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THE MEDITERRANEAN REGION A MAJOR CENTRE OF PLANT DIVERSITY

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ABSTRACT

The Mediterranean is a major world centre of plant diversity, although this fact tends to be overlooked in global considerations when emphasis tends to be placed on the great richness and diversity of the plant life that occurs in tropical regions. The Mediterranean basin not only houses some 25-30 000 species, up to 50% of which are endemic to the region but is also a major centre of crop origins and diversity. The reasons for reasons for this diversity are discussed; and opportunities for agricultural and social development and the problems of conservation are reviewed.

KEY-WORDS

MEDITERRANEAN, FLORISTIC DIVERSITY, CENTRES OF DIVERSITY, WILD RELATIVES, ISLAND FLORAS

MOTS-CLES

MEDITERRANEEN, DIVERSITE FLORISTIQUE, CENTRES DE DIVERSITE, PARENTS SAUVAGES, FLORES DES ILES

INTRODUCTION

Although we talk about the Mediterranean region, it is not a geographical unity (Quézel 1985). In practice it is a difficult area to define since it is not coincide with any political delimitation and is made up of a series of territories that surround an almost enclosed sea but only some parts of the countries bordering the it, such as Spain and France, can be considered Mediterranean in a true sense. The region includes a diversity of ecological conditions, a range of different climates and has had a very diverse history. Various definitions based on bioclimate, biogeography or floristics have been proposed as discussed by Quézel (1985) but there is no completely diagnostic set of criteria that can be used although a delimitation based on bioclimatic criteria (summer is the driest period and there is a period of effective physiological drought – Daget 1997) is most widely employed today. The map given by Quézel (1985) is based on such criteria.

The importance of the Mediterranean region derives from a number of considerations (based partly on Heywood 1977):

(1) The Mediterranean region is one of the world's major centres of plant diversity containing 11 of the 231 centres selected for their global importance (Davis *et al.* 1994).

(2) The region is one of the centres of diversity for crop plants (Harlan 1995; Hawkes 1995).

(3) Many crop relatives occur in the Mediterranean basin (Heywood and Zohary 1995; Zohary and Hopf 1993).

(4) The region covers some 2.3 million km^2 that represents some 1.6% of the land surface yet contains about 10% of the world's flowering plants (Quézel 1985; Quézel & Medail 1995; Greuter 1991, Heywood 1991, 1995).

(5) The flora of the Mediterranean region is floristically rich in comparison with adjacent temperate and desert regions. As a whole it comprises approximately 24–25 000 species (or approximately 29–30 500 taxa including subspecies) (Greuter 1991; Heywood 1995; Quézel 1985, 1995).

(6) High number of species are found in unit areas. Thus Naveh & Whittaker (1977) report having found sites in Mediterranean Israel that have as many species per 0.1 ha sample plots as have been found for woody species in sample areas in Ecuador. Likewise Greuter (1991) found that after plotting taxon numbers against area sizes that the flora of the Mediterranean region as a whole is about twice as large as would be expected, even though deserts make up half of its total surface area without adding significantly to floristic diversity.

(7) The high degree of local endemism. It has been estimated by Quézel that about 50% of the flora is endemic to the region while Greuter (1991) in his analysis of the flora based on the published volumes of MedChecklist gives an extrapolated figure of nearly 37.5% are considered to be locally endemic (i.e. confined to a single area) and 63.5% endemic to the region covered by the Med-Checklist (see below under floristic diversity). Certain countries or areas in the region are especially rich in endemics: about half the 5000 species of the flora of Spain and half the endemics occur in the Baetic and Sub-Baetic sierras; and Sierra Nevada itself within that region contains 2000 vascular plants within an area of 2000 km^2 and includes the highest concentration of endemic species in the Iberian Peninsula – more than 250 of which 85 are restricted to the massif, 170 are peninsular endemics and more than 200 ibero-african.

(8) The high degree of human interference and disturbance of the vegetation, a process that dates back over ten thousand years, that has been responsible for the transformation of much of the native vegetation and led to the formation of many secondary or subseral communities such as the characteristic shrubland communities (maquis, phrygana, matorral, garrigue, etc.) that form such a conspicuous part of Mediterranean landscapes. Naveh and Dan (1973) described the region as a whole as 'composed of innumerable variants of different degradation and regeneration phases'. The various components of this human disturbance are largely responsible for the high degree of floristic and ecological diversity shown by the region. In particular fire (Trabaud 1981), water stress, grazing (Le Houerou 1981) and cutting. Fire in particular has been a powerful factor in the evolution and differentiation of the Mediterranean flora and Naveh (1991) considers it the driving force in the co-evolution of Mediterranean humans and landscapes in the Pleistocene.

(9) The dry summers and the restricted seasonal rainfall that allow the development of a mosaic pattern of different soil types. Different combinations of species are adapted to grow on these different soil types. This diversity of spoil types, along with varied topography and altitudinal variation has led to active evolution and adaptive radiation in several groups.

(10) The year to year variations in climate that have been particularly marked in recent years (part of the global patterns of climate change) have had significant effects, especially on annual species whose population size may suffered major changes from season to season.

(11) The high percentage of annual species in the flora, especially in families such as the *Caryophyllaceae*, *Cruciferae*, *Compositae*, *Umbelliferae*.

(12) The large number of exotic or invasive species that have become established in the region. In a reverse direction, many Mediterranean weeds are noxious weeds in other parts of the world (Heywood 1989).

THE GLOBAL AND REGIONAL CONTEXT

The plant diversity of the Mediterranean area, especially as regards its conservation and sustainable use, has to be viewed in the light of several major developments that have had an influence on our attitudes to biodiversity in general and to the conservation of genetic diversity in particular. The Convention on Biological Diversity (CBD) that had been signed at the UN Conference on Environment and Development at Rio de Janeiro in 1992 came into effect on 29 December 1993 and placed biodiversity on the international scene. It required the parties to take the necessary steps to consider ways of inventorying and monitoring their biological resources so as to ensure their conservation and sustainable use. The Convention specifically mentions species and communities that are of medicinal, agricultural or other economic value and wild relatives of domesticated or cultivated species.

The Global Plan of Action, adopted by 150 countries and the European Community at the International Technical Conference on Plant Genetic Resources, convened by FAO in June 1995, promotes the conservation and use of wild plants for food and agricultural production. The Mediterranean preparatory meeting for the Conference emphasised the need to develop under-utilised species of the region for food and non-food use, including stress-tolerant species.

In the Mediterranean basin, the Mediterranean Action Plant (MAP) for the protection and development of the Mediterranean basin as adopted in 1975 by 17 states bordering the Mediterranean sea and the European Community. Amongst its other aims, it recognized the need for integrated planning of the development and management of the resources of the Mediterranean basin. Within the framework of the Mediterranean Action Plan a Blue Plan was established in 1979 to study alternatives for the future of the region by assessing interactions between populations, resources, the environment and development. The aims of the MEDUSA Network fall clearly into this framework by focusing on international cooperation, sharing of knowledge and experience.

In addition, there are two pieces of European legislation that concern us here.

The first is the Bern Convention on the Conservation of European Wildlife and Habitats that came into effect in 1982. Appendix I (Strictly Protected Plant Species) of the Convention lists about 500 species, including some of the wild relatives of European cultivated plants. It is now being extended and in December 1996, a further 107 Central and Eastern European species were added. In addition, the Standing Committee decided to implement a recommendation to create a network (called the 'Emerald Network') that is similar to the EU Natura 2000 network and is intended to cover the whole of Europe. The Group of experts on the conservation of plants of the Bern Convention is also encouraging the preparation of Action Plans for threatened species.

The second is the EU Habitats Directive which was adopted in June 1992 and makes provisions for the conservation of habitats and species (other than birds). Under the Directive, member states are required to create special areas for conservation (SACs) to conserve the sites of a given list of threatened species and of threatened habitat types.

Together with national legislation, these agreements provide a background against which the issues concerning Mediterranean plants and communities that occur in Europe have to be viewed. In addition, we must not lose sight of the more general context of the continuing loss or fragmentation of habitats as a result of human activities in most parts of Europe, including areas that have been designated as reserves or sites of special scientific or conservation interest.

LANDSCAPE CHANGES

Agriculture and animal husbandry has been practised in the Mediterranean basin for 10 000 years and most of the ecosystems have been modified by human action (Cowling & al. 1996). Today many plant wild species occur in small, fluctuating and poorly dispersed populations as a result of habitat fragmentation and face extinction or severe genetic loss, but detailed information is lacking. For most of the endangered plant species no conservation measures have been taken and the reserve networks are inadequate. Additionally, knowledge on the use of plant genetic resources by traditional societies is now threatened with extinction.

The landscapes, vegetation and flora of the Mediterranean have been subjected for thousands of years to change on a scale not yet seen on any other continents. Deforestation, transhumance, grazing, agriculture, fire, plantation forestry, introduction of exotic species, urban and industrial development, tourism and population growth and movements have dramatically altered the face of the Mediterranean, especially the European parts, whose biomes are now made up of remnants of natural and semi-natural vegetation in a mosaic of agricultural land, planted forests, wasteland, roads, industrial landscapes and urbanizations.

Recent developments have included:

- changes in agriculture towards large-scale operations;
- merging of farms into larger units'
- loss of boundaries with a consequent loss of biodiversity;
- abandonment of terracing;
- movement away from the land to the towns and cities;
- crop substitution both in terms of individual crops (such as the replacement of root or tubercle crops such as salsify and parsnip by potatoes) or of whole agroecosystems (such as the replacement dryland cultivation in the Mediterranean littoral of almonds, olives, vines, figs, carob by subtropical American species under irrigation such as cherimoya, avocado or horticultural quality crops under plastic (tomato, pepper, courgette, beans) alternating with early potatoes (cf. Nuez and Hernández-Bermejo 1992);
- introduction of new crops and intensive commercial horticulture, including extensive areas devoted to plasticulture (strawberries, tomatoes; ornamentals)
- an increase in the spread of alien and invasive species such as species of *Amaranthus*, *Conyza*, *Phytolacca*, *Oxalis*, etc.;
- invasion by exotics such as *Agave americana* or *Opuntia* that were introduced as living hedge plants displacing other local species as they became naturalized;
- the devastating effects of agricultural, industrial and urban pollution; and
- the endangerment of plant genetic resources by genetic erosion, genetic pollution, and some of the agricultural changes just listed (cf. Jaradat 1995)

Yet most of the Mediterranean's plant species have managed to survive, albeit some of them in small populations, although their habitats – most of our natural biotopes – have been dramatically reduced in area or modified. Nonetheless the continuing pressures on these habitats makes the survival and management of remaining populations of many of our plant wild relatives a complex and demanding task.

FLORISTIC DIVERSITY

The Mediterranean region, as noted above, houses around 25 000 species of flowering plants. It is difficult to give precise figures because no overall floristic assessment of the region has been completed, although a complete catalogue, Med-Checklist is in progress (Greuter & al. 1984–›). Many of the individual territories that comprise the region still do not possess a complete or comprehensive modern Flora although one of the most remarkable phenomena in the last 10-15 years has been the remarkable resurgence of taxonomic activity in some Mediterranean countries. Spain is exceptional in that in addition to the monumental *Flora Iberica* (Castroviejo et al. 1989-) that is underway (5 out of a projected 21 volumes have appeared by April 1997), other major regional works include the *Flora de Andalucia Occidental* (Valdés & al. 1987) and *Flora dels Països Catalans* (Bolòs & al. 1984–) as well as many provincial Floras. Unfortunately these different works do not employ the same classification or nomenclature for many of the species – the same entity may occur in these different works as a species, a subspecies, a variety, or a synonym, and disguised under an array of different name - nor do they always agree with either *Med-Checklist* or *Flora Europaea* (Tutin & Heywood & al., 1964–1980, 1993), all of which cause problems of interpretation of the user.

For some parts of the Mediterranean, floristic and knowledge is still highly incomplete as is the basic field inventory. Estimates of the floristic diversity of the different countries of the Mediterranean are given in Table 1. The It is a matter of priority to produce as rapidly as possible a comprehensive taxonomic survey of the flowering plants of the whole Mediterranean Basin and this is one of the aims of the project Sisyphus of the Euro-Mediterranean Working Group on Plant Systematics.

Again, our knowledge of the demography, population structure, reproductive biology and genetic diversity of most species is limited or virtually non-existent.

CENTRES OF PLANT DIVERSITY

The Mediterranean region contains several major concentrations of plant diversity - sometimes called 'hotspots' (cf. Myers 1990). Centres of diversity may be recognized at local, national, regional and global scales. What is selected at one scale, e.g. nationally, may have little significance at another, e.g. global scale. Sufficient detailed work has now been undertaken for several groups to allow such centres to be located at this scale. In a major survey undertaken by IUCN and WWF of the world's major centres of plant diversity, 234 sites were selected that are considered of global importance for conservation based primarily on plant species richness and endemism (Davis & al. 1994-7). Other characteristics that were taken into account in selecting the sites were the presence of an important gene pool of plants useful to humans, a diverse range of habitat types represented, the presence of a significant proportion of species adapted to special edaphic conditions, and the threat of large-scale devastation.

The location of the sites in the Mediterranean regions is given in Table 2. The sites were selected as a result of extensive consultation with experts, especially those in the countries concerned and were placed in context by the preparation of a major review for each region of its physical characteristics, vegetation, floristics, economically useful plants, factors causing the loss of biodiversity, and conservation, in which many other than those selected for full data sheet treatment were listed and briefly described.

CENTRES OF CROP DIVERSITY

As Harlan (1995) points out, the importance of the Mediterranean as regards crop diversity can be judged by the fact that about a third of the foodstuff used by humankind comes from the

Mediterranean climatic region, if not strictly from the topographic basin proper. The Mediterranean basin was one of the most important of the eight centres of cultivated plant origin and diversity identified by Vavilov although as Hawkes (1995) notes, many cultivated plant prototypes (and many ancient cultures) come from more easterly parts of the Fertile Crescent. Vavilov list over 80 crops but the most important of these are the cereal crops, pulses, fruit tress and vegetables. We should not, however, neglect the economically less important species including notably herbs and spice-producing plants, nor the neglected horticultural crops such as *Eruca sativa*, *Lepidium sativum*, *Portulaca oleracea*, *Smyrnium olusatrum*, *Scolymus hispanicus* (cf. Nuez & Hernández-Bermejo 1992), and the ornamentals, that play an important role in local cultures. Some of these may well be worth consideration for further development and improvement as crops suitable for marginal areas.

Several factors have contributed to this remarkable crop diversity in the Mediterranean (Jana 1995): (a) socio-political such as the political climate and royal interests in agricultural innovation; (b) agroclimatic such as the stress-resistant alleles developed in response to the harsh climatic conditions of the region (see above); (c) ecological such as the habitat diversity that contributes to adaptive diversity in indigenous crops and wild relatives; and (d) genetic such as dynamic interactions between natural and human factors that maintain crop genetic diversity, and evolutionary processes such as geographical isolation, limited gene migration through seed exchange, etc. leading to adaptive divergence and geographical differentiation in crop species.

ISLAND FLORAS

Many of the endemic species occur on islands or on mountains (themselves a form of terrestrial islands). The importance of Mediterranean island plants has led a number of new initiatives recently. One of these was an international conference held in Corsica in October 1993 on 'Knowledge and conservation of the Mediterranean islands flora' that addressed the threats facing the plantlife of these islands and the lack of basic knowledge that still prevails. The results were published as 'Premiers bilans sur la flore des îles de la Méditerranée: Etat de connaissances et état de conservation'. (Olivier & al. 1995). This conference led to the creation of a Plant Specialist Group of the Species Survival Commission in early 1995 and this Group has recently published a strategy for action (Delanoë & al. 1996).

Island floras in general are particularly vulnerable and their future is often very much at risk. The main factors involved on older wooded islands have been summarized by Heywood (1979):

- deforestation and fire giving rise to secondary vegetation, soil erosion and increasing aridity;
- introductions of goats, sheep, etc. leading to excessive grazing;
- cultivation of lower slopes;
- introduction of alien species (weeds, invasive species);

These lead to consequential climatic changes: reduction in rainfall, the establishment and spread of new types of plant community - secondary forest, subseral communities, and the opening up and invasion of marginal habitats by exotics.

At a biological level, several effects then operate such as: breaking down of reproductive barriers, the spread of invasive species and the adaptation of plant populations to the new conditions once established (e.g. escape from inbreeding by the evolution of dioecism), changes in or loss of dispersal mechanism.

WILD RELATIVES

As already noted, the Mediterranean region houses many wild relatives of crop species. A list for Europe has recently been published (Heywood & Zohary 1995) that includes many Mediterranean species and it is hoped to be able to expand this to cover the whole of the region. The volume by Zohary & Hopf (1993), *Domestication of Plants in the Old World* is an invaluable source of information on Mediterranean crop relatives.

The conservation of wild relatives of crop species is a largely neglected field and has only recently come into prominence. The reason for this neglect, as Gómez-Campo (1997) notes, stems from the obvious fact that they are wild species and that consequently the approaches needed for their study and conservation are very different from those that have been applied to the cultivars or landraces of agricultural crops. Much experience has been gained by agricultural genetic resource agencies and seed banks in undertaking ecogeographical surveys, formulating collecting and sampling strategies, seed storage, establishment and maintenance of field gene banks, clonal collections, tissue and cell culture, cryopreservation and germination studies, but we have little experience so far of applying or adapting this for wild species. Conservation agencies and organizations for their part acquired great experience of setting up and managing protected area systems and in identifying rare and endangered wild species but have paid little heed to the genetic conservation and gene banking on the one hand banking or to conserving target species within protected areas on the other. The series of workshops that originated from the Council of Europe Group of Specialists on Biodiversity and Biosubsistence (Valdés & al. 1997) marks is a convergence of interest between the agricultural (and forestry) genetic resource sector and the conservation sector.

Some of the conclusions drawn from the these workshops (Heywood 1997) are as follows:

- the need for an integrated multidisciplinary approach to solving the problems of the conservation and sustainable use of these plants. The range of disciplines involved is remarkably wide, including genetics, plant breeding, population biology, population genetics, demography, phytochemistry, molecular biology, taxonomy, ecology, sociology, legislation, seed physiology, gene bank management, protected area management, and conservation biology.
- the conservation of wild relatives of tree species is quite different in many respects from that of agricultural and horticultural crop species. This is very evident from several of the papers, especially those in Section VII (Protection of genetic variability in forest tree populations). The *in situ/ex situ* separation that plagues other areas of conservation breaks down here and the sampling and conservation methods (and even the terminology) are special.
- Following on from this last point, another general conclusion made by several papers is that the situations described in so many of the groups and species are so complex, and as we have seen, multidisciplinary, that an integrated approach to conservation is required in which *in situ*, *ex situ*, *in vitro*, static, dynamic, reintroduction or whatever approaches are appropriate are applied. Undue stress on any one approach for political reasons should be avoided.

INSTITUTIONAL RESOURCES

The European part of the Mediterranean houses a number of the world's leading plant science institutions. Important herbaria include those of Barcelona, Coimbra, Lisbon, Lyon, Montpellier, Madrid, Florence, Rome, Palermo, Athens, Kifissia.

The region also contains a large number of botanic gardens - at least 100 – including some of the earliest to be founded in the world (in the Western tradition) such as Pisa, Padua, Florence, Bologna and Montpellier and some of the most recent foundations such as Cordoba (see map in

Ramade Fig. 15 (1990)) and the French Conservatoires Botaniques Nationaux at Gap-Charance and Porquerolles (part of a national chain) whose role under a mandate form the Ministry of the Environment is specifically to protect the plantlife of the region in which they are situated. These gardens represent a major resource for the study, conservation and sustainable use of the plant resources of the Mediterranean region.

CONCLUSIONS

The diversity of plantlife in the Mediterranean basin has been a major source for humankind for millennia. Today this diversity is at risk, not for the first time but now on an unprecedented scale as a result of changes in agricultural practice, industrialization and mass tourism. As Greuter (1996) comments '... the Mediterranean ... is threatened by the very culture it engendered, a culture which has become dangerous and destructive.' If we are to continue to profit from the cornucopia of plant diversity for agricultural improvement and social development, then we must ensure that our knowledge is sufficient for us to make wise choices when establishing priorities for conservation and sustainable use.

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Table 1: Floristic diversity of the countries of the Mediterranean Basin
(After Quézel & Medail 1995)

Sources unless otherwise indicated: (a) Davis *et al.* (1986) and (b) Quézel (1985). Contrary evidence (c): original observations, (d) Enriquez Barroso & Gómez-Campo (1991), (e) Bartolo ***et al.*** (1987), (f) Davis *et al.* (1994), (g) Davis (1988), (h) Iatrou, pers. comm., (I) Polunin (1987), (j) J.P. Roux, *pers. comm.* (k) National Spanish List, (l) Gómez-Campo *et al.* (1984). The figures do not include subspecies unless preceded by an asterisk.

[1] Continental.

Country	Total surface	Area in Km^2 Mediterranean	Number of species Total	Number of species In Med.Region	Number & % number	Number & % %
Morocco	659900	300000	*4800	*3800	*(d)829	19.7
Algeria	2381000	300000	3150	2700	*(d)256	8.1
Tunisia	164000	100000	1800	1600	*(d)39	2.2
Libya	1759000	100000	1600	1400	*(d)140	8.7
Egypt	1000000	15000	2100	1100	70	3.3
Israel	20700	10000	2200	2000	*(f)165	6.6
Jordan	97600	10000	2200	(c)1800	(f)145	7
Syria	185000	50000	3100	(c)2600	*(f)395	10.6
Lebanon	10400	10000	2600	2600	(f)311	12
Turkey	779000	48000	8600	5000	(g)2651	30,8
Greece[1]	131900	100000	6450	*4000	(h)1350	20.9
Albania	28700	20000	3000	2000	46	1.5
Jugoslavia	255000	40000	5000	2500	137	2.75
Italy[1]	251400	200000	(c)4870	(c)3850	570	11.7
France[1]	549600	50000	4800	3200	(j)180	3.75
Spain[1]	504000	400000	7500	5000	*(k)730	9.7
Portugal	91000	70000	3100	2500	(l)114	3.7

Table 2: Centres of plant diversity in the Mediterranean region
(from Davis & al. 1994)

North Africa
(Mediterranean Regional Centre of Endemism)

Af83.	Al Jabal al Akhdar (Libya)
Af.84	**High Atlas** (Morocco)

Europe
Iberian Peninsula

Eu1.	Peneda-Gêres (Portugal)
Eu2.	Serra da Estrêla (Portugal)
Eu3.	Algarve (Portugal)
Eu4.	**Baetic and Sub-Baetic Mountains** (Spain)
Eu5.	Guadalquivir Estuary and Coto Doñana (Spain)
Eu6.	Sierra de Gredos and Sierra de Guadarrama (Spain)
Eu7.	**Massifs of Gudar and Jabalambre** (Spain)
Eu8.	Picos de Europe (Spain)
Eu9.	Islas Baleares (Spain)

Southern Europe

Eu12.	Appennini and Alpe Apuane

Aegean Region and Cyprus

Eu13.	Tyrrhenian Islands: Corsica, Sardinia, Sicily and offshore islands (France, Italy)
Eu15.	Mount Olympus (Thessalian Olympus (Greece)
Eu16.	**Mountains of Southern and Central Greece** (Greece)
Eu17.	**Crete** (Greece)
Eu18.	**Troodos Mountains** (Cyprus)

South-West Asia
(Mediterranean Regional Centre of Endemism)

SWA15.	**Isaurian, Lycaonian** and **Cilician Taurus** (Turkey)
SWA16.	**South-west Anatolia** (Turkey)
SWA7.	Levantine Uplands (Turkey, Syria, Lebanon, Israel, Jordan)
SWA19.	**North-east Anatolia** (Turkey)
SWA.20	Ulu Dağ (Turkey)

Sites selected for full data sheet treatment in *Centres of Plant Diversity* appear in **bold.**