

The Mediterranean Island of Alborán: a review of its flora and vegetation

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Abstract

The island of Alborán lies in the middle of the Alborán Sea (Mediterranean Sea, South Spain) and is characterised by high mean temperatures and scarce precipitation. Its botanical importance led the authors to analyse the floristic changes occurred through the XIX and XX centuries as related to the increased human pressure on the Isle, as well as to elucidate the significant environmental variables causing the observed vegetation patterns by analysing published relevés. It can be concluded that the flora of this island has been dramatically affected by temporary or permanent human presence: some species have come into extinction while others have been progressively introduced into the island as newcomers –in our visits to the island five neophytes have been recorded-. Despite the low species richness of the area, historically the island has harboured four endemic taxa: *Anacyclus alboranensis*, *Senecio alboranicus*, *Frankenia corymbosa* subsp. *alboranensis* and *Diplotaxis siettiana*, although the latter species is practically extinct in the wild nowadays. Man-disturbance and, to a lesser extent, edaphic salts content are probably the environmental parameters influencing the most the species distribution and floristic composition of the island plant communities. Consequently, disappearance of some particular habitats –e.g. unsteady sandy soils- and creation and over-representation of new man-made habitats are highlighted as the main factor responsible for the floristic variations accounted in the Isle of Alborán throughout the last two centuries.

Keywords: neophytes, man-disturbance, habitats changes, extinction, ruderal species, halophily, psammophily.

Resumen

La isla mediterránea de Alborán: una revisión de su flora y vegetación. La isla de Alborán se encuentra en el mar de Alborán (Mar Mediterráneo, Sur de España) y se caracteriza por sus altas temperaturas medias y escasas precipitaciones. Su importancia botánica ha llevado a los autores de este estudio a analizar los cambios florísticos ocurridos durante los siglos XIX y XX, conocer cómo están relacionados con la creciente presión antrópica sobre la isla y, mediante el análisis de inventarios fitosociológicos disponibles en la bibliografía, elucidar los factores ambientales responsables de los patrones de la distribución de las especies y comunidades. Los resultados indican que la flora de esta isla ha sido severamente afectada por la presencia humana temporal o permanente: numerosas especies se han extinguido, mientras otras han sido introducidas por primera vez –en las visitas realizadas se han detectado cinco neófitos-. Pese al bajo número de especies de la isla, ha albergado cuatro táxones endémicos: *Anacyclus alboranensis*, *Senecio alboranicus*, *Frankenia corymbosa* subsp. *alboranensis* y *Diplotaxis siettiana*, aunque el último está probablemente extinto hoy día en el medio natural. La perturbación antrópica y, en menor medida, la salinidad edáfica son probablemente los factores que más influyen en la composición específica de los rodales y en su distribución espacial en la isla. Además, la desaparición de algunos hábitats específicos –e.g. suelos arenosos no estabilizados- y la creación y sobre-representación de hábitats antrópicos son probablemente los principales factores responsables de las variaciones florísticas acontecidas en la Isla de Alborán en los últimos dos siglos.

Palabras clave: alteración de los hábitats, especies ruderales, extinción, halofilia, neófitos, perturbación antrópica, sammofilia.

Introduction and aims

The Isle of Alborán, of only 7 ha of extent harbours a low species number. However, three of these taxa are endemic to the island: *Anacyclus alboranensis* Esteve & Varo, *Senecio alboranicus* Maire and *Diplotaxis siettiana* Maire –cataloged as “Extinct” by Anon. (2000)- a circumstance that evidences the botanical interest of the enclave. In the last two centuries, there have been frequent visitors and small settlements on the island, publications in which the vascular plant species composition of the island is reported are available since 1848.

The aim of the present paper was to collect all the information about the island flora in order to investigate the possible floristic changes since 1830 and, if so, the

environmental fluctuations caused by human pressure. This information would be a useful tool to study in further investigations how and why some taxa, such as the island endemism *Diplotaxis siettiana*, became extinct.

Study area

Physical environment

Alborán is a little Spanish volcanic island, latitude 35° 56′ north and longitude 3° 62′ west (Fig. 1). It is located 80 km far from the Spanish coast (Adra) and 60 km from North Africa coast (Cabo Tres Forcas, Morocco). It is flat with an area of 7.12 ha, triangular



Fig. 1 - Location of the island of Alborán

in shape, a little over 15 m above sea level, with a maximum length of 612 m (NE-SW) and maximum width of 275 m (NW-SE).

From a geological point of view, the island is a volcanic, well stratified accumulation of calcic deposits –probably of Miocene origin– with blocks of andesites or basalt-andesite rocks, visible in the cliff faces (IGME, 1983). Given the peculiar mineral profile of these rocks, halfway between basalt and andesite, and their high contents in CaO and low Na₂O contents, Becke (1899) called them alboranites, a special class of volcanic rocks. On the other hand, Hernández-Pacheco & Asensio (1968) considered that the island is an abrasion platform of marine origin covered with Quaternary sediments.

Annual mean temperatures range from 18° C to 20° C, and in the coldest winters temperatures are rarely below 9° C. Average annual rainfall is slightly over 100 mm, usually with none in the summer months (July, August and September).

Historical background: human presence and botanical expeditions

The size of Alborán, the distance to the mainland and the absence of natural water sources made permanent human settlements on the island almost impossible in the past. It was not until 1860, on the construction of an acetylene lighthouse, that there was a permanent human settlement on the island. A succession of lighthouse keepers and their families inhabited the island up to 1966, when the lighthouse was adapted to operate with solar energy and automatic control. The detachment of marines also left after the automation of the lighthouse and no

civil population remained on the island since then. The Spanish Navy maintained a new detachment there from 1968 to 1994, when the heliport and the first army Nissen huts were built. In the following four years the military presence was intermittent. Almost three years ago, a new permanent military settlement was established and a dock is now being built for the fishing fleet.

The first recorded scientific expedition to the island took place in 1830, when Webb and Berthelot (1848), on their way back from the Canary Islands, visited Alborán. Other expeditions during the 19th century were in 1876 Dávila, 1881 Mac Pherson, 1882 Captain E. D'Alberty. Some of these expeditions were sponsored by generous aristocrats, such as the Archduke of Austria Louis Salvator in 1898 or Prince Albert of Monaco in 1896, in which the zoologists J. Richard y H. Neuville (1897) took part. Although these expeditions provided data on the vegetation, it was not until 1932, with Sietti's expedition, that a comprehensive recording of the island flora was carried out. In his inventory a total of 6 vascular plants and 5 lichens are mentioned (Sietti, 1933). Two of the phanerogams collected by Sietti (*Diplotaxis siettiana* and *Senecio alboranicus*) were recorded for the first time and were described by Maire (1933).

The next scientific expedition to the island took place in 1970 and was carried out by the botanists F. Esteve Chueca and J. Varo Alcalá. They provided us with a more updated inventory of flora and a vegetation map (Esteve & Varo, *op. cit.*). The inventory includes five taxa non previously recorded on the island, being *Anacyclus alboranensis* described as a new taxon. About *Diplotaxis siettiana* these authors say, "It is particularly abundant in the SW part of the island; in fact, on the sandy platform west of the lighthouse, almost no other taxa, apart from *Frankenia corymbosa alboranensis*, are to be found".

In June 1974 Gómez-Campo visited the island and estimated the population of *Diplotaxis siettiana* in some 150-200 individuals (Gómez Campo, 1978; 1979; 1981), all of them growing in the area near the helicopter landing platform. In his study Gómez Campo does not mention any other species since the study of *Diplotaxis* populations was his main interest.

The next botanical expedition to the island took place 15 years later (Génova *et al.*, 1986). This expedition provided a new vegetation map of the island and an inventory of 9 species. For the first time *Diplotaxis siettiana* is declared in danger of extinction, since no individual could be found. Gómez-Campo (1987) considers this species extinct in its wild state.

According to Martínez Laborde (1993), the expeditions carried out between 1984 and 1990 failed to find any individual of this cruciferous. Plants obtained from seeds collected in 1974 were reintroduced onto the island with no success (Hernández-Bermejo & Clemente, 1994).

During recent years (1996-99), we have visited the island on a regular basis and we have only once (24th June, 1997) recorded the presence of three individuals of *Diplotaxis siettiana*, all of them in reproductive stage. Fortunately, there was a store of seeds collected in 1974, and from these seeds reproduction techniques carried out in Madrid during 1975 and 1976 have increased this supply to 60.000 new seeds (Gómez-Campo, 1978). Some of these seeds were donated to the Botanical Garden of Córdoba, which provided the 48 seedlings we reintroduced on 7th April 1999.

Methods

Taking as a starting point the first reliable plant inventory of the island by Sietti (*op. cit.*), the proportion of invader taxa since 1932 can be determined. Esteve & Varo (*op. cit.*) have drawn vegetation maps and carried out phytosociological inventories using the Braun-Blanquet method, and Génova *et al.* (*op. cit.*) provide valuable cartographic analyses. In order to make the most accurate use of these data, we have plotted an updated vegetation map of the island with the aid of photographs taken either from the lighthouse or from a helicopter. To make an updated assessment of the floristic changes accounted in Alborán and compare them with the previous reports, we visited the island in five different but consecutive years (from 1996 to 1999) and always in springtime.

Data on island vegetation -helpful in determining both the ecology of plant communities- and the variable distribution of the taxa on the island are also available in literature. Thus, the phytosociological relevés sampled in 1972 by Esteve & Varo (*op. cit.*) have been computerised by multivariate analysis (DCA, Detrended Correspondence Analysis) with the aid of the PC-ORD programme (McCune & Mefford, 1995; 1997). Our aim was to determine the ecological groups of the island and the environmental factors influencing the species composition of the island communities in order to find out the likely reasons for the recorded extinction of certain species accounted throughout time.

Nomenclature: Esteve & Varo (1972); Valdés *et al.* (1987).

Results and discussion

A. The flora of Alborán

A comprehensive collection of records provided by all scientific expeditions to Alborán include a total of 18 plant species. However, the inventories carried out before Sietti's (*op. cit.*) can be considered neither reliable nor exhaustive. Sietti's report mentioned six species, but did not include five of the species recorded by Esteve & Varo (*op. cit.*). This same variation can be seen when comparing successive inventories: new recordings are noted while other previously mentioned taxa are missing (Tab. 1).

Generally speaking, human presence has tended to increase the number of species on the island. This tendency can be deduced by comparing recently elaborated lists, in which botanists have taken part. The most recently recorded taxa on the island (*Salsola kali* L., *Halogeton sativus* (Loefl. ex L.) Moq., *Heliotropium europaeum* L. and *Mesembryanthemum cristallinum* L.) support this point of view. They thrive particularly well on ruderal and man-altered habitats. On the contrary, *Triplachne nitens* (Guss.) Link, a psammophilous therophyte, has not been recorded in recent years. To declare a plant on Alborán extinct is, however, a difficult task. Many plants are annuals and scientific expeditions have not taken place on a sufficiently regular basis. In the case of *Triplachne nitens*, despite its therophytic nature and as observed in the Mediterranean coasts, the dried stalks of the plant remain visible after the plant has died, which makes difficult to believe that the plant presence on the island was not noted by botanists explorers. *Polycarpon tetraphyllum* L., another therophyte peculiar to sand dunes, has not been recorded on the island since 1970. These two species grew mostly in the area near to the heliport (Esteve & Varo, *op. cit.*), as did the last individuals of *Diplotaxis siettiana* recorded by Gómez-Campo (1978; 1979) and by us in 1997.

B. Vegetation

The first catalogues of the flora of Alborán (Richard & Neville, *op. cit.*; Louis Salvador, *op. cit.*) mentioned only two species: *Frankenia corymbosa* Desf. subsp. *alboranensis* Esteve & Varo and *Mesembryanthemum nodiflorum* L. Later, this same description was given by Fernández-Navarro (1907), "The island surface is very flat and is covered by poor and unattractive vegetation, almost exclusively by one *Frankenia* and *Mesembryanthemum nodiflorum*". Sietti (*op. cit.*) also

Tab. 1 - Species recorded by different expeditions from Alborán: the last four columns contain data from our visits. Gómez Campo's expedition (1974) is not shown because in his study he only mentions the endemism *Diplotaxis siettiana*.

Species	Webb & Berthelot, 1848	Richard & Neuville, 1896	Sietti, 1933	Esteve & Varo, 1972	Génova <i>et al.</i> , 1986	1996	1997	1998	1999
	Last years expeditions								
<i>Mesembryanthemum nodiflorum</i>	-	Very abundant	Very abundant	Very abundant	Very abundant	Very abundant	Very abundant	Very abundant	Very abundant
<i>Frankenia corymbosa</i>	-	Very abundant	Very abundant	Very abundant	Very abundant	Very abundant	Very abundant	Very abundant	Very abundant
<i>Diplotaxis siettiana</i>	-	-	Abundant	Abundant	-	-	Very rare	-	Reintroduced
<i>Lavatera mauritanica</i>	-	-	Rare	Rare	Abundant	Very abundant	Very abundant	Very abundant	Very abundant
<i>Senecio alboranicus</i>	-	-	Abundant	Abundant	Rare	Abundant	Abundant	Abundant	Very abundant
<i>Chenopodium murale</i>	-	-	Rare	-	Rare	Very rare	Very rare	Rare	Abundant
<i>Triplachne nitens</i>	-	-	-	Abundant	Rare	-	-	-	-
<i>Spergularia bocconei</i>	-	-	-	Rare	Rare	Rare	Rare	Rare	Very abundant
<i>Polycarpon tetraphyllum</i>	-	-	-	Rare	-	-	-	-	-
<i>Frankenia pulverulenta</i>	-	-	-	Very rare	Very rare	Very rare	Very rare	-	-
<i>Anacyclus alboranensis</i>	-	-	-	Abundant	Very abundant	Very abundant	Very abundant	Very abundant	Very abundant
<i>Lycium europaeum</i>	+	-	-	-	-	-	-	-	-
<i>Asphodelus</i> spp	+	-	-	-	-	-	-	-	-
<i>Echium plantagineum</i>	-	-	-	-	-	Very rare	-	-	-
<i>Salsola kali</i>	-	-	-	-	-	Very rare	Rare	Rare	Rare
<i>Halogeton sativus</i>	-	-	-	-	-	Very rare	Very rare	-	-
<i>Heliotropium europaeum</i>	-	-	-	-	-	-	Very rare	-	-
<i>Mesembryanthemum cristallinum</i>	-	-	-	-	-	-	-	Very rare	-

mentions these two taxa as the most abundant ones on the island.

The most detailed description of the island vegetation was provided by Esteve & Varo (*op. cit.*).

According to them, the vegetation was that typical of coastal settled dunes, being dominated by *Frankenia corymbosa* subsp. *alboranensis*. Other taxa co-existing with these two species characterised various facies of Alborán vegetation: *Triplachne nitens* and *Senecio alboranicus* in the sandiest areas, being the remaining species nitrophilous introduced either by man or animals.

According to Génova *et al.* (*op. cit.*), the island vegetation is dominated by *Mesembryanthemum nodiflorum* and, to a lesser extent, by *Frankenia corymbosa* subsp. *alboranensis*. Therophytes are the best represented, many of them well adapted to salty or ruderal-nitrophilous habitats (e.g. *Anacyclus alboranensis*, *Lavatera mauritanica* Duv.). Outstanding is the case of *Spergularia bocconei* (Scheele) Asch., reported as a 'Rare species' in the last decades and found as very abundant in our most recent visits (Tab. 1). All of these species form dense stands near the buildings. After the expedition of Weber & Berthelot in 1830, the only woody species always reported for the island is *Frankenia corymbosa* subsp. *alboranensis* (Tab. 1).

The DCA applied to the inventories of Esteve & Varo (*op. cit.*) yielded 0.74 as first eigenvalue and 0.21 as the second. The first two axes were stable for the varied numbers of segments defined. The ordination diagram (Fig. 2) clearly indicates the presence of two gradients. Axis 1 is proportional to the intensity of human pressure on the habitats, with *Lavatera mauritanica* and *Anacyclus alboranensis* showing the highest values. On the other hand, the more halophytic a species is, the higher values it has along the second axis of the diagram. Psammophilous or superficially rooted plants tend to appear on the opposite site of this second axis. Nowadays the most widely extended stand is that of *Frankenia corymbosa* subsp. *alboranensis*, in which *Mesembryanthemum nodiflorum* is also abundant (Fig. 2). Both of them tend to form mono-specific patches. Nevertheless, in recent years *Lavatera mauritanica* has spread more than any other species on the island. Maps of 1972 and 1986 show its aggressive expansion and its dependence upon extremely altered grounds, a circumstance that explain its position on the right extreme of Axis 1 (Fig. 3).

C. Habitats modification

The populations of several taxa as that of

Diplotaxis siettiana, *Polycarpon tetraphyllum* or *Triplachne nitens* have vanished, mostly due to the reduction of their natural habitats as a result of building (a heliport, Nissen huts, the communications aerial, the lighthouse cemetery, and other constructions). Sand extraction for such buildings and the removal of soil with the consequently alteration of the environment; in conjunction with a augment of salts in soil –the heliport and the nearby area were frequently sprayed with sea water (Génova *et al.*, *op. cit.*)– may also have played a great role in these extinctions favouring habitat modification. To this list of human impacts, the frequent visits by fishermen, pirates, lighthouse keepers and military detachments on the island, must be added. In addition, natural factors, such as the strong winds blowing salt and sand onto the unsteady sandy-soil, the enormous number of colonies of seagulls (especially in the north of the island), the small size of the area, which determines small population sizes of plant stands-, the isolation and harsh climatic conditions, can help to explain the habitats instability, the reduced size of populations and their low recovering capability after human-impacts.

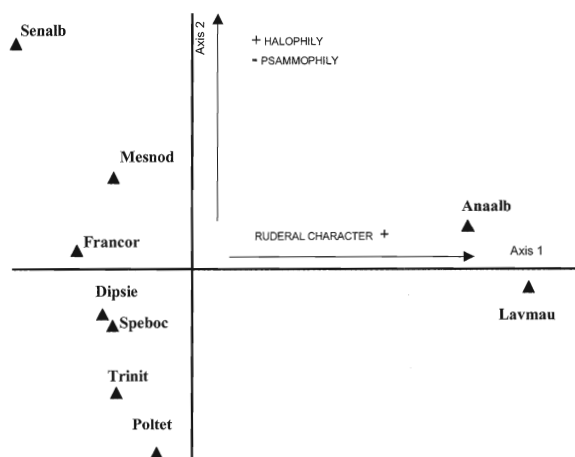


Fig. 2 - Species ordination diagram of phytosociological samples (from Esteve & Varo, *op. cit.*) analysed by Detrended Correspondence Analysis (DCA). Scientific names of the species are abbreviated (Trinit: *Triplachne nitens*; Dipsie: *Diplotaxis siettiana*; Poltet: *Polycarpon tetraphyllum*; Speboc: *Spergularia bocconei*; Francor: *Frankenia corymbosa* subsp. *alboranensis*; Mesnod: *Mesembryanthemum nodiflorum*; Senalb: *Senecio alboranicus*; Lavmau: *Lavatera mauritanica*; Anaalb: *Anacyclus alboranensis*)

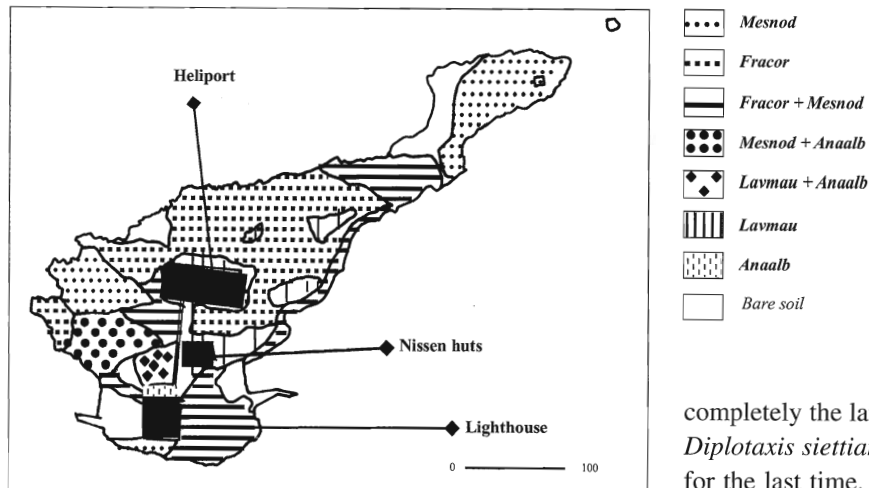


Fig. 3 - Vegetation map of Alborán. It shows some of the buildings mentioned in the text. Scientific names of the dominant species are abbreviated (see Fig. 2)

Conclusions

Conclusions about the extinctions and new arrivals of plant species in Alborán must be made carefully given the lack of deep botanical knowledge in the expeditions conducted before that of Sietti in 1933 and given the large ephemeral character of island flora. This, for example, must have been the case of *Chenopodium murale* L., unrecorded by Esteve & Varo (*op. cit.*) despite of having been reported by Sietti (*op. cit.*). However, this is not probably applicable to the majority of species. Thus, *Anacyclus alboranensis* (= *A. valentinus* according to Génova *et al.*, *op. cit.*) was, in our view, a newcomer when it was first recorded on the island. Its presence cannot be easily missed because, despite being an annual, the dry plants remain visible all year as happens with *Triplachne nitens*.

In the cases of *Polycarpon tetraphyllum* and *Triplachne nitens*, since in recent years researchers have failed to find any individual on the island, extinction may be a hypothesis. Nevertheless, it would be wise to implement a systematic search programme before coming to this conclusion since the seed bank has not been sufficiently studied and favourable weather conditions could trigger the appearance of new seedlings. In this respect, the comparison of data for *Senecio alboranicus* along time clearly revealed significant changes in the populations.

The position of *Diplotaxis siettiana* in the DCA with respect to axis 2 confirms the psammophilous character

of this species, already noted by some authors (Gómez-Campo, 1981; Esteve & Varo, *op. cit.*).

It is unlikely that this species will colonise the altered new habitats on grounds where this species settled, especially so if it proves to exhibit more psammophilous than ruderal character. At present, *Lavatera mauritanica* surrounds almost completely the landing platform, where individuals of *Diplotaxis siettiana* (Gómez-Campo, 1978) were seen for the last time. *Anacyclus alboranensis* is also very abundant in the area around the heliport. Although we do not know exactly how close the individuals of *Diplotaxis siettiana* found in 1974 were to the landing platform, the three individuals that we recorded in 1997 were exactly at the foot of this platform, which strongly suggests that they had been reintroduced by man.

Cartographical data on vegetation (Esteve & Varo, *op. cit.*; Génova *et al.*, *op. cit.*) have been very useful in determining the changes in the composition of the flora over a long period of time. From these data it is easy to conclude that *Frankenia coymbosa* subsp. *alboranensis* and *Mesembryanthemum nodiflorum* have always been the most abundant species, but that the populations of *Anacyclus alboranensis* and *Lavatera mauritanica* have increased considerably. Given the ruderal character of these two taxa, always present near buildings or debris grounds, their increased number can only be interpreted as the sign of an ever more man-influenced island. *Salsola kali*, *Halogeton sativus* and *Heliotropium europaeum*, three neophytes recorded here for the first time, occur in this kind of environment, close to the lighthouse and alongside the paths leading to the landing stage. Undoubtedly, the island continues to import flora. The mono-specific stands of *Mesembryanthemum nodiflorum* are to be found only on grounds recently affected by fires or sand extraction.

As in many other cases (Davis *et al.*, 1986; Primack, 1993; Meffe & Carroll, 1997), the critical situation or the extinction of species on Alborán is due to the destruction of habitats. Thus, sand extraction to construct the heliport has probably buried the most important seed bank of *Diplotaxis siettiana* under the concrete platform. Generally speaking, the ruderal taxa tend to substitute the coastal-psammophilous ones.

In conclusion, the destruction of pristine habitats must be considered as responsible for the critical situation or

actual disappearance of the plant populations on Alborán that characterised the island before humans established permanently.

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