadori 2018) and in historical ages (Greek: Florenzano 2016; Roman: Caramiello & al. 2013; Montecchi & Mercuri 2018; Moser & al. 2018; Bosi & al. 2018; Medieval and Renaissance: Bandini Mazzanti & al. 2005; Bosi & al. 2009; Rottoli 2014; Buonincontri & al. 2017). The research is usually highly interdisciplinary promoting a holistic and ecological approach to knowledge (Stagno & al. 2014; Vittori Antisari & al. 2016; Benvenuti & al. 2017; Arobba & al. 2018), also connecting palaeoecology with historical perspective (Izdebski & al. 2016), historical ecology (Moreno & Montanari 2008; Molinari & Montanari 2016), ecology (Marignani & al. 2017) and conservation themes (Bosi & al. 2015; Piovesan & al. 2018). Land cover and land use are explored in interdisciplinary investigations carried out through the analyses of pollen, non-pollen palynomorphs, microcharcoals, seeds and fruits, woods/charcoals, and less frequently via starch grains, phytoliths and other plant parts (Revedin & al. 2010; Guido & al. 2013; Mariotti Lippi & al. 2015; Pini & al. 2016a, 2016b; Mariotti Lippi & al. 2017). The research demonstrates that palynology is not only able to reconstruct long-term and regional vegetation history (Sadori & al. 2013), as well as the fire history of certain regions (e.g. Lago di Como: Martinelli & al. 2017), but this versatile science is also useful to known the 'where, when and how' of cultural landscapes development at ecological, formal and cognitive levels (Mercuri 2014). Indeed, the different approaches complement each other, highlighting the power of archaeobotany as a basic tool in reconstructing the history of past cultures and societies (Sadori & al. 2010; Celant & al. 2015).

From the scientific cooperation to the network

In 2014, the 9th EPPC European Palaeobotanical and Palynological Conference was held in Padua and saw the joint action of many Italian scholars in the fields of palaeobotany, palynology and archaeobotany. This stimulated the preparation of the book ‘La Storia delle piante fossili in Italia/Palaeobotany of Italy’ (Kustatscher & al. 2014) which deals with the long and illustrious history of the Italian palaeobotanical studies and the classical and modern methods for analyzing plant remains. The last paper of this book (Mariotti Lippi & al. 2014) consists of the first synthesis on the main researches (more than 200 research papers) and approaches on the botanical investigation on archaeological sites in Italy.

In this central Mediterranean country, archaeobotany was born during the first half of the 18th century when plant remains from archaeological excavations of the Vesuvian area became the focus of interest for a number of scholars (Borgongino 2006). The well-preserved plant remains were exhibited in Palazzo Caramanico (the Royal Palace) at Portici, near Naples. Starting with the researches in Palaeolithic sites, which shed light on the diet of the hunter-gatherer populations, the paper takes into consideration the origin of agriculture, the plant resource exploitation and human impact in the Bronze Age and Iron Age, cultivation and landscape management during the Roman Period up to the Middle Ages.

As an output of that congress, moreover, a volume on ‘Changing flora and vegetation in Italy through time’ was edited by Bertini & al. (2015) as special issue of the Review of Palaeobotany and Palynology hosted seventeen papers/syntheses on Permian and Triassic, Jurassic, Messinian, up to Pliocene, Pleistocene and Holocene vegetation history, probably one of the best examples of trans-chronological overview of Palaeobotany with high-level scientific examples. Three papers especially focused on archaeobotanical general (Roman harbours: Sadori & al. 2015) and site-centered themes (Fiorentino & Parra 2015; Mercuri & al. 2015a). Moreover, in a synthesis on the archaeobotanical research on Italian contexts (Mercuri & al. 2015b), fifteen archaeobotanist teams working on records collected from archaeological sites put together their data to write the first paper on the ‘state of the art’ of the archaeobotanical research in this country.

After that joint paper, the data collected were organised in a database that is free online and ready to be improved at www.brainplants.successoterra.net (formerly https://brainplants.unimore.it/index.html).

The database-network BRAIN

BRAIN - Botanical Record of Archaeobotany Italian Network was firstly introduced at the MedPalyno2015 Congress in Rome. It is a database of archaeobotanical research and analyses from archaeological sites in Italy. Under request, this database is now integrated with sites close to archaeological sites (off-sites, or near-sites: Mercuri & al. in press), and from sites located in the Mediterranean countries (Fig. 1).

Following the idea that archaeobotany is a key tool ‘for the understanding of the biocultural diversity’, the web site hosts the inventory of the archaeological researches including pollen, palynomorphs, seeds/fruits, wood, charcoals and other plant remains analyses,

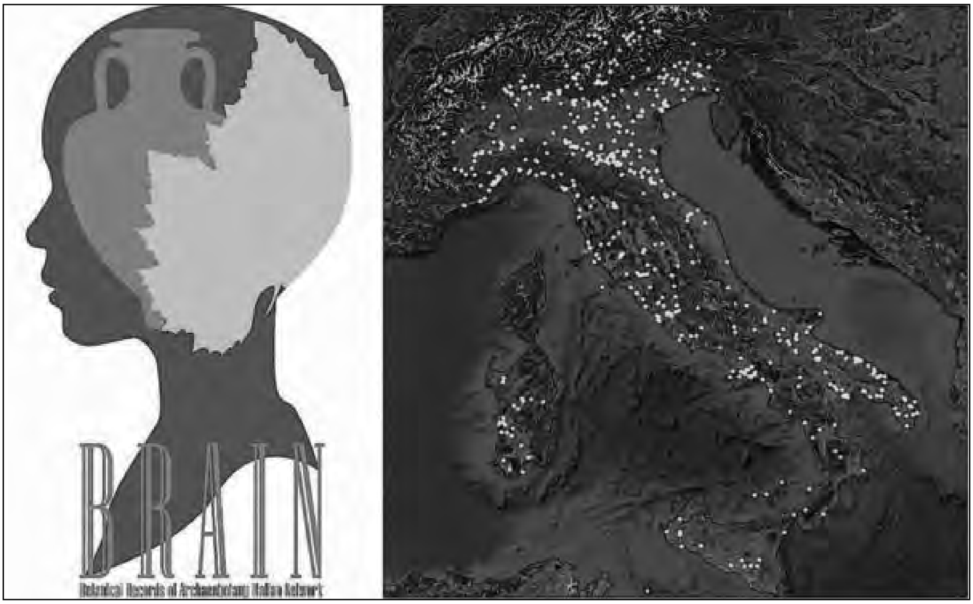

Fig. 1. BRAIN: The Logo (left) puts together humans and plants in one design whose profile recalls a female entity like science, botany and archaeobotany (by Serena Ferretti, Reggio Emilia). Distribution map of the sites in BRAIN (right).

fruitfully used to deepen the history of past vegetation, land cover, land-uses and palaeoethnobotany.

Currently, BRAIN includes >660 sites which has been object of archaeobotanical studies, among which 110 in Emilia Romagna, 74 in Apulia, 67 in Lombardy, 64 in Latium, and 39 in Tuscany. The studies have been mainly carried out on Neolithic (119), Bronze age (117), Iron Age (97), Roman (192), and Medieval contexts (119) (Fig. 2).

The website consists of six pages, two of which are especially dedicated to the database including Sites and References. Site position and density are immediately visible in a map while three graphs show updated statistics on the number of sites per area, or Cultural period, or type of plant remain. References may be sorted in alphabetical order, or author names. The first section included only On-sites; recently, three new sections were added: Off-sites, Spot records, and Extra-Italy. New contributors are welcomed.

BRAIN network is a useful instrument for both single and joint researches. The website is also a good way to publicize the impressive work done in the field of archaeobotany in the Italian on-sites (archaeological) or near-sites (human-related environmental sites) and makes the archaeobotanical data available for archaeological researches and studies on conservation and biodiversity on a long-term perspective.

The huge amount of data produced in the last few decades demonstrates that Botany has a key role in improving the knowledge of cultural/archaeological and natural heritage. The increase of the number of papers on archaeobotany (as evinced from BRAIN) shows the versatility and increasing importance of this science in the last years (Fig. 3).

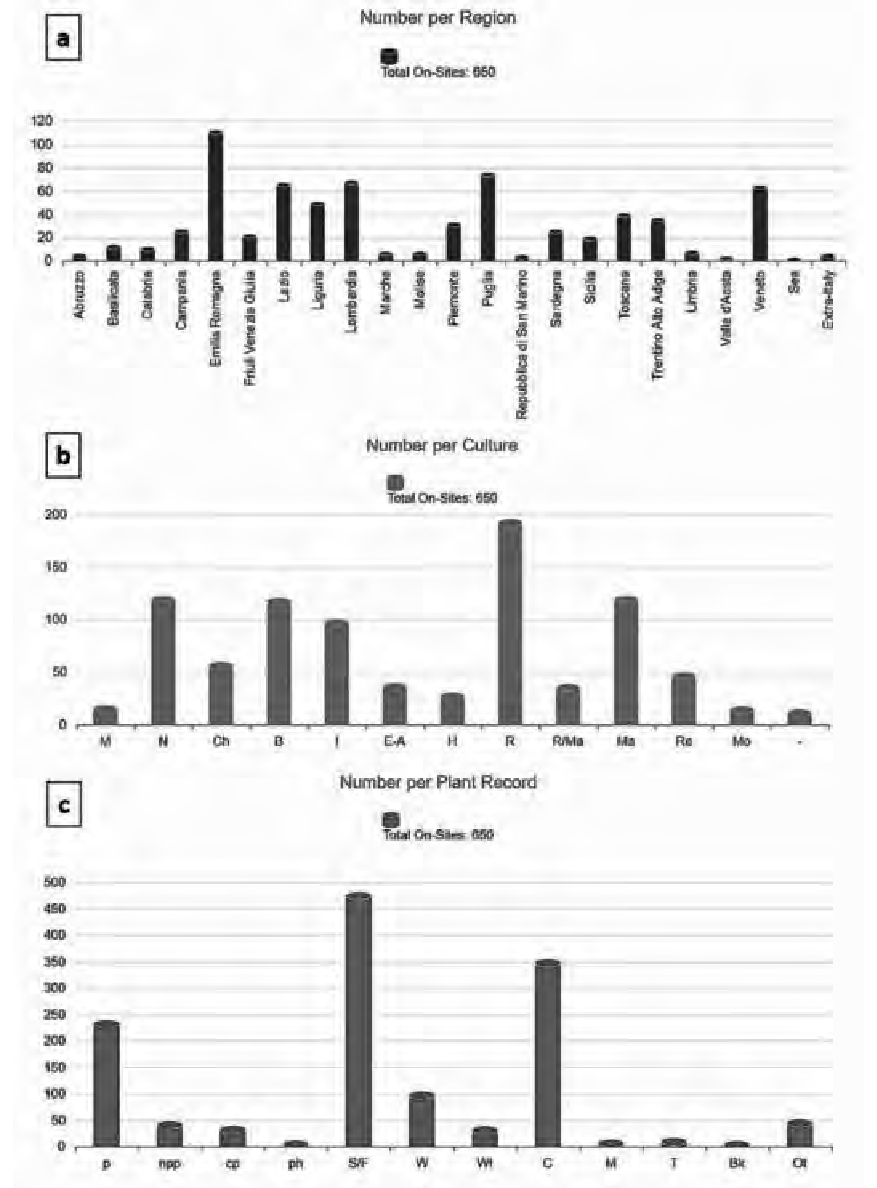

Fig. 2. BRAIN database: real-time statistics on the sites (retrieved October 12, 2018, from https://brainplants.unimore.it/sites.html): a) number of on-sites per region; b) on-sites per culture (M = Mesolithic; N = Neolithic; Ch = Chalcolithic; B = Bronze age; I = Iron age; E-A = Etruscan-Archaic period; H = Hellenistic period; R = Roman age; Ma = Medieval ages; Re = Renaissance; Mo = Modern age); c) on-sites per type of botanical record (p = pollen; npp = non-pollen palynomorphs; cp = micro-charcoal particles; ph = phytoliths; S/F = seed and fruit; W = wood; Wt = wood tool; C = charcoal; M = mould; T = textiles; Bk = basketry; Ot = adobe, bread or similar food, leaves and microsporophylls, mastic, moss, plant tissues, ropes, straw, wick).

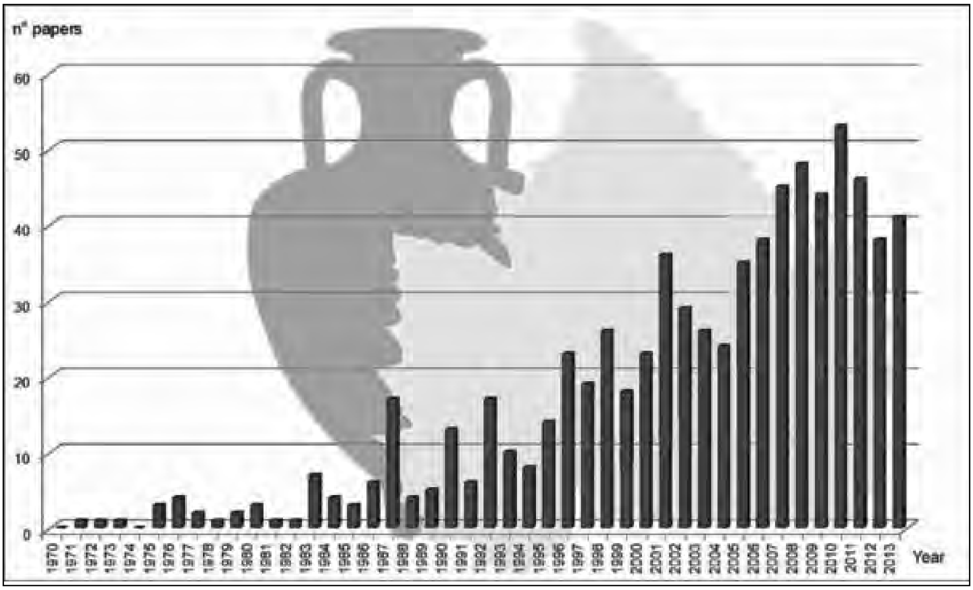

Fig. 3. Number of published archaeobotanical studies according to the list in the BRAIN website. Note the increase in time.

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MML and AMM planned the contribution and wrote the text, with the help of AF and RR; all Authors read and contributed to the synthesis.

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Contributions to the study of the historical gardens of Sicily. The garden of Villa Filangeri in Santa Flavia (Palermo)

Abstract

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The Villa Filangeri in Santa Flavia is among the most remarkable historical residences in the plane between Bagheria and Santa Flavia, south of Palermo. Built in 1742, in the last decades its garden has gradually lost its original richness and elegance. Presently its general structure is not still in good condition, and the plant heritage appears significantly varied and impoverished with respect to its original composition. Therefore, in the absence of recent surveys, the inventory of the present ornamental plant heritage was carried out. This, in order of adding new data to the ornamental flora of Sicilian parks and gardens and of giving a contribution to the possible restoration for public and cultural purposes.

Key words: ornamental plants, heritage, inventory, restoration.

Introduction

The city of Palermo with its surroundings, lying in a well protected basin by a crown of reliefs and fed by ample water reserves, was the seat of rich agricultural crops and of gardens for which for its cultivated plant heritage it has been appreciated and valued by the dominations that have left you, more or less deep traces since the origins. Thus we can recognize the signs of the passage of the Carthaginians, Greeks, Romans, Byzantines, Muslims, Normans and various other peoples who have followed it until today. All this also applies to the rest of Sicily but especially the areas in contact with Palermo itself.

In these places, starting from the XVII century, flourishing activities typical of the dominations that took place in Sicily have developed (introduction of citrus, rice, cotton, etc.) and, during the development, extended private properties with the relative residences which were real villas that were considered valuable expressions of wealth and power. Concentrated on the outskirts of the city of Palermo, they would gradually shape large sections of the growing urban fabric in which they would soon be incorporated. Today most of these villas have disappeared. Several others located between the urban centers of Bagheria and Santa Flavia, are more or less abandoned but still are the testimony of the aforementioned splendours. Among them, here we just examine the garden of Villa Filangeri, one of the most important fate in the XVIII century.

The Sicilian garden between the 18th and 19th centuries

As we know, the culture of the informal garden spread in the nineteenth century. It includes various examples of English inspiration as well as the transformation of the garden into new romantic trends. Added to this is the entry of numerous exotic elements that impart to the ornamental heritage of the Sicilian coast the well-known tropical cosmopolitan character for which it stands out as an autonomous cultural unit even compared to the historic Italian garden. Furthermore, the Sicilian gardens that have developed as informal gardens are marked by a Masonic symbolism, just like the new English gardening theories (Lanza Tomasi 1974; Cazzato & Maresca 2006).

The garden of the Villa Filangeri

Along the path marked by the axis, leaving behind the winter garden, hidden by the imposing front overlooking the village of Santa Flavia, you will discover the garden, a reality that was once used exclusively by the Filangeri family (Figs. 1-3). Inscribed in a

Fig. 1. The prospectus of the villa. Today the building is the seat of the administration of Santa Flavia.

Fig. 2. The transversal path with two nineteenth century statues placed the at the entrance. In the background the central fountain.

Fig. 3. The central fountain at the intersection of the main paths.

rectangular area of 8,500 m^2, almost flat, according to archive sources, the installation dates back to 1742, when Mastro Antonio Paladino and Mastro Antonio Sperandeo, led by Giuseppe Caccaminisi, worked on the enlargement of the villa, creating the wall of the back garden and the fountain in the middle of the octagonal space at the intersection of the two orthogonal avenues that cross the garden. The planimetric layout of the garden gives a not unusual image in the gardens of the contemporary villas in the territory (similar compositional schemes can be identified in the gardens of Villa Galletti-San Cataldo and in the now disappeared garden of Villa Butera, lying in Bagheria. However, both the Villa Filangeri and the Villa Butera plan are based on a doubled form, unlike that of Villa Galletti-San Cataldo which is more complex due to the presence of oblique avenues. The plant, originally from the eighteenth century, still legible, consists of a regular pattern, formed by two avenues, of which the longitudinal one is the continuation of the road axis in front of the villa and the other orthogonal to it, divides the parterre into four rectangular modules of 48 × 30 m. The axes, intersecting form an octagonal space that finds at its center a quadrangular lobed fountain, around which four stone seats are arranged in front of some recently built statues pedestals. Other statues, also of recent construction, can be found scattered in the garden without ever having been placed there. The enclosure consists of limestone walls that terminate in a semicircular exedra at the main axis. Another exedra is found at the transversal axis, which does not find its correspondent to the opposite extremity of the north-west axis. This leads to the hypothesis that a part of the garden has been renewed or sold. In the second half of the nineteenth century the plant was trans-

Fig. 4. The artificial hill surmounted by an iron pagoda-shaped gazebo and one of the accesses to the cave below.

formed, with the creation of flower beds and irregular paths, some of which mirrored with respect to the longitudinal axis that continues the road axis in front of the architectural complex along which the inhabited center developed . The nineteenth-century plant is a complete "romantic" landscape arrangement. It is probably the work of an amateur aware of the Anglo-Chinese models that interprets the taste of the landscape garden in a Mediterranean key. Of the previous geometric layout, the two orthogonal avenues, the fountain and the exedras were maintained, while other elements were introduced with the nineteenth century transformation. Among the subsequent additions we find the hill, slightly sloping, at the top of which is a characteristic Aspra stone bench, hidden among the rich tropical vegetation (Fig. 4). Remains of another bench the same as the one on the hill are located next to the characteristic artificial rock "montagnola", whose height reaches 6 meters from the base. Inside it develops an artificial cave of about 4 meters in diameter which is accessed by four entrances. The exterior of the relief is furrowed by paths that lead to the summit that ends in a pagoda-shaped iron gazebo. An irregularly shaped basin is home to aquatic animals; moreover, in the garden are scattered various structures for exotic animals.

The plant heritage

The florula, moderately diversified, is composed of 241 specific and infraspecifictaxa, belonging to 237 species, 176 genera of 88 families of spermatophytes and one of pteridophytes. These are mainly exotic, in part already represented in the Sicilian ornamental flora at the time of the first planting of the garden. Many others plants were gradually planted later, even in recent times. The families represented by a greater number of specific ranks or lower taxa are *Arecaceae* with 9 taxa, *Agavaceae* with 7 taxa and *Fabaceae* with 6 taxa. The species occurring in the greatest number of specimens are *Aloe ×caesia*, *Aloe saponaria*, *Brachychiton populneus*, *Cercis siliquastrum*, *Chamaerops humilis*, *Chlorophytum comosum*, *Crassula ovata*, *Ficus microcarpa*, *Lantana camara*, *Nerium oleander*, *Olea europaea*, *Opuntia ficus-indica*, *Pelargonium ×hortorum*, *Phoenix canariensis*, *Pinus halepensis*, *Pittosporum tobira*, *Tecomaria capensis*, *Viburnum tinus*, *Washingtonia robusta,* and *Yucca elephantipes*. It should be noted that the current floristic composition does not correspond to the initial one; many specimens are lacking both for lack of replacement and for inadequate maintenance, as

Fig. 5. The specimen of *Rhus lancea* unique in the historic Sicilian gardens.

Fig. 6. The imposing *Araucaria bidwillii* in the central part of the garden.

shown in the flowerbeds various dead but not yet wasted strains. The marked deterioration is also evidenced by the presence of young specimens that, born from seed (*Cercis siliquastrum*, *Lantana camara*, *Olea europaea*, *Pittosporum tobira, Washingtonia robusta*, etc.), are common throughout the area, along with many other elements completely unrelated to the garden context. In a hypothesis of recovery and functional restoration, these elements should be removed. In the plant, however, there are various other elements that can be considered to represent real floristic emergencies and embellish the cultivated heritage. This is the case of a mature specimen of *Rhus lancea* (Fig. 5), native to South Africa, unique in the historic Sicilian (and perhaps even Italian) gardens (Ciccarello & al. 2015), as well as of a large specimen of *Araucaria bidwillii*, rare throughout western Sicily. Other floristic emergencies are: *Casuarina equisetifolia* and *Grevillea robusta* which, apart from the considerable size reached in the garden, are a distinctive sign that characterize the historic Sicilian gardens of the nineteenth century; *Washingtonia flilifera* for the size and chronological context (early twentieth century) in which it was inserted. Also noteworthy are the two specimens of *Ficus microcarpa*, one at the entrance to the garden, the other near the rocky hill; the *Dracaena draco* specimen near the entrance to the garden; the two specimens of *Pinus halepensis*, in a central position near the fountain; on the gentle slope of the hill; the four specimens of *Washingtonia robusta*, arranged around the *Araucaria bidwilli* (Fig. 6)*, Rhus lancea*, *Agave sisalana*, *Schinus molle*, *Arbutus unedo,* and *Spartium Junceum* characterize the slope of the artificial hill.

Below is the complete list of specific and infraspecific taxa detected in the garden object of our study. In it, the generic, specific and infraspecific taxa are arranged in alphabetical order. Nomenclature is according to Mazzola & Di Martino (1996).

The plant list

ACANTHACEAE
Justicia adhatoda L.
Thunbergia coccinea Wall.

ACERACEAE
Acer negundo L.

ADIANTACEAE
Adiantum capillus-veneris L.

AGAVACEAE
Agave americana L.
Agave americana var. *marginata* Trel.
Agave attenuata Salm-Dyck.
Agave ferox C. Koch
Agave sisalana Perrine
Cordyline australis (G. Forst.) Endl.
Yucca elephantipes Regel
Yucca aloifolia L.
Yucca aloifolia L. 'Tricolor'
Yucca gloriosa L.

AIZOACEAE
Aptenia cordifolia (L. f.) Schwantes
Carpobrotus acinaciformis (L.) Bolus
Carpobrotus edulis (L.) N.E.Br.
Drosanthemum floribundum (Haw.) Schwantes
Lampranthus sp.

ALOACEAE
Aloe arborescens Mill.
Aloe arborescens var. *frutescens* (Salm.-Dyck) Link
Aloe ×*caesia* Salm-Dyck
Aloe ciliaris Haw.
Aloe lastii Baker
Aloe saponaria (W. T. Aiton) Haw.

AMARYLLIDACEAE
Amaryllis belladonna L.
Clivia miniata Reg.
Crinum sp.
Narcissus jonquilla L.
Narcissus tazetta L.

ANACARDIACEAE
Schinus molle L.

ANTHERICACEAE
Chlorophytum comosum (Thumb.) Jacques

APOCYNACEAE
Catharanthus roseus G.Don
Mandevilla sanderi (Hemsl.) Woodson
Nerium oleander L.
Plumeria rubra L. s. l.
Thevetia peruviana (Pers.) Schum.
Trachelospermum jasminoides (Lindl.) Lem.
Vinca major L.
Vinca major L. 'Variegata'

ARACEAE
Alocasia macrorrhiza (L.) G.Don
Colocasia esculenta (L.) Schott
Monstera deliciosa Liebm.
Zantedeschia aethiopica (L.) Spreng.

ARALIACEAE
Hedera canariensis Willd.
Hedera helix L.
Fatsia japonica (Thumb.) Decne.
Meryta denhamii Seem.
Oreopanax dactylifolium hort.
Tetrapanax papyrifer (Hook.) K. Koch

ARAUCARIACEAE
Araucaria bidwillii Hook.

ARECACEAE
Chamaedorea elegans Mart.
Chamaerops humilis L.
Livistona australis (R.Br.) Mart.

Phoenix canariensis Chabaud
Phoenix dactylifera L.
Syagrus romanzoffianum (Cham.) Glassman
Washingtonia filifera (Linden) H. Wendl.
Washingtonia robusta H. Wendl.

ASCLEPIADACEAE
Araujia sericofera Brot.
Asclepias fruticosa L.

ASPARAGACEAE
Asparagus asparagoides (L.) Druce
Asparagus densiflorus (Kunth) Jessop
Asparagus falcatus L.
Asparagus setaceus (Kunth) Jessop

ASTERACEAE
Argyranthemum frutescens (L.) Sch. Bip
Barlettina sordida (Less.) R. King & H. Rob.
Dahlia ×hortensis Guillaumin
Farfugium japonicum (L.) Kitan. 'Aureomaculatum'
Santolina chamaecyparissus L.
Senecio cineraria DC.
Senecio angulatus Otto
Senecio petasitis DC.

BIGNONIACEAE
Campsis grandiflora (Thumb.) Schum.
Campsis radicans Fuss.
Distictis buccinatoria (DC.) A. Gentry
Jacaranda mimosifolia D. Don
Macfadyena unguis-cati (L.) Gentry
Tecoma stans (L.) Humb, Bonpl. & Kunth
Tecomaria capensis (Thumb.) Spach

BOMBACACEAE
Chorisia speciosa A. St. Hil.

BORAGINACEAE
Heliotropium arborescens L.

BRASSICACEAE
Matthiola incana (L.) R. Br.

BUDDLEJACEAE
Buddleja davidii Franch.

BUXACEAE
Buxus sempervirens L.

CACTACEAE
Cereus jamacaru Dc.
Hylocereus undatus (Haw.) Briton & Rose
Myrtillocatus geometrizzans (Pfeiff.) Console
Opuntia dillenii Haw.
Opuntia ficus-indica (L.) Mill.
Opuntia maxima Mill.
Opuntia microdasys (Lehm.) Pfeiff.
Opuntia monacantha (Willd.) Haw.
Opuntia subulata (Muehlenpf.) Engelm.

CANNACEAE
Canna indica L. s. l.

CAPRIFOLIACAEAE
Lonicera japonica Thumb.
Viburnum tinus L.

CASUARINACEAE
Casuarina equisetifolia Forst. & Forst.

CELASTRACEAE
Euonymus japonica L.

CONVALLARIACEAE
Aspidistra elatior Blume

CONVOLVULACEAE
Ipomoea indica (Burm.) Merr.

CRASSULACEAE
Aeonium arboreum (L.) Webb & Berthel. 'Atropurpureum'
Aeonium arboreum (L.) Webb & Berthel. 'Holochrysum'
Aeonium decorum Webb ex Bolle
Cotyledon orbiculata L.
Crassula arborescens (Mill.) Willd.
Crassula ovata (Mill.) Druce
Graptopetalum paraguayense (N.E.Br) Walter

CUPRESSACEAE
Chamaecyparis lawsoniana (Murray) Parl.
×*Cupressocyparis leylandii* (Dallim. & A.B. Jacks.) Dallim.
Cupressus arizonica Greene

Cupressus macrocarpa Gordon
Cupressus sempervirens L.
Platycladus orientalis (L.f.) Franco
Tetraclinis articulata (Vahl) Mast.

CYCADACEAE
Cycas revoluta Thunb.

CYPERACEAE
Cyperus alternifolius L.
Cyperus papyrus L.

DRACAENACEAE
Dracaena draco L.
Nolina recurvata (Lem.) Hemsl.

EBENACEAE
Diospyros lotus L.

EUPHORBIACEAE
Euphorbia candelabrum Kotschy
Euphorbia milii Des Moul.
Euphorbia pulcherrima Klotszsch
Euphorbia ramipressa Croizat
Euphorbia tirucalli L.
Euphorbia triangularis Desf.

FAGACEAE
Quercus ilex L.

GERANIACEAE
Pelargonium capitatum Sol.
Pelargonium peltatum (L.) L'Hér.
Pelargonium ×domesticum (L.) L. H. Bailey
Pelargonium ×hortorum L. H. Bailey
Pelargonium zonale (L.) L'Hér.

HYDRANGEACEAE
Hydrangea macrophylla (Thumb.) Ser.

HIPPOCASTANACEAE
Aesculus hippocastanus L.

IRIDACEAE
Antholyza aethopica L.
Iris germanica L.

LAMIACEAE
Lavandula angustifolia L.
Rosmarinus officinalis L.
Salvia officinalis L.

LAURACEAE
Laurus nobilis L.
Persea gratissima Mill.

FABACEAE
Acacia cyanophylla Lindl.
Acacia dealbata Link
Acacia karoo Hayne
Albizzia julibrissin Benth.
Bauhinia diphylla Buch.-Ham.
Caesalpinia gilliesii (Hook.) Benth.
Ceratonia siliqua L.
Cercis siliquastrum L.
Parkinsonia aculeata L.
Robinia pseudoacacia L.
Sesbania punicea (Cav.) Benth.
Sophora japonica L.
Spartium junceum L
Wisteria floribunda (Willd.) DC.
Wisteria sinensis Sweet.

LILIACEAE
Agapanthus africanus (L.) Hoffm.

LYTHRACEAE
Lagerstroemia indica L.

MAGNOLIACEAE
Magnolia grandiflora L.

MALVACEAE
Abutilon ×hybridum (Lam.) Sweet
Alcea rosea L.
Hibiscus mutabilis L.
Hibiscus rosa-sinensis L.
Lagunaria patersonii (Anderss.) G.Don.

MELIACEAE
Melia azedarach L.

MORACEAE
Ficus carica L.
Ficus elastica Roxb. ex Hornem. 'decora'
Ficus macrophylla Desf.
Ficus microcarpa L.

MUSACEAE
Musa ×paradisiaca L.

MYOPORACEAE
Myoporum tenuifolium G.Forst.

MYRTACEAE
Callistemon citrinus (Curtis) Skeels
Eucalyptus camaldulensis Dehnh.
Myrtus communis L.

NEPHROLEPIDACEAE
Nephrolepis cordifolia (L.) Presl

NYCYAGINACEAE
Bougainvillea glabra Choisy

OLEACEAE
Jasminum azoricum L.
Jasminum fruticans L.
Jasminum officinale L. f. 'Grandiflorum '
Jasminum nudiflorum Lindl.
Jasminum sambac (L.) Aiton
Ligustrum lucidum W. T. Aiton
Olea europaea L. var. *europaea*

PASSIFLORACEAE
Passiflora coerulea L.

PHORMIACEAE
Phormium tenax Forst & Forst

PINACEAE
Abies cephalonica Loud.
Pinus canariensis Sweet

PITTOSPORACEAE
Pittosporum tobira (Thumb.) Aiton f.

PLATANACEAE
Platanus ×hybrida Brot.

PLUMBAGINACEAE
Plumbago auriculata Lam.

POACEAE
Cortaderia selloana (Schult. & Schult. f.) Asch. & Graebn.
Phyllostachys nigra Munro

POLYGONACEAE
Polygonum aubertii L. Henry

PORTULACACEAE
Portucalaria afra Jacq.

PROTEACEAE
Grevillea robusta R. Br.

PUNICACEAE
Punica granatum L.

RHAMNACEAE
Rhamnus alaternus L.

ROSACEAE
Cydonia oblonga Mill.
Eriobotrya japonica (Thumb.) Lindl.
Prunus armeniaca L.
Prunus cerasifera Ehrh. 'Pissardii'
Prunus dulcis (Mill.) D.A. Web
Prunus persica (L.) Batsch.
Pyracantha coccinea Roem.
Spiraea ×vanhouttei Zabel
Rosa banksiae Ait.

RUSCACEAE
*Ruscus hypophyllum*L.

RUTACEAE
Citrus aurantium L.
Citrus deliciosa Ten.
Citrus ×paradisi Macfad.
Citrus limon (L.) Burm.
Citrus sinensis (L.) Osbeck
Fortunella margarita (Lourr.) Swingle
Murraya paniculata (L.) Jack

SALICACEAE
Populus alba L.
Populus ×canadensis Moench
Salix babilonica L.

SAPINDACEAE
Cardiospermum halicacabum L.
Koelreuteria paniculata Laxm.

SAXIFRAGACEAE
Bergenia crassifolia (L.) Fritsch

Philadelphus coronarius L.

SCROPHULARIACEAE
Paulownia tomentosa (Thunb.) Steud.
Russelia equisetiformis Schldl & Cham.

SIMAROUBACEAE
Ailanthus altissima (Mill.) Swingle

SOLANACEAE
Brugmansia suaveolens (Willd.) Bercht. & C. Presl
Solandra maxima (Sessé & Moc) P. Green
Solanum capsicanstrum Link
Solanum wendlandii Hook. f.

STERCULIACEAE
Brachychiton populneus (Schott & Endl.) R. Br

STRELITZIACEAE
Strelitzia alba (L.) Skeels.
Strelitzia reginae Banks

TAMARICACEAE
Tamarix africana Poir.
Tamarix parviflora DC

ULMACEAE
Celtis australis L.
Ulmus aff. *canescens* Melville

VERBENACEAE
Aloysia triphylla (L'Hér) Brit.
Duranta plumieri Jacq.
Lantana camara L.

VITACEAE
Parthenocissus quinquefolia Planch.
Vitis vinifera L.

ZINGIBERACEAE
Alpinia zerumbet (Pers.) B.L. Burtt. & Rosemary M. Sm.

Final considerations

The florula recorded in the garden of Villa Filangeri reflects, with few exceptions, that found in the nineteenth-century gardens of the adjacent city of Palermo.

In conclusion, the historical garden of Santa Flavia, although relatively diversified, does not present particular elements related to the ornamental floristic heritage with the exceptions of *Rhus lancea* and *Araucaria bidwillii*. Such specimens could be usefully employed in the hypothesis of a functional and landscape recovery and requalification.

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F. M. Raimondo, G. Domina, V. Spadaro & P. Campisi

Plant landscape and phytodiversity in the archeological area of Segesta (NW Sicily)

Raimondo, F. M., Domina, G., Spadaro, V. & Campisi, P.: Plant landscape and phytodiversity in the archeological area of Segesta (NW Sicily). — Bocc. 28: 363-364. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: Mediterranean maquis, flora, landscape management.

In the system of Sicilian archaeological parks, the area of Segesta - an ancient city of western Sicily referring to the Carthaginian eparchy, - represents, together with Selinunte, Erice and Mothia, another integrated hotspot of biodiversity and archeaology. The current plant landscape is strongly influenced by a millenary anthropic transformation. There are no residual expressions of the original plant covering that, with reference to the environmental potential of the area, can be traced back to the evergreen Mediterranean forest dominated by *Quercus ilex*, presently only sporadically occurring in the area of the ruins, together with other species related to associations and upper syntaxa referable to the class *Quercetea ilicis* (*Olea europaea* subsp. *sylvestris*, *Ceratonia siliqua*, *Pyrus spinosa* s.l., *Rhamnus alaternus*, *Chamaerops humilis*, *Crataegus laevigata*, *Ruscus aculeatus*, *Asparagus albus*, *A. acutifolius*, etc.). Sporadic is the presence of *Celtis australis* and *Ficus carica*.

The whole area of Segesta is included in the potential belt of both maquis and Mediterranean evergreen forest, formations once present but progressively replaced with classical Mediterranean tree crops (olive, almond, carob and vines). The abandonment of these crops allowed the advent of grasslands, sometimes with trees, until the introduction of new plants scattered to further mark the anthropization of the area. Quite widespread in the hill next to the theatre is the garrigue with *Chamaerops humilis* and *Ampelodesnmos mauritanicus*, here diversified by the presence of *Plumbago europaea* which, due to its high degree of coverage, sociability and frequency, is a good unpublished plant association. The whole area is rich in aromatic (*Phoeniculm vulgare*, *Origanum vulgare*, *Mentha pulegium* and *M. rotundifolia*, *Salvia sclarea*) and medicinal species (*Atractylis gummifera*, *Hypericum perforatum*, *H. perfoliatum*, *Sylibium marianum*, *Urginea maritima*).

Elements of landscape importance in spring-summer are *Asphodelus ramosus*, some spiny *Asteraceae*, such as *Cynara cardunculus* subsp. *cardunculus* and *Onopordum illyricum*, and other *Apiaceae*, as *Magydaris tomentosa*, *Thapsia garganica* and the most frequent and expressive *Ferula communis*.

There are several exotic plants introduced in the last century (*Eucalyptus* sp. pl., *Cupressus* sp. pl., *Pinus* sp. pl.), or naturalized since longer time (*Agave americana*, *Opuntia ficus-indica*, *Myoporum serratum*). The presence of the invasive *Ailanthus altissima*, widespread even in the most sensitive areas, has negative repercussions on the stability of the already precarious monuments and on the landscape in general, away from the stereotypical images of Segesta.

Some iconographic documents, dating back to the illustrations of the travellers of the *Grand Tour*, give a representation of the vegetation covering this area before its transformations. It would be advisable inspiring to this period the actions of landscape restoration to be undertaken in this area.

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F. M. Raimondo, P. Mazzola, M. G. Dia & V. Magro

The plant landscape of the Sicilian archaeological areas through the iconographic documentation of travellers and naturalists

Raimondo, F. M., Mazzola, P., Dia, M. G. & Magro, V.: The plant landscape of the Sicilian archaeological areas through the iconographic documentation of travellers and naturalists. — Bocc. 28: 365-366. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: *Grand Tour*, flora, travel diaries.

The landscape is commonly defined as the set of physical and historical-anthropological characters expressed by a territory. Our re-elaboration defines the landscape as the set of perceivable characters of a territory expressed in relation to the stratification of the occurred natural and cultural processes. The *Grand Tour* reports are one of the most effective means to fix at least one stage of evolution from the Sicilian landscape, before its further transformation. These reports provide often a stereotypical image of the landscape of the Island, in particular as regards the major archaeological areas subjected to particular attention by the cultured travellers.

The authors summarize the characters of the plant landscape of the main Sicilian archaeological areas, through the analysis of both the rich documentation handed down by travellers, in particular of the *Grand Tour*, and the descriptions of some naturalists who visited the region, between the second half of the 18th and the whole 19th century portraying and /or describing the most expressive places of its classicism.

In the landscape of these areas, the ruins are almost always framed by men in transit or in front of the archaeological remains or in the surrounding area dedicated to the livestock care, with sparse trees and bushes, sometimes constituted by exotic elements very incisive for the travellers,in majority European from across the Alps; being unknown in the travellers'countriesthey represented very attractive subjects. In fact, *Opuntia ficus-indica*, *Agave americana* and the historicized *Phoenix dactylifera* are frequent. Among the indigenous elements we can recognize *Olea europaea*, *Ceratonia siliqua*, *Ficus carica* and other species of leafy trees, partly survived and still present on the margins of the ancient temples and theatres. Among these there would be *Celtis australis*, *Fraxinus ornus*, *Quercus ilex*, *Ulmus canescens*. In the archaeological landscapes of the time, pines and cypresses are missing: these trees were already introduced and widespread in Italy in Roman times but they appeared around the Sicilian archaeological areas starting from the late nineteenth century.

The subject of this demonstration is presented by relating some photographic images of the places – obviously later - beginning with the Alinari Archive (end of the 800s beginning of the 20th century), with reproductions of iconographic documents by J.P.L.L. Houel (1782-87), P. Brydone (1806), R. Saint-Non (1785), J.W. Goethe (1787) and other travellers (J.F. D'Ostervald, 1822-24; D.-D. Farjasse, 1835; C. A. Schneegans, 1890 and G. Vuillier, 1893). In this path of great utility was the reading of the travel diaries of some naturalists, in particular C.S. Rafinesque Schmaltz (1810) and K. Presl (1817).

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F. M. Raimondo, G. Castiglia, S. Ciccarello, F. Scafidi & C. Salmeri

Plant landscape of the archaeological site of Selinunte and its restoration: tribute to scholars and professionals who worked on it

Raimondo F. M., Castiglia G., Ciccarello, S., Scafidi, F. & Salmeri C.: Plant landscape of the archaeological site of Selinunte and its restoration: tribute to scholars and professionals who worked on it. — Bocc. 28: 367-368. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: landscape restoration, landscape management, vegetation.

Plant cover of the Selinunte archaeological site has been receiving special attention by various landscape ecologists, mainly with regard to its restoration. Since the Eighties, the then Superintendent to the western Sicily Monuments, professor **Vincenzo Tusa**, was concerned with the landscape restoration of Selinunte area, and the stabilization of the nearby mobile dunes potentially affecting the ruins excavation in this site, which would rapidly become the widest archaeological park of Magna Graecia thanks to its 270 hectares. Tusa began his work by involving one of the most renowned landscape architects at that time, professor **Pietro Porcinai**, Florentine by birth and leader of a School that left substantial cultural heritage and expertise in Italy. He appreciated multidisciplinary and collaborative approaches, including different specializations such as botany. The then director of the Botanical Garden of Palermo, professor **Andrea Di Martino**, also known for his studies on the flora and vegetation of some circum-Sicilian islands (Pantelleria and Egadi), was requested to cooperate to the project plan, which also involved the first author of this contribution. The vegetation of the area was analyzed and fisionomically typified. Main directives were provided to reconstitute the Mediterranean shrubland, partly covering the ruins, in the degraded or bare areas next to the accesses and the Acropolis. A list of appropriate native plants useful for the intervention was also provided. The results of these plantings, carried out under the direction of the knight **Ettore Paternò del Toscano**, who was an open-minded agronomist and expert of Sicilian gardens, are still visible in the Park to the unaware visitors and to those people, specialists included, who approach them. Hence, this represents a valid example of multidisciplinary methodology for reconstituting and rearranging the natural landscape features in a sensitive area; a good model to be repeated in other archaeological sites, as well as in the remaining degraded areas of the Selinunte archaeological Park.

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Francesco M. Raimondo

Evolution of the forest landscape in the Punic Eparchy area (West Sicily): the importance of cork oak in natural residual vegetation for the purposes in the restoration of the forest landscape

Raimondo, F. M.: Evolution of the forest landscape in the Punic Eparchy area (West Sicily): the importance of cork oak in natural residual vegetation for the purposes in the restoration of the forest landscape. — Bocc. 28: 369-370. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: *Oleo-Ceratonion*, *Erico-Quercion ilicis*, *Quercus suber.*

The natural forest vegetation in the territory of the western provinces of Sicily (Palermo, Trapani and Agrigento) has almost completely disappeared. This area coincides with the ancient administrative territorial unit that precedes the division into three "valleys" of the most inhabited island of the Mediterranean: it is the Val di Mazara, remembered by archaeologists as "Punic Eparchy". As a seat of important Greek cities (Himera, Solunto, Entella, Agrigento, Gela, Eraclea Minoa, Segesta, Selinunte, Erice, Lilibeo, Mozia, etc.), it was a Punic domain before being abandoned. Due to the lack of a marked relief and the benefit of climate, agriculture was practiced for three millennia. In the last centuries – first in extensive and then intensive way – this form of agriculture was progressively occupying all practicable spaces and the cultivation of woody plants replaced the natural vegetation - the scrub and the Mediterranean evergreen forest - thus determining a landscape with a strong agricultural imprint, devoid of forest formations; from almond groves, olive groves and vineyards of classic cultivations it has been passed to modern, more rational woody plants which mainly make up the two extreme provinces, the most important wine and olive cultivation area of Sicily. The study of the remains of the natural vegetation that have been re-ignored – almost always small surviving plant communities in the less suitable spaces for traditional agricultural activities – presently allows us to reconstruct the potential vegetation of the area, partly referring to phytocoenosis of the *Oleo-Ceratonion* (*Pistacia-Rhamnetalia alaterni*) and *Erico-Quercion ilicis* (*Quercetalia ilicis*). In this scenery the cork oak (*Quercus suber*) plays an important role, considering its presence as isolated plants or rather open stands, mainly in the westernmost provinces of the Island. These elements of the local natural heritage can be assessed as important relics of the destroyed climacic vegetation of the extensive area stretching from the northern Tyrrhenian coast to the southern one, in contact with the African sea.

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Filippo Scafidi & Francesco M. Raimondo

Contribution to the vascular flora of the archaeological park of Selinunte and Cave of Cusa (South-Western Sicily, Italy): preliminary results*

Abstract

Scafidi, F. & Raimondo, F. M.: Contribution to the vascular flora of the archaeological park of Selinunte and Cave of Cusa (South-Western Sicily, Italy): preliminary results. — Bocconea 28: 371-390. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

This study aims to present a complete inventory of the vascular flora of the Archaeological Park of Selinunte. A total of 443 specific and infraspecific taxa are here reported. *Fabaceae* was the most collected family with 47 species. *Asteraceae* and *Poaceae* were the next largest families with 45 and 35 species, respectively. *Euphorbia* was the largest genus, represented by 9 species. The analysis of the biological spectrum of the vascular flora indicate the predominance of therophytes (42%) and hemicryptophytes (22%) while, from a chorological point of view, most of the species show a Mediterranean distribution. The presence of *Cynara cardunculus* subsp. *zingaroensis* (taxon endemic to W-Sicily) is reported for the first time for the investigated area.

Key words: archaeological areas, vascular flora, endemics, alien species, Sicily, Italy.

Introduction

Archaeological sites in the Mediterranean Basin are often of great artistic and historical value and play an important role in the tourist industry (Celesti-Grapow & Blasi 2004).

Among these, the Archaeological Park of Selinunte and Cave of Cusa (Trapani Province) is, certainly, one of the largest and most extraordinary archaeological sites in the Western Mediterranean.

This contribution is limited only to the part of the park around the ancient city of Selinunte. This area and its temples represented the western part of the Greek advance in Sicily. It was founded in 651-650 B.C. and built with calcarenites extracted from the quarries of the near locality Cusa, in Campobello di Mazzara territory (Trapani Province) (Brai & al. 2004).

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The toponym “Selinunte” probably, is due to savage parsley, ‘selinon’ in ancient Greek, which in tern refers to *Apium* spp. growing wild in such moist habitats (Guarino & Pasta 2017) and was also present on the local coins (Fabbrocino & al. 2001).

The Archaeological Park, with almost 270 hectares of extension, houses also elements of flora and vegetation of great natural value.

The site is also characterized by the presence of wide sandy dunes included in “The Natural Reserve Foce of Belice and Dune Limitrofe" and in the SIC (Sites of Community Interest) ITA010011 named “Dunal system of Capo Granitola, Porto Palo and Foce of Belice”.

Nevertheless, very poor are studies carried out on the flora and vegetation on this area (Frei 1937; Brullo & al. 1974; Speranza & al. 1993; Troia & Spallino 2009).

Furthermore, in the past, plant cover and Mediterranean maquis of the Selinunte archaeological site have been attentioned by various landscape ecologists, mainly with regard to its restoration (Raimondo & al. 1991; Raimondo & al. 2018), however at today, a floristic inventory of the whole area is still missing.

In 2018, the project “Census of the vascular plants of the Archaeological Park of Selinunte and Cave of Cusa” started, with the aim of improving the botanical knowledge of this area and to produce a complete check-list of this flora.

The studied area

The Archaeological area of Selinunte is located on the southwest coast of Sicily in the central part of the coastline, between Capo Granitola and Capo San Marco (south-western Sicily).

It is stretched over three hills that from east to west are: Marinella or Eastern Hill, Manuzza and Gaggera Hills (Piro & Vesinon 1995), and it is part of a territory that is represented by Modione basin and partially by the Belice basin (Fig. 1). The area is characterized by clay or clayey-marl with sand breakthroughs covered by calcarenites (Liguori & Porcaro 2010) it falls in the floristic subunit “2.3.1 Southern and Western coast” (Domina & al. 2018a). Phytogeographically, the site falls in the Drepano-Panormitano district. (Brullo & al. 1995).

According to Bazan & al. (2015), the bioclimate of the area can be defined lower thermomediterranean and lower dry, with annual average temperature around 18 ° C and upper dry ombrotype (average annual rainfall of 500 mm) (La Rosa & al. 2012).

Material and Methods

Inventory of the flora was carried in the year 2018, from February to August, several samplings were performed in order to cover the whole area investigated.

Herbarium specimens have been collected and stored in the Herbarium Mediterraneum Panormitanum (PAL-Gr), acronym according to Thiers (2018).

For the taxa identification, we mainly referred mainly to the Italian floras (Fiori 1923-29; Pignatti 1982) and systematic revisions and monographs (Delforge 2005; Giardina & al. 2007; Venturella & al. 2007; Domina & al. 2011).

In the floristic list, the systematic order and taxonomic circumscription of the families

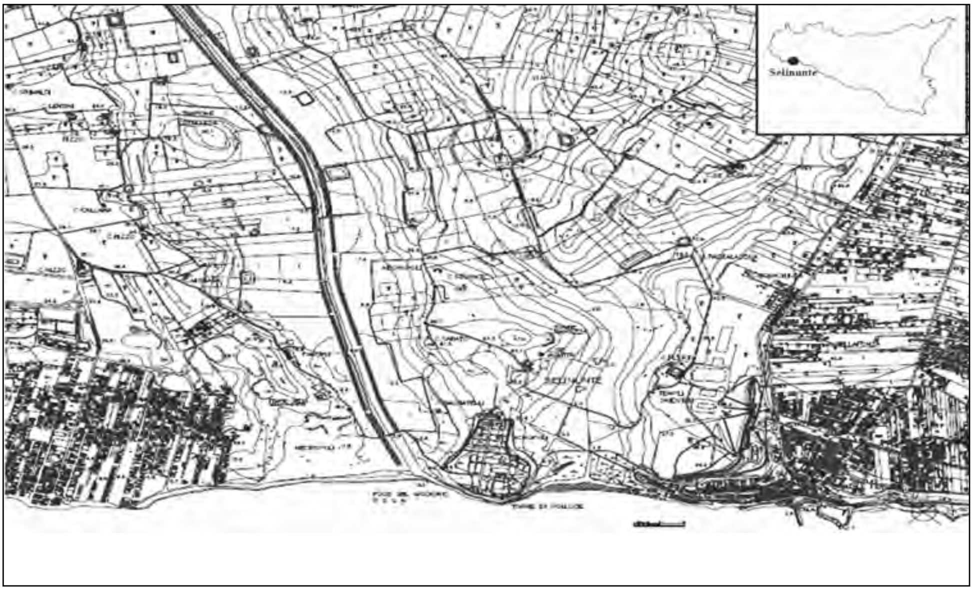

Fig. 1. Study area: the Archaeological Park of Selinunte (Sicily, Italy).

follow Bartolucci & al. (2018) and Galasso & al. (2018). Taxa are ordered alphabetically within each family. Life forms and chorological types of natural and alien taxa are according respectively to Raimondo & al. (2010) and Raimondo & al. (2005), while cultivated plant follow Bazan & al. (2005).

Results and Discussion

A total of 443 specific and infraspecific taxa currently occur on the Archaeological Park of Selinunte, belonging to 302 genera and 85 families. *Fabaceae* was the largest family with 47 species. *Asteraceae* and *Poaceae* were the next largest families with 45 and 35 species. *Euphorbia* was the largest genus, represented by 9 species.

The life form spectrum (Fig. 2A) shows a dominance of Therophytes (42%), followed by Hemicryptophytes (22%), Phanerophytes (15%) and Geophytes (11%). From a chorological viewpoint, most species show a Mediterranean distribution (Stenomedit. and Eurimedit.) (Fig. 2B).

Italian endemics are seven (Raimondo & al. 2010; Bartolucci & al. 2018) which amounted to 2% of the taxa observed. In particular, only two taxa are endemic to Sicily:

- *Cynara cardunculus* subsp. *zingaroensis* (Raimondo & Domina) Raimondo & Domina (Fig. 3A), is endemic to W-Sicily (Raimondo & al. 2004). The population founded in the Eastern Hill has never been reported at today and therefore it is the first record for this area.
- *Limonium selinuntinum* Brullo (Fig. 3B), is a narrow endemic that occur only on the sea cliffs in in the Archaeological Park of Selinunte. (Brullo 1980). At today, the total pop-

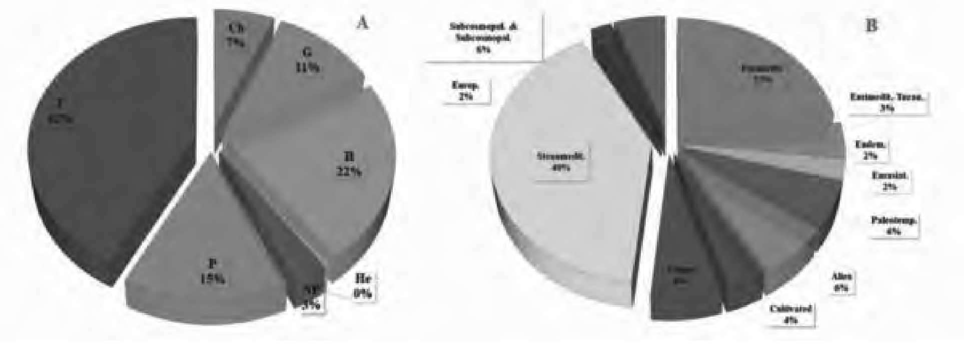

Fig. 2. A) Biological spectrum of the vascular flora of Archaeological Park of Selinunte. Ch - chamaephytes; G - geophytes; H - hemicryptophytes; He - helophytes; NP - nanophanerophytes; P - phanerophytes; T - therophytes; and B) The Chorological spectrum.

ulation is estimated to be fewer than 200 individuals. Its range is seriously threatened due to strong anthropogenic pressure present in the investigated area.

Antirrhinum siculum Mill. shows wide Italian distribution, three taxa are endemic to Southern Italy (*Euphorbia ceratocarpa* Ten; Gypsophila arrostii Guss. subsp. *arrostii; Retama raetam* (Forssk.) Webb & Berthel. subsp. *gussonei* (Webb) Greuter), and *Seseli tortuosum* subsp. *maritimum* (Guss.) C.Brullo, Brullo, Giusso & Sciandr. is endemic to Southern Italy and Sardinia.

Others taxa with particular phytogeographical interest are: *Ajuga iva* subsp. *pseudoiva* (DC.) Briq., *Crucianella marittima* L. *Echium sabulicola* Pomel subsp. *sabulicola, Launaea fragilis* (Asso) Pau, *Lomelosia rutifolia* (Vahl) Avino & P. Caputo, and *Pancratium maritimum* L.

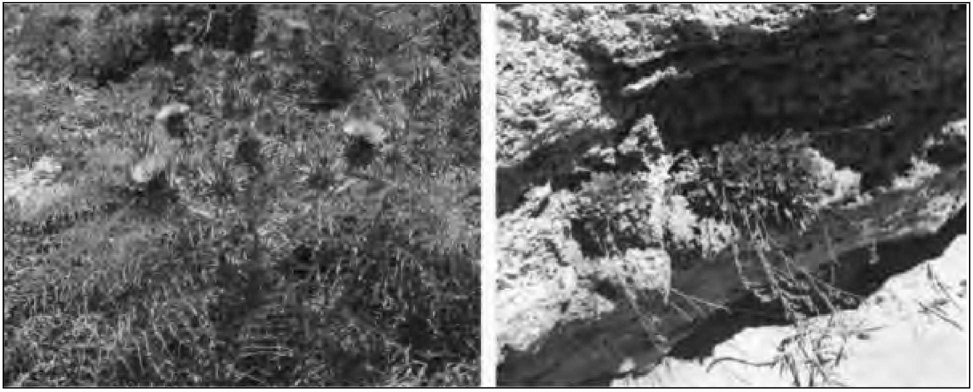

Fig. 3. A) *C. cardunculus* L. subsp. *zingaroensis* (Raimondo & Domina) Raimondo & Domina; B) *L. selinuntinum* Brullo.

Fig. 4. Some alien taxa in the Archaeological Park of Selinunte: A) *Ailanthus altissima*; B) *Agave americana* subsp. *americana;* C) *Carpobrotus edulis*.

Our results confirm that this area is among the richest in biodiversity of the southern coast of Sicily as reported in Domina & al. (2018b). The present contribution has also highlighted the presence of the high number of alien species (29 taxa), mostly naturalized and sometimes more or less invasive (Fig. 4) such as: *Ailanthus altissima* (Mill.) Swingle, *Carpobrotus edulis* (L.) N. E. Br., *Eucalyptus camaldulensis* Dehnh. subsp. *camaldulensis, Phoenix canariensis* H. Wildpret. and *Vachellia karroo* (Hayne) Banfi & Galasso. Other alien species (13 taxa) are cultivated in the Archaeological Park for ornamental purposes.

Moreover, on the basis of our observations in the field the exclusion of *Scrophularia frutescens* L., is confirmed. In the past, its presence in the dune system was reported by Brullo & al. (1974) and misidentified with *S. canina* L.

At the end, due to its specific climatological position and habitat diversity, we can expect that the investigated area hosts more species than currently recorded.

Floristic list

PTERIDOPHYTA

EQUISETACEAE
Equisetum ramosissimum Desf. – G rhiz – Circumbor.
Equisetum telmateia Ehrh. – G rhiz – Circumbor.

SELAGINELLACEAE
Selaginella denticulata (L.) Spring – Ch rept – Stenomedit.

GYMNOSPERMAE

ARAUCARIACEAE
Araucaria heterophylla (Salisb.) Franco – P scap – Australia – Cultivated as ornamental.

CUPRESSACEAE
Cupressus sempervirens L. – P scap – Eurimedit. Orient.

PINACEAE
Pinus halepensis Mill. subsp. *halepensis* – P scap – Stenomedit.
Pinus pinea L. – P scap – Eurimedit. – Naturalized alien.

ACANTHACEAE
Acanthus mollis L. – H scap – Stenomedit.

AIZOACEAE
Carpobrotus edulis (L.) N.E.Br. – Ch suffr – South Africa – Naturalized alien.

AMARANTHACEAE
Amaranthus albus L. – T scap – America – Naturalized alien.
Amaranthus deflexus L. – T scap – S-Amer. – Naturalized alien.
Amaranthus hybridus subsp. *cruentus* (L.) Thell – T scap – America Trop. e Subtrop. – Naturalized alien

ANACARDIACEAE
Pistacia lentiscus L. – P caesp – Stenomedit.
Pistacia terebinthus L. subsp. *terebinthus* – P caesp – Eurimedit. – Cultivated as ornamental.
Rhus coriaria L. – P caesp – S-Stenomedit.
Schinus molle L. – P scap – America – Cultivated as ornamental. Schinus terebinthifolia Raddi – P scap – S-Amer. – Cultivated as ornamental.

APIACEAE
Crithmum maritimum L. – Ch suffr – Eurimedit.
Daucus aureus Desf. – T scap – S-Stenomedit.
Daucus carota L. subsp. *carota* – H bienn – Paleotemp.
Daucus pumilus (L.) Hoffmanns. & Link – T scap – Stenomedit.
Echinophora spinosa L. – H scap – Eurimedit.
Eryngium maritimum L. – G rhiz – Stenomedit.
Eryngium triquetrum Vahl – H scap – SW-Stenomedit.
Ferula communis L. – H scap – S-Eurimedit.
Foeniculum vulgare Mill. subsp. *vulgare* – H scap – S-Eurimedit.
Helosciadium nodiflorum (L.) W.D.J.Koch subsp. *nodiflorum* – H scap – Eurimedit.
Kundmannia sicula L. – H scap – Stenomedit.
Magydaris pastinacea (Lam.) Paol. – H scap – W-Stenomedit.
Oenanthe pimpinelloides L. – H scap – Eurimedit.-Subatl.
Opopanax chironium (L.) W.D.J.Koch – H scap – Stenomedit.
Seseli tortuosum L. subsp. *maritimum* (Guss.) C.Brullo, Brullo, Giusso & Sciandr. – H bienn – Endem. *Smyrnium olusatrum* L. – H bienn – Eurimedit.-Subatl.
Thapsia garganica L. – H scap – S-Stenomedit.
Tordylium apulum L. – T scap – Stenomedit.

APOCYNACEAE
Nerium oleander L. subsp. oleander – P caesp – S-Stenomedit.
Vinca major L. subsp. *major* – Ch rept – Eurimedit.

ARALIACEAE
Hedera helix L. – P lian – Eurimedit.

ASTERACEAE
Achillea maritima (L.) Ehrend. & Y.P.Guo subsp. *maritima* – Ch suffr – Stenomedit.-Atl.
Andryala integrifolia L. – T scap – W-Eurimedit.

Anthemis arvensis L. subsp. *arvensis* – T scap – Stenomedit.
Artemisia arborescens L. – NP – S-Stenomedit.
Bellis annua L. – T scap – Stenomedit.
Bellis sylvestris Cyr. – H ros – Stenomedit.
Calendula arvensis (Vaill.) L. – T scap – SW-Stenomedit.
Carduus pycnocephalus L. subsp. *pycnocephalus* – H bienn – Eurimedit.-Turan.
Centaurea aspera L. subsp. *aspera* – H scap – Stenomedit.
Centaurea napifolia L. – T scap – SW-Stenomedit.
Centaurea sphaerocephala L. subsp. *sphaerocephala* – H scap – W-Stenomedit.
Chamaemelum fuscatum (Brot.) Vasc. – T scap – W Medit.-Mont.
Cichorium intybus L. – H scap – Paleotemp.
Crepis vesicaria L. subsp. *vesicaria* – T scap – Eurimedit.-Subatl.
Cynara cardunculus subsp. *zingaroensis* (Raimondo & Domina) Raimondo & Domina – H scap – Endem.
Dittrichia viscosa (L.) Greuter subsp. *viscosa* – H scap – Eurimedit.
Eclipta prostrata (L.) L. – T scap – Neotropic. – Naturalized alien.
Erigeron bonariensis L. – T scap – America Trop. – Naturalized alien.
Filago germanica (L.) Huds. – T scap – Paleotemp.
Filago pygmaea L. – T rept – Stenomedit. Filago pyramidata L. – T scap – Stenomedit.
Galactites tomentosus Moench – H bienn – Stenomedit.
Glebionis coronaria (L.) Spach – T scap – Stenomedit.
Hedypnois rhagadioloides (L.) F.W.Schmidt – T scap – Stenomedit.
Helminthotheca aculeata (Vahl) Lack subsp. aculeata – H scap – SW-Stenomedit.
Hyoseris radiata L. – H ros – Stenomedit.
Hypochaeris achyrophorus L. – T scap – Stenomedit.
Xanthium italicum Moretti – T scap – Eurimedit.
Lactuca sativa subsp. *serriola* (L.) Galasso, Banfi, Bartolucci & Ardenghi – H bienn – S-Europ.-Sudsib.
Launaea fragilis (Asso) Pau – Ch frut – SaharoSind.
Logfia gallica (L.) Cosson & Germ. – T scap – Eurimedit.
Pallenis spinosa (L.) Cass. subsp. *spinosa* – T scap – Eurimedit.
Phagnalon rupestre subsp. *illyricum* (H.Lindb.) Ginzb. – Ch suffr – W-Stenomedit.
Pulicaria dysenterica (L.) Bernh. – H scap – Eurimedit.
Reichardia picroides (L.) Roth – H scap – Stenomedit.
Scolymus grandiflorus Desf. – H scap – SW-Stenomedit.
Scolymus hispanicus L. subsp. *hispanicus* – H bienn – Eurimedit.
Senecio leucanthemifolius Poir. subsp. *leucanthemifolius* H scap – Stenomedit.
Senecio vulgaris L. subsp. *vulgaris* – T scap – Eurimedit.
Sonchus bulbosus (L.) N.Kilian & Greuter subsp. *bulbosus* – H ros – Stenomedit.
Sonchus oleraceus L. – T scap – Eurasiat.
Sonchus tenerrimus L. – T scap – Stenomedit.
Silybum marianum (L.) Gaertn. – H bienn – Eurimedit.-Turan.
Symphyotrichum squamatum (Spreng.) G.L.Nesom – T scap – S-Amer. – Naturalized alien.
Tragopogon porrifolius L. – H bienn – Eurimedit.
Tolpis virgata (Desf.) Bertol. subsp. *virgata* – T scap – Stenomedit.
Urospermum dalechampii (L.) F.W.Schmidt – H scap – Eurimedit.

BORAGINACEAE
Alkanna tinctoria Tausch subsp. *tinctoria* – H scap – Stenomedit.

Borago officinalis L. – T scap – Eurimedit.
Cerinthe major L. subsp. *major* – T scap – Stenomedit.
Cynoglossum cheirifolium L. – H bienn – Stenomedit.
Cynoglossum creticum Mill. – H bienn – Eurimedit.
Echium italicum subsp. *siculum* (Lacaita) Greuter & Burdet – H bienn – Eurimedit.
Echium plantagineum L. – T scap – Eurimedit.
Echium sabulicola Pomel subsp. sabulicola – H scap – W-Stenomedit.
Heliotropium europaeum L. – T scap – Eurimedit.

BRASSICACEAE
Brassica tournefortii Gouan – T scap – SaharoSind.
Biscutella maritima Ten. – T scap – SW-Medit.
Capsella bursa-pastoris (L.) Medik. subsp. *bursa-pastoris* – H bienn – Eurimedit.
Cakile maritima Scop. subsp. *maritima* – T scap – Eurosib.
Cardamine graeca L. – T scap – Cosmopol.
Diplotaxis erucoides (L.) DC. subsp. *erucoides* – T scap – W-Stenomedit.
Hirschfeldia incana (L.) Lagr.-Foss. subsp. *incana* – H scap – Eurimedit.
Lobularia maritima (L.) Desv. – H scap – Stenomedit.
Matthiola tricuspidata (L.) R.Br. – T scap – Stenomedit.
Nasturtium officinale R.Br. – H scap – Cosmopol.
Raphanus raphanistrum subsp. *landra* (DC.) Bonnier & Layens – T scap – Eurimedit.
Sinapis alba subsp. *dissecta* (Lag.) Bonnier – T scap – E-Medit.-Mont.
Sinapis arvensis L. subsp. *arvensis* – T scap – Stenomedit.
Sisymbrium irio L. – T scap – Paleotemp.

CACTACEAE
Opuntia ficus-indica (L.) Mill. – P succ – America Trop. – Naturalized alien.

CAMPANULACEAE
Campanula dichotoma L. – T scap – Stenomedit.
Campanula erinus L. – T scap – Stenomedit.

CAPPARACEAE
Capparis spinosa L. – NP – Medit.-Turan.

CAPRIFOLIACEAE
Lonicera etrusca Santi – P lian – Eurimedit.
Lonicera implexa Aiton subsp. implexa – P lian – Stenomedit.

CARYOPHYLLACEAE
Arenaria leptoclados (Rchb.) Guss. subsp. *leptoclados* – T scap – Paleotemp.
Arenaria serpyllifolia L. subsp. *serpyllifolia* – T scap – Subcosmop.
Cerastium glomeratum Thuill. – T scap – Eurimedit.
Gypsophila arrostii Guss. subsp. *arrostii* – Ch suffr – Endem.
Paronychia argentea Lam. – H caesp – Stenomedit.
Polycarpon tetraphyllum (L.) L. subsp. *tetraphyllum* – T scap – Eurimedit.
Rhodalsine geniculata (Poir.) F.N.Williams – Ch suffr – Stenomedit.
Sagina apetala Ard. subsp. *apetala* – T scap – Eurimedit.
Sagina procumbens L. – H caesp – Subcosmop.

Silene colorata Poir. – T scap – Stenomedit.
Silene gallica L. – T scap – Eurimedit.
Silene latifolia Poir. – H bienn – Stenomedit.
Silene niceensis All. – T scap – Stenomedit.
Spergularia rubra (L.) J.Presl & C.Presl – Ch suffr – Subcosmop.
Stellaria media (L.) Vill. subsp. *media* – T rept – Cosmopol.

CHENOPODIACEAECE
Beta vulgaris subsp. *maritima* (L.) Arcang. – H scap – Eurimedit.
Atriplex halimus L. – P caesp – Stenomedit.-Atl.
Chenopodiastrum murale (L.) S.Fuentes, Uotila & Borsch – T scap – Subcosmop.
Chenopodium album L. subsp. *album* – T scap E Europ-Asia.
Salsola kali L. – T scap – Paleotemp.
CISTACEAE
Tuberaria guttata (L.) Fourr. – T scap – Eurimedit.
Fumana laevis (Cav.) Pau – Ch suffr – Stenomedit.

CONVOLVULACEAE
Cressa cretica L. – Ch suffr – Cosmopol.
Convolvulus althaeoides L. – H scap – Stenomedit.
Convolvulus arvensis L. – G rhiz – Paleotemp.
Convolvulus cantabrica L. – H scand – Eurimedit.
Convolvulus lineatus L. - Ch suffr – Stenomedit.
Convolvulus silvaticus Kit. – H scand – Eurimedit.–Turan.
Convolvulus soldanella L. – G rhiz – SE-Europ.
Convolvulus tricolor subsp. *cupanianus* (Tod.) Cavara & Grande – T scap – Stenomedit.
Cuscuta epithymum (L.) L. subsp. *epithymum* – T par – Eurasiat.
Ipomoea purpurea (L.) Roth – G rhiz – America Trop. – Naturalized alien.

CRASSULACEAE
Crassula tillaea Lest.–Garl. – T scap – Subatlant.
Phedimus stellatus (L.) Raf. – T scap – Stenomedit.
Petrosedum sediforme (Jacq.) Grulich – Ch succ – Stenomedit.
Sedum album L. subsp. *album* – Ch succ – Eurimedit.
Sedum caeruleum L. – T scap – SW–Medit.
Sedum dasyphyllum L. subsp. *dasyphyllum* – Ch succ – Eurimedit.
Sedum rubens L. – T scap – Eurimedit.-Subatl.
Umbilicus horizontalis (Guss.) DC. – G bulb – Stenomedit.

CUCURBITACEAE
Ecballium elaterium (L.) A.Rich. – G bulb – Eurimedit.

DIPSACACEAE
Dipsacus fullonum L. subsp. *fullonum* – H bienn – Eurimedit.
Lomelosia rutifolia (Vahl) Avino & P.Caputo – T scap – Stenomedit.
Sixalix atropurpurea (L.) Greuter & Burdet – H bienn – Stenomedit.

EUPHORBIACEAE
Chrozophora tinctoria (L.) A.Juss. – T scap – Eurimedit.-Turan.

Euphorbia ceratocarpa Ten. – Ch suffr – Endem.
Euphorbia exigua L. subsp. *exigua* – T scap – Eurimedit.
Euphorbia helioscopia L. subsp. *helioscopia* – T scap – Cosmopol.
Euphorbia maculata L. – T scap – N-America – Naturalized alien.
Euphorbia paralias L. – Ch frut – Eurimedit.
Euphorbia peplis L. – T rept – Eurimedit.
Euphorbia peplus L. – T scap – Eurosib.
Euphorbia prostrata Aiton – T rept – N-America – Naturalized alien.
Euphorbia terracina L. – T scap – Stenomedit.
Mercurialis annua L. – T scap – Paleotemp.
Ricinus communis L. – P scap – Paleotrop. – Naturalized alien.

FABACEAE
Acacia saligna (Labill.) H.L.Wendl. – P scap – Australia – Naturalized alien.
Anagyris foetida L. – P caesp – S-Stenomedit.
Astragalus boeticus L. – T scap – S-Stenomedit.
Bituminaria bituminosa (L.) Stirton – H scap – Eurimedit.
Ceratonia siliqua L. – P caesp – S-Stenomedit.
Cercis siliquastrum L. subsp. *siliquastrum* – P scap – S-Europe.
Cytisus villosus Pourr – P caesp – W-Stenomedit.
Erythrina humeana Spreng. – P scap – South Africa – Cultivated as ornamental.
Ervum pubescens DC. – T scap – Eurimedit.
Hippocrepis multisiliquosa L. – T scap – Stenomedit.
Lathyrus clymenum L. – T scap – Stenomedit.
Lathyrus grandiflorus Sm. – G rhiz – NE-Stenomedit.
Lotus creticus L. – H scap – Stenomedit.
Lotus biflorus Desr. – T scap – SW-Stenomedit.
Lotus cytisoides L. – Ch suffr – Stenomedit.
Lotus parviflorus Desf. – T scap – Stenomedit.
Lotus tetragonolobus L. – T scap – Stenomedit.
Lupinus angustifolius L. – T scap – Stenomedit.
Medicago littoralis Loisel. – T scap – Eurimedit.
Medicago lupulina L. – T scap – Stenomedit.
Medicago marina L. – Ch rept – Eurimedit.
Medicago minima (L.) L. – T scap – Eurimedit.
Medicago monspeliaca (L.) Trautv. – T scap – Eurimedit.
Medicago polymorpha L. – T scap – Eurimedit.
Medicago rigidula (L.) All. – T scap – Eurimedit.
Medicago truncatula Gaertner – T scap – Eurimedit.
Ononis natrix subsp. *ramosissima* (Desf.) Batt. – T scap – S-Stenomedit.
Ononis variegata L. – T scap – Stenomedit.
Parkinsonia aculeata L. – P scap – America Trop. – Invasive alien.
Retama raetam subsp. *gussonei* (Webb) Greuter – P caesp – Endem.
Scorpiurus muricatus L. – T scap – Eurimedit.
Sulla coronaria (L.) Medik. – T scap – Stenomedit.
Trifolium bocconei Savi – T scap – Stenomedit.
Trifolium campestre Schreber – T scap – Paleotemp.
Trifolium cherleri L. – T scap – Eurimedit.
Trifolium nigrescens Viv. subsp. *nigrescens* – T scap – Eurimedit.

Trifolium resupinatum L. – T rept – Paleotemp.
Trifolium scabrum L. – T rept – Eurimedit.
Trifolium stellatum L. – T scap – Eurimedit.
Trigonella sulcata (Desf.) Coulot & Rabaute – T scap – S-Stenomedit.
Tripodion tetraphyllum (L.) Fourr. – T scap – Stenomedit.
Vachellia karroo (Hayne) Banfi & Galasso – P scap – Australia – Naturalized alien.
Vicia ervoides (Brign.) Hampe – T scap – Stenomedit.
Vicia hybrida L. – T scap – Eurimedit.
Vicia leucantha Biv. – T scap – SW-Stenomedit.
Vicia sativa L. subsp. *sativa* – T scap – Eurimedit.-Turan.
Vicia villosa subsp. *varia* (Host) Corb. – T scap – Eurimedit.-Turan.

FAGACEAE
Quercus ilex L. – P scap – Stenomedit.
Quercus suber L. – P scap – W-Stenomedit.

FRANKENIACEAE
Frankenia hirsuta L. – Ch suffr – Stenomedit.

GENTIANACEAE
Blackstonia perfoliata (L.) Huds. subsp. *perfoliata* – T scap – Eurimedit.
Centaurium erythraea Rafn subsp. *erythraea* – H bienn – Paleotemp.

GERANIACEAE
Erodium acaule (L.) Bech. & Thell. – H ros – Medit.-Mont.
Erodium cicutarium (L.) L'Hér. – T scap – Subcosmop.
Erodium malacoides (L.) L'Hér. subsp. *malacoides* – T scap – Stenomedit.
Geranium dissectum L. – T scap – Eurasiat.
Geranium robertianum L. – T scap – Subcosmop.
Geranium rotundifolium L. – T scap – Paleotemp.
Geranium sanguineum L. – H scap – Europ.-Caucas
Pelargonium zonale (L.) Aiton. – Ch suffr – Africa – Cultivated as ornamenal.

HYPERICACEAE
Hypericum perfoliatum L. – H scap – Stenomedit.

LAMIACEAE
Ajuga iva subsp. *pseudoiva* (DC.) Briq. – Ch suffr – Stenomedit.
Ballota nigra subsp. *uncinata* (Fiori & Bég.) Patzak – H scap – Eurimedit.
Clinopodium nepeta (L.) Kuntze subsp. *nepeta* – H scap – Orof. S-Europ.
Lamium amplexicaule L. – T scap – Paleotemp.
Micromeria graeca (L.) Rchb. subsp. *graeca* – Ch suffr – Stenomedit.
Micromeria nervosa (Desf.) Benth. – Ch suffr – Stenomedit.
Mentha pulegium L. subsp. *pulegium* – H scap – Eurimedit.
Salvia clandestina L. – H scap – SE-Europ.
Salvia rosmarinus Schleid. – NP – Europ.
Salvia verbenaca L. – H scap – Stenomedit.-Atl.
Stachys major (L.) Bartolucci & Peruzzi – Ch suffr – Stenomedit.
Stachys ocymastrum (L.) Briq. – T scap – W-Stenomedit.

Stachys romana (L.) E.H.L.Krause – T scap – Stenomedit.
Teucrium capitatum L. subsp. *capitatum* – Ch suffr – Stenomedit.
Teucrium flavum L. subsp. *flavum* – Ch suffr – Stenomedit.
Teucrium fruticans L. subsp. *fruticans* – NP – W-Stenomedit.
Thymbra capitata (L.) Cav. – Ch suffr – Stenomedit.
Vitex agnus-castus L. – P caesp – Eurimedit.-Turan.

LAURACEAE
Laurus nobilis L. – P caesp – Stenomedit.
LINACEAE
Linum bienne Mill. – H bienn – Eurimedit.
Linum decumbens Desf. – T scap – W-Stenomedit.

LYTHRACEAE
Lythrum hyssopifolia L. – T scap – Subcosmop.
Lythrum junceum Banks & Sol – H scap – Stenomedit.
Punica granatum L. – P scap – Asia – Cultivated as ornamental.

MALVACEAE
Hibiscus rosa-sinensis L. – T scap – China – Cultivated as ornamental.
Malva arborea (L.) Webb & Berthel. – H bienn – Stenomedit.
Malva cretica Cav. subsp. *cretica* – T scap – Stenomedit.
Malva nicaeensis All. – T scap – Stenomedit.
Malva olbia (L.) Alef. – P caesp – Stenomedit.
Malva parviflora L. – T scap – Stenomedit.
Malva trimestris (L.) Salisb. – T scap – Stenomedit.

MELIACEAE
Melia azedarach L. – P scap – Asia – Cultivated as ornamental.

MYRTACEAE
Eucalyptus camaldulensis Dehnh. subsp. *camaldulensis* – P scap – Australia – Naturalized alien
Myrtus communis L. – P caesp – Stenomedit.

MORACEAE
Broussonetia papyrifera (L.) Vent. – P caesp – Asia – Naturalized alien.
Ficus carica L. – P scap – Eurimedit.-Turan.
Ficus microcarpa L.f. – P scap – Australia – Cultivated as ornamental.

NYCTAGINACEAE
Bougainvillea spectabilis Willd. – P lian – S-Amer. – Cultivated as ornamental.
Mirabilis jalapa L. – G bulb – America Trop. – Naturalized alien.

OLEACEAE
Olea europaea L. – P caesp – Stenomedit.
Phillyrea latifolia L. – P caesp – Stenomedit.

ONAGRACEAE
Epilobium hirsutum L. – H scap – Paleotemp.

OROBANCHACEAE
Bellardia trixago (L.) All. – T scap – Eurimedit.
Orobanche crenata Forssk. – T par – Eurimedit.-Turan.
Orobanche hederae Duby – T par – Eurimedit.
Orobanche minor Sm. – T par – Paleotemp.
Orobanche sanguinea C.Presl – T par – Stenomedit.
Parentucellia latifolia (L.) Caruel – T scap – Eurimedit.
Phelipanche lavandulacea (Rchb.) Pomel subsp. *lavandulacea* – T par – W-Stenomedit.
Phelipanche nana (Reut.) Soják – T par – Paleotemp.
Phelipanche ramosa (L.) Pomel – T par – Paleotemp.
Phelipanche schultzii (Mutel) Pomel – T par – Paleotemp.

OXALIDACEAE
Oxalis corniculata L. – H rept – Eurimedit.
Oxalis pes-caprae L. – G bulb – S-Africa – Invasive alien

PAPAVERACEAE
Fumaria capreolata L. subsp. *capreolata* – T scap – Eurimedit.
Glaucium flavum Crantz – H scap – Eurimedit.
Papaver rhoeas L. subsp. *rhoeas* – T scap – E-Medit.-Mont.

PHYTOLACCACEAE
Phytolacca americana L. – P scap – N-Americ. – Naturalized alien

PITTOSPORACEAE
Pittosporum tobira (Thunb.) W.T.Aiton – P caesp – China – Cultivated as ornamental.

PLANTAGINACEAE
Kickxia spuria (L.) Dumort. subsp. *spuria* – T scap – Eurasiat.
Plantago afra L. subsp. *afra* – T scap – Stenomedit.
Plantago bellardii All. subsp. *bellardii* – T scap – S-Stenomedit.
Plantago coronopus L. – T scap – Eurimedit.
Plantago lagopus L. – T scap – Stenomedit.
Plantago lanceolata L. – H ros – Eurasiat.
Plantago serraria L. – H ros – Stenomedit.
Veronica arvensis L. – T scap – Paleotemp.
Veronica cymbalaria Bodard subsp. *cymbalaria* – T scap – Eurimedit.
Veronica polita Fr. – T scap – Paleotemp.

PLUMBAGINACEAE
Limonium selinuntinum Brullo – H ros – Endem.
Limonium narbonense Mill. – H ros – Eurimedit.

POLYGONACEAE
Polygonum aviculare L. subsp. *aviculare* – T rept – Cosmopol.
Polygonum maritimum L. – H rept – Subcosmop.
Rumex bucephalophorus L. subsp. *bucephalophorus* – T scap – Eurimedit.-Macaron.
Rumex crispus L. – H scap – Subcosmop.
Rumex thyrsoides Desf. – H scap – W-Stenomedit.

PORTULACACEAE
Portulaca oleracea L.aggr. – T scap – Subcosmop.

PRIMULACEAE
Lysimachia arvensis (L.) U.Manns & Anderb. subsp. *arvensis* – T rept – Eurimedit.
Lysimachia foemina (Mill.) U.Manns & Anderb. – T rept – Subcosmop.
Samolus valerandi L. – H caesp – Cosmopol.

RANUNCULACEAE
Adonis annua L. – T scap – Eurimedit.-Subatl.
Anemone hortensis L. subsp. *hortensis* – G bulb – N-Eurimedit.
Clematis cirrhosa L. – P lian – Stenomedit.
Clematis vitalba L. – P lian – Europ.-Caucas.
Nigella damascena L. – T scap – Eurimedit.
Ranunculus bulbosus L. – H scap – Eurasiat.
Ranunculus bullatus L. – H ros – Stenomedit.
Ranunculus lanuginosus L. – H scap – Europ.
Ranunculus millefoliatus Vahl – H scap – Medit.-Mont.
Ranunculus muricatus L. – T scap – Eurimedit.

RESEDACEAE
Reseda alba L. – T scap – Stenomedit.

RHAMNACEAE
Rhamnus alaternus L. – P caesp – Eurimedit.

ROSACEAE
Crataegus monogyna Jacq. – P scap – Paleotemp.
Pyrus communis L. subsp. *communis* – P scap – Medit.
Pyrus spinosa Forssk. – P caesp – Stenomedit.
Rosa sempervirens L. – NP – W-Medit.-Mont.
Rubus ulmifolius Schott – NP – Eurimedit.
Sanguisorba minor Scop. – H scap – Paleotemp.

RUBIACEAE
Asperula aristata subsp. *scabra* Nyman – H scap – Eurimedit.
Crucianella maritima L. – Ch suffr – Stenomedit.
Galium aparine L. – T scap – Eurasiat.
Galium lucidum All. subsp. *lucidum* – H scap – Eurimedit.
Galium murale (L.) All. – T scap – Stenomedit.
Galium verrucosum Huds. subsp. *verrucosum* – T scap – Stenomedit.
Rubia peregrina L. – T scap – Stenomedit.
Sherardia arvensis L. – T scap – Eurimedit.
Theligonum cynocrambe L. – T scap – Stenomedit.
Valantia muralis L. – T scap – Stenomedit.

RUTACEAE
Citrus × *aurantium* L. – P scap – Asia – Cultivated as oramental.
Citrus × *limon* (L.) Osbeck – P scap – Uncertain origin – Cultivated as oramental.

SALICACEAE
Populus alba L. – P scap – Paleotemp.
Salix pedicellata Desf – P caesp – Stenomedit.

SANTALACEAE
Osyris alba L. – NP – Eurimedit.

SCROPHULARIACEAE
Antirrhinum siculum Mill. – Ch suffr – Endem.
Myoporum insulare R.Br. – P caesp – Australia – Cultivated as ornamental.
Scrophularia canina L. – H scap – Eurimedit.
Scrophularia peregrina L. – T scap – Stenomedit.
Verbascum creticum (L.) Kuntze – H bienn – SW-Stenomedit.
Verbascum sinuatum L. – H bienn – Eurimedit.

SIMAROUBACEAE
Ailanthus altissima (Miller) Swingle – P scap – E-Asia – Invasive alien.

SOLANACEAE
Hyoscyamus albus L – T scap – Stenomedit.
Lycium europaeum L. – H sca – Paleotemp.
Mandragora autumnalis Bertol. – H ros – Stenomedit.
Nicotiana glauca Graham – NP – S-Amer. – Naturalized alien.
Solanum linnaeanum Hepper & P.-M.L.Jaeger – NP – S-Africa – Naturalized alien.
Solanum nigrum L. – T scap – Cosmopol.

ULMACEAE
Ulmus canescens Mill. subsp. *canescens* (Melville) Browicz & Ziel.– P caesp – E-Eurimedit.

TAMARICACEAE
Tamarix africana Poir. – P caesp – W-Stenomedit.
Tamarix gallica L. – P caesp – W-Stenomedit.

THYMELAEACEA
Daphne gnidium L. – P caesp – Stenomedit.
Thymelaea hirsuta (L.) Endl. – NP – S-Stenomedit.

URTICACEAE
Parietaria judaica L. – H scap – Eurimedit.-Macaron.
Parietaria lusitanica L. subsp. *lusitanica* – T rept – Stenomedit.
Urtica membranacea Poir. – T scap – S-Stenomedit.
Urtica urens L. – T scap – Subcosmop.

VALERIANACEAE
Centranthus calcitrapae (L.) Dufr. subsp. *calcitrapae* – T scap – Stenomedit.
Centranthus ruber (L.) DC. subsp. *ruber* – Ch suffr – Stenomedit.
Fedia graciliflora Fisch. & C.A.Mey. – T scap – Stenomedit.
Valerianella eriocarpa Desv. – T scap – Stenomedit.

VERBENACEAE
Lantana camara subsp. *aculeata* (L.) R.W.Sanders – P caesp – Neotropic. – Naturalied alien.
Verbena officinalis L. – H scap – Paleotemp.

ZYGOPHYLLACEAE
Tribulus terrestris L. – T rept – Cosmopol.

VITACEAE
Vitis vinifera L. – P lian – Medit.

LILIOPSIDA
AMARYLLIDACEAE
Allium chamaemoly L. subsp. *chamaemoly* – G bulb – Stenomedit.
Allium pendulinum Ten. – G bulb – W-Stenomedit.
Allium neapolitanum Cirillo – G bulb – Stenomedit.
Allium roseum L. – G bulb – Stenomedit.
Allium subhirsutum L. subsp. *subhirsutum* – G bulb – Stenomedit.
Allium triquetrum L. – G bulb – W-Stenomedit.
Narcissus serotinus L. – G bulb – Stenomedit.

ARACEAE
Arisarum vulgare O.Targ.Tozz. subsp. *vulgare* – G rhiz – Stenomedit.
Arum italicum Mill. – G rhiz – Stenomedit.

ARECACEAE
Chamaerops humilis L. – P scap – W-Stenomedit**.**
Phoenix canariensis H.Wildpret – P scap – Canarie – Naturalized alien.
Phoenix dactylifera L. – P scap – Paleosubtrop. – Casual alien.

ASPARAGACEAE
Agave americana L. subsp. *americana* – P caesp – Mexico – Naturalized alien.
Asparagus acutifolius L. – NP – Stenomedit.
Asparagus pastorianus Webb & Berth. - NP - SW Stenomedit.
Prospero autumnale (L.) Speta – G bulb – Eurimedit.
Muscari commutatum Guss. – G bulb – E-Stenomedit.

ASPHODELACEAE
Aloë arborescens Mill. – P succ – South Africa – Cultivated as ornamental.
Asphodelus ramosus L. – G rhiz – Stenomedit.

CYPERACEAE
Carex riparia Curtis – G rhiz – Eurasiat.
Cyperus badius Desf. – He – Paleotemp.
Cyperus capitatus Vand. – G rhiz – Stenomedit.
Cyperus rotundus L. – G rhiz – Subcosmop.
Scirpoides holoschoenus (L.) Soják – G rhiz – Eurimedit.-Subatl.

IRIDACEAE
Chasmanthe aethiopica (L.) N.E.Br. – G rhiz – South Africa – Naturalized alien.

Gladiolus italicus Mill. – G bulb – Eurimedit.
Moraea sisyrinchium (L.) Ker Gawl. – G bulb – Stenomedit.
Juno planifolia (Mill.) Asch. – G bulb – S-Stenomedit.
Romulea bulbocodium (L.) Sebast. & Mauri – G bulb – Stenomedit.
Romulea rollii Parl. – G bulb – W-Stenomedit.

JUNCACEAE
Juncus articulatus L. subsp. *articulatus* – G rhiz – Circumbor.
Juncus acutus L. subsp. *acutus* – H caesp – Eurimedit.
Juncus littoralis C. A. Mey. – H caesp – Eurimedit.-Turan.
Juncus maritimus Lam. – G rhiz – Subcosmop.

ORCHIDACEAE
Anacamptis collina (Russell) R.M.Bateman, Pridgeon & M.W.Chase – G bulb – Stenomedit.
Anacamptis pyramidalis (L.) Rich. – G bulb – Eurimedit.
Barlia robertiana (Loisel.) Greuter – G bulb – Stenomedit.
Ophrys lutea Cav. – G bulb – Stenomedit.
Ophrys speculum Link – G bulb – Stenomedit.
Orchis italica Poir. – G bulb – Stenomedit.
Serapias vomeracea (Burm.f.) Briq. – G bulb – Eurimedit.

POACEAE
Agrostis stolonifera subsp. *maritima* (Lam.) Vasc. – H rept – Circumbor.
Ampelodesmos mauritanicus (Poir.) T.Durand & Schinz – H caesp – SW-Stenomedit.
Andropogon distachyos L. – H caesp – Paleotemp.
Anisantha madritensis (L.) Nevski subsp. *madritensis* – T scap – Eurimedit.
Anisantha sterilis (L.) Nevski – T scap – Eurimedit.
Anthoxanthum gracile Biv. – T scap – E-Stenomedit.
Anthoxanthum odoratum L. – H caesp – Eurasiat.
Arundo donax L. – G rhiz – Subcosmop.
Avena barbata Link – T scap – Eurimedit.
Brachypodium retusum (Pers.) P.Beauv. – H caesp – Eurasiat.
Briza maxima L. – T scap – Subtrop.
Bromus hordeaceus L. subsp. *hordeaceus* – T scap – Subcosmop.
Calamagrostis epigejos (L.) Roth subsp. *epigejos* – H caesp – Medit.
Calamagrostis arenaria subsp. *arundinacea* (Husn.) Banfi, Galasso & Bartolucci – G rhiz – Eurimedit.
Cynodon dactylon (L.) Pers. – G rhiz – Cosmopol.
Corynephorus divaricatus (Pourr.) Breistr. – T scap – Stenomedit.
Dactylis glomerata subsp. *hispanica* (Roth) Nyman – H caesp – Stenomedit.
Dasypyrum villosum (L.) P.Candargy – T scap – Eurimedit.-Turan.
Digitaria sanguinalis (L.) Scop. – T scap – Cosmopol.
Elymus farctus (Viv.) Melderis – G rhiz – Eurimedit.
Festuca maritima L. – T scap – Stenomedit.
Hyparrhenia hirta (L.) Stapf subsp. *hirta* – H caesp – Paleotrop.
Hordeum marinum Huds. – T scap – W-Stenomedit.
Hordeum murinum L. subsp. *murinum* – T scap – Circumbor.
Lagurus ovatus L. subsp. *ovatus* – T scap – Eurimedit.
Lolium perenne L. – H caesp – Circumbor.

Melica minuta L. subsp. *minuta* – H caesp – Stenomedit.
Oloptum miliaceum (L.) Röser & H.R.Hamasha – H caesp – Stenomedit.
Panicum repens L. – G rhiz – Paleosubtrop.
Parapholis incurva (L.) C.E.Hubb. subsp. *incurva* – T scap – Stenomedit
Phalaris coerulescens Desf. – H caesp – Stenomedit.
Phragmites australis (Cav.) Steud. subsp. *australis* – G rhiz – Subcosmop.
Poa annua L. – T caesp – Cosmopol.
Rostraria cristata (L.) Tzvelev – NP – Stenomedit.
Sorghum halepense (L.) Pers. – G rhiz – Termocosmop.
Stipellula capensis (Thunb.) Röser & H.R.Hamasha – T scap – Stenomedit.
Sporobolus virginicus (L.) Kunth – T caesp – N. Amer.

SMILACACEAE
Smilax aspera L. – NP – Subtrop.

TYPHACEAE
Typha angustifolia L. – G rhiz – Circumbor.

Conclusion

This study not only highlighted the great naturalistic value of the studied area, but also allowed to verify some critical issues such as the presence and sometimes large spread of some invasive alien species which threaten not only local biodiversity but also the monuments themselves. In fact, the damage inflicted by alien plants on the country's historical heritage is a particularly relevant issue in Italy (Celesti-Grapow & al. 2009).

It would be desirable in the future, that alien species present in this archaeological site to be constantly monitored and to prevent their diffusion through a landscape management plan that involving regular containment and eradication interventions.

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Anna Scialabba & Francesco M. Raimondo

The "Sicilian Plant Germplasm Repository" of the University of Palermo: 25 years of activity in biological conservation

Scialabba, A. & Raimondo, F. M.: The "Sicilian Plant Germplasm Repository" of the University of Palermo: 25 years of activity in biological conservation. — Bocc. 28: 391-392. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: *ex situ* conservation, germplasm bank, DNA bank.

The "**S**icilian **P**lant **G**ermplasm **R**epository" was created in 1993 from the Department of Botanical Sciences of the University of Palermo (SGCR/PA) – today section of Botany and Plant Ecology of the Department "STEBICEF" - with the aim to preserve the genetic diversity of endemic or endangered native plants, species of economical relevance and wild progenitors of plant cultivars. The collections are mostly constituted by seeds, and were recently expanded with tissues and DNA accessions.

The specific tasks of SPGR/PA include the short- and long-term *ex situ* conservation and exchange of seeds, the recovery of the phytogenetic heritage, the reintroduction of threatened or endangered species into the wild, as well as basic research on reproductive biology and conservation strategies.

Furthermore, SPGR/PA contains monitoring collections routinely used for seed quality tests upon and during long-term storage, as well as the safety "black boxes" of seed accessions from other Seed Banks. The core collection, one of the most extensive and representative ones, contains over 480 taxa specific and infraspecific of the Sicilian vascular flora. Within this collection, there are represented 38% of the existing endemic taxa and 32% of the critically endangered ones. More specifically, more than 75% of the taxa listed among "The Top 50 Mediterranean Island Plants" are preserved in the SPGR/PA bank, with over 102 individual accessions. Additionally, the individual entries of the tissue and DNA collections are used for scientific exchange and to promote globally researches in the field of genetic characterization, systematic biology and phylogenetics. Moreover, reference samples, documenting and supporting published scientific researches related to taxonomy of critical species and inherent molecular characterization, are deposited and preserved in separate collections.

Recently, the management of Palermo Botanical Garden and Herbarium Mediterraneum – which has historically and traditionally led the scientific education and research in the field of botany - has been transferred to a newly created athenaeum museum system “SiMuA, Centro Servizi Sistema Museale”, whose main aim is to rationalize and advertise university-related museums of all disciplines, and promoting their fruition to a wider audience. Within this context, the fate and scientific mission of SPGR/PA has become uncertain, and a concrete risk of losing both the biological assets and the invaluable scientific expertise and know-how built over the past 20 years has come to light.

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V. Spadaro, M. Pasqualetti, A. S. Faqi & F. M. Raimondo

From ethnobotany to experimental research: the therapeutic properties of Sicilian hellebore*

Abstract

Spadaro, V., Pasqualetti M., Faqi, A.S. & Raimondo F.M.: From ethnobotany to experimental research: the therapeutic properties of Sicilian hellebore . — Bocconea 28: 393-398. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

The Sicilian hellebore (*Helleborus bocconei* subsp. *intermedius*) is an endemic plant of the family *Ranunculaceae* from southern Italy and Sicily. This plant is known for the traditional use of dried rhizomes for treating pneumonia in domestic animals, cattle and horses in particular. In recent years, this plant was subject to various ethnobotanical, phytochemical, morpho-anatomical and mycological investigations. In addition, lately, was evaluated antibacterial activity of *Chaetomium strumarium* strain RR1, an endophytic ascomycete of this plant.
On the whole, the different phases of this study are here reported and can be interrelated. However, they support our initial hypothesis, that the therapeutic effect of the hellebore's rhizomes extract is due to metabolites reputedly produced by an endophytic fungus.

Key words: *Helleborus bocconei* subsp. *intermedius*, *Ranunculaceae*, endemic plant, endophytic fungi, folk veterinary medicine, pneumonia.

Introduction

Nowadays, the main objective of ethnobotany is to document traditional knowledge about plants before it disappears and to explore and preserve the heritage of the folk medicine (Cámara-Leret & al. 2014). On the basis of the documentation of indigenous knowledge on the folk use of plants, in some countries ethnobotanical surveys have been used for the discovery of new drugs. The further development of these phytotherapeutical resources comes just from the experimental research.

The biological and ethnopharmacobotanical study on Sicilian hellebore can also be seen in this context (Spadaro 2006).

The medicinal properties and the toxic effects of some species of the genus *Helleborus* L. were pointed out by different authors. In Sicily, according Pignatti (1982), the genus *Helleborus* (*Ranuculaceae*) is only represented by *H. bocconei* subsp. *siculus* (Schiffner)

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Merxm. & Podl [= *Helleborus bocconei* subsp. *intermedius* (Guss.) Greuter & Burdet], commonly known as Sicilian hellebore or “radicchia”. In some mountainous areas of the Island, the rhizomes of this plant, harvested in a particular month of the year (May) and dried, are used in traditional veterinary practice for treating pneumonia in domestic animals, cattle and horses in particular (Raimondo & Lentini 1990). The same use – with rhizomes of other *Helleborus* species or subspecies – is reported from various other areas of Mediterranean Europe (Viegi & al. 2003).

According to the traditional knowledge on this medicinal remedy in some rural communities, it was considered appropriate to carry out experimental researches on *H. bocconei* subsp. *intermedius* from Sicily in order to highlight the therapeutic effect on which is based the local use of the hellebore’s dried rhizomes in the folk veterinary medicine for treating pneumonia in domestic animals.

Materials and methods

This study is referred to *H. bocconei* subsp. *intermedius* (Fig.1) and subsequently to *Chaetomium strumarium* (J. N. Rai, J. P. Tewari & Mukerji) P. F. Cannon RR1 (Fig. 2).

The examined materials were collected in different seasons, between April and September 2010, in the locality Grotta del Garrone, near Monte Pizzuta (Piana degli

Fig. 1. *Helleborus bocconei* subsp. *intermedius* in the locality Grotta del Garrone (Piana degli Albanesi, Palermo).

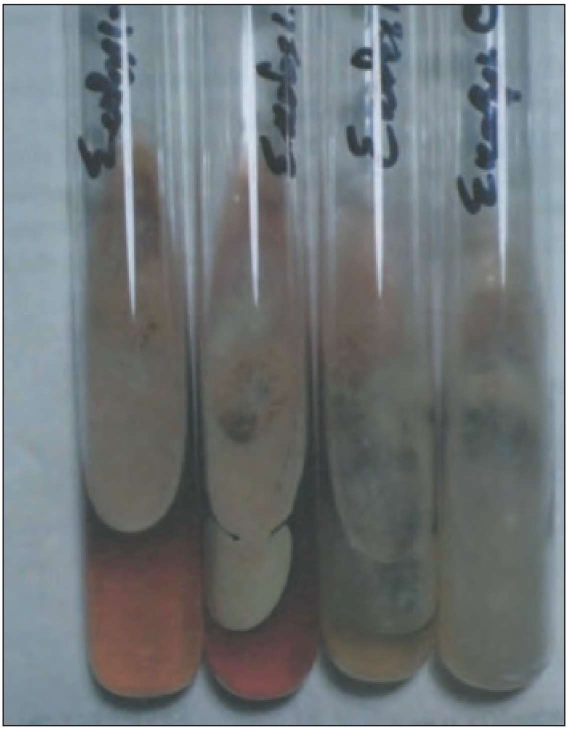

Fig. 2. *Chaetomium strumarium* strain RR1: colony on Mycological agar.

Albanesi, Palermo). A voucher specimen (No. 3/10) is kept in PAL (Spadaro & al. 2014).

C. strumarium RR1, an endophytic fungus, was isolated from different organs (root, rhizome, stem and leaf) of *H. bocconei* subsp. *intermedius* with surface-sterilizing method (Bayman & al. 1997). Molecular characterization of the strain RR1 endophyte, a non-sporulating fungus, based on the internal transcribed spacer (ITS) region of the rRNA gene sequences was done (Spadaro & al. 2014).

This microfungus maintained as stock culture was utilized in the antibiotic property assays. The strain was maintained in Czapek-Dox Agar (DIFCO) plate at 27°C and transferred to a new medium at 15 days intervals.

Results and discussion

The results of the various investigations have been extremily promising. Phytochemical tests have permitted the isolation and characterization of new biologically active molecules; in particular, two new furostanol saponins helleboroside A and helleboroside B were isolated from the hellebore's rhizomes methanolic extract along with the furospirostanol saponin and two ecdysones: ecdysterone and polypodyne B (Spadaro 2006; Rosselli & al. 2006). The extracts of rhizomes and aerial parts of the plant showed antibacterial properties (Rosselli & al. 2007). Some compounds, specifically furostanol saponins and ecdysones, isolated from the methanolic extract of the rhizomes, were tested against rat C6 glioma cells showing a significant cytotoxicity (Rosselli & al. 2009). Additional, morpho-anatomical studies have revealed the presence of different endophytic and commensal fungi in all organs of the plant (Fig. 3), which could be isolated and cultured. One of the isolates has been identified as the endophytic fungus *Ciborinia allii* (Sawada) L. M. Kohn (sub: *Botrytis byssoidea* J. C. Walker), which is also widely present in soil (Spadaro & al. 2007). Further fungal isolates include *C. strumarium,* strain RR1*,* an endophytic ascomycete the identity of which was confirmed by molecular analyses (Spadaro & al. 2014). This endophyte was constantly found and - by preliminary antibiosis assays - has a remarkable antibacterial activity not on a single species but on the complex of species commonly present in soil (Spadaro & al. 2011). When cultured, it developed plentifully; in Mycological agar, the development of RR1 strain is rapid, tumultuous, perfectly centrifugal. RR1 endophyte produced only sterile mycelium and was not taxonomically identifiable by morphological study. To obtain sporulation different media were utilized PDA, CYA and MEA 2%. No sexual or asexual reproductive structures were observed; in MEA 2% cultures up to 90 days old, some pseudoparenchymatous hyphal aggregations cleistotecial-like, were observed. For taxonomic attribution the strain was subjected to the molecular analysis of ITS region (Spadaro & al. 2014). Recently, the filtered broth from these cultures was used in antibiotic property assays (Spadaro & al. 2011); the tests were positive. In recent literature (Ranadive & al. 2013), *C. strumarium* is reported among the fungi with antimicrobial activity.

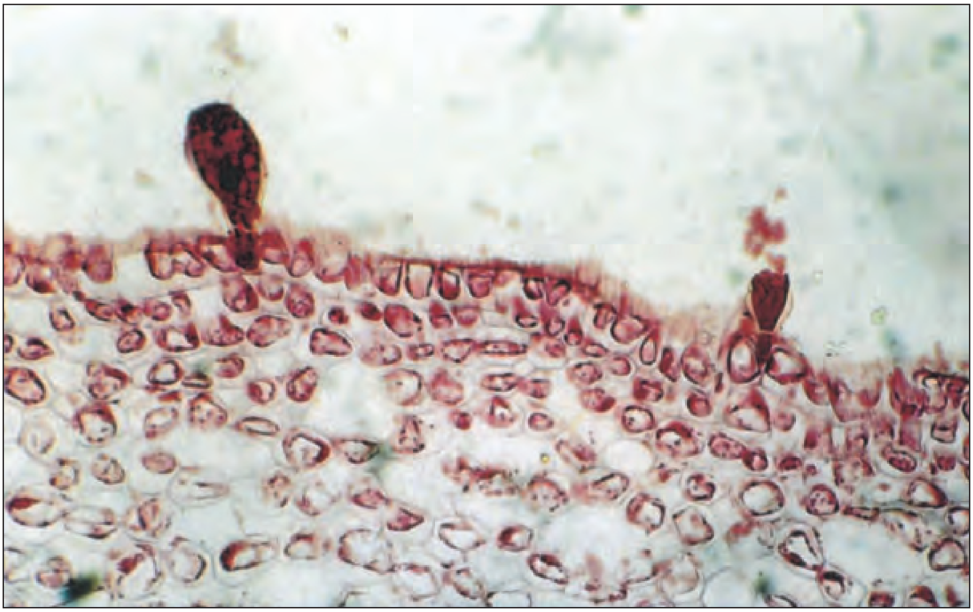

Fig. 3. Detail of cross section of floral peduncle of *Helleborus bocconei* subsp. *intermedius* (×200) highlighting pseudoparenchymatous hyphal aggregations of the endophyte.

Conclusions

As evidenced by the results, this study was particularly stimulating for significant elements of biological and ethnopharmacobotanical importance. Firstly, it is very important the relationship between endophytic microorganisms and Sicilian Hellebore in order to explain the traditional use of dried rhyzomes of *H. bocconei* subsp. *intermedius* in the veterinary treatment of pneumonia in domestic animals. According to these findings and considering the importance of endophytic microorganisms as sources of new biologically active molecules, further mycological analyses of *H. bocconei* subsp. *intermedius* from Sicily are considered advisable (Spadaro & al. 2014).

Particular attention was given to the antibacterial activity of *C. strumarium* strain RR1, one of the endophytic microfungi isolated from this plant and resulted recurrent in the subsequent isolations. In fact, this interesting endophyte grows in the living tissues of the host plant and therefore. we studied the mycelium development and tested the antibacterial activity. The filtered broth from these cultures was used in antibiotic property assays. The tests were positive; the detailed results are forthcoming. They support our initial hypothesis, that the therapeutic effect of the hellebore's rhizome extract is due to metabolites produced by an endophytic fungus. This phenomenon appears particularly relevant and could explain the antibacterial activity of the plant in the folk veterinary medicine.

It remains to be seen whether the plant itself, devoid of the microfungus, produces the same therapeutically effective metabolites that are present in the extracts of plants from the wild or from outdoor cultivation. The study of the Sicilian hellebore, beyond its biological interest, has potential for its relevance for therapeutic applications both in veterinary and human medicine.

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Marta Mariotti Lippi

The contribution of starch grain and phytolith analyses in reconstructing ancient diets*

Abstract

Mariotti Lippi, M.: The contribution of starch grain and phytolith analyses in reconstructing ancient diets. — Bocconea 28: 399-406. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Starch grains and phytoliths are often found trapped in dental calculus or on the surface of lithic grinding tools. In the last decades, their analysis provided new information about the dietary habits of ancient populations, a topic that has recently become the object of numerous researches by archaeobotanists, archaeozoologists and anthropologists. The study of these micro-remains not only indicates which plants were used for feeding purposes but may also highlight our ancestors' ability to manipulate food.

Key words: starch grains, food plants, grinding tools, dental calculus.

Introduction

Numerous papers are currently devoted to the study of ancient diets, which can provide useful information for an understanding of the economic development of ancient cultures – specific technologies for the production and use of food crops, commerce, food manipulation etc. – and also the physiological adaptation processes of the human organism to the chemical components of food. Moreover, the study of the ancient human nutrition might shed new light on the essentials of the human diet and possibly contribute to the prevention of modern chronic degenerative diseases (Eaton 2006). Regarding the exploitation of food plants, direct information comes from the findings of seeds and fruits during archaeological excavations, especially in hearths and deposits; but these findings become more and more scarce as we regress in time. Therefore, archaeobotanists started to pay attention to micro-remains which could be found on the surface of ancient tools used for processing plant materials or were trapped in dental calculus: principally starch grains and phytoliths.

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These residues are not the most legible evidence to be interpreted among plant remains although they are, sometimes, the only available finds. Furthermore, when they are found on grinding tools or in dental calculus, they can offer accurate information. Indeed, through their analysis, it is possible not only establish which plants were used for feeding purposes but also deduce cultural information on food preparation, with very important implications when we think that we have very scarce knowledge of dietary habits in the Paleolithic period.

Plant remains on tool surfaces

In the Mediterranean area, the first important results in this type of research are those related to studies on the epi-Paleolithic site of Ohalo in Israel (Piperno & al. 2004; Nadel & al. 2012). These findings demonstrated that wild cereals, mainly *Hordeum* and *Avena*, were not only collected but also ground to make flour, a product which is easy to preserve but that requires a specific preparation before consumption. Thus, the discovery has highlighted the local population's ability to manipulate food.

Regarding Europe, the first study on grinding tools was performed on artefacts found in Mugello, Italy (Fig. 1), in an area now submerged by the waters of the Bilancino reservoir (Aranguren & al. 2007; Revedin & al. 2010). The site was a seasonal camp dating to the

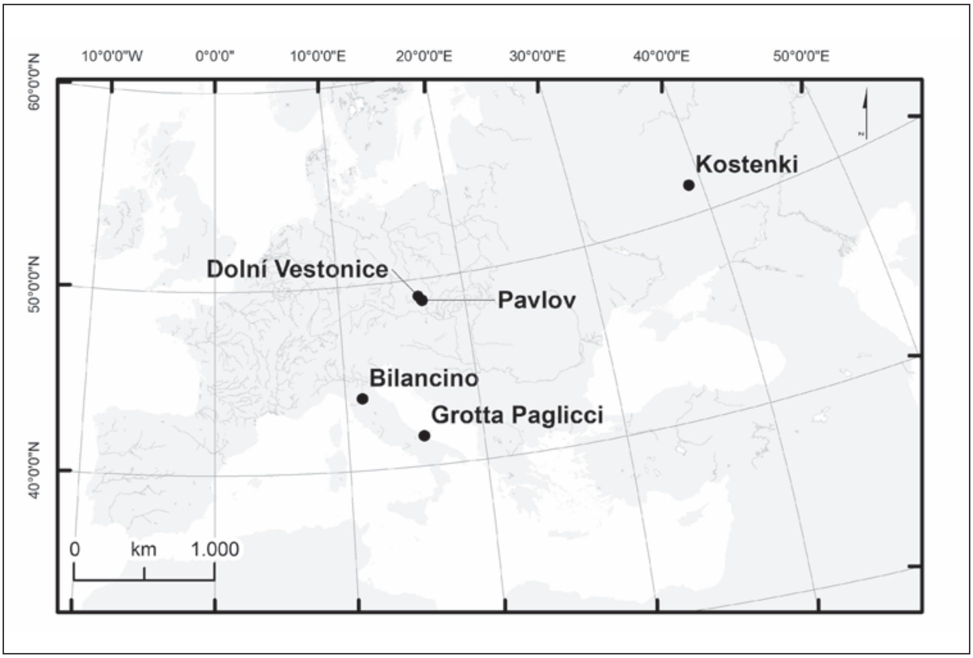

Fig. 1. Palaeolithic sites where starch analysis on grinding tools revealed plant processing, indicating that the production of flour has been a widespread practice across Europe for at least 30,000 years.

Gravettian, in the middle-upper Paleolithic, a period characterized by a colder climate than the present one. The site is located in an open area characterized by numerous wetland plants (Mariotti Lippi & Mori Secci 2002). The analysis of these tools revealed traces of use compatible with grinding. By washing their surfaces, it was possible to recover starch grains, which allowed us to establish that they were tools used for the grinding of plant materials. In particular, a portion of the starch grains had a morphology very similar to those of the caryopses of wild grasses and the rhizome of *Typha*, a part of the plant that can easily be ground once dry. Other grains have a morphology which did not allow their attribution to a specific plant.

Similar analyses were also carried out on grinding tools coming from other famous Paleolithic sites, such as Kostenki in Russia and Pavlov and Dolni Vestonice in the Czech Republic (Fig. 1). Plant micro-remains - and especially starch grains – were found on these artefacts as well (Revedin & al. 2010).

The mere finding of starch grains is important evidence in itself, as it places these tools in a different context from that of the tools used to grind minerals for dyes. But the identification of the plant remains is also of great interest.

The attribution of the starch grains to a specific plant is fairly difficult for two main reasons. First, the number of detectable features on the grains is quite limited: we can analyse size, presence and shape of the hilum, shape and position of the cross formed under polarized light, and very little else. Second, there is scarce reference material, as the existing atlases are mainly dedicated to the flours in use nowadays. Moreover, the same plant may produce starch grains which differ in shape and/or dimension (see for example Fig. 2), and only some of those are identifiable.

The identification requires the examination of the morphology of the starch grains of many plants. For this purpose, the knowledge of the flora present around the archaeological site at the time of its occupation is very useful to reduce the number of plants to be considered. A great indication of the past environment comes from other archaeobotanical analyses, mainly pollen analysis.

Another important information which may be deduced from the analysis of the starch grains on tool surfaces involves the treatment of the food plant material before processing. The study carried out on a pestle-grinder from Paglicci in Apulia, Italy (Mariotti Lippi & al. 2015, Fig.1), revealed that the starch grains had been treated thermally in the absence of water (perhaps toasted) before grinding, as attested by their swelling in water/glycerin solution (Fig. 3).

Grinding is generally done for material that has been previously dried, but here the behavior of the grains attests to a proper thermal treatment, probably used to accelerate the drying in a time of colder climate than the present. The Grotta Paglicci has a very long history of human occupation from about 39,000 years ago to the middle of the nineteenth century. The pestle-grinder comes from the Gravettian levels, dated to 32,000 years BP. The grains found on the tool were attributed to caryopses and acorns. In particular, the grinding of the caryopses is attested both by the scarce phytoliths and the numerous starch grains. Many of them have been attributed to *Avena*, very likely *Avena barbata*. The starch grains on the tool of the Grotta Paglicci are currently the oldest documentation of the grinding of cereals in the world and of the use of cereals in Europe.

Concerning phytoliths, they are more rarely recorded in noticeable amount than the starch grains on the surface of the grinding tools. Liu & al. (2013) suggested that the

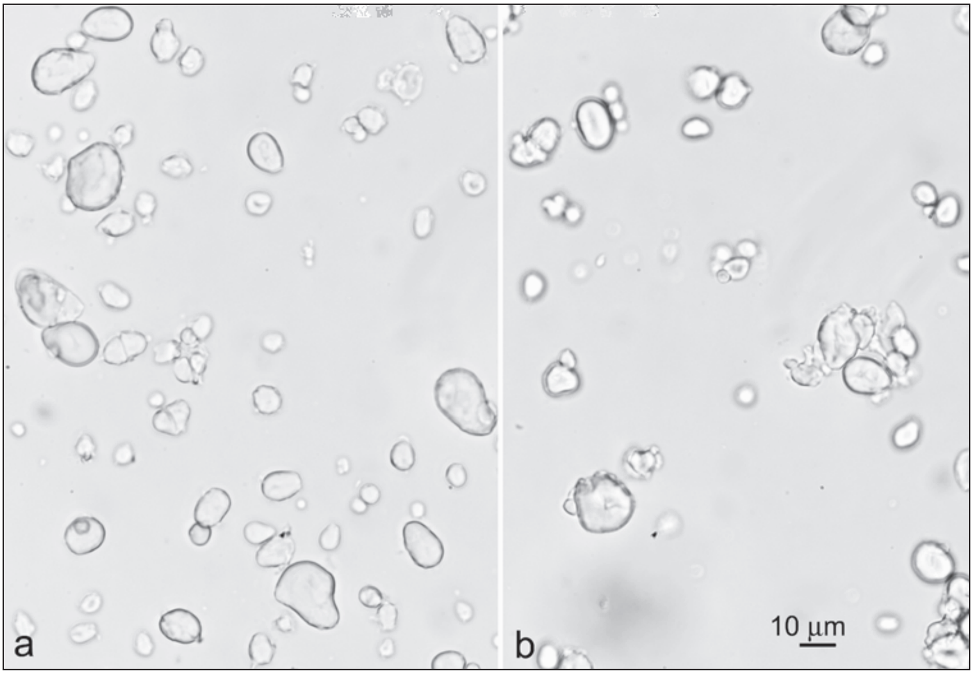

Fig. 2. Starch grains obtained by grinding the acorns of *Quercus ilex* (a) and *Q. pubescens* (b). Note the remarkable variety of morphotypes.

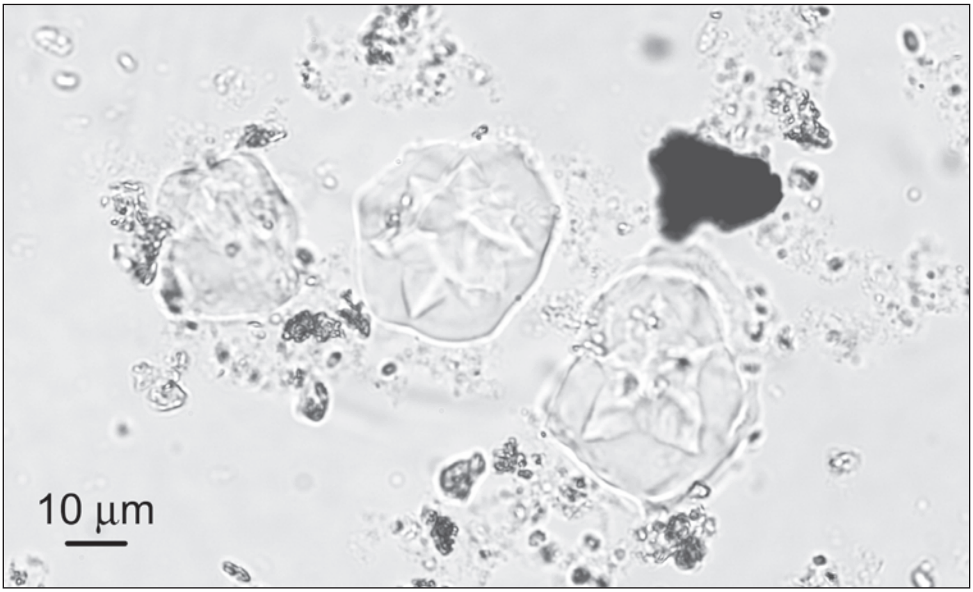

Fig. 3. Gelatinized and swollen starch grains from the Paglicci grinding stone.

scarcity of phytoliths may be due to the grinding of plant portions which do not produce large amounts of silicified bodies, such as cereal caryopses after dehusking.

The study of grinding tools provides further information inferred from the size distribution of the plant remains on the surface of the grinders, since different parts of the tool may collect remains of different sizes. Together with traces of use, the distribution of the remains suggests the usage motions of the grinder and, consequently, may also provide valuable information for studies on the human anatomy. Indeed, asymmetrical developments of the arms are detectable in females from the Mesolithic to the Iron Age and may be the direct consequence of the change in the grinding methods (Sladek & al. 2016).

Finally, we must emphasize the cultural relevance of the grinding process (Revedin & al. 2015), which provided humans with an edible product which was not only easy to preserve but also easy to transport, a characteristic of primary importance for nomadic populations of hunters and gatherers.

Plant remains in dental calculus

While we always find a larger quantity of starch grains than phytoliths on grinding tools, when we analyze dental calculus the quantities of both can vary a great deal. Tartar incorporates minute particles and fragments of whatever is present and whatever is introduced in the oral cavity. This is due to its chemical nature and process of formation (Warinner & al. 2015) that make the calculus act as a trap for various debris and become a veritable archive of information on the lifestyle, health state, hygiene, activities, and dietary habits of the ancient populations. Obviously, the kind of the information obtained depends on the nature of the residues found on the calculus (Radini & al. 2017).

Over the past two decades, dental calculus has become the object of an increasing number of investigations. Concerning plant remains embedded in the tartar matrix, studies on human and non-human teeth has provided valuable data for reconstructing a comprehensive view of diets in the past (e.g. Lalueza Fox & Pérez-Pérez 1994; Lalueza Fox & al. 1996; Henry & Piperno 2008). In Italy, analyses of dental calculus are not numerous. Nonetheless, the study of plant remains in dental calculus may complement the information obtained through other examinations. At the Grotta dello Scoglietto, a cave located on the Western slope of the Uccellina Mountain range, Italy, the analysis of the teeth of nine individuals has demonstrated the consumption of cereals such as wheat, barley and millets during the Copper-Bronze Age (Mariotti Lippi & al. 2017). These finds have enriched our knowledge of the food spectrum already shown by the previous analysis of stable isotopes (Varalli & al. 2015).

As already mentioned, starch grain analysis offers the opportunity to collect data about plant exploitation and alimentary uses and the treatments and manipulations of plant matter. This information may be inferred also from grains recovered in dental calculus. Regarding phytolith analysis, these remains may confirm and enrich the known list of the plants that were introduced in the oral cavity, for dietary or not dietary purpose (Radini & al. 2016) or even accidentally.

As in the case of the starch grains, it must be noted that morphological studies on the phytolith morphology are scarce and a single taxon may produce a wide variety of phy-

Fig. 4. Bulliform cells/phytoliths in a leaf of *Festuca exaltata*: note the difference of size of the adjacent cells. (courtesy Prof. A. Papini, Dr. D. Attolini and Mr. C. Tani, involved with the author in studying the phytoliths of *Festuca*).

tolith morphotypes: a phenomenon indicated as "multiplicity". Moreover, the same morphotypes may occur with a wide dimensional range in the same part of the plant (Fig. 4). At the same time, similar morphotypes may be produced by different taxa - "redundancy" - both related and unrelated. And, finally, despite attempts (see for example Madella & al. 2005), scholars have still not developed a univocal nomenclature for the different morphotypes, and this is an obstacle for the comparison of phytoliths found in diverse archaeological sites.

In conclusion, even with these limitations, the study of starch grains and phytoliths has allowed us to highlight our ancestors' ability to manipulate food already during the Stone Age. And the study of the starch grains attests to the use of wild cereals – more exactly oats – in Europe over 30,000 years ago. All this, well before the beginning of agriculture.

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Marcello Martinelli

Environmental cartography: methodological and practical references

Martinelli, M.: Environmental cartography: methodological and practical references. — Bocc. 28: 407. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

Key words: nature, society, methodology.

The aim of this contribution is to make a reflection upon the methodological question of environmental mapping, aiming to reach a systematization proposal. It is assumed that the considerations made regarding the environment are not only directed to nature itself, but also to society. This elaboration begins through the study of the area of interest focusing on its thematic ramifications via analysis maps. After that, a synthesis approach is made which would confirm analysis characterized by groups of features or variables – the Types of environment – also present in relevant literature on types of landscapes, which would be traced over the synthesis map.

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Fabio Garbari

A Hermitage Garden. The Herb Garden of Rio nell'Elba, Tuscany

Abstract

Garbari, F.: A Hermitage Garden. The Herb Garden of Rio nell'Elba, Tuscany. — Bocc. 28: 409-416. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

This is a short description of the Herb Garden (*Orto dei Semplici Elbano*) of Rio nell'Elba. Dedicated to the cultivation of endemic or significant plants of the Tuscan Archipelago, it was also created to save varieties of fruit trees typical of the island of Elba, such as some grapevines, fig trees, plum trees, etc. The garden is placed in an area adjacent to an ancient hermitage dedicated to Saint Catherine of Alexandria that has become an important cultural centre for the promotion of scientific activities - botany in particular - as well as the arts, literature and music. The garden has been open to the public since 1996.

Key words: Endemic flora, Science communication, Tuscany.

Introduction

I am going to talk to you about a Botanic Garden dedicated to spontaneous and rare flora of the Tuscan Archipelago and about an orchard comprising ancient varieties of fruit trees of the island of Elba. I will tell you about a rose garden hidden in the ancient *hortus conclusus* of the remote Hermitage of Santa Caterina, for centuries a place of worship for the Riesi, the inhabitants of a small town of medieval origins on the island of Elba, for centuries inhabited by many miners, a few farmers and some shepherds, up to the end of mining in the 1960's.

"To create a garden, following its development, living and working in it; offering it to friends as a meeting space, promoting its knowledge, growing beautiful and rare plants in it, inspiring the creation of poems and novels, to save memories and works of art are among the deepest and most fulfilling pleasures of an entire life."

These are the words used by Hans Georg Berger, a writer, man of letters and photographer of Trier, the ancient city of Rhineland-Palatinate, founded by the Romans in 16 BCE, on the banks of the German Moselle. Hans Berger arrived at the Hermitage of Santa Caterina on a day when the north wind was blowing, in January 1977. The ancient building was abandoned, surrounded by the maquis: some signs of the shepherds and their sheep; no visible trace of agriculture, no tree. The collapsed side walls covered with thorns to the north, an imaginary wall to the west, the distant wall of water of the Tyrrhenian Sea.

After many on-site surveys lasting several years, Hans understood that the Hermitage was located in a place once rich of fields, orchards and vineyards, that a *hortus conclusus* once existed, a place of spiritual retreat and where the Hermits grew useful plants (Fig. 1). In 1988, after cleaning, reconstruction and restoration of some walls, the Hermitage Garden could host the first trees. Hans planted there some roses from the garden of his home in Trier and from the famous rose garden of Sangerhausen, in Turingia. He settled at the Hermitage, started to host people of letters, philosophers, writers, urbanists, historians, poets, artists and researchers. Without running water, without electricity - still lacking up to this very day - staying at the Hermitage represents a spiritual retreat, but also a challenge marked by all types of weather, by simple food and by rough rest. I met Hans Berger in 1990: he came to see me at the Botanic Garden of Pisa, he told me about his passion for ancient roses and invited me to the Hermitage where I went with my wife Gabriella Corsi (1936-1999), then Professor of Pharmaceutical Botany at Pisa University: she was following a student's degree thesis on the Riesi wild food and medicinal plants. We visited the rose garden, the Hermitage and its surroundings, and we suggested to Hans to create a Botanic Garden where the most significant plant species of the Tuscan Archipelago and the fruit varieties typical of the island of Elba would be grown for didactic, scientific, and cultural purposes and for the *ex-situ* conservation of the plants threatened by extinction.

I prepared a draft on how to set up the herb garden and after some restoration works in 1996 the Garden of the Hermitage of Santa Caterina was opened to the public. Architects Roberto Gabetti and Aimaro Isola, from the Turin Politecnico, designed walls and new spaces. The Italian Botanical Society gave its scientific support.

Fig. 1. The Hermitage of Santa Caterina near Rio nell' Elba, Tuscan Archipelago.

A short walk on a small street flanked by cypresses leads to the entrance to the garden, that took the name *Orto dei Semplici Elbano* (Fig. 2). Placed at 260 m above sea level, it covers about one hectare, spread over different levels. The area is organized into a dozen thematic sections, divided into spaces bordered by structures made of local lime stone, tuff or wood (Fig. 3). A pergola features the seven traditional grape varieties of the island: Ansonica, Sangiovese, Alicante, Moscato, Biancone, Procanico and Aleatico. The latter is typical of Elba: since the fifteenth century, the Medici Dukes greatly appreciated the *passito* wine made from it.

Then, in a section devoted to the psammophilous flora of the sand dunes, the visitor finds: sea rocket (*Cakile maritima*), cotton lavender or sand yarrow (*Achillea maritima*), sea lily (*Pancratium maritimum*), Mediterranean stock (*Matthiola tricuspidata*), sea chamomile (*Anthemis maritima*), convolvulus or morning glory (*Calystegia soldanella*), horned yellow poppy (*Glaucium flavum*), etc.

Other species considered sacred or symbolic in ancient times are planted as well: laurel, pomegranate, myrtle, lavender, rue, and others. Today, the essential oil of *Ruta chalepensis*, a frequent presence in the surroundings of the Hermitage, is being studied and experimented as an antiparasitic.

A space is reserved to plants traditionally cultivated in Elba's gardens: lemons, bergamots, oranges, cedars, as well as ornamental species such as the glycine, acanthus, dwarf palm, and other rhizomatous and bulbous plants.

Fig. 2. The entrance to the Orto dei Semplici next to the church of Santa Caterina.

Fig. 3. An aspect of the Orto dei Semplici with tufa tubs.

The name "labyrinth" indicates the most remarkable area of the Herb Garden. It is made up of tanks in tufa, where traditional medicinal and food plants still used on the island of Elba are cultivated.

There is also a "butterfly garden"; it is extremely valuable for educational purposes, because it allows learning more about *lepidoptera* and other pollinators, attracted by the various polliniferous and nectariferous species. There are also some beehives, which are taken care of by a passionate local apiarist who keeps watch and does the maintenance of the Garden.

A study started in 2000 led to the identification of a considerable amount of fruit varieties, once cultivated on the island but at present either abandoned or in danger of extinction. A project financed by the Tuscany Region through the Regional Agency for the Development and Innovation in the Agricultural and Forestry Sector, made it possible to recover more than 60 varieties of pome fruits, stone fruits and mulberry species, planted in a specific terraced area. Many of these varieties of apple, plum, pear, cherry, peach, almond, fig trees (Fig. 4), etc., represent the century-old popular tradition of the island's gastronomy. During a recent meeting, some farmers, traders, agricultural and tourism operators as well as 22 caterers from Elba signed an agreement to create food and agriculture chains to offer a "basket of Elban products" to consumers.

Obviously, many endemic species of the Tuscan Archipelago for which the garden was initially created are cultivated. There are about 1600 vascular plants populating the Archipelago (the Galapagos Islands have 570); among them, the endemic plants are to be

Fig. 4. A cultivated variety of fig, called “fico popone” in a watercolor by E. Zito.

Fig. 5. Saint Catherine of Alexandria treats a wounded unicorn (engraving by Neri Torrigiani).

considered the finest and most important expressions. There are about thirty endemic species hitherto identified, some of them recently or very recently recorded. Some of their Latinised names reveal their distribution: *Linaria capraria* (Capraia Island), *Limonium ilvae* (Elba Island), *Limonium planasiae* (Pianosa Island), *Limonium gorgonae* (Gorgona Island), *Centaurea aetaliae* (from the ancient Latin name of Elba), *Crocus ilvensis*, and *Viola ilvensis* (Elba Island). There are also sub-endemic or relict specimens, some of them related to the system of Sardinia and Corsica, such as *Gennaria diphylla*, *Saxifraga corsica*, *Arenaria bertolonii*, *Genista desoleana*, and *Mentha requienii*; the dwarf palm (*Chamaerops humilis*), very rare in the Tuscan Archipelago, is of a relict nature.

The agriculture biodiversity, testified by the cultivated varieties mentioned before, is coupled with the autochthonous plant biodiversity: both are represented in the Herb Garden, which therefore plays an extraordinary role in the conservation of the germplasm, recognized at local and regional levels and by the National Park of the Tuscan Archipelago.

In 2019 the garden has become part of the National Park of the Tuscan Archipelago; its activity is under the Unesco Biosphere scheme. The scientific direction is entrusted to the Department of Biology and Botanic Garden of the University of Pisa.

I have told you about the Herb Garden, the fruit garden, and the endemic plants. But at the beginning I mentioned the rose garden, hidden within the walls of the ancient *hortus conclusus*. In a small volume printed in Bangkok, Thailand, but written in Luang Prabang in Laos, where he lives and works in a community of Theravada Buddhist monks, Hans Berger drew up a *Botanic and Sentimental List*, as he called it, of the roses in Santa Caterina.

He recalls the origin, the flowering with its colors, the vegetation and cultivation characteristics of about one hundred varieties.

It is a small guide for passionate gardeners as well as a tribute to the flowers that have inspired poems and literary compositions, novels and plays, music and deep feelings in millions of people all over the world. For Hans, a gardener, orderer and demiurge called to cultivate the ethical myth of beauty, the rose garden is a *hortulus animae,* an intimate place that has been restored, waiting for the flowering like an epiphany of beauty.

The Hermitage of Santa Caterina is still a place of worship, but also has become a place for artists, poets and people of letters. The church, visited by Napoleon Bonaparte on 6

May 1814, today hosts exhibitions of sculpture and painting, concerts of contemporary music, and theatrical performances. An important event was the exhibition of a Carolingian parchment discovered in a codex with the statutes of Rio nell'Elba, dating back to 1605 and kept in the town's municipal library. It is a comment on psalms 30 and 31 by St. Augustine, bishop of Hippo in Africa since 395. The discovery was made by Peter Zahn from the University of Berlin. Painters Sarah Pickstone, Duncan Bullen, Thomas Weczerek, Gianluca Gori, Karl Oppermann created extensive work at Santa Caterina and held exhibitions in the Hermitage; Thai artists like Surapon Saenkum and Yannawit Kunchaethong illustrated this place in their paintings. 30 leading Japanese calligraphers dedicated their works to the hermitage. Susanne Besch, a German ceramist and sculptress, created art works made with the remains of the iron worked in the island's mines. It is impossible to enumerate the concerts, exhibitions, and encounters held in this unique and magic place. For example, at the beginning of June 2019 the Sicilian botanical artist Elena Zito exhibited her watercolors of some selected Italian plants in the church of the Hermitage, followed by the delicate photographs of the Elban Andrea Lunghi, titled "Tacet". During starry nights in this place without electricity, the guests can appreciate the "silver garden" created by Daniel Mount, an American botanist and gardener, with plants with snow-white leaves such as *Centaurea gymnocarp*a, *Jacobaea maritima*, *Achillea maritima*, *Lobularia maritima,* and others. During the day, walking along the paths, visitors come across twenty-four large clay cubes arranged in the grass. They bear the engraved names of friends and supporters of the Santa Caterina Garden: the writer Hervé Guibert, the philosophers Norberto Bobbio and Michel Foucault, the architect Roberto Gabetti, the botanist Gabriella Corsi and others who passed away. These "signs of memory and silence", are created by a Piedmont artist, Cesario Carena. Other works by Carena grace the garden celebrating the power of Nature: mother earth generating life.

This is the short but intense story of the Herb Garden of Rio nell'Elba. We have mentioned art, the site's spirituality, the simple beauty of a peaceful place where the spirit flows in freedom. Where, in a drawing, St. Catherine of Alexandria, virgin and martyr worshipped both by the Catholic and Orthodox Church, the patron of writers and philosophers, is portrayed while she is rescuing a unicorn wounded in the rose garden of the Hermitage (Fig. 5). The Saint is celebrated on November 25th; in France, it is considered the date to plant trees ("A Sainte Catherine, tout prend racine"). Many plants have taken root in the garden of the Hermitage. The hope is to see them there for a long time.

Appendix

Here the scientific names of all the plants considered as endemics, sub-endemics, relicts or phytogeographically and ecologically relevant for the Tuscan Archipelago. Some of them, as previously mentioned, are growing in the beds of the Garden.

Arum pictum L. fil.; *Biscutella pichiana* subsp. *ilvensis* Raffaelli; *Borago pygmaea* (DC.) Chater & Greuter; *Brassica procumbens* (Poir.) O.E. Schulz; *Carex microcarpa* Bertol.; *Centaurea aetaliae* (Sommier) Bég.; *Centaurea gymnocarpa* Moris & De Not.; *Centaurea ilvensis* (Sommier) Arrigoni; *Chamaerops humilis* L.; *Cneorum tricoccon* L.; *Crocus ilvensis* Peruzzi & Carta; *Cymbalaria aequitriloba* (Viv.) A. Chev.; *Festuca gamisansii* subsp. *aethaliae* Signorini & Foggi; *Gagea bohemica* (Zauschn.) Schult. & Schult. fil.; *Galium caprarium* Natali; *Genista desoleana* Vals.; *Gennaria diphylla* (Link) Parl.; *Hypericum hircinum* L. subsp. *hircinum*; *Limonium gorgonae*

Pignatti; *L. ilvae* Pignatti; *L. montis-christi* Rizzotto; *L. planasiae* Pignatti; *L. sommierianum* (Fiori) Arrigoni; *Linaria capraria* Moris & De Not.; *Mentha requienii* subsp. *bistaminata* Mannocci & Falconcini; *Pancratium illyricum* L.; *Ptilostemon casabonae* (L.) Greuter; *Ranunculus bullatus* L.; *Romulea insularis* Sommier; *Sagina revelierei* Jord. & Fourr.; *Saxifraga caprariae* Mannocci, Ferretti, Mazzoncini & Viciani; *S. montis-christi* Mannocci, Ferretti, Mazzoncini & Viciani; *Scrophularia trifoliata* L.; *Sedum brevifolium* DC.; *Silene badaroi* Breistr.; *Soleirolia soleirolii* (Req.) Dandy; *Stachys glutinosa* L.; *Stachys salisii* Jord. & Fourr.; *Urtica atrovirens* Req. ex Loisel.; *Viola corsica* subsp. *ilvensis* (W. Becker) Merxm.

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Some preliminary botanical remarks about the frescoes of the Oratory of San Pellegrino at Bominaco (L'Aquila)

Abstract

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Some frescoes of the small building of the Oratory of San Pellegrino (Bominaco – village of Caporciano, in the Navelli plain) are illustrated and commented for the first time from a botanical point of view. In addition to a general commentary of the works, a description is provided of the botanical details and the landscape view of the two cycles of Christ's Childhood and Passion. While the floral elements linked to the tradition are repeated, such as stylised lilies and acanthi, there are new floral motifs of some oval and heart-shaped plants that can perhaps be attributed to violets throughout their vegetative cycle until flowering and fructification. A comment is made about the trees portrayed with sinuous lines and thick crown from which the leaves emerge; finally, some forms similar to acanthi can be referred to plants of cabbage and cauliflower, which were grown in Benedictine monasteries.

Key words: Christ's passion, Byzantine art, Benedictine garden.

Introduction

The Oratory of San Pellegrino is located near Bominaco (village of Caporciano) on the orographic right of the Navelli plain, famous up to this very day for the cultivation of saffron, probably introduced there, according to tradition, by St. Bernardine of Siena (1380-1444). The building, rectangular in shape, is part of a wider complex belonging to the Benedictine Monastery; the monks also built here the Church of Santa Maria Assunta on a pre-existing building of the eight century devoted to a Syrian saint, St. Peregrine, who lived between the third and fifth centuries. The monastery experienced many difficulties because of the dispute of the monks with the dioceses of L'Aquila and Valva, whose ancient Lombard roots can be recognised; the complex was destroyed by Braccio da Montone (1368-1424) during the war between the Angevins and Aragonese, which was waged near L'Aquila, where the commander died; surely for the respect of this sacred place, the church and the oratory were spared. For this reason, the building has reached our times almost undamaged, except for a probable eighteenth-century addition of a portico opposite one of the entrances. The frescos and perhaps the entire building date back to 1263 as reported in an inscription on the inside, referring to Abbot Teodino's will; another inscription bearing Charles' name may refer to Charlemagne or Charles of Anjou.

The architectural complex and the description of the frescoes were investigated for their importance in several studies, among which we had the opportunity of consulting in an original way that by Maria Della Valle (2006) in which other authors are mentioned, including Baschet (1991) for the frescoes and De Dominicis (1970) for the restoration works. Other monographs are of a popular nature (Dander 1979; Lo Iacono 1993 & 1995). More recent is the work by Arbace (2012) together with other authors.

This work, of a preliminary nature, takes into consideration only some figures of the two cycles (Christ's Childhood and Passion) waiting to have more details and documents on the whole series of cycles and paintings.

Materials and Methods

The interest in the frescoes of Bominaco starts from some visits carried out between 2013 and 2015 together with some other more purely botanical research studies in this area.

The area of the complex is located at about 975 m a.s.l. and lies in the municipality of Caporciano, 30 km away from L'Aquila and 80 km from Pescara, on the Via Claudia Nova, a major Roman road axis, to which the nearby archaeological site of Peltuinum bears testimony and on which the Tratturo Magno or del Re (L'Aquila-Foggia) would also develop; inhabited settlements dating back to the period of the fortifications following the fall of the Carolingian Empire developed along this axis. Ancient pre-Roman populations of the Aterno Valley are to be attributed to the Vestini of Osco-Umbrian origin, whose relations with the Sabines of the Tiber Valley are testified by the linguistic similarities found in the paleo-Sabellian stelae of Penne S. Andrea (TE), which can be dated to the fifth century BBCE. It is important to note that these ethnic and linguistic affinities are matched by those highlighted in the figurative arts (Andaloro 1987-1989; 1990; 1991) from the Middle Ages to the Renaissance.

The climate of this area is that typical of the inland Abruzzi valleys with sharp temperature differences between summer and winter, such as in L'Aquila (continental climate, average minimum temperature of the coldest month 2.7 °C; average of the highest temperatures of the warmest month 29 °C) and with the lowest differences as regards rainfall (in Capestrano, 500 mm of rain, in L'Aquila 730 mm); near Capestrano, however, the presence of Mediterranean elements such as *Quercus ilex*, *Arbutus unedo*, *Phillyrea latifolia* and *Clematis flammula* is surprising, as well as olive groves that can be observed along the road from Navelli to Capestrano. The most important species characterising both the Aterno Valley and the Navelli Plain is the *Goniolimon italicum*, an exclusive endemic of the Abruzzi typical of cold and arid valleys, with a location near Navelli in Colle S. Eugenia. The forest vegetation (Tammaro 1998) surrounding Caporciano consists of woods with a prevalence of *Quercus pubescens*, as well as *Acer campestre*, *A. monspessulanum*, *Fraxinus ornus, Hippocrepis emerus,* and *Cytisophyllum sessilifolium*, in addition to *Ostrya carpinifolia*. The grasslands are arid, characterised by *Bromus erectus* or *Brachypodium rupestre*; in the more stony and arid areas like those above Navelli there are meadows with *Stipa* *dasyvaginata* subsp. *apenninicola* and *S. capillata*. The cultivated lands extend over the plain and feature mainly cereals with some fields specialised in the cultivation of saffron. The agricultural landscape is also characterised by the spread of almonds, with their blossoms that can be admired in the spring, but which are now almost entirely abandoned with emaciated individual specimens attacked by mistletoe (*Viscum album*). The spread of the almond tree in Abruzzo characterises all the anthropised and cultivated areas of the mountain zone, a sign of a landscape that is now disappearing and that still survives in some paintings, for example Cascella (1892-1989) or Cencioni (1906-1994).

In the observation of the frescoes in Bominaco, we considered whether some floral or arboreal elements depicted could have been inspired by what the authors saw directly in the area where they worked; also the research on natural landscape elements, such as fields or mountains, has also been taken into account during the visits made.

It was not possible to include photographic images of the frescoes in this work as no official request was made to the competent authority.

It is advisable however to refer to the abundant material that can be downloaded from the web at the following main links:

https://www.beniculturali.it/mibac/opencms/MiBAC/sito-MiBAC/Luogo/MibacUnif/Luoghi-della-Cultura/visualizza_asset.html?id=150510&pagename=57
http://www.progettostoriadellarte.it/discovering-italia/oratorio-di-san-pellegrino-e-santa-maria-assunta-a-bominaco/
http://www.abruzzo-vivo.it/il-complesso-benedettino-di-bominaco/
http://www.spaziovidio.it/medievale/HTML/cartina/caporciano2.html
http://www.edizionizip.it/edizioni/?p=103
http://www.iluoghidelsilenzio.it/oratorio-di-san-pellegrino-caporciano-aq/

The cycles of the frescoes, general overview

The interior of the chapel consists of a single room whose walls and part of the vault are covered with frescoes with images of sacred cycles, while topmost part of the vault features a sky with floral elements and stars. The frescoes and embellishments consisting mainly of spirals with probable vine shoots and floral motifs completely cover all the spaces of the walls. Experts have identified three cycles: 1) Christ's Childhood; 2) Christ's Passion; 3) the cycle of St. Peregrine and the calendar; in addition to these cycles, there are a series of isolated figures of Saints, including St. Christopher, St. Francis, St. Onuphrius and St. Peregrine again, also depicted in the Christ Enthroned. Because of the complexity of the religious motifs, including the Last Judgment, the Oratory of San Pellegrino has been defined the "Sistine Chapel of Abruzzi".

Experts have discussed the distinction into styles of each of the cycles ascribing them to three different authors or masters, recognising a "Master of the Passion," a "Master of the Childhood," and a "Miniaturist Master," finding differences in more or less Byzantine, Gothic or Romanesque trends and thus trying to attribute each of the cycles to a different author. Comparisons with other works have been made to find historical and stylistic connections, such as with the nearby church of Santa Maria ad Cryptas in Fossa, the abbey of Sant'Angelo in Formis in Capua and with the oratory of San Silvestro ai Quattro Santi Coronati, Santa Maria in Trastevere and Santa Maria Maggiore in Rome, also considering the Sicilian influences with Monreale; since the dating of 1263 for the frescoes in Bominaco is certain, contaminations and influences from other more recent monuments can therefore be excluded, while it is certain that the extension of the monastic orders up to the more isolated rural locations facilitated the spreading of similar themes. Apart from these issues, our analysis allowed us to identify the floral and naturalistic elements in the representations, whose comparison perhaps makes it possible to also find differences in the stylistic sensitivity of the different painters.

Botanical iconography and interpretation

The cycle of Christ's Childhood

a) The Nativity. In the box we can see a composition and a movement of lines (the cave, the position of the Infant in swaddling clothes and of Saint Joseph, etc.) that follow those that can be observed in the Palatine Chapel of Palermo, where the coloring tends though towards an intense green, while in the fresco in Bominaco the shade tends more to reddish, which unsurprisingly stands out in all the paintings (this "warm" shade intensifies the participation of the faithful). The only relevant floral elements are the stylised three-pointed lily motif adorning with a line the perimeter of the table-manger (or canvas stretched over it) on which the Child rests and a naturally shaped lily adorning a circular base of a tub for bathing.

b) The annunciation to the shepherds. The box referring to the Gospel of Luke is located to the right of the previous one and shows an Angel holding a cartouche with the word "Gloria" (Glory). His gaze is turned to the faithful, as he flies over the scene where the shepherds are surprised with their sheep; a fourth shepherd on the left seems to enter the scene at that very moment under a tree like a pilgrim with a stick and a saddlebag on his shoulder.

1) The mountains. This is the most naturalistic scene of all the cycles because the panorama opens wide on the grazed meadows towards the background where several tall mountains rise, at least seven of which can be clearly distinguished (a reference to the three messianic mountains?). The mountains have a conical shape, they seem almost volcanoes, and show a clear separation between a lower and an upper part; the first is crossed by long slopes, the second is covered by simplified rocks with curved lines (there are different types represented in other Byzantine examples and in Giotto where the mountains are seen as smooth and angular rocks). An identical shape of a mountain divided into two parts, high and low, indicated in the literature as a "pine cone head", is found in the oratory of San Silvestro ai Quattro Santi Coronati in Rome in the depiction of the discovery of the true Cross in Jerusalem by St- Helena, Constantine's mother; there we also observe the scene of Constantine's envoys ascending Mount Soratte to find St. Silvester and the mountain is painted in the same way (in this case we do not want to emphasise the altitude, but rather the remoteness of the place). The detail of the furrowed slopes refers to what was observed personally in the neighboring areas (Fig. 1), where the slopes of some mountains between Navelli and Ocre showed evident ploughed furrows; briefly, the distinction between a high

and a low part establishes the almost net transition between the cultivated “civil” area and the “wild” one where rocks and snow seem to keep humanity at a distance. Only three of the seven mountains have this aspect, while the other four are clearly less elevated. It is quite evident that the painters were impressed by the majesty of the high peaks around the Gran Sasso and depicted them as rocky and inaccessible peaks. While for Bominaco we have a precise dating – 1263 – the frescoes of San Silvestro in Rome are believed to date from the second half of the thirteenth century, therefore more or less in the period of time. It is possible that the artists of Bominaco and Rome knew each other, but it is also probable that the painters of that time used sketches which through communications between the different monasteries areas could be an easy tool for disseminating works.

2) Trees. The two trees to the left of the box have a strange twisted shape with bare branches that end only towards the tip with a stylized conical crown where the leaves emerge clearly; this shape is typical of other figures at Byzantine sites also distant from each other, while to see a tree in a more natural form with distinct individual leaves we need to return to the Gothic Hall of the Quattro Santi Coronati; in the Calendar for the month of May we observe a man on a tree picking fruit; the tree is clearly a cherry tree due to the shape of its leaves and fruits (in this case the inspiration of the style is no longer Byzantine but northern Gothic). The stylised Byzantine forms of the tree crowns are a constant motif in Byzantine painting, where the main focus is the overall perceived vision in its stylized form rather than the details.

Fig. 1. Landscape of ploughed fields in the Navelli plain with the background of the Gran Sasso.

The cycle of Christ's Passion

a) The Deposition in the Sepulchre. The box shows the deposition of the dead Christ, a theme, as Della Valle (oc) says, is present extensively in the Byzantine tradition, although in this case the Byzantine influence is less felt throughout the cycle, as ancillary characters such as the angels disappear, while Mary Magdalene is present, holding a hand of Christ.

1) The sarcophagus. An interesting aspect is the sarcophagus in which Christ is deposed because it does not seem to be a real sarcophagus but a bed instead. From a botanical point of view, it is interesting to note the depiction of Christ placed on a cloth, almost a carpet, the weft of which is visible; on the front side a white cloth descends, where ten similar plants are painted aligned with large oval acuminate leaves. It is not possible to assign the plants to a particular species, but it seems that the flowers represent the recurrent symbology of the lily. The shape of the leaves is oval, almost heart-shaped (a detail that also recalls violets, but which we have not observed other times, since the herbs are almost always painted as linear, except for some cases, such as the acanthus), establishing a connection with Christ's heart, whose devotion began in the Germanic world in more or less the same period as that of the frescoes. The choice of a violet could be related to the liturgical colour for mourning and the Passion. Careful observation revealed to us us that, from left to right, of the ten plants six are in the vegetative state of only leaves, three are with flowers, and the last one on the right has flowers and fruits; it is also evident that the last four plants on the right have fewer leaves than those on the left, as happens in real life when a plant reaches maturity. It seems almost obvious that this detail, missed so far as in the texts, conveys an important meaning in relation to the cycle of life, from birth to death. As the flower dies, the fruit is born and from it the seeds propagate new life, as the Evangelists wrote: "it is from death that life is born" (Matthew 10:39; John 12:24) and so Tertullian repeated: "the blood of martyrs is the seed of new Christians." This particular plant also denotes the spiritual sensitivity of the painter who does not limit himself to copying what was already visible in other works, also nearby, such as in San Pietro in Vineis in Anagni (bare marble sarcophagus, unique and cold expression of death) or in other more cheerful representations of flowering lilies arranged in a row in the San Silvestro cycle in Rome.

2) Columns with capitals. Another plant motif in this box can be found in two columns placed set against the background of a blue sky and between which a candelabrum hangs from above. The columns are not smooth but seem to have a tortuous line that could recall the paschal candle of the nearby church of Santa Maria Assunta which may have inspired the painters; the colours too reveal a redder column on the left and a whiter one on the right, as can be seen also in the panel of the Annunciation, in which the two columns are very similar. What is most striking are the three leaves (or a single large leaf divided into three lobes) that act as capitals. These too are similar to those in the panel of the Annunciation; it seems obvious that we are dealing with acanthus according to a Graeco-Roman tradition in use for centuries, but the form can lead to identifying another aspect. In the Benedictine context, in fact, the cultivation of the fields and the construction of vegetable gardens annexed to the monasteries developed. The Benedictines cultivated medicinal herbs and food, activities that were already important in the field of Byzantine monasteries (see Littlewood & al. 1996). It does not therefore seem completely unlikely that the painter could have used cabbage leaves as a model and that therefore the capitals of some columns of the Bominaco frescoes are more likely to be cabbage leaves (*Brassica oleracea* L.) In its varieties of black

cabbage or curly kale, a very important winter vegetable in the medieval diet for both humans and animals. Even today, the cabbage in all its varieties, including the coloured ones, is used as an ornamental plant for the beauty and elegance of the leaves, so it is not surprising that in a strict context such as a monastery cabbage was taken as a vegetable model to replace the acanthus. In other ornamental motifs in the frescoes of Bominaco a large cabbage leaf shape with a pinecone-shaped element at the centre could be a cauliflower rather than an acanthus or lotus fruit or a pinecone proper. However, this interpretation has not been confirmed yet since the cauliflower was not known in medieval Europe and seems to have been introduced from the East (perhaps originating on the island of Cyprus) around the fifteenth century (Smith 1995). An attribution of cauliflower in this case would be justified by the fact that the painter might have thought of references to eastern Byzantine motifs, where this vegetable was already known.

Conclusions

The building of the Oratory of San Pellegrino has very small dimensions (18.70 × 5.60 m), but the unique shape of the vault enhances the space thanks to an incredible amount of floral decorations (spirals and festoons with lilies) to which eight-pointed Byzantine stars are added; this exaltation of a space, in which the effect of “horror vacui” is achieved with the explosion of flowers and images, creates an immediate feeling of wonder in visitors and a moment of spiritual ecstasy towards the divine among the faithful. The name of “Sistine Chapel of the Abruzzi” does not therefore seem inappropriate and if in the Vatican the idea is to exalt divine power, the small Oratory wants to offer a moment of peace and contemplation, as a pilgrim seeks along his path that is not only physical, but also the inner one of mind and soul while walking. This space can therefore be seen as a “shelter” from the external sensitive world in an internal supra-sensitive sphere.

As for the naturalistic figures, from the landscape of the mountains to the shape of the trees and the stylised flowers, in addition to the repeated Byzantine canons, we can see an approach rooted in reality both in the series of plants seen in their life cycle of flowering and in the probable figures of cabbage and cauliflower, both in an effort to represent the shapes of trees with twisted branches and with the crowns that are not only flat but take on a vibrant movement. This same effect is obtained in the paintings of the great expressionist painters, such as in Van Gogh where the trees, cypresses or olive trees, are outlined by dense foliage with strong sinuous lines. An expressionistic approach to the Byzantine style is mentioned by several authors and in particular by Gatto (2016-2017), finding Byzantine motifs in the art of El Greco, Matisse, Cezanne, Kandiskij, and Klimt; in Roualt’s works, the spiritualism that imbues every original Byzantine work reappears. In Sironi, in the Sapienza cycle in Rome and in the Palazzo di Giustizia in Milan, every three-dimensional form disappears and everything becomes two-dimensional, returning to forms of mosaicism (Gatto 2016-2017).

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Cristina Cattaneo & Mauro Grano

Checklist updating and analysis of the flora of Symi island and of the nearby island of Seskli (Dodecanese, Greece)

Abstract

Cattaneo, C. & Grano, M.: Checklist updating and analysis of the flora of Symi island and of the nearby island of Seskli (Dodecanese, Greece). — Bocc. 28: 425-463. 2019. — ISSN: 1120-4060 printed, 2280-3882 online.

A contribution to the knowledge of the vascular flora of Symi and the nearby island of Seskli is presented, being an update of the vascular flora of Symi and Seskli islands, 32 years after the first checklist published by Carlström. The occurrence of *Limonium hirsuticalyx* is reported on Symi for the first time; for Seskli, 41 new floristic records are provided, in addition to a species inquirenda: *Limonium* cfr. *hirsuticalyx* / *meyeri*. The strong floristic affinity between Symi and SW Anatolia, to which Symi was linked until the upper Pleistocene, is confirmed by the large number of range-restricted and rare taxa occurring on Symi and for the most part shared with the Muğla province in SW Anatolia. Despite its relatively recent insular isolation, Symi hosts a fair rate of endemics, including three single-island endemics: *Allium symiacum*, *A. panormitisi* and *Origanum symes*.

Key words: floristic investigation, endemism, active speciation, ruderal species.

Introduction

Symi island belongs to the Dodecanese. It is located between Rhodes and the Turkish coast (Datça Peninsula, Muğla Province) from which it is only 5 km (Fig. 1). Symi has a surface area of 58 km² and a coastline of 85 km, with numerous bays, capes and steep cliffs. Symi is surrounded by smaller, uninhabited rocky islands, the largest of which are Nimos (N) and Seskli (S). Symi is chiefly hilly and culminates in Mt. Vigla at 620 m a.s.l. The island together with the peninsulas Daraçya and Reşadiye is made up mainly of Mesozoic limestone (Carlström 1987), which makes up the high costal cliffs and the deep inlet of Dhysalonas, Nanou, Lapathos and Ladhi. There are also some areas of flysch (Desio 1924a, 1924b). Due to the island's rocky nature, cultivated land is very scarce, except in the Pedi and Niborios valleys. Symi lacks surface water courses; there are only wells and cisterns. The climate is semi-arid Mediterranean with short, mild, wet winters followed by long, hot dry summers (Galanos & Tzanoudakis 2017). The island's eastern part and the surrounding uninhabited islands are included in the Natura 2000 network of protected areas (GR4210025), as they host to rare bird species as well as old conifer wood-

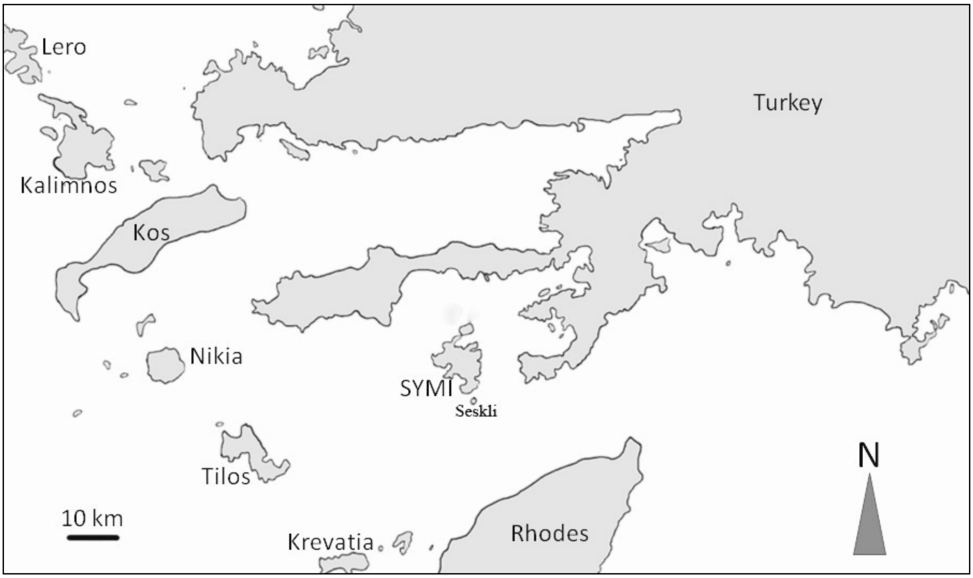

Fig. 1. Geographical position of Symi and Seskli Islands in the Aegean Sea.

land of *Cupressus sempervirens* L. with stands of *Pinus brutia* Ten., covering the island's SE part (www.ypeka.gr).

The island of Seskli was completely uninhabited until the 1980s. It is property of the Panormitis Monastery and lies about 1 km south of the island of Symi (Broggi 2002). Its surface area is 1,826 Km² with a maximum altitude of 117 m. The island is fairly flat with several cultivated and terraced areas with olive groves. Most of the island is characterized by low evergreen sclerophyllous maquis organized around arborescent junipers. It is a primary maquis whose most representative elements are *Pistacia lentiscus* L. (pulvinate) and *Juniperus turbinata* Guss.

Th. Orphanides was the first to collect plants on Symi, in 1856, and his data have been reported in Heldreich (1877), Pampanini (1926), Rechinger (1944), Ciferri (1944), and Davis (1965-1985). Subsequently Desio during his travels in the SE Aegean area, gathered several specimens on Symi, which were reported by Pampanini (1926), Rechinger (1944), Ciferri (1944), and Davis (1965-1985). Rechinger visited Symi on 28-29 June 1935, including its highest peak Mt. Vigla, and later published his records (Rechinger 1944). The material collected in 1961 by Gathorne-Hardy was reported by Davis (1965-1985). Davis himself carried out botanical research on Symi in 1981 (Davis 1965-1985). Finally, the most substantial contribution to the knowledge of the island's flora was provided by Carlström (1987). She visited Symi in different times between July 1981 and October 1982. Keitel & Remm (1991) studied the orchid flora of the island. In 2001, Jahn collected several taxa on Symi: his records have been published by Strid (2016). Later Chilton (2010) compiled a plant list of Symi. The most recent contributions to the flora of Symi have been provided by Galanos (2016), Galanos & Tzanoudakis (2017; 2019), Burton & Tan (2017), and Cattaneo

& Grano (2017; 2018a). The floristic data relating to Symi have been excerpted from all these published sources and from Strid (2016). Carlström investigated Seskli on 11.06.1982 and recorded 70 species. Formerly, on 31.05.1966 Bothmer visited the island, where he collected 7 species, and the small island of Trambeto (W of Seskli).

The first inventory of the vascular flora of Seskli was drawn up by Carlström (1987). An unpublished checklist of the plants collected on Seskli by Carlström and Bothmer has been kindly provided by Strid. The present authors add here their own data on the flora of Seskli.

Materials and methods

Symi has been investigated by the authors on three occasions: from 30 July to 11 August 2017, from 26 to 30 April 2018 and on 26 and 27 April 2019. On 7 August 2017 and 29 April 2018, two excursions were made to the island of Seskli, south of Symi. All specimens are kept in the first author's personal herbarium. Plant identifications are mainly based on Rechinger (1944, 1949), Rechinger & Rechinger, (1951), Davis (1965-1985), Davis & al. (1988), Tutin & al. (1964-1980, 1993), Greuter & al. (1984-1989), Pignatti (1982), Strid & Tan (1997, 2002), Brullo & Erben (2016), and Strid (2016). Species nomenclature mostly follow Greuter & al. (1984-1989), Greuter & Raab-Straube (2008) and Euro+Med (2006-). Regarding the distribution of the genus *Limonium*, Brullo & Erben's (2016) innovative treatment has been followed. The definition and naming of families comply with Strid (2016), and information regarding the presence of species on Symi has been extractated from the database "Flora of Greece Web" (Dimopoulos & al. 2018). The status of endemic taxa recorded for Symi is based on Dimopoulos & al. (2018). With regard to the status of alien taxa, Arianoutsou & al. (2010) and Dimopoulos & al. (2018) have been followed. The life-form and chorological categories follow Dimopoulos & al. (2018). For recording altitudes and geographical coordinates, the Android application AlpineQuest GPS was used. Place names mentioned in the text follow the map of Symi produced by Terrain Cartography Group in 2009. The authors established an updated checklist of the flora of Symi and Seskli, in which all taxa recorded from either island from 1987 to date is included. The database of Lund (LD) Herbarium (https://www.biomus.lu.se/en/botanical-collections) was consulted for compiling the checklists and for the correct identification of several specimens (last access 01/10/2019). Unless otherwise specified, the term "endemic" is used to denote taxa with a distribution area confined to Greece plus SW Turkey and the term "range-restricted" refers to taxa with a limited area of distribution not exceeding a distance of 500 km (sensu Dimopoulos & al. 2018). SW Turkey refers to the area between the provinces of Aydin, Muğla, Denizli, Burdur, Isparta and Adalia.

Results

Features of Symi's flora

This paper brings an updated inventory of the vascular flora of Symi and Seskli, 32 years after Carlström's (1987) checklist. It also highlights Symi's endemism rate, which is substantial when one considers Symi's recent origin as an island (Sfenthourakis & Triantis

2017). Symi has a varied landscape. The northern part of the island is covered with low xeric scrub vegetation (phrygana) that results from protracted and reiterated anthropic impact (land cultivation and overgrazing). The most representative species of this plant community are *Thymbra capitata* (L.) Cav., *Origanum onites* L., *Sarcopoterium spinosum* (L.) Spach, and *Salvia fruticosa* Mill. The southern part of the island hosts pre-anthropic conifer woodland of great scientific value, dominated by *Cupressus sempervirens* f. *horizontalis* (Mill.) Loudon with stands of *Pinus brutia*. Two woodland communities have been recognised: species-poor *Quercus coccifera*-*Cupressus sempervirens* woods, and *Pistacia lentiscus*-*Cupressus sempervirens* woodland, which pertains mainly to the thermo-Mediterranean vegetation belt (Brofas & al. 2006). In addition, Symi, in the crevices of hard limestone cliffs, hosts a very interesting chasmophytic flora, characterized by many rare and endemic species (Phitos & al. 2009) such as *Hirtellina fruticosa* (L.) Dittrich, *Lomelosia variifolia* (Boiss.) Greuter & Burdet, *Teucrium montbretii* subsp. *heliotropiifolium* (Barbey) P. H. Davis, and *Linum arboreum* L. It occurs along the SE coast (Dhysalonas, Nanou, Faneromeni) and the SW coast (Lapathos and Ladhi).

Analysis of the flora

To date, the vascular flora of Symi, including cultivated and naturalized taxa, comprises 679 taxa (678 species and one additional subspecies), belonging to 364 genera and 93 families. Alien taxa not well established in Greece, such as *Schinus molle* L., *Senecio angulatus* L., and *Euphorbia hypericifolia* L., are disregarded. The most species-rich families are *Asteraceae* (90 taxa), *Fabaceae* (72 taxa), and *Poaceae* (67 taxa). *Apiaceae* (31 taxa) and *Lamiaceae* (30 taxa) are also well represented. As for life-forms, therophytes predominate, followed by hemicryptophytes, geophytes, chamaephytes, phanerophytes, and halophytes (Table. 1). The high proportion of therophytes combined with the high number of Mediterranean elements (Table. 2) underpins the strongly Mediterranean character of Symi's flora (Christodoulakis 1996). As compared to the island of Tilos, Symi hosts a higher number of chamaephytes due to its rocky nature and the noticeable presence of cliffs. The alien flora on Symi represents 4.12% with 28 taxa (Table. 2), belonging to 22 genera and 18 families. So far, none seem to have an invasive character. This percentage is fairly high compared with that of Tilos 2.04% (Cattaneo & Grano 2018b) and Chalki 1.73% (Tsakiri & al. 2016), and this is probably due to the closeness of Symi to the Anatolian mainland. Analysing the phytogeographical connections of the island within the Aegean area, Symi falls in the phytogeographical region of the East Aegean Islands (EAe) and shares the highest number of taxa with the phytogeographical region of Kriti and Karpathos (KK) with 607 taxa, followed by the phytogeographical region of Kiklades (Kik) with 581 taxa, and Peloponnisos (Pe) with 574 taxa. Along with Tilos (Cattaneo & Grano 2018b), Rhodes and Chalki (Tsakiri & al. 2016), Symi seems to have closer phytogeographical affinities with the South Aegean islands (KK) than with Kiklades (Kik). From a chorological point of view, the Mediterranean group predominates constituting 72.45% of the flora of the island. More specifically, species with a circum-Mediterranean distribution constitute about 33.72% of the flora (229 taxa), followed by species restricted to E Mediterranean with 21.79% (148 taxa) (Table. 2). About 8.83% of the species (60 taxa) belong to the Mediterranean-SW Asian group and this substantial number is due to the phytogeographical position of Symi (Table. 2). The high percentage of the E

Table. 1. Life-form spectrum of Symi's flora (life-forms are as defined by Dimopoulos & al. 2018).

Life-forms	Number of species	%
Therophytes	354	52.13
Phanerophytes	50	7.36
Hemicryptophytes	127	18.70
Geophytes	94	13.84
Chamaephytes	50	7.36
Aquatic	3	0.44
Total	679	100.00

Mediterranean taxa is due to the migration of eastern floristic elements during paleogeographic events that occurred when Symi was linked to the Anatolian mainland (Dermitzakis & Papanikolaou 1981; Sfenthourakis & Triantis 2017), and in particular with the peninsular areas of Daraçya Yarimadasi and Reşadiye Yarimadasi (Marmaris district), with which it constituted a biogeographical unit.

Update of the flora of Symi

An update of the flora of Symi has been performed comparing the data obtained from Carlström's checklist (Symi plant list 1987) with those of the checklist drawn up by the authors (Symi plant list 2019), which groups all the published floristic data from 1987 to 2019. As it has already been said, the vascular flora of Symi to date amounts to 679 taxa, 422 of which have been recorded in Symi plant list 1987 and 257 in Symi plant list 2019. From the analysis of both checklists, a considerable enrichment of the flora over 32 years is highlighted. Due to the lack of adequate data available, a turnover of the flora of Symi could not be outlined. It was not possible to evaluate any extinction, as the island was visited in the past and by the authors only in rather short sessions. However, with the data at our disposal it was possible to make a comparison between the biological and chorological spectra of both checklists. From a biological point of view, comparing Symi plant list 2019 with the previous one, no significant percentage variations of each biological form have been detected (Table. 3), except for a good percentage of therophytes and the notable increase of the geophytes especially with regard to the family of *Orchidaceae* with 15 taxa more than the previous list. Normally the increase in therophytes and geophytes is related to a decrease / cessation of grazing (Snogerup & Snogerup 1987; Bergmeier & Dimopoulos 2003; Panitsa & al. 2008). However, grazing is currently very present on Symi, and the development of agricultural-pastoral activities on the island has led to a marked increase of the *Fabaceae*, with 29 taxa more than the previous list. For this reason, it is more plausible that behind these data there was a lack of research performed on Symi in the past. Even the entry of 10 endemics in the flora of Symi underlines a lack of previous research. Indeed, Rechinger carried out research on Symi only in June 1935, Davis in October 1981 and Carlström only for a few days during the months of May, June and July of 1981 and October of 1982. Subsequent visits to the island by several botanists have been able to fill some gaps. From a chorological point of view an increase in alien taxa and

Table. 2. Chorological spectrum of the native flora of Symi (chorological groups are as defined by Dimopoulos & al. 2018).

Chorological groups	Number of taxa	%	Total number of taxa	%
Widely distributed taxa			132	19.44
European	2	0.29		
European-SW Asian	65	9.57		
Euro-Siberian	5	0.73		
Palaeotemperate	22	3.24		
Circumtemperate	5	0.73		
Saharo-Sindian	1	0.14		
Subtropical-Tropical	9	1.32		
Cosmopolitan	23	3.38		
Mediterranean Taxa			492	72.45
E Mediterranean	148	21.79		
Mediterranean	229	33.72		
Mediterranean-Atlantic	14	2.06		
Mediterranean-European	41	6.03		
Mediterranean-SW Asian	60	8.83		
Balkan Taxa			8	1.17
Balkan	0	0		
Balkan-Italian	0	0		
Balkan-Anatolian	8	1.17		
Endemic Taxa			19	2.79
Endemic	19	2.79		
Alien taxa			28	4.12
Am.	1	0.14		
N-Am.	6	0.88		
S-Am.	6	0.88		
S-Afr.	3	0.44		
Neotrop.	6	0.88		
C-As.	1	0.14		
S-As.	1	0.14		
SW-As.	2	0.29		
SW-Eur.	1	0.14		
W-Med.	1	0.14		
Total	679	100.00	679	100.00

wide-ranging plants has been observed. In more detail, with regard to the Mediterranean taxa, an increase of elements with Mediterranean-European distribution (+7.39%) and with Mediterranean-SW Asian distribution (+10.89%) has been detected. As concerns the widely distributed taxa, the major contribution came from European-SW Asia elements

Table. 3. Comparison between the biological spectra obtained from Symi plant list 1987 and Symi plant list 2019.

Life-forms	Symi plant list 1987		Symi plant list 2019	
	Number of taxa	%	Number of taxa	%
Therophytes	224	53.08	130	50.58
Phanerophytes	31	7.34	19	7.39
Hemicryptophytes	81	19.19	47	18.28
Geophytes	48	11.37	46	17.89
Chamaephytes	37	8.76	13	5.05
Aquatic	1	0.23	2	0.77
Total	422	100.00	257	100.00

(+10.89%) following Circumtemperate, Subtropical/Tropical and Cosmopolitan taxa (Table. 4). Regarding the alien taxa, most of the new entries are nitrophilous, ruderal plants, typical of fallow or cultivated fields, suburban areas and gardens such as *Agave Americana* L., *Austrocylindropuntia subulata* (Muehlenpf.) Backeb, *Opuntia ficus-indica* (L.) Mill., *Oxalis pes-caprae* L., *Amaranthus cruentus* L., *Anethum graveolens* L., *Chenopodium album* L., *Chenopodiastrum murale* (L.) S. Fuentes & al., *Euphorbia nutans* Lag., *E. prostrata* Aiton, *Malva neglecta* Wallr., *Datura innoxia* Mill., *Nicotiana glauca* Graham, *Solanum nigrum* L. and *S. villosum* Mill. Undoubtedly the extreme closeness to the Turkish mainland and the frequent commercial and tourism exchanges between Symi, Rhodes and Marmaris, are to be regarded as main factors for the propagation of these new species. This is the expression of the advent of man, who has wiped out the insular isolating effect of the sea. A large number of alien propagules have always been introduced by man into suitable or degraded habitats. In this way the flora has been enriched in its variety, but sometimes has been trivialized (Greuter 2001).

Biogeographical considerations

Greek endemics

Symi hosts 19 Greek endemics (at a percentage of 2.79%), five of which are also present in SW Anatolia. This percentage is interesting given the very short distance from the Anatolian mainland as well as the rather recent origin of the island and the fact that Symi hosts three single-island endemics: *Allium panormitisi* Galanos & Tzanoud. (Galanos & Tzanoudakis 2019), *A. symiacum* Galanos & Tzanoud., and *Origanum symes* Carlström. The endemics belong to 11 families and 16 genera. The *Asteraceae* shows the highest rate of endemism, followed by *Lamiaceae*. Symi shares the most endemics (10 taxa) with the phytogeographical region of Kriti and Karpathos (KK) compared to that of Kiklades (Kik) (7 taxa), despite the fact that the phytogeographical region of the East Aegean Islands (EAe) is chorologically closer to Kik than to KK (Georghiou & Delipetrou 2010). Furthermore, the presence of biregional endemics on Symi, like *Lomelosia variifolia*, Table. 4. Comparison between the chorological spectra obtained from Symi plant list 1987 and Symi plant list 2019.

Chorological group	Symi plant list 1987				Symi plant list 2019			
	Number of taxa	%	Total number of taxa	%	Number of taxa	%	Total number of taxa	%
Widely distributed taxa			75	17.77			57	22.17
European	1	0.23			1	0.39		
European-SW Asian	37	8.76			28	10.89		
Euro-Siberian	3	0.71			2	0.77		
Paleotemperate	17	4.02			5	1.94		
Circumtemperate	1	0.23			4	1.55		
Saharo-Sindian	0	0.00			1	0.39		
Subtropical-Tropical	5	1.18			4	1.55		
Cosmopolitan	11	2.60			12	4.66		
Mediterranean Taxa			327	77.48			165	64.20
E Mediterranean	104	24.64			44	17.12		
Mediterranean	158	37.44			71	27.62		
Mediterranean-Atlantic	11	2.60			3	1.16		
Mediterranean-European	22	5.21			19	7.39		
Mediterranean-SW Asian	32	7.58			28	10.89		
Balkan Taxa			7	1.65			1	0.39
Balkan	0	0.00			0	0.00		
Balkan-Italian	0	0.00			0	0.00		
Balkan-Anatolian	7	1.65			1	0.39		
Endemic Taxa			9	2.13			10	3.89
Endemic	9	2.13			10	3.89		
Alien taxa			4	0.94			24	9.33
Am.	0	0.00			1	0.39		
N-Am.	1	0.23			5	1.94		
S-Am.	1	0.23			5	1.94		
S-Afr.	0	0.00			3	1.16		
Neotrop.	1	0.23			5	1.94		
C-As.	1	0.23			0	0.00		
S-As.	0	0.00			1	0.39		
SW-As.	0	0.00			2	0.77		
SW-Eur.	0	0.00			1	0.39		
W-Med.	0	0.00			1	0.39		
Total	422	100.00	422	100.00	257	100.00	257	100.00

Phlomis cretica C. Presl and *Teucrium montbretii* subsp. *heliotropiifolium* that occur exclusively in KK and EAe, shows the good phytogeographical connection between these two floristic regions. This may be attributable to the land bridge between Kriti, Karpathos and the East Aegean Islands that occurred during the Messinian salinity crisis and the early Pliocene (Sfenthourakis & Triantis 2017). Reported on Symi for the first time, is the presence of *Limonium hirsuticalyx* Pignatti. This taxon is also present on Naxos (Kik), Kos, Patmos and Rhodes (EAe). The occurrence on Symi of endemic allopatric taxa like *Nigella arvensis* subsp. *brevifolia* Strid (belonging to the *Nigella arvensis* complex represented by six species (12 taxa) in the Aegean Archipelago), *Campanula rhodensis* A. DC, (included with *Campanula simulans*, also present on Symi, in the *Campanula drabifolia* Sm. complex), *Dianthus fruticosus* subsp. *rhodius* (Rech. f.) Runemark and *Erysimum rhodium* Snogerup may be the outcome of a differentiation promoted by genetic drift that occurred in the Aegean area and in particular in the S-SE Aegean during periods of climatic fluctuation and edaphic changes in the Pleistocene (Carlström 1986a). Repeated bottlenecks due to seasonal fluctuations in population size would led to genetic drift (Runemark 1970) and favorable conditions in several Aegean Islands would have promoted allopatric speciation. This is easily recognizable within the *Nigella arvensis* complex (Bittkau & Comes 2009; Comes & al. 2008; Cattaneo & Grano 2018b) as well as in other angiosperm groups like in the *Campanula drabifolia* complex (Carlström 1986b). *Nigella arvensis* subsp. *brevifolia* that occurs in Peloponnisos, Kriti, Rhodes and Symi, shows a connection between the floristic regions Pe, KK and EAe (Georghiou & Delipetrou 2010) and seems to follow the S Aegean island arc, connecting the Balkans to Anatolia. Probably *N. arvensis* subsp. *brevifolia* occurring on Symi and Chalki (Tsakiri & al. 2016), belongs to the same lineage of *N. a. brevifolia* that occurs on Rhodes. Recent studies regarding re-colonization events and genetic exchange between divergent populations through the formation of land bridges during the Pleistocene within the *Nigella arvensis* complex, show that *N. a.* subsp. *brevifolia* together with subsp. *aristata*/*arvensis* from Crete belong to a Western Aegean (WAe) lineage, while *N. a.* subs. *brevifolia* from Rhodes and *N. carpatha* Strid from Karpathos/Kasos are members of an Eastern Aegean (EAe) lineage, along with *N. a.* subsp. *glauca* (Boiss.) N. Terracc. (Jaros & al. 2017). The single-island endemic *Origanum symes*, closely related to *Origanum calcaratum* Juss., seems to be an extremely specialized and rare taxon in that Carlström found this species on only one site: in Dhysalonas Bay on N-exposed cliffs of hard limestone, close to the sea (Carlström 1984), and the authors found this taxon in the same place between two shaded limestone cliffs. *Origanum symes* belongs to the section *Amaracus* (Gleditsch) Bentham and this section comprises eight species of *Origanum*: *O. ayliniae* Dirmenci & Yazici (Dilek Peninsula/Kuşadasi, SW Turkey) (Dirmenci & al. 2018), *O. boissieri* Ietswaart (Mersin, S Turkey), *O. calcaratum* Juss. (Kiklades, Crete and Chalki, Greece), *O. cordifolium* (Benth.) Vogel (Cyprus), *O. dictamnus* L. (Crete, Greece), *O. saccatum* P.H. Davis (Antalya, S Turkey), *O. solymicum* P.H. Davis (Antalya, S Turkey) and *O. symes* (Symi, Greece). These taxa are endemic of islands or mountain groups, all restricted to the east Mediterranean region with only *Origanum calcaratum* extending to some Cycladic islands (Ietswaart 1980; Carlström 1984; Kintzios 2003). These species are all subshrubs that grow in crevices on limestone rocks, often in shady places. It's plausible that these taxa originated from a common center of radiation, SW Anatolia, which is considered a biodiversity hotspot or a reservoir of genetic diversity favourable to the evolutionary processes of Mediterranean plant species (Médail & Diadema 2009). For this reason, these species belonging to the section *Amaracus* could all be considered allopatric taxa that show a differentiation that probably occurred in the east

Mediterranean area during the Pleistocene. Particularly the Aegean taxa *Origanum calcaratum*, *O. dictamnus*, *O. symes*, would seem to be the result of active speciation processes that resulted from genetic drift on small populations in suitable insular environmental conditions. The others two single-island endemics are *Allium panormitisi* and *A. symiacum*. Both these taxa belong to *Allium* section *Codonoprasum* and are autumn-flowering. They are the only species in the section *Codonoprasum* that have exserted stamens and are the only species with this characteristic in the autumn-flowering subgroup of this section. Furthermore, leaf sheats are more than 3/4 of the stem in *A. symiacum* and 3/4 - 4/4 in *A. panormitisi* (Galanos & Tzanoudakis 2017; 2019). These features, as well as their morphology and life cycle, lead to the determination of these taxa as floristic relics. Finally, Symi constitutes the easternmost distributional border of *Hirtellina fruticosa* (L.) Dittrich (Fig. 2), a distinctive paleoendemic of the S and SE Aegean area and the easternmost distributional border of the Greek endemic *Filago aegaea* Wagenitz subsp. *aegaea*.

Range-restricted and interesting taxa

Symi hosts 48 range-restricted taxa, 16 of which are Greek endemics. It is a chersogenous island (Greuter 2001) and its Anatolian origin is very clear in that its flora includes 148 East Mediterranean elements (21.79% of the total flora) (Table. 2), 28 of which are range-restricted and are shared with SW-Anatolia, in particular with the Muğla Province. During ancient times, many species migrated through land bridges that formed due to climatic and geological changes. In this regard, the S Aegean island arc (Miocene to early Pliocene) constituted an important migratory route for species between the Balkans and Anatolia (Carlström 1987), and the influence of the Anatolian element on the Balkan flora

Fig. 2. *Hirtellina fruticosa* (L.) Dittrich, Nanou Bay (Symi).

was of even greater importance. The relevance of the role of the land bridge between the Anatolian mainland and the south eastern Aegean islands as a biogeographical link is also confirmed by the great number of Aegean endemics and range-restricted taxa shared between these two regions. In fact, on Symi, we see many taxa with distributions that are very restricted to only a few E-SE Aegean Islands and to SW Turkey, such as: *Biarum marmarisense* (P.C. Boyce) P.C. Boyce, *Fritillaria sibthorpiana* (Sm.), *Anthemis macrotis* (Rech. f.) Oberpr. & Vogt., *Erysimum rhodium*, *Silene echinospermoides* Hub.-Mor., *Quercus aucheri* Jaub. & Spach, *Phlomis bourgaei* Boiss., *Sideritis albiflora* Hub.-Mor., *Teucrium montbretii* subsp. *heliotropiifolium*, *Ophrys speculum* subsp. *regis-ferdinandii* (Renz) Soó, *Rhamnus pichleri* Bornm., *Asperula brevifolia* Vent., *Campanula simulans*, *Verbascum propontideum* Murb. and *Verbascum symes* Murb. & Rech. f. There may be good reason to define Symi as part of SW-Anatolia and, more specifically, the Marmaris district. Lastly, an interesting taxon, *Prunus graeca* (Lindl.) Steud (Fig. 3), recorded by the authors in the locality of Nanou Bay (Cattaneo & Grano 2017) further underlines the linkage between SW Anatolia and Symi, since this species has only been reported for Kalymnos and Rhodes in the Aegean area, and its range primarily consists of SW-Anatolia and SW-Syria (Boratynska & Dolatowski 1986).

Seskli Island

From an edaphic and floristic point of view, Seskli seems to be an extension of the southern part of Symi (Panormitis). The island is affected by heavy overgrazing that does not allow the normal growth of vascular flora. Only on the northeast coast of Seskli, on

Fig. 3. *Prunus discolor* (Spach) C. K. Schneid., Nanou Bay (Symi).

restricted limestone cliffs away from the goats, has a well-developed chasmophytic flora been observed, with taxa such as *Ptilostemon chamaepeuce* (L.) Less., *Inula verbascifolia* subsp. *heterolepis* (Boiss.) Tutin, *Achillea cretica* L., *Matthiola incana* subsp. *glandulosa* (Vis.) Vierh., *Crithmum maritimum* L., *Capparis spinosa* L. and a new species of *Limonium* (Fig. 4). It is a diploid species with 2*n* = 18 chromosomes and belongs to *L. hirsuticalyx* or *L. meyeri* group (Erben pers. comm.). One of the peculiarities of genus *Limonium* is its ability to segregate into many small species, especially in insular and peninsular areas, and this is evident in critical habitats like rocky coasts and salt marshes. The plants that grow in this kind of habitat are characterized by hybridization, polyploidy, chromosome rearrangement, backcrosses and apomictic reproduction. Environmental conditions and reproductive mechanisms may have contributed to the evolutionary process, leading to the rapid speciation of plants (Brullo & Erben 2016). It can be assumed that in the past, Seskli and Symi constituted a single land mass and that the geographical separation that occurred during ancient times interrupted the gene flow in the population of *L. hirsuticalyx*, and lead to allopatric speciation. The new taxon found on Seskli, is an example of how genetic drift acts on small populations that are confined to restricted environments and characterized by rather critical ecological conditions.

Update of the florula of Seskli

In this contribution, 41 new floristic records are provided by the authors. The vascular flora of Seskli (although incomplete), amount to 118 taxa to date. Logistical difficulties in reaching the island, restricted the exploration of Seskli to only a few hours, on two days: 7 August 2017 and 29 April 2018. The life-form spectrum of the florula of Seskli highlights the prevalence of therophytes (44.91%) followed by hemicryptophytes, (18.64%) and chamaephytes (17.79) (Table. 5). With regards to the chorological spectrum of Seskli, the

Fig. 4. *Limonium* cfr. *hirsuticalyx* / *meyeri*, Seskli.

Mediterranean element is the most represented (45.76%) (Table. 6). The remarkable lack of biological and chorological data at our disposal did not allow an exhaustive analysis of the flora. Only a slight increase in therophytes and geophytes and increases in the east Mediterranean element and the widely distributed taxa, were detected. The new species recorded on Seskli are most likely the outcome of anemochorous and thalassochorous dispersion of propagules coming from the nearby mother island Symi (species source pools). However, even the extremely scarce human presence has allowed the entry of new taxa. These species are mainly related to cultivated, fallow fields and ruderal environments, such as *Hirschfeldia incana* (L.) Lagr.-Foss., *Rumex pulcher* L., *Papaver rhoeas* L., *Notobasis syriaca* (L.) Cass., *Silybum marianum* (L.) Gaertn., *Chenopodiastrum murale*. Indeed, these species have been observed in cultivated or near cultivated areas.

Discussion

The updated inventory of the flora of Symi and Seskli has highlighted the increase in the nitrophilous and ruderal species typical of fallow and cultivated fields, suburban areas and gardens. This is mainly due to the closeness of Symi to the Turkish mainland and the frequent commercial and tourist exchanges between Symi, Rhodes and Marmaris. Symi is located in the southeastern Aegean area, one of the richest Aegean regions in terms of Greek endemics. This is probably due to the fact that islands like Symi, Tilos, Nisyros, etc. remained isolated through the Pleistocene. Symi is a very particular island in that, despite its closeness to the Anatolian mainland, it shows a good rate of endemics. Its good environmental heterogeneity and the presence of vertical limestone cliffs with good exposure, has allowed the development of very interesting chasmophytic endemic flora. Most likely, the existence of this kind of suitable habitat allowed the subsistence of paleoendemics that may date back to the Tertiary, such as *Hirtellina fruticosa* and *Allium symiacum* and the formation of neoendemics during the Quaternary such as *Origanum symes*, *Erysimum rhodium*, and *Dianthus fruticosus* subsp. *rhodius*. During the intervals between the great glaciations in the Pleistocene, the Mediterranean region constituted both a global refuge for relic plants and an area of active speciation. The Mediterranean refugia, which were less affected by past environmental changes than European refugia thanks to a milder climate, constitute key areas for the long-term conservation of genetic and species diversity.

Table. 5. Life-form spectrum of the florula of Seskli.

Life-forms	Number of taxa	%
Therophytes	53	44.91
Phanerophytes	13	11.01
Hemicryptophytes	22	18.64
Geophytes	9	7.62
Chamaephytes	21	17.79
Aquatic	0	0.00
Total	118	100.00

Table. 6. Chorological spectrum of the florula of Seskli.

Chorological groups	Number of species	%	Total number of species	%
Widely distributed taxa			17	14.40
European	0	0.00		
European-SW Asian	8	6.77		
Euro-Siberian	2	1.69		
Paleotemperate	3	2.54		
Circumtemperate	1	0.84		
Saharo-Sindian	0	0.00		
Subtropical-Tropical	1	0.84		
Cosmopolitan	2	1.69		
Mediterranean Taxa			97	82.20
E Mediterranean	20	16.94		
Mediterranean	54	45.76		
Mediterranean-Atlantic	4	3.38		
Mediterranean-European	9	7.62		
Mediterranean-SW Asian	10	8.47		
Balkan Taxa			2	1.69
Balkan	0	0.00		
Balkan-Italian	0	0.00		
Balkan-Anatolian	2	1.69		
Endemic Taxa			2	1.69
Endemic	2	1.69		
Alien taxa			0	0.00
Am.; N-Am.; S-Am.; S-Afr.; Neotrop; C-As.; S-As.; SW-As.; SW-Eur.; W-Med.	0	0.00		
Total	118	100.00	118	100.00

This has enabled the co-existence of distinct lineages, high plant richness, and local persistence of endemic plants (Médail & Diadema 2009). Symi, like the other southeastern islands, is located across from SW Anatolia, considered one of the most interesting refugia, in that it is a biodiversity hotspot and a source of genetic diversity favorable to the evolutionary processes of Mediterranean plant species. The high rate of endemics in terms of paleoendemics and neoendemics occurring in the southeastern Aegean islands could be explained as the result of an active speciation promoted by a common center of radiation: the SW Anatolia. The discovery on Seskli of a new species of *Limonium* sp. demonstrates that the Aegean region as a whole, and in particular the SE Aegean area, is, to date, a center of active speciation thanks to the presence of suitable conditions that should be preserved.

Updated inventory of the flora of Symi and Seskli

Abbreviations and symbols used:

Life forms:

P = Phanerophyte
C = Chamaephyte
H = Hemicryptophyte
G = Geophyte
T = Therophyte
A= Aquatic

Chorological groups:

Widely distributed taxa:

Eu = European
EA = European-SW Asian
ES = Euro-Siberian
Pt = Paleotemperate
Ct = Circumtemperate
ST = Subtropical-Tropical
SS = Saharo-Sindian
Co = Cosmopolitan

Mediterranean taxa:

EM = Eastern Mediterranean
Me = Mediterranean
MA = Mediterranean-Atlantic
ME = Mediterranean-European
MS = Mediterranean-SW Asian

Balkan taxa:

Bk = Balkan
BI = Balkan-Italian
BA = Balkan-Anatolian

Endemic taxa

Endemic

Alien taxa:

Am. = American
N-Am. = North American
S-Am. = South American

S-Afr. = South African
Neotrop. = Neotropical
C-As. = Central Asian
S-As. = South-Asian
SW-As. = South West Asian
SW-Eur. = South West European
W-Med. = West Mediterranean

Record information:
AC = Annette Carlström's thesis
AS = Arne Strid's Atlas
Both = Bothmer
BR = Burton
C! = observed by the authors
C!* = first observation substantiated by a photograph
Cattaneo's = own findings
CH = Chilton's list
Fae = Rechinger's Flora aegaea
FT = Davis's Flora of Turkey
LD = Lund Herbarium (with catalogue number)
Si = Symi
Sk = Seskli
(!) = names placed between parentheses refer to literature records not confirmed.

Aspleniaceae

Asplenium bourgaei Milde - H - EM; **Si**: AC, CH, AS.
Asplenium ceterach L. - H - EA; **Si**: AC, CH, AS, *C!*.

Dryopteridaceae

Dryopteris pallida (Bory) Maire & Petitm. subsp. *pallida* - G - Me; **Si**: AC, CH, AS, as *Dryopteris villarii* subsp. *pallida* (Bory) Heywood, *Cattaneo's*.

Polypodiaceae

Polypodium cambricum L. - G - MA; **Si**: AC, CH, as *Polypodium cambricum* subsp. *australe* (Fée) Greuter & Burdet, AS.

Pteridaceae

Adiantum capillus-veneris L. - G - ST; **Si**: *C*!*; **Sk**: *Both* (LD 1247542), *Cattaneo's*.
Anogramma leptophylla (L.) Link - T - Co; **Si**: AC, CH, AS, *C!*.
Cheilanthes acrostica (Balb.) Tod. - G - Me; **Si**: AC, CH, AS, *C!*.
Allosurus persicus (Bory) Christenh. - G - Me; **Si**: AC, CH, both as *Cheilanthes persica* (Bory) Kuhn, AS.

Selaginellaceae

Selaginella denticulata (L.) Spring. - H - Me; **Si**: AC, CH, AS, *C!*.

Cupressaceae

Cupressus sempervirens L. - P - EM; **Si**: Pampanini 1926; AC, CH, AS, *C!*.
Juniperus turbinata Guss. - P - MA; **Si**: AC, CH, AS, all as "*Juniperus phoenicea*"; *C!*; **Sk**: AC, as

"*Juniperus phoenicea*", *C!*.
According to Adams (2014), the genuine *J. phoenicea* L. is a species confined to SE Spain and S France; whereas the species widespread in the Mediterranean area that has been so named generally must be known as *Juniperus turbinata.*

Ephedraceae
Ephedra foeminea Forssk. - P - Me; **Si**: AC, CH, both as *Ephedra campylopoda* C.A. Mey., AS.

Pinaceae
Pinus brutia Ten. - P - Me; **Si**: Ciferri 1944; AC, CH, AS, *C!*; **Sk**: *C*!*.
(*Pinus halepensis* Mill.)
On Symi, Desio (Pampanini 1926) collected a specimen classified as *P. halepensis* Mill., which is preserved at the Herbarium of Florence (FI 055512). The record needs confirmation though, and for biogeographical reasons, the specimen is most likely attributable to *P. brutia* Ten.

Acanthaceae
Acanthus spinosus L. - H - Me; **Si**: AC, AS.

Agavaceae
Agave americana L. - P - N-Am; **Si**: AS.

Aizoaceae
Mesembryanthemum cordifolium L. f. - C - S-Afr; **Si**: CH, as *Aptenia cordifolia* (L. f.) Schwantes.

Alliaceae
Allium amethystinum Tausch - G - EM; **Si**: AC, AS.
Allium ampeloprasum L. - G - Me; **Si**: AC, AS.
Allium archeotrichon Brullo & al. - G - Endemic; **Si**: Galanos 2016.
Allium guttatum Steven subsp. *guttatum* - G - Me; **Si**: Fae; AC, as *Allium guttatum* subsp. *sardoum* (Moris) Stearn, AS.
Allium junceum Sm. - G - EM; **Si**: AC, AS; **Sk**: AC.
Allium neapolitanum Cirillo - G - Me; **Si**: AC, AS, *C!*.
Allium paniculatum L. - G - ME; **Si**: AC, AS.
Allium panormitisi Galanos & Tzanoudakis - G - Endemic; **Si**: Galanos & Tzanoudakis 2019.
Allium sandrasicum Kollmann,Özhatay & Bothmer - G - EM; **Si**: AC, AS.
(*Allium stamineum* Boiss. - G - EM; AC.)
This species shows an eastern Mediterranean range. According to Brullo & al. (2007) this taxon was erroneously reported for Greece, since it should have a strictly Anatolian distribution. The specimen was collected by Carlström in Nanou Bay in 1982, (LD 1251969) and its classification as *Allium stamineum* Boiss., needs confirmation.
Allium subhirsutum L. - G - Me; **Si**: AC, AS, *Cattaneo's*.
Allium symiacum Galanos & Tzanoudakis - G - Endemic; **Si**: Galanos & Tzanoudakis 2017.
Allium trifoliatum Cirillo - G - Me; **Si**: AS.

Amaranthaceae
Amaranthus albus L. - T - N-Am.; **Si**: AC, CH, AS.
Amaranthus blitoides S. Watson - T - N-Am.; **Si**: BR, Cattaneo & Grano 2017.
Amaranthus cruentus L. - T - Neotrop.; **Si**: BR.
Amaranthus viridis L. - T - S-Am; AC, CH, AS, *C!*.

Amaryllidaceae

Narcissus obsoletus (Haw.) Spach. - G - Me; **Si**: Pampanini 1926, AC, both as “*Narcissus serotinus*”, AS.

According to Díaz Lifante & Andrés Camacho (2007), *Narcissus serotinus* L. is confined to Algeria, Morocco, Portugal, Spain and Tunisia. In Greece, occurs *N. obsoletus* (Haw.) Spach.

Narcissus tazetta L. - G - MS; **Si**: BR.

Sternbergia lutea subsp. *lutea* (L.) Spreng. - G - MS; **Si**: BR.

Anacardiaceae

Pistacia atlantica Desf. - P - MS; **Si**: AC, CH, AS.

Pistacia lentiscus L. - P - Me; **Si**: AC, CH, AS, *C!*; **Sk**: AC, *C!*.

Pistacia terebinthus subsp. *palaestina* (Boiss.) Engl. - P - EM; **Si**: AC, CH, AS, *C!*.

Schinus molle L.; **Si**: AC.

This species has not been taken into account in the floristic analysis since it is actually considered a non-established alien in Greece (Dimopoulos & al. 2018).

Apiaceae

Ammi majus L. - T - MS; **Si**: BR.

Anethum graveolens L. - T - SW-As.; **Si**: BR.

Bunium ferulaceum Sm. - G - EM; **Si**: AC, CH, AS.

Bupleurum gracile d’Urv - T - Me; **Si**: AC, CH, AS.

Bupleurum lancifolium Hornem - T - MS; **Si**: AS.

Bupleurum subovatum Spreng. - T - EA; **Si**: AS.

Cachrys cristata DC. - H - Me; **Si**: AC, CH, AS, *C!*.

Crithmum maritimum L. - C - ME; **Si**: AC, CH, AS, *C!*; **Sk**: AC, *C!*.

Daucus broteri Ten. - T - Me; **Si**: AS.

Daucus involucratus Sm. - T - EM; **Si**: AC, CH, AS, *Cattaneo's*; **Sk**: *C*!*.

Eryngium campestre L. - H - EA; **Si**: AC, AS, *C!*.

Eryngium glomeratum Lam. - H - EM; **Si**: AC, CH, AS, *C!*.

Ferula communis L. - H - ME; **Si**: CH, AS.

Foeniculum vulgare Mill. - H - Me; **Si**: AC, CH, AS.

Lagoecia cuminoides L. - T - ME; **Si**: AC, CH, AS, *C!*; **Sk**: *C*!*

Malabaila aurea (Sm.) Boiss. - H - EM; **Si**: AC, AS.

Opopanax hispidus (Friv.) Griseb. - H - MS; **Si**: AC, CH, AS.

Orlaya daucoides (L.) Greuter - T - MS; **Si**: AC, CH, AS.

Pimpinella cretica Poir. - T - EM; **Si**: AC, CH, AS, *Cattaneo's*.

Pimpinella peregrina L. - H - EA; **Si**: AC, CH, AS.

Scaligeria napiformis (Spreng.) Grande - H - EM; **Si**: AC, as *Scaligeria cretica* (Mill.) Boiss., CH, AS, *Cattaneo's*.

Scandix australis L. subsp. *australis* - T - ME; **Si**: AC, CH, AS.

Scandix pecten-veneris L. - T - EA; **Si**: AS.

Smyrnium creticum Mill. - H - EM; **Si**: AC, CH, AS.

Smyrnium olusatrum L. - H - MA; **Si**: CH, AS, *C!*.

Tordylium apulum L. - T - Me; **Si**: AC, CH, AS.

Tordylium pestalozzae Boiss. - T - EM; **Si**: CH, AS, both as *Tordylium aegaeum* Runemark, *Cattaneo's*.

Torilis africana Spreng. - T - ME; **Si**: *Carlström* (LD 1418744), AS.

Torilis arvensis (Huds.) Link -T - ME; **Si**: AS.

Torilis leptophylla (L.) Rchb. f. - T - EA; **Si**: AC, CH, AS, *Cattaneo's*.

Torilis nodosa (L.) Gaertn. - T - EA; **Si**: AC, CH, AS.

Apocynaceae

Nerium oleander L. - P - Me; **Si**: CH, AS.

Araceae

Arisarum vulgare O. Targ. Tozz. - G - Me; **Si**: AC, AS.
Arum concinnatum Schott - G - EM; **Si**: AS.
Arum creticum Boiss. & Heldr. - G - EM; **Si**: AC, AS, *C!*.
(*Biarum bovei* Blume)
This record by Desio (Pampanini 1926) is probably erroneous (Carlström 1987).
(*Biarum davisii* Turrill)
This species, closely related to *B. marmarisense* (P. C. Boyce) P. C. Boyce, is reported in the literature for Symi but is apparently endemic to Crete. The record is probably erroneous.
Arum dioscoridis Sm. - G - EM; **Si**: AC, AS; **Sk**: *C*!*.
Biarum marmarisense (P.C. Boyce) P.C. Boyce - G - EM; **Si**: AS.
Biarum tenuifolium subsp. *zelebori* (Schott) P.C. Boyce - G - EM; **Si**: AC, as *Biarum tenuifolium* var. *zelebori* (Schott) Engl., AS.
Dracunculus vulgaris Schott - G - Me; **Si**: AC, AS, *C!*; **Sk**: *C*!*.

Aristolochiaceae

Aristolochia hirta L. - H - EM; **Si**: AC, CH, AS.
Aristolochia parvifolia Sm. - H - Me; **Si**: AC, CH, AS.

Asparagaceae

Asparagus aphyllus subsp. *orientalis* (Baker) P.H. Davis - C - EM; **Si**: AC, AS, *C!*; **Sk**: AC, *C!*.
Asparagus horridus L. - C - Me; **Sk**: AC, as *Asparagus stipularis* Forssk.

Asphodelaceae

Asphodeline lutea (L.) Rchb. - G - ME; **Si**: Fae, AC, AS.
Asphodelus ramosus L. - G - Me; **Si**: AC, as "*Asphodelus aestivus*" AS; **Sk**: AC, as "*Asphodelus aestivus*".
According to Dimopoulos & al. (2013) *Asphodelus aestivus* L. is absent from Greece and confined to the W Mediterranean area. Greek records refer to *A. ramosus* subsp. *ramosus*.

Asteraceae

Achillea cretica L. - C - EM; **Si**: AC, CH, AS; **Sk**: *Both* (LD 1547398), *Cattaneo's*.
Anthemis chia L. - T - Me; **Si**: AC, CH, AS.
Anthemis macrotis (Rech. f.) Oberpr. & Vogt - T - EM; **Si**: AC, as *Matricaria macrotis* Rech. f., CH, AS, *Cattaneo's*.
Anthemis rigida Heldr. - H - EM; **Si**: AC, CH, AS.
Asteriscus aquaticus (L.) Less. - T - ME; **Si**: AC, CH, AS; **Sk**: *C*!*.
Atractylis cancellata L. - T - Me; **Si**: AC, CH, AS; **Sk**: AC, AS.
Bellis annua L. - T - Me; **Si**: AC, CH, AS.
Bellis sylvestris Cirillo - H - Me; **Si**: BR.
Calendula arvensis (Vaill.) L. - T - ME; **Si**: AC, CH, AS.
Carduus argentatus L. - T - EM; **Si**: AS, *C!*.
Carduus pycnocephalus L. - T - ME; **Si**: AC, AS; **Sk**: AC.
Carlina graeca Heldr. & Sartori - H - BA; **Si**: AC, AS, both as *Carlina corymbosa* subsp. *graeca* (Heldr. & Sartori) Nyman, CH, *C!*; **Sk**: *C*!*.
Carlina gummifera (L.) Less. - T - Me; **Si**: AC, as *Atractylis gummifera* L., CH, AS, *C!*.

Carlina lanata L. - H - Me; **Si**: AC, CH, AS, *Cattaneo's*; **Sk**: AC.
Carlina tragacanthifolia Klatt - H - EM; **Si**: AS.
Carthamus boissieri Halácsy - T - EM; **Si**: Fae, AC, CH, AS, *C!*.
Carthamus creticus L. - T - Me; **Si**: AC, AS, both as *Carthamus lanatus* subsp. *baeticus* (Boiss. & Reut.) Nyman, CH; **Sk**: AC, as *Carthamus lanatus* subsp. *baeticus* (Boiss. & Reut.) Nyman.
Carthamus dentatus subsp. *ruber* (Link) Hanelt - T - EM; **Si**: AC, CH, AS, *C!*.
Carthamus leucocaulos Sm. - T - Endemic; **Si**: AS.
Catananche lutea L. - T - Me; **Si**: AC, CH, AS.
Centaurea solstitialis L. - H - Me; **Si**: AC, CH, AS, *Cattaneo's*.
Centaurea acicularis Am. - H - EM; **Si**: AC, CH, as *Centaurea acicularis* var. *urvillei*, *C!*.
Chondrilla juncea L. - H - ME; **Si**: BR, *C!*.
Cichorium intybus L. - H - EA; **Si**: AC, CH, AS, *C!*; **Sk**: *Carlström* (LD 1991887), *C!*.
Cichorium pumilum Jacq. - T - MS; **Si**: AC, CH, AS; **Sk**: *C*!*.
Cichorium spinosum L. - C - Me; **Si**: CH, AS, *C!*.
Crepis commutata (Spreng.) Greuter - H - EM; **Si**: AC, as *Crepis foetida* subsp. *commutata* (Spreng.) Babcock, CH, AS, *Cattaneo's*; **Sk**: AC, as *Crepis foetida* subsp. *commutata* (Spreng.) Babcock.
(*Crepis foetida* subsp. *rhoeadifolia* (M. Bieb.) Čelak.)
Carlström's observation of this species on Symi needs confirmation.
Crepis multiflora Sm. - T - EM; **Si**: AS, *Cattaneo's*.
Crepis pusilla (Sommier) Merxm. - T - Me; **Si**: AS, *Cattaneo's*.
Crepis sancta (L.) Bornm. - T - EA; **Si**: AS, *Cattaneo's*.
Crupina crupinastrum (Moris) Vis. - T - EA; **Si**: AC, CH, AS.
Cyanus segetum Hill - T - Me; **Si**: AC, AS, both as *Centaurea cyanus* L., CH.
Dittrichia graveolens (L.) Greuter - T - Me; **Si**: AC, CH, AS, *C!*.
Dittrichia viscosa (L.) Greuter - C - Me; **Si**: Pampanini 1926, as *Cupularia viscosa* (L.) Godr. & Gren., AC, AS, *C!*.
Echinops spinosissimus subsp. *bithynicus* (Boiss.) Greuter - H - EM; **Si**: AC, CH, AS, *C!*.
Echinops spinosissimus Turra subsp. *spinosissimus* - H - Me; **Si**: AC, CH, AS, *C!*.
Erigeron bonariensis L. - H - Neotrop.; **Si**: BR, *Cattaneo's*.
Filago aegaea subsp. *aristata* Wagenitz - T - EM; **Si**: AS, *Cattaneo's*.
Filago aegaea Wagenitz subsp. *aegaea* - T - Endemic; **Si**: AS.
Filago eriosphaera (Boiss. & Heldr.) Chrtek & Holub - T - EM; **Sk**: *C*!*.
Filago cretensis subsp. *cycladum* Wagenitz - T - Endemic; **Si**: AC, CH, AS.
Filago eriocephala Guss. - T - Me; **Si**: AC, CH, AS, *Cattaneo's*.
Filago gallica L. - T - MA; **Si**: AC, CH, AS, *C!*.
Filago pygmaea L. - T - Me; **Si**: AC, CH, AS; **Sk**: AC.
Filago pyramidata L. - T - Me; **Si**: AC, CH, AS, *Cattaneo's*; **Sk**: AC, *Cattaneo's*.
Galatella cretica Gand. - H - EM; **Si**: Galanos 2016.
Geropogon hybridus (L.) Sch. Bip. - T - Me; **Si**: AC, CH, AS.
Glebionis coronaria (L.) Spach - T - Me; **Si**: AC, as *Chrysanthemum coronarium* L., CH, AS; **Sk**: *Carlström* (LD 1973837).
Glebionis segetum (L.) Fourr. - T - Me; **Si**: AC, as *Chrysanthemum segetum* L., CH, AS, *C!*.
Hedypnois rhagadioloides (L.) F. W. Schmidt - T - Me; **Si**: AC, CH, as *Hedypnois cretica* (L.) Dum. Cours, AS; **Sk**: AC, *Cattaneo's*.
Helichrysum orientale (L.) Vaill. - H - EM; **Si**: AC, CH, AS, *C!*.
Helichrysum stoechas subsp. *barrelieri* (Ten.) Nyman - C - Me; **Si**: AC, CH, as *Helichrysum conglobatum* (Viv.) Steud., AS., *C!*.
Hirtellina fruticosa (L.) Dittrich - C - Endemic; **Si**: AC, AS, both as *Staehelina fruticosa* (L.) L., CH, *Cattaneo's*.

Hyoseris scabra L. - T - Me; **Si**: AS.
Hypochaeris achyrophorus L. - T - Me; **Si**: AS, *Cattaneo's*; **Sk**: *C*!*.
Hypochaeris glabra L. - T - Me; **Si**: AS.
Inula heterolepis Boiss - H - EM; **Si**: AC, AS, both as *Inula verbascifolia* subsp. *heterolepis* (Boiss.) Tutin, CH, *C!*; **Sk**: AC, *C!*.
Lactuca serriola L. - H - Pt; **Si**: AC, CH, AS, *C!*.
Lactuca tuberosa Jacq. - H - EA; **Si**: AS, *C!*.
Leontodon tuberosus L. - H - Me; **Si**: AC, CH, AS, *Cattaneo's*; **Sk**: *C*!*.
Limbarda crithmoides (L.) Dumort. - C - MA; **Si**: AC, as *Inula crithmoides* L., CH, AS.
Matricaria chamomilla L. - T - Co; **Si**: AC, AS, both as *Matricaria recutita* L., CH.
Notobasis syriaca (L.) Cass. - T - Me; **Si**: AC, CH, AS; **Sk**: *C*!*.
Onopordum bracteatum Boiss. & Heldr. - H - EM; **Si**: AC, CH, AS, *C!*.
Onopordum illyricum L. - H - Me; **Si**: AS.
Pallenis spinosa (L.) Cass. - H - Me; **Si**: AC, CH, AS; **Sk**: AC.
Phagnalon rupestre subsp. *graecum* (Boiss. & Heldr.) Batt. - C - Me; **Si**: AC, CH, AS, *C!*; **Sk**: AC.
Picnomon acarna (L.) Cass. - T - Pt; **Si**: AC, CH, AS, *C!*.
Picris pauciflora Willd. - T - EA; **Si**: AC, CH, AS.
Picris rhagadioloides (L.) Desf. - T - Pt; **Si**: AC, CH, both as *Picris altissima* Delile, AS, *C!*.
Podospermum canum C.A. Mey. - H - EA; **Si**: AS.
Ptilostemon chamaepeuce (L.) Less. - C - EM; **Si**: AC, CH, AS, *C!*; **Sk**: *C*!*.
Reichardia picroides (L.) Roth - H - Me; **Si**: AC, CH, AS, *C!*.
Rhagadiolus stellatus (L.) Gaertn. - T - Me; **Si**: AS, *C!*.
Scolymus hispanicus L. - H - ME; **Sk**: AC, *C!*.
Scorzonera elata Boiss. - H - EM; **Si**: AC, CH, AS, *C!*; **Sk**: *Carlström* (LD 1979590), *C!*.
Scorzonera sublanata Lipsch. - H - BA; **Si**: AS.
Senecio angulatus L. f.; **Si**: BR.

This taxon has not been taken into account in the floristic analysis since it is actually a non-established alien in Greece (Dimopoulos 2018+).

Senecio vulgaris L. - T - Pt; **Si**: AC, CH, AS.
Sonchus asper subsp. *glaucescens* (Jord.) Ball - T - Pt; **Si**: AC, CH, AS.
Sonchus bulbosus (L.) N. Kilian & Greuter - G - Me; **Si**: AS, as *Aetheorhiza bulbosa* (L.) Cass., *Cattaneo's*.
Sonchus oleraceus L. - T - ME; **Si**: AC, CH, AS.
Silybum marianum (L.) Gaertn. - T - Me; **Si**: BR.; **Sk**: *C*!*.
Symphyotrichum squamatum (Spreng.) G.L. Nesom - C - Neotrop.; **Si**: AS.
Taraxacum minimum (Guss.) N. Terracc. - H - Me; **SI**: BR. *C!*.
Tolpis umbellata Bertol. - T - Me; **Si**: Cattaneo & Grano 2018, *Cattaneo's*.
Tolpis virgata (Desf.) Bertol. - H - Me; **Si**: BR, *Cattaneo's*.
Tragopogon porrifolius subsp. *longirostris* (Sch. Bip.) Greuter. - H - EM; **Si**: AC, AS, both as *Tragopogon longirostris* Sch. Bip., CH.
Tragopogon porrifolius L. - H - Me; **Si**: AS, *C!*.
Tyrimnus leucographus (L.) Cass. - T - Me; **Si**: Fae, AC, CH, AS.
Urospermum picroides (L.) F.W. Schmidt - T - Me; **Si**: AC, CH, AS, *Cattaneo's*; **Sk**: *C*!*.

Boraginaceae
Anchusa aegyptiaca (L.) A. DC. - T - EM; **Si**: CH, AS.
Anchusa azurea Mill. - H - Me; **Si**: BR.
Anchusa hybrida Ten. - H - Me; **Si**: AS.
Cerinthe major L. - T - MS; **Si**: CH, AS, *Cattaneo's*.

Cynoglossum columnae Ten. - T - Me; **Si**: AC, CH, AS.
Cynoglossum creticum Mill. - H - EA; **Si**: AC, CH, AS.
Echium arenarium Guss. - H - Me; **Si**: AC, CH, AS.
Echium italicum subsp. *biebersteinii* (Lacaita) Greuter & Burdet - H - EA; **Si**: BR.
Echium parviflorum Moench - T - Me; **Si**: AC, CH, AS.
Echium plantagineum L. - T - ME; **Si**: AC, CH, AS, *C!*.
Heliotropium europaeum L. - T - ME; **Si**: CH, AS, as *Heliotropium dolosum* De Not.
Heliotropium hirsutissimum Grauer - T - EM; **Si**: AC, CH, AS, *C!*.
Lithodora hispidula (Sm.) Griseb. subsp. *hispidula* - C - EM; **Si**: AC, CH, AS; **Sk**: *C*!*.
Myosotis ramosissima Rochel - T - EA; **Si**: AC, CH, AS.
Neatostema apulum (L.) I.M. Johnst. - T - Me; **Si**: AC, CH, AS, *Cattaneo's*; **Sk**: AC.
Onosma graeca Boiss. - H - EM; **Si**: Fae, AC, CH, AS.

Brassicaceae
Alyssum simplex Rudolphi - T - ES; **Si**: AC, CH, AS, *Cattaneo's*.
Alyssum strigosum Banks & Sol. - T - MS; **Si**: AC, CH, AS.
Arabis verna (L.) R. Br. - T - Me; **Si**: AC, CH, AS.
Biscutella didyma L. - T - Me; **Si**: AC, CH, AS.
Brassica cretica subsp. *aegaea* (Heldr. & Halácsy) Snogerup, M. A. Gust. & Bothmer - C - EM; **Si**: Cattaneo & Grano 2017.
Cakile maritima Scop. - T - ME; **Si**: BR.
Capsella bursa-pastoris (L.) Medik. - T - Co; **Si**: AC, CH, AS.
Cardamine hirsuta L. - T - Co; **Si**: AC, CH, AS.
Clypeola jonthlaspi L. subsp. *jonthlaspi* - T - MS; **Si**: AC, CH, AS, *Cattaneo's*.
Draba verna L. - T - EA; **Si**: AC, as *Erophila verna* subsp. *macrocarpa* (Boiss.) Walters, (*Carlström* LD 1834669 as *Erophila verna* (L.) Chevall subsp. *praecox* nomen corrigendum pro *Draba verna* L.), CH, as *Draba macrocarpa*, AS, as *Erophila verna* L.
Eruca vesicaria (L.) Cav. - T - MS; **Si**: AC, as *Eruca sativa* Mill, CH, AS.
Erucaria hispanica (L.) Druce - T - MS; **Si**: BR.
Hirschfeldia incana (L.) Lagr.-Foss. - T - EA; **Si**: AC, CH, AS; **Sk**: *C*!*.
Lepidium graminifolium L. - H - EA; **Si**: AS, *Cattaneo's*.
Malcolmia chia (L.) DC. - T - EM; **Si**: AS, *Cattaneo's*; **Sk**: *Both* (LD 1877562).
Malcolmia flexuosa (Sm.) Sm. subsp. *flexuosa* - T - EM; **Si**: AC, CH, AS.
Matthiola sinuata subsp. *glandulosa* (Vis.) Vierh. - H - ME; **Si**: AS; **Sk**: *Both* (LD 1877562), *Cattaneo's*.
Noccaea perfoliata (L.) Al-Shehbaz - T - Pt; **Si**: AC, as *Thlaspi perfoliatum* L., CH, AS.
Raphanus raphanistrum L. - T - EA; **Si**: AS.
Rapistrum rugosum (L.) All. - T - EA; **Si**: AC, CH, AS.
Sinapis alba L. - T - EA; **Si**: AS.
Sinapis arvensis L. - T - ES; **Si**: AS.
Sisymbrium officinale (L.) Scop. - T - ES; **Si**: AC, CH, AS.
Sisymbrium orientale L. - T - EA; **Si**: AC, CH, AS.
Sisymbrium polyceratium L. - T - Me; **Si**: AC, CH, AS.

Cactaceae
Austrocylindropuntia subulata (Móhlenpf.) Backeb. - P - S-Am; **Si**: Galanos 2016.
Opuntia ficus-indica (L.) Mill. - P - Neotrop.; **Si**: Ciferri 1944, AS, *C!*.

Caesalpiniaceae
Ceratonia siliqua L. - P - Me; **Si**: CH, AS, *C!*; **Sk**: *C*!*.

Campanulaceae

Campanula delicatula Boiss. - T - EM; **Si**: AC, CH, AS, *Cattaneo's*.
Campanula erinus L. - T - ME; **Si**: AC, CH, AS, *Cattaneo's*.
Campanula hagielia Boiss. - H - EM; **Si**: AC, CH, AS, *Cattaneo's*.
Campanula lyrata Lam. - H - EM; **Si**: AS.
Campanula nisyria Papatsou & Phitos - H - Endemic; **Si**: CH.
Campanula rhodensis A. DC. - T - Endemic; **Si**: AS, *Cattaneo's*.
Campanula simulans Carlström - T - EM; **Si**: AC, CH, AS, *Cattaneo's*.
Legousia pentagonia (L.) Druce - T - EM; **Si**: AC, CH, AS, *C!*.
Legousia speculum-veneris (L.) Chaix - T - ME; **Si**: AC, CH, AS.

Cannabaceae

Cannabis sativa L. - T - C-As; **Si**: AC, CH.

Capparaceae

Capparis spinosa L. - C - Me; **Si**: AC, *C!*; **Sk**: AC, *C!*.

Caprifoliaceae

Lonicera etrusca Santi - P - Me; **Si**: AC, CH, AS.
Sambucus nigra L. - P - EA; **Si**: CH, AS.

Caryophyllaceae

Arenaria deflexa Decne. - H - EM; **Si**: AC, AS.
Arenaria leptoclados (Rchb.) Guss. - T - EA; **Si**: AC, CH, AS, *C!*.
Cerastium comatum Desv. - T - EM; **Si**: AC, CH, AS.
*Cerastium glomeratum*Thuill. - T - Co; **Si**: AC, CH, AS.
Dianthus elegans d'Urv. - H - EM; **Si**: CH, AS.
Dianthus fruticosus subsp. *rhodius* (Rech. f.) Runemark - C - Endemic; **Si**: AC, CH, AS; **Sk**: AC.
Dianthus strictus Banks & Sol. - H - EM; **Si**: BR.
Dianthus tripunctatus Sm. - T - Me; **Si**: AC, CH, AS, *Cattaneo's*; **Sk**: *Both* (LD 1413394).
Minuartia hybrida (Vill.) Schischk. - T - EA; **Si**: AC, CH, AS, *Cattaneo's*.
Paronychia macrosepala Boiss. - H - EM; **Sk**: *C*!*.
Petrorhagia dubia (Raf.) G. López & Romo - T - Me; **Si**: AS.
Polycarpon tetraphyllum (L.) L. - T - MS; **Si**: AC, CH, AS, *Cattaneo's*; **Sk**: AC.
Sagina apetala Ard. - T - EA; **Si**: AC, CH, AS.
Silene behen L. - T - Me; **Si**: AC, CH, AS.
Silene cretica L. - T - Me; **Si**: AS.
Silene echinospermoides Hub.-Mor. - T - EM; **Si**: AC, CH, AS, *Cattaneo's*.
Silene italica (L.) Pers. - H - EA; **Si**: AC, CH, AS.
Silene nocturna L. - T - Me; **Si**: AC, CH, AS, *Cattaneo's*.
Silene sedoides Poir. - T - Me; **Si**: AC, CH, AS; **Sk**: AC, *Cattaneo's*.
Silene vulgaris subsp. *macrocarpa* Turrill - H - Me; **Si**: AC, CH, AS.
Spergularia bocconei (Scheele) Graebn. - T - MA; **Si**: AS.
Spergularia marina (L.) Griseb. - T - Pt; **Si**: AC, CH, both as *Spergularia salina* J. Presl & C. Presl, AS.
Stellaria pallida (Dumort.) Piré - T - EA; **Si**: AC, CH, AS, as *Stellaria apetala* Ucria.

Chenopodiaceae

Arthrocnemum macrostachyum (Moric.) K. Koch - C - Me; **Si**: AS.
Atriplex halimus L. - P - MS; **Si**: AS.

Atriplex prostrata DC. - C - ES; **Si**: BR.
Beta vulgaris subsp. *maritima* (L.) Arcang. -T - EA; **Si**: AC, as *Beta maritima* L., CH, AS; **Sk**: AC.
Beta vulgaris subsp. *adanensis* Pamuk - T - EM; **Si**: AS; **Sk**: AC.
Chenopodiastrum murale (L.) S. Fuentes & al. - T - EA; **Si**: AC, CH, AS, *C!*; **Sk**: *C*!*.
Chenopodium album L. - T - Co; **Si**: BR.
Halimione portulacoides (L.) Aellen - C - ME; **Si**: AC, CH, as *Atriplex portulacoides* L., AS; **Sk**: AC, as *A. portulacoides*.
Salsola tragus L. - T - Pt; **Si**: AS, as *Salsola kali* L., *C!*.

Cistaceae
Cistus creticus L. subsp. *creticus* - C - Me; **Si**: AC, CH, AS, *C!*; **Sk**: AC, *C!*.
Cistus parviflorus Lam. - C - EM; **Si**: CH, AS.
Cistus salviifolius L. - C - Me; **Si**: AS, *C!*; **Sk**: *C*!*.
Fumana arabica (L.) Spach - C - Me; **Si**: AC, CH, AS; **Sk**: AC.
Fumana thymifolia (L.) Webb - C - Me; **Si**: AS, *C!*.
Tuberaria guttata (L.) Fourr. - T - MA; **Si**: AC, CH, AS.

Colchicaceae
Colchicum balansae Planch. - G - BA; **Si**: AC, AS.
Colchicum macrophyllum B.L. Burtt - G - EM; **Si**: AC, AS.
Colchicum pusillum Sieber - G - EM; **Si**: AC, AS.
Colchicum variegatum L. - G - EM; **Si**: AC, AS.

Convolvulaceae
Convolvulus althaeoides L. - H - Me; **Si**: AC, CH, AS, *C!*; **Sk**: *C*!*.
Convolvulus althaeoides subsp. *tenuissimus* (Sm.) Batt. - H - Me; **Si**: BR, as *Convolvulus elegantissimus* Mill.
Convolvulus arvensis L. - H - Co; **Si**: CH, AS, *C!*.
Convolvulus oleifolius Desr. - C - Me; **Si**: AC, CH, AS; **Sk**: AC.
Convolvulus pentapetaloides L. - T - Me; **Si**: AC, CH, AS.
Convolvulus siculus L. - T - Me; **Si**: AS, *Cattaneo's*.
Cuscuta palaestina Boiss. - T - Me; **Si**: AS.
Cuscuta planiflora Ten. - T - Me; **Si**: AS.

Crassulaceae
Rosularia serrata (L.) A. Berger - H - EM; **Si**: AC, CH, AS, *C!*; **Sk**: *C*!*.
Sedum litoreum Guss. - T - Me; **Si**: AC, CH, AS.
Sedum rubens L. - T - MA; **Si**: AC, CH, AS; **Sk**: *C*!*.
Umbilicus chloranthus Boiss. - G - Me; **Si**: AC, CH, AS, *C!*.
Umbilicus horizontalis (Guss.) DC. - G - Me; **Si**: AC, CH, AS, *C!*.

Cucurbitaceae
Ecballium elaterium (L.) A. Rich. - G - MS; **Si**: AC, CH, AS, *C!*.

Cymodoceaceae
Cymodocea nodosa (Ucria) Asch. - A - MA; **Si**: AC, AS.

Cyperaceae
Carex divisa Huds. - G - EA; **Si**: AC, AS.

Cyperus rotundus L. - G - Co; **Si**: AC, AS.
Scirpoides holoschoenus (L.) Soják - G - Pt; **Si**: AS.

Dipsacaceae
Knautia integrifolia (L.) Bertol. - T - Me; **Si**: AC, CH, AS, *C!*; **Sk**: AC.
Lomelosia divaricata (Jacq.) Greuter & Burdet - T - Me; **Si**: AS.
Lomelosia variifolia (Boiss.) Greuter & Burdet - C - Endemic; **Si**: AC, as *Scabiosa variifolia* Boiss., CH, AS, *C!*.
Pterocephalus plumosus (L.) DC. - T - MS; **Si**: AC, CH, AS, *Cattaneo's*.

Ericaceae
Erica manipuliflora Salisb. - C - Me; **Si**: AC, CH, AS.

Euphorbiaceae
Chrozophora tinctoria (L.) A. Juss. - T - MS; **Si**: BR.
Euphorbia acanthothamnos Heldr. & Sart. ex Boiss. - C - EM; **Si**: AC, CH, AS; **Sk**: AC.
Euphorbia chamaesyce L. - T - ME; **Si**: AS.
Euphorbia dendroides L. - P - Me; **Si**: AC, CH, AS, *C!*; **Sk**: *C*!*.
Euphorbia exigua L. - T - ME; **Si**: AC, CH, AS.
Euphorbia falcata L. - T - EA; **Si**: AC, CH, AS; **Sk**: AC.
Euphorbia helioscopia L. - T - Co; **Si**: BR.
Euphorbia hypericifolia L.; **Si**: Galanos 2016, *Cattaneo's*.
This alien species is reported as being introduced in EAe (Euro+Med 2006–) but not established, hence it has not been counted among the vascular flora of Symi.
Euphorbia nutans Lag. - T - N-Am; **Si**: BR.
Euphorbia peplis L. - T - ME; **Si**: AC, CH, AS.
Euphorbia peplus L. - T - Co; **Si**: AC, CH, AS.
Euphorbia prostrata Aiton - T - Neotrop.; **Si**: BR.
Mercurialis annua L. - T - Pt; **Si**: AC, CH, AS, *C!*; **Sk**: AC.

Fabaceae
Anagyris foetida L. - P - Me; **Si**: AC, CH, AS, *C!*; **Sk**: AC, *C!*.
Astragalus hamosus L. - T - MS; **Si**: AC, CH, AS.
Bituminaria bituminosa (L.) C.H. Stirt. - H - ME; **Si**: AC, as *Psoralea bituminosa* L., CH, AS, *Cattaneo's*.
Calicotome villosa (Poir.) Link - P - Me; **Si**: AC, CH, AS, *C!*; **Sk**: AC.
Genista acanthoclada DC. - C - EM; **Si**: AC, CH, AS, *C!*.
Hymenocarpos circinnatus (L.) Savi - T - Me; **Si**: AC, CH, AS.
Lathyrus annuus L. - T - MS; **Si**: AS.
Lathyrus aphaca L. - T - MS; **Si**: AC, CH, AS.
Lathyrus cicera L. - T - MS; **Si**: AS.
Lathyrus setifolius L. - T - Me; **Si**: AS.
Lens culinaris subsp. *odemensis* (Ladiz.) M. E. Ferguson & al. - T - EM; **Si**: AC, as *L. nigricans* (M. Bieb.) Godr., (*Carlström* LD 1992710 as *L. nigricans*, nomen corrigendum pro *L. odemensis* Ladiz.) AS, as *L. odemensis* Ladiz.
Lotus angustissimus L. - T - ME; **Si**: AS.
Lotus cytisoides L. - H - Me; **Si**: AC, CH, AS, *C!*; **Sk**: AC, *C!*.
Lotus edulis L. - T - Me; **Si**: AC, CH, AS.
Lotus ornithopodioides L. - T - Me; **Si**: AC, CH, AS.

Lotus peregrinus L. - T - EM; **Si**: AC, CH, AS.
Lupinus angustifolius L. - T - Me; **Si**: AS.
Lupinus pilosus L. - T - EM; **Si**: AC, as *Lupinus varius* L., CH, AS.
Medicago arborea L. - P - Me; **Si**: Heldreich 1877, AC, CH.
Medicago coronata (L.) Bartal. - T - MS; **Si**: AC, CH, AS.
Medicago disciformis DC. - T - Me; **Si**: AS.
Medicago littoralis Loisel - T - MS; **Si**: AS, *Cattaneo's*.
Medicago minima (L.) L. - C - Pt; **Si**: AS.
Medicago monspeliaca (L.) Trautv. - T - MS; **Si**: AC, CH, AS; **Sk**: AC.
Medicago polymorpha L. - T - Pt; **Si**: AC, CH, AS.
Medicago rugosa Desr. - T - Me; **Si**: AS.
Medicago sativa L. - H - EA; **Si**: BR.
Melilotus indicus (L.) All. - T - EA; **Si**: AC, CH, AS.
Onobrychis aequidentata (Sm.) d'Urv. - T - Me; **Si**: AS.
Onobrychis caput-galli Lam. - T - Me; **Si**: AC, CH, AS.
Ononis mitissima L. - T - Me; **Si**: AC, CH, AS.
Ononis reclinata L. - T - ME; **Si**: AC, CH, AS; **Sk**: AC.
Ononis spinosa L. - C - Eu; **Si**: AS.
Ornithopus compressus L. - T- Me; **Si**: AS.
Pisum fulvum Sm. - T - EM; **Si**: AS.
Pisum sativum L. - T - Co; **Si**: AS.
Robinia pseudoacacia L. - P - N-Am; **Si**: AS.
Scorpiurus muricatus L. - T - Me; **Si**: AC, CH, AS.
Securigera carinata Lassen - T - EM; **Si**: *Carlström* (LD 1998792), AS.
Securigera cretica (L.) Lassen - T - Me; **Si**: AS.
Securigera parviflora (Desv.) Lassen - T - EM; **Si**: AS.
Securigera securidaca (L.) Degen & Dörfl. - T - Me; **Si**: AC, as *Coronilla securidaca* L., CH, AS.
Trifolium affine C. Presl. - T - BA; **Si**: AC, CH, AS.
Trifolium argutum Banks & Sol. - T - EM; **Si**: AS, *Cattaneo's*.
Trifolium arvense L. - T - Pt; **Si**: AC, CH, AS, *C!*.
Trifolium boissieri Guss. - T - EM; **Si**: AC, CH, AS.
Trifolium campestre Schreb. - T - EA; **Si**: AC, CH, AS, *C!*.
Trifolium clypeatum L. - T - EM; **Si**: AC, CH, AS.
Trifolium fragiferum L. - H - EA; **Si**: AS.
Trifolium grandiflorum Schreb. - T - MS; **Si**: AC, CH, AS.
Trifolium hirtum All. - T - Me; **Si**: AC, CH, AS.
Trifolium infamia-ponertii Greuter - T - Me; **Si**: AC, CH, AS.
Trifolium lappaceum L. - T - MS; **Si**: AC, CH, AS.
Trifolium leucanthum M. Bieb. - T - Me; **Si**: AC, CH, AS.
Trifolium nigrescens subsp. *petrisavii* (Clementi) Holmboe - T - EM; **Si**: AC, CH, both as *Trifolium nigrescens* Viv., AS.
Trifolium pilulare Boiss. - T - EM; **Si**: AC, CH, AS.
Trifolium scabrum L. - T - EA; **Si**: AC, CH, AS; **Sk**: *C*!*.
Trifolium scutatum Boiss. - T - EM; **Si**: AS.
Trifolium stellatum L. - T - Me; **Si**: AC, CH, AS, *C!*.
Trifolium subterraneum L. - T - ME; **Si**: AS.
Trifolium suffocatum L. - T - ME; **Si**: AS.
Trifolium tomentosum L. - T - Me; **Si**: AS.
Trifolium uniflorum L. - H - EM; **Si**: AC, CH, AS.

Trigonella balansae Boiss. & Reut. - T - EM; **Si**: AC, AS, as *T. corniculata* subsp. *balansae* (Boiss. & Reut.) Lassen; **Sk**: AC, as *T. corniculata* subsp. *balansae* (Boiss. & Reut.) Lassen, *Cattaneo's*.
Vicia cretica Boiss. & Heldr. - T - EM; **Si**: AC, CH, AS.
Vicia cuspidata Boiss. - T - EM; **Si**: AC, CH, AS.
Vicia hybrida L. - T - ME; **Si**: AC, CH, AS.
Vicia lutea L. - T - Me; **Si**: BR.
Vicia palaestina Boiss. - T - EM; **Si**: BR.
Vicia parviflora Cav. - T - MA; **Si**: AC, as *Vicia laxiflora* Brot., CH, AS, *Cattaneo's*.
Vicia sativa L. subsp. *sativa* - T - Pt; **Si**: AC, CH, AS.
Vicia villosa subsp. *eriocarpa* (Hausskn.) P.W. Ball - T - EM; **Si**: AC, as *Vicia villosa* Roth., CH, AS.

Fagaceae
Quercus aucheri Jaub. & Spach - P - EM; **Si**: AC, CH, AS, *C!*.
Quercus coccifera L. - P - Me; **Si**: AC, CH, AS, *C!*; **Sk**: AC, *C!*.
Quercus ilex L. - P - Me; **Si**: Fae, AC, AS.
Quercus ithaburensis subsp. *macrolepis* (Kotschy) Hedge & Yalt. - P - Me; **Si**: AC, CH, AS, *C!*.

Frankeniaceae
Frankenia pulverulenta L. - T - MS; **Si**: AS.

Fumariaceae
Fumaria macrocarpa Parl. - T - Me; **Si**: AC, AS.

Gentianaceae
Blackstonia perfoliata (L.) Huds. - T - ME; **Si**: Cattaneo & Grano 2018.
Centaurium erythraea Rafn. subsp. *erythraea* - T - EA; **Si**: AC; **Sk**: AC, *C!*.
(*Centaurium erythraea* subsp. *rhodense* (Boiss. & Reut.) Melderis)
This record by Carlström (1987) for Symi needs confirmation.
Centaurium spicatum (L.) R. M. Fritsch - T - MS; **Si**: BR, as *Schenkia spicata* (L.) G. Mans.
Centaurium pulchellum (Sw.) Druce - T - EA; **Si**: AC, AS, *C!*.
Centaurium tenuiflorum (Hoffmanns. & Link) Fritsch - T - ME; **Si**: AC, AS; **Sk**: AC, *C!*.

Geraniaceae
Erodium chium (L.) Willd. - T - Me; **Si**: AC, AS, *C!*; **Sk**: *C*!*.
Erodium ciconium (L.) L'Hér. - T - EA; **Si**: AS.
Erodium cicutarium (L.) L'Hér. - T - Ct; **Si**: AS; **Sk**: *C*!*.
Erodium gruinum (L.) L'Hér. - T - EM; **Si**: AC, AS.
Erodium laciniatum (Cav.) Willd. - T - Me; **Sk**: *C*!*.
Erodium malacoides (L.) L'Hér. - T - MS; **Si**: AC, AS.
Erodium moschatum (L.) L'Hér. - T - EA; **Si**: AS.
Geranium dissectum L. - T - EA; **Si**: AS.
Geranium lucidum L. - T - EA; **Si**: AC, AS.
Geranium molle L. - T - Pt; **Si**: AC, AS, *C!*; **Sk**: *C*!*.
Geranium purpureum Vill. - T - Me; **Si**: Galanos 2016, *C!*.
Geranium rotundifolium L. - T - Pt; **Si**: AC, AS.

Hyacinthaceae
Bellevalia trifoliata (Ten.) Kunth - G - Me; **Si**: BR.
Drimia maritima (L.) Stearn, - G - EM; **Si**: AC, as *Urginea maritima* (L.) Baker, AS, *C!*; **Sk**: *C*!*.

Leopoldia comosa (L.) Parl. - G - ME; **Si**: AS, as *Muscari comosum* (L.) Mill., *C!*.
Leopoldia weissii Freyn - G - EM; **Si**: AS, as *Muscari weissii* Freyn.
Muscari macrocarpum Sweet - G - EM; **Si**: Fae, AC, AS.
Muscari parviflorum Desf. - G - Me; **Si**: BR.
Ornithogalum arabicum L. - G - Me; **Si**: AC, AS.
Ornithogalum narbonense L. - G - Me; **Si**: AC, AS, both as *Ornithogalum brachystylum* Zahar., *C!*.
Ornithogalum sphaerolobum Zahar. - G - EM; **Si**: AS.
Prospero autumnale (L.) Speta - G - Me; **Si**: AC, as *Scilla autumnalis* L., AS.

Hydrocharitaceae
Halophila stipulacea (Forssk.) Asch. - A - S-As.; **Si**: AS.

Hypericaceae
Hypericum empetrifolium Willd. - C - EM; **Si**: AC, AS, *Cattaneo's*.
Hypericum triquetrifolium Turra - G - MS; **Si**: AC, AS, *Cattaneo's*; **Sk**: AC, *C!*.

Iridaceae
Crocus biflorus subsp. *nubigena* (Herb.) B. Mathew - G - EM; **Si**: BR.
Crocus tournefortii J. Gay - G - Endemic; **Si**: Ciferri 1944, AC, as *Crocus boryi* subsp. *tournefortii* (J. Gay) Greuter & al., AS.
Freesia refracta (Jacq.) Klatt - G - S-Afr.; **Si**: BR.
Gladiolus anatolicus (Boiss.) Stapf - G - EM; **Si**: AC, AS.
Gladiolus italicus Mill. - G - MS; **Si**: AS.
Iris unguicularis subsp. *carica* (Wern. Schultze) A.P. Davis & Jury - G - EM; **Si**: BR.
Moraea sisyrinchium (L.) Ker-Gawl. - G - Me; **Si**: AS.
Romulea ramiflora Ten. - G - Me; **Si**: AC, AS.
Romulea tempskyana Freyn - G - EM; **Si**: BR.

Juncaceae
Juncus bufonius L. - T - Co; **Si**: AS.
Juncus heldreichianus T. Marsson ex Parl. - H - EM; **Si**: AC, AS.

Lamiaceae
Ballota acetabulosa (L.) Benth. - C - BA; **Si**: AC, AS, *C!*; **Sk**: AC, *C!*.
Clinopodium graveolens (M.Bieb.) Kuntze - T - Me; **Si**: AC, as "*Satureja rotundifolia*", AS, as *Acinos graveolens* (M. Bieb.) Link, *Cattaneo's*.
According to Govaerts (2003) *Satureja rotundifolia* (Pers.) Briq. is a synonym of *Clinopodium graveolens* subsp. *rotundifolium* (Pers.) Govaerts, and the distribution of this subspecies is confined to Algeria, Morocco, Spain and Tunisia, whereas *Clinopodium graveolens* (M. Bieb.) Kuntze is widespread in Mediterranean area until Central Asia.
Lamium amplexicaule L. - T - Pt; **Si**: AS.
Lamium moschatum Mill. - T - EM; **Si**: AS.
Lavandula stoechas L. - P - Me; **Si**: AS.
Marrubium vulgare L. - H - EA; **Si**: AC, AS.
Mentha pulegium L. - H - Me; **Si**: AS.
Mentha spicata L. - H - EA; **Si**: BR.
Micromeria juliana (L.) Benth. ex Rchb. - C - Me; **Si**: AC, as *Satureja juliana* L., AS.
Micromeria myrtifolia Boiss. & Hohen. - C - EM; **Si**: AC, as *Satureja myrtifolia* (Boiss. & Hohen.) Greuter & Burdet, AS; **Sk**: AC.

Micromeria nervosa (Desf.) Benth. - C - Me; **Si**: AS.
Origanum onites L. - C - Me; **Si**: AC, AS, *C!*.
Origanum symes Carlström - C - Endemic; **Si**: AC, AS, *Cattaneo's*.
Phlomis bourgaei Boiss. - P - EM; **Si**: AS.
Phlomis cretica C. Presl - H - Endemic; **Si**: AS, *Cattaneo's*.
Phlomis lycia D. Don - P - EM; **Si**: AC, AS, *Cattaneo's*.
Prasium majus L. - P - Me; **Si**: AC, AS.
Rosmarinus officinalis L. - P - Me; **Si**: AC, AS.
Salvia fruticosa Mill. - P - EM; **Si**: AC, AS, *C!*; **Sk**: AC, *C!*.
Salvia sclarea L. - H - MS; **Si**: AS.
Salvia verbenaca L. - H - MA; **Si**: AC, AS; **Sk**: AC.
Salvia viridis L. - T - Me; **Si**: AC, AS.
Satureja thymbra L. - C - Me; **Si**: AC, AS, *C!*.
Sideritis albiflora Hub.-Mor. - H - EM; **Si**: AC, AS.
Sideritis romana subsp. *curvidens* (Stapf) Holmboe - T - EM; **Si**: AC, AS, both as *Sideritis curvidens* Stapf.
Stachys cretica subsp. *smyrnaea* Rech. f. - H - EM; **Si**: AC, AS, *C!*.
Stachys spinulosa Sm. - H - BA; **Si**: AC, AS, *C!*.
Teucrium divaricatum Heldr. - C - EM; **Si**: AC, AS, *C!*.
Teucrium montbretii subsp. *heliotropiifolium* (Barbey) P.H. Davis - C - Endemic; **Si**: AC, AS, *Cattaneo's*.
Thymbra capitata (L.) Cav. - C - Me; **Si**: AC, as *Coridothymus capitatus* (L.) Rechb. fil., AS, *C!*; **Sk**: AC, as *C. capitatus* (L.) Rechb. fil., *C!*.

Liliaceae
Fritillaria sibthorpiana (Sm.) Baker - G - EM; **Si**: AS.
Gagea graeca (L.) Irmisch - G - BA; **Si**: AC, AS. *C!*.

Linaceae
Linum arboreum L. - C - EM; **Si**: AC, AS, *C!*.
Linum bienne Mill. - T - Me; **Si**: AS.
Linum corymbulosum Rchb. - T - EA; **Si**: AC, AS.
Linum strictum L. - T - Me; **Si**: AC. AS, *C!*; **Sk**: AC, *C!*.

Lythraceae
Lythrum hyssopifolia L. - T - EA; **Si**: AS; **Sk**: *Both* (LD 1425104).

Malvaceae
Alcea heldreichii (Boiss.) Boiss. - H - BA; **Si**: AC, AS, *C!*.
Althaea hirsuta L. - T - EA; **Si**: AC, AS, as *Malva setigera* K.F. Schimp. & Spenn.
Malva arborea (L.) Webb & Berthel. - P - Me; **Si**: AC, as *Lavatera arborea* L., AS.
Malva cretica Cav. subsp. *cretica* - T - Me; **Si**: AC, AS.
Malva multiflora (Cav.) Soldano & al. - T - Me; **Si**: AC, as *Lavatera cretica* L., AS.
Malva neglecta Wallr. - T - EA; **Si**: Cattaneo & Grano 2018.
Malva nicaeensis All. - T - Me; **Si**: AC, AS.
Malva parviflora L. - T - MS; **Si**: AC, AS.
Malva punctata (All.) Alef. - T - Me; **Si**: AC, as *Lavatera punctata* All., AS, *C!*; **Sk**: AC, as *L. punctata* All.
Malva sylvestris L. - T - EA; **Si**: AS, *C!*.

Moraceae

Ficus carica L. - P - MS; **Si**: Ciferri 1944, AC, AS, *C!*; **Sk**: *C*!*.

Myrtaceae

Myrtus communis L. - P - Me; **Si**: AC, AS.

Nyctaginaceae

Mirabilis jalapa L. - H - S-Am.; **Si**: Galanos 2016.

Oleaceae

Olea europaea L. - P - Me; AC, AS, *C!*; **Sk**: AC, *C!*.

Orchidaceae

Anacamptis coriophora (L.) R.M. Bateman & al. - G - EA; **Si**: AS.
Anacamptis pyramidalis (L.) Rich. - G - Eu; **Si**: AC, AS.
Anacamptis sancta (L.) R.M. Bateman, Pridgeon & M. W. Chase - G - EM; **Si**: AC, as *Orchis sancta* L., AS, *C!*.
Himantoglossum robertianum (Loisel.) P. Delforge - G - Me; **Si**: AS.
Neotinea maculata (Desf.) Stearn - G - Me; **Si**: AS.
Ophrys argolica subsp. *lucis* (Kalteisen & H.R. Reinhard) H.A. Pedersen & Faurh. - G - EM; **Si**: AS.
Ophrys fusca Link - G - Me; **Si**: AS.
Ophrys lutea subsp. *galilaea* (H. Fleischm. & Bornm.) Soó - G - Me; **Si**: AS.
Ophrys omegaifera H. Fleischm. subsp. *omegaifera* - G - EM; **Si**: AS.
Ophrys speculum Link - G - Me; **Si**: AS.
Ophrys speculum subsp. *regis-ferdinandii* (Renz) Soó - G - EM; **Si**: AS, as *O. regis-ferdinandii* (Renz) Buttler.
Ophrys tenthredinifera Willd. - G - Me; **Si**: AS.
Ophrys umbilicata Desf. subsp. *umbilicata* - G - Me; **Si**: AS.
Orchis anatolica Boiss. - G - EM; **Si**: AS.
Orchis anthropophora (L.) All. - G - MA; **Si**: AS.
Orchis italica Poir. - G - Me; **Si**: AS.
Serapias bergonii E.G. Camus - G - EM; **Si**: AC, as *Serapias vomeracea* subsp. *laxiflora* (Soó) Gölz & H.R. Reinhard, AS.
Serapias parviflora Parl. - G - Me; **Si**: AS.

Orobanchaceae

Bellardia trixago (L.) All. - T - MS; **Si**: AS.
Orobanche crenata Forssk. - T - ME; **Si**: AS.
Orobanche minor Sm. - T - EA; **Si**: AS.
Orobanche pubescens d'Urv. - T - Me; **Si**: AS, *Cattaneo's*.
Parentucellia latifolia (L.) Caruel - T - MS; **Si**: AS, as *Bellardia latifolia* (L.) Cuatrec.
Phelipanche mutelii (F.W. Schultz) Pomel - T - Pt; **Si**: AC, as *Orobanche ramosa* var. *brevispicata* (Ledeb.) Graham, AS, *C!*.
(*Orobanche ramosa* L. var. *ramosa*)

Carlström (1987) reports this species for Symi but it is in synonymy with *Orobanche ramosa* L. According to Dimopoulos & al. (2018) this species is confined to the W & C Mediterranean area and regarded as being absent from Greece. Greek records are almost certainly referring to *Phelipanche mutelii* (F.W. Schultz) Pomel.

Oxalidaceae

Oxalis corniculata L. - H - Pt; **Si**: AS, *C!*.
Oxalis pes-caprae L. - G - S-Afr.; **Si**: AS, *C!*.

Papaveraceae

Papaver dubium L. - T - EA; **Si**: AC, AS.
Papaver purpureomarginatum Kadereit - T - EM; **Si**: AS, *C!*.
Papaver rhoeas L. - T - Pt; **Si**: AC, AS, *C!*; **Sk**: *C*!*.

Phytolaccaceae

Phytolacca americana L. - P - N-Am.; **Si**: AS.
Phytolacca dioica L. - P - S-Am.; **Si**: AS.

Plantaginaceae

Plantago afra L. - T - Me; **Si**: AC, AS, *Cattaneo's*; **Sk**: AC.
Plantago albicans L. - H - Me; **Si**: AC, AS; **Sk**: AC.
Plantago arenaria Waldst. & Kit. - T - MS; **Si**: BR, as *Plantago indica* L.
Plantago cretica L. - T - EM; **Si**: AC, AS, *Cattaneo's*.
Plantago lagopus L. - T - Me; **Si**: AC, AS; **Sk**: AC.
Plantago weldenii Rchb. - T - Me; **Si**: AC, as *P. coronopus* subsp. *commutata* (Guss.) Pilg, AS, as *P. coronopus* subsp. *weldenii* (Rchb.) Arcang.; **Sk**: *C!*.

Platanaceae

Platanus orientalis L. - P - EM; **Si**: Cattaneo & Grano 2018.

Plumbaginaceae

Limonium hirsuticalyx Pignatti - C - Endemic; **Si**: *C*!*.
Limonium cfr. *hirsuticalyx / meyeri* - C - Endemic; **Sk**: *C*!*.
Limonium narbonense Mill. - H - MS; **Sk**: *Both* (LD 1573070).
Limonium ocymifolium - C - Endemic; **Si**: AC, AS.
Limonium sinuatum (L.) Mill. - H - Me; **Si**: AC, AS.

Poaceae

Achnatherum bromoides (L.) P. Beauv. - H - Me; **Si**: AC, as *Stipa bromoides* (L.) Dörfl., AS.
Achnatherum fallacinum H. Scholz & Raus - H - Endemic; **Si**: AS.
Aegilops biuncialis Vis. subsp. *biuncialis* - T - MS; **Si**: AC, AS.
Aegilops caudata L. - T - EM; **Si**: AS, as *Aegilops markgrafii* (Greuter) K. Hammer.
Aegilops geniculata Roth - T - Me; **Si**: AS.
Aegilops triuncialis L. subsp. *triuncialis* - T - MS; **Si**: AC, AS.
Aegilops umbellulata Zhuk. - T - EM; **Si**: AS.
Aira elegans Willd. ex Roem. & Schult. - T - MS; **Si**: AS, as *Aira elegantissima* Schur.
Andropogon distachyos L. - H - ST; **Si**: AC, AS.
Anisantha madritensis (L.) Nevski - T - MS; **Si**: AC, AS, as *Bromus madritensis* L.
Anisantha fasciculata (C. Presl) Nevski - T - Me; **Si**: AS, as *Bromus fasciculatus* C. Presl.
Anisantha sterilis (L.) Nevski. - T - MS; **Si**: AS, as *Bromus sterilis* L.
Aristida adscensionis subsp. *caerulescens* (Desf.) Auquier & J. Duvign. - H - SS; **Si**: AS.
Arrhenatherum palaestinum Boiss. - H - EM; **Si**: AC, AS.
Arundo donax L. - G - Co; **Si**: BR.
Avena barbata Link subsp. *barbata* - T - Me; **Si**: AC, AS, *C!*.

Avena sterilis L. subsp. *sterilis* - T - MS; **Si**: AS, *C!*.
Avena sterilis subsp. *ludoviciana* (Durieu) Gillet & Magne - T - MS; **Si**: AS.
Brachypodium retusum (Pers.) P. Beauv. - H - Me; **Si**: AS.
Briza maxima L. - T - ST; **Si**: AC, AS, *C!*.
Bromus alopecuros Poir. subsp. *alopecuros* - T - Me; **Si**: AC.
Bromus alopecuros subsp. *caroli-henrici* (Greuter) P.M. Sm. - T - EM; **Si**: AC, AS.
Bromus chrysopogon Viv. - T - MS; **Si**: AS.
Bromus intermedius Guss. - T - Me; **Si**: AC, AS.
Bromus lanceolatus Roth - T - Pt; **Si**: AC, AS.
Bromus scoparius L. - T - Me; **Si**: AC, AS.
Catapodium marinum (L.) C.E. Hubb. - T - MA; **Si**: AC, AS.
Catapodium rigidum (L.) C.E. Hubb. - T - Me; **Si**: AC, AS.
Cornucopiae cucullatum L. - T - EM; **Si**: AS.
Cynodon dactylon (L.) Pers. - G - Co; **Si**: AC, AS, *C!*; **Sk**: AC.
Cynosurus echinatus L. - T - Me; **Si**: AC, AS.
Dactylis glomerata subsp. *hispanica* (Roth) Nyman - H - Me; **Si**: AC, AS; **Sk**: AC.
Echinaria capitata (L.) Desf. - T - Me; **Si**: AC, AS.
Echinochloa crus-galli (L.) P. Beauv. - T - Co; **Si**: BR.
Gastridium phleoides (Nees & Meyen) C.E. Hubb. - T - Me; **Si**: AC.
Gastridium ventricosum (Gouan) Schinz & Thell. - T - Me; **Sk**: AC, *C!*.
Hordeum bulbosum L. - H - ST; **Si**: AC, AS.
Hordeum murinum subsp. *leporinum* (Link) Arcang. - T - Me; **Si**: AC, AS.
Hordeum vulgare subsp. *spontaneum* (K. Koch) Thell. - T - MS; **Si**: Ciferri 1944, AS.
Hyparrhenia hirta (L.) Stapf - H - ST; **Si**: AC, AS, *C!*.
Lagurus ovatus L. - T - Me; **Si**: AC, AS.
Lolium perenne L. - H - ES; **Si**: AC, AS.
Lolium rigidum Gaudin - T - ST; **Si**: AS.
Lolium temulentum L. - T - Co; **Si**: AS.
Melica ciliata subsp. *glauca* (F. W. Schultz) K. Richt. - H - Me; **Si**: Fae, AC, both as *M. ciliata* L.
Melica minuta L. - H - Me; **Si**: AC, AS.
Ochlopoa infirma (Kunth) H. Scholz - T - Me; **Si**: AC, AS, both as *Poa infirma* Kunth.
Parapholis incurva (L.) C.E. Hubb. - T - MA; **Si**: AC, AS; **Sk**: *C*!*.
Parapholis marginata Runemark - T - Me; **Si**: AC, AS.
Paspalum distichum L. - G - Neotrop.; **Si**: AC, as *Paspalum paspalodes* (Michx.) Scribn., AS.
Phalaris minor Retz. - T - ST; **Si**: AS.
Phalaris paradoxa L. - T - Me; **Si**: AC, AS.
Phleum subulatum (Savi) Asch. & Graebn. - T - Me; **Si**: AC, as *Phleum subulatum* subsp. *ciliatum* (Boiss.) Humphries, AS; **Sk**: AC, as *P. subulatum* subsp. *ciliatum* (Boiss.) Humphries, *C!*.
Phragmites frutescens H. Scholz - G - EM; **Si**: BR.
Piptatherum coerulescens (Desf.) P. Beauv. - H - Me; **Si**: AC, AS.
Piptatherum miliaceum (L.) Coss. subsp. *miliaceum* - C - Me; **Si**: AC, AS.
Poa bulbosa L. - H - Pt; **Si**: AC, AS.
Poa pelasgis H. Scholz - H - EM; **Si**: AC, AS.
Polypogon monspeliensis (L.) Desf. - T - ST; **Si**: AC, AS.
Psilurus incurvus (Gouan) Schinz & Thell. - T - Me; **Si**: AS.
Rostraria cristata (L.) Tzvelev - T - Co; **Si**: AC, AS.
Setaria adhaerens (Forssk.) Chiov. - T - Ct; **Si**: BR.
Setaria verticillata (L.) P. Beauv. - T - Ct; **Si**: BR.
Sorghum halepense (L.) Pers. - G - Co; **Si**: BR.

Sporobolus pungens (Schreb.) Kunth - G - ST; **Si**: AS.
Stipa capensis Thunb. - T - Me; **Si**: BR.
Trachynia distachya (L.) Link - T - MS; **Si**: AC, AS, as *Brachypodium distachyon* (L.) P. Beauv.
Vulpia ciliata Dumort. - T - MS; **Si**: AS.
Vulpia myuros (L.) C.C. Gmel. - T - Me; **Si**: AC, AS.

Polygonaceae
Emex spinosa (L.) Campd. - T - Me; **Si**: AS.
Polygonum aviculare L. - T - Ct; **Si**: BR.
Polygonum maritimum L. - H - ME; **Si**: BR.
Rumex bucephalophorus subsp. *aegaeus* Rech. f. - T - EM; **Si**: AS, *C!*.
Rumex pulcher subsp. *anodontus* (Hausskn.) Rech. f. - H - Me; **Si**: AS.
Rumex pulcher subsp. *woodsii* (De Not.) Arcang. - H - MS; **Si**: AC, AS; **Sk**: *Carlström* (LD 1973269), *C!*.
Rumex tuberosus subsp. *creticus* (Boiss.) Rech. f. - G - EM; **Si**: AC, AS, *C!*.

Portulacaceae
Portulaca oleracea aggr. - T - Co; **Si**: AC, AS, *C!*.

Posidoniaceae
Posidonia oceanica (L.) Delile - A - Me; **Si**: AS, *C!*.

Primulaceae
Anagallis arvensis L. - T - Co; **Si**: AC, AS; **Sk**: AC*, C!*.
Cyclamen persicum Mill. - G - Me; **Si**: AC, AS, *C!*; **Sk**: *C*!*.

Punicaceae
Punica granatum L. - P - SW-As.; **Si**: AS, *C!*.

Rafflesiaceae
Cytinus hypocistis (L.) L. - G - Me; **Si**: AS.

Ranunculaceae
Anemone coronaria L. - G - Me; **Si**: BR.
Anemone pavonina Lam. - G - Me; **Si**: AS.
Clematis cirrhosa L. - P - Me; **Si**: AC, AS.
Delphinium peregrinum L. - T - MS; **Si**: Fae, AC, AS, *C!*.
Myosurus sessilis S. Watson - T - Ct; **Si**: AC, as *Myosurus minimus* L., AS, as *Myosurus heldreichii* H. Lév.
Nigella arvensis subsp. *brevifolia* Strid - T - Endemic; **Si**: AC, AS.
Nigella arvensis subsp. *glauca* (Boiss.) N. Terracc. - T - EM; **Si**: AC, AS.
Ranunculus asiaticus L. - H - MS; **Si**: AS.
Ranunculus chius DC. - T - MS; **Si**: AS.
Ranunculus creticus L. - H - EM; **Si**: AC, AS, *Cattaneo's*.
Ranunculus muricatus L. - T - MS; **Si**: AC, AS.
Ranunculus paludosus Poir. - H - ME; **Si**: AS.
Ranunculus sardous Crantz - T - EA; **Si**: BR.
Staphisagria macrosperma Spach. - T - Me; **Si**: AC, AS, both as *Delphinium staphisagria* L., *C!*; **Sk**: *C*!*.

Rhamnaceae

Rhamnus lycioides subsp. *graeca* (Boiss. & Reut.) Tutin - P - EM; **Si**: BR, Cattaneo & Grano 2017.
Rhamnus pichleri C. K. Schneid. & Bornm. - P - EM; **Si**: AC, AS.

Rosaceae

Aphanes arvensis L. - T - EA; **Si**: AC, AS.
Crataegus azarolus L. - P - EM; **Si**: AC, AS, *C!*.
Prunus discolor (Spach) C. K. Schneid. - P - EM; **Si**: Cattaneo & Grano 2017 as *Prunus graeca* (Lindl.) Steud.
Pyrus spinosa Forssk. - P - Me; **Si**: Fae, AC, AS, *C!*.
Sanguisorba minor subsp. *balearica* (Nyman) Muños Garm. & C. Navarro - H - EA; **Si**: AS.
Sanguisorba verrucosa (G. Don) Ces. - H - Me; **Si**: AC, as *Sanguisorba minor* subsp. *magnolii* (Spach) Cout., AS, *Cattaneo's*.
Sarcopoterium spinosum (L.) Spach - C - EM; **Si**: AC, AS, *C!*; **Sk**: AC, *C!*.

Rubiaceae

Asperula brevifolia Vent. - H - EM; **Si**: AC, AS.
Crucianella imbricata Boiss. - T - EM; **Si**: AC, AS.
Crucianella latifolia L. - T - ME; **Si**: AC, AS, *Cattaneo's*.
Galium aparine L. - T - EA; **Si**: AS.
Galium brevifolium Sm. subsp. *brevifolium* - T - EM; **Si**: AC, AS, as *Galium brevifolium* Sm.
Galium canum subsp. *ovatum* Ehrend. - C - EM; **Si**: AC, AS, *C!*.
Galium floribundum Sm. subsp. *floribundum* - T - EM; **Si**: AC, AS, as *Galium floribundum* Sm.
Galium graecum L. subsp. *graecum* - C - EM; **Si**: AC, AS, as *Galium graecum* L., *Cattaneo's*.
Galium murale (L.) All. - T - Me; **Si**: AC, AS.
Galium setaceum Lam. - T - Me; **Si**: AC, AS.
Rubia tenuifolia d'Urv. - P - EM; **Si**: AC, AS.
Sherardia arvensis L. - T - EA; **Si**: AC, AS.
Theligonum cynocrambe L. - T - Me; **Si**: AC, AS, *C!*.
Valantia hispida L. - T - Me; **Si**: AS.
Valantia muralis L. - T - Me; **Si**: AS; **Sk**: *C*!*.

Rutaceae

Ruta chalepensis L. subsp. *chalepensis* - C - Me; **Si**: AC, AS.

Santalaceae

Osyris alba L. - P - Me; **Si**: AC, AS; **Sk**: AC.

Saxifragaceae

Saxifraga hederacea L. - T - EM; **Si**: AC, AS.

Scrophulariaceae

Scrophularia canina L. - H - ME; **Si**: AS.
Scrophularia lucida L. - H - Me; **Si**: AC, AS.
Scrophularia peregrina L. - T - Me; **Si**: AC, AS.
Verbascum aschersonii Murb. - H - EM; **Si**: AC, AS.
Verbascum glomeratum Boiss. - H - MS; **Si**: Fae, AC, AS.
Verbascum propontideum Murb. - H - EM; **Si**: AC, AS, *C!*.

Verbascum sinuatum L. - H - MS; **Si**: AC, AS, *C!*; **Sk**: AC, *C!*.
Verbascum symes Murb. & Rech. f. - H - EM; **Si**: Fae, AC, AS, *C!*.

Solanaceae
Datura inoxia Mill. - T - Am.; **Si**: RB.
Hyoscyamus albus L. - T - Me; **Si**: AC, AS.
Hyoscyamus aureus L. - H - EM; **Si**: BR.
Mandragora officinarum L. - H - Me; **Si**: AS; **Sk**: *C*!*.
Nicotiana glauca R.C. Graham - P - S-Am.; **Si**: Ciferri 1944, AS, *C!*.
Solanum nigrum L. subsp. *nigrum* - P - Co; **Si**: AS.
Solanum villosum Mill. - T - EA; **Si**: AS.

Tamaricaceae
Tamarix smyrnensis Bunge - P - EA; **Si**: BR.

Tropaeolaceae
Tropaeolum majus L. - T - S-Am; **Si**: Galanos 2016.

Urticaceae
Parietaria cretica L. - T - EM; **Si**: AC, AS, *C!*; **Sk**: *C*!*.
Parietaria judaica L. - H - EA; **Si**: AC, AS, *C!*.
Parietaria lusitanica L. - T - ME; **Si**: AS.
Urtica membranacea Poir. - T - MS; **Si**: AC, AS.
Urtica pilulifera L. - T - MS; **Si**: Fae, AC, AS; **Sk**: *C*!*.
Urtica urens L. - T - Co; **Si**: AS.

Valerianaceae
Centranthus calcitrapae (L.) Dufr. - T - Me; **Si**: AC, AS.
Centranthus ruber (L.) DC. - H - Me; **Si**: BR.
Valerianella coronata (L.) DC. - T - EA; **Si**: AS.
Valerianella discoidea (L.) Loisel. - T - Me; **Si**: AC, AS.
Valerianella eriocarpa Desv. - T - Me; **Si**: AC, AS, both as *Valerianella muricata* (Roem. & Schult.) W.H. Baxter.
Valerianella obtusiloba Boiss. - T - EM; **Si**: AS.

Verbenaceae
Vitex agnus-castus L. - P - MS; **Si**: AC, AS; **Sk**: AC.

Veronicaceae
Antirrhinum majus L. - C - W-Med.; **Si**: BR.
Cymbalaria longipes (Boiss. & Heldr.) A. Cheval. - H - EM; AC, AS, *Cattaneo's*.
Cymbalaria muralis G. Gaertn., B. Mey. & Scherb. - H - SW-Eur.; **Si**: Cattaneo & Grano 2018.
Kickxia commutata subsp. *graeca* (Bory & Chaub.) R. Fern. - H - EM; **Si**: AC, AS.
Kickxia elatine subsp. *crinita* (Mabille) Greuter - T - Me; **Si**: AC, AS; **Sk**: *Both* (LD 1331640), AC.
Linaria chalepensis (L.) Mill. - T - ME; **Si**: AS.
Linaria pelisseriana (L.) Mill. -T - MS; **Si**: AS.
Misopates orontium (L.) Raf. - T - ME; **Si**: AS.
Veronica arvensis L. - T - EA; **Si**: AC, AS.

Veronica cymbalaria Bodard - T - Me; **Si**: *C*!*.
Veronica polita Fr. - T - EA; **Si**: AS.

Zygophyllaceae
Tribulus terrestris L. - T - Co; **Si**: AS.

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