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Diversity of Mediterranean island floras

Abstract

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The awareness of the importance of exploring and safeguarding the floristic diversity of Mediterranean islands has increased dramatically in the last few years. A symposium on the topic was held in Ajaccio, Corsica, in October 1993. Since then, a Mediterranean Islands Plant Specialist Group has been established within IUCN's Species Survival Commission, which has developed a strategic plan for action. From this document, it is obvious that there is still a major "taxonomic impediment", or lack of basic knowledge of the plants themselves, that hinders the implementation of fully operational action plans for the efficient safeguard of the Mediterranean islands' botanical patrimony. A number of relevant questions is addressed here, such as: How much do island floras contribute to the floristic diversity of the Mediterranean region as a whole? What is the historical, evolutionary background of today's insular floras? To what extent did human activities either enrich or deplete these floras? How well are island plants known, and where are our gaps of knowledge? What kinds of islands and island habitats, being particularly at risk and of special interest, offer themselves as prime targets for future, scientifically based action plans?

Introduction

What are islands, biologically speaking? Are they areas of salvation for past diversity no longer competitive? Are they traps in which immigrant elephants get caught, to become dwarfed and eventually die out? Or are they the very furnaces of creative evolution in which the world's diversity has been and is being forged? The sad fact is: no one appears to know for certain. What we probably can assert with some confidence is that islands are threatened areas, threatened by Man, threatened in whatever role they may play in the context of the world's biological heritage.

Recently the islands of the Mediterranean Sea have become a focal point for conservation-orientated plant biologists. This renewed interest was triggered by a symposium on "The state of knowledge and conservation of the flora of the islands of the Mediterranean", held in Ajaccio, Corsica, in October 1993 (Muracciole & Olivier 1995). The concluding synthesis of that symposium (Olivier & al. 1995) had its first concrete spin-off in the creation of a Mediterranean Islands Plant Specialist Group within IUCN's Species Survival

Commission, which in turn commissioned a "Strategy for action" for the conservation of Mediterranean island plants (Delanoë & al. 1996), a text which, remarkably, emphasises most prominently the need for further research. OPTIMA, one of the sponsoring organisms of the Ajaccio symposium, has quite naturally decided to devote a special symposium of its 1998 Meeting in Paris to discuss the plant diversity of Mediterranean islands.

Islands and plant diversity

At the Sixth OPTIMA Meeting in Delphi I had attempted a first statistical analysis of botanical diversity of the Mediterranean area as a whole and of its individual countries, an analysis that was subsequently expanded to cover all three published volumes of *Med-Checklist* (Greuter 1991a). It became then evident that the circum-Mediterranean countries house almost one tenth of the world's vascular flora and are therefore one of the major centres of botanical diversity of the globe; and that this high diversity is not due to a particularly great number of species being present in any one place. In fact, local species densities in Germany and those observed in the countries surrounding the Mediterranean Sea are of the same order of magnitude.

The real cause of the floristic wealth of the Med-Checklist region is the high incidence of species with a narrow distributional range, many of them local endemics (Fig. 1), which makes increase of species number in relation to area much steeper than it is elsewhere. In terms of species number to area relation, the main islands and island groups of the Mediterranean do not deviate to any significant degree from the overall diversity pattern on the mainland surrounding the Mediterranean Sea (discounting those with a large Saharo-Arabian desert portion). Major islands and mainland areas all group around one straight, relatively steep progression line when a double logarithmic scale is applied (Fig. 2).

One obvious and perhaps the main reason of high endemism is the pronounced fragmentation that characterises the Mediterranean area as a whole, and of which the islands scattered over the Mediterranean Sea are the most palpable and most durable expression. It is therefore appropriate to ask whether the figures presently available support the assumption that endemism is particularly high on the islands when compared to mainland areas. At a first glance, such a hypothesis does not appear to hold true, when we note endemism rates of 19 % for peninsular Spain, 20 % for Morocco, and 31 % for Anatolia, as compared to barely 12 % for the Cretan area, 9 % for Cyprus, 8 % for the Balearic Islands, and down to less than 1 % for Malta. But these figures are misleading since endemism rates will naturally tend to increase as the area of reference widens (to reach 100 % when the globe as a whole is considered). A double logarithmic diagram (Fig. 3) plotting numbers of endemic taxa (species and additional subspecies) against surface area neatly resolves the Med-Checklist territories (again omitting the poor, largely desertic ones) into two groups: all insular areas are rich in endemics when compared with the mainland territories around the Mediterranean Sea. It is of note that Greece (which includes many islands) and the Crimea (almost insular in nature) come closest to the island level of endemism among the mainland areas; whereas France, being predominantly non-Mediterranean, is on the low side with regard to endemism.

At this point we should ask ourselves about the biological meaning of the term "island". We all know its common-language sense of a land surrounded by water. Land life on islands is isolated, the term isolation being derived from the Latin equivalent of island, *insula.* But

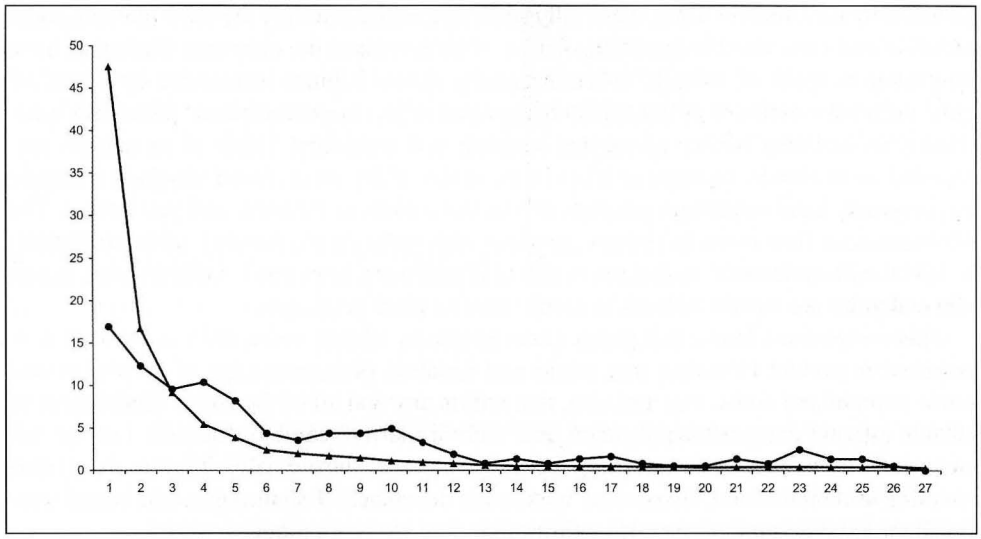

Fig. 1. Frequencies (ordinate: % of wild taxa [species + subspecies]) of range sizes (abscissa: number of territories in which each taxon occurs) for the Mediterranean flora (▲ –▲ –▲) and for extra-Mediterranean Europe (●–●–●). From Greuter (1991), based on *Med-Checklist* (Greuter & al. 1984-1989) and a sample from *Flora europaea* (Tutin & al. 1964-1980), respectively.

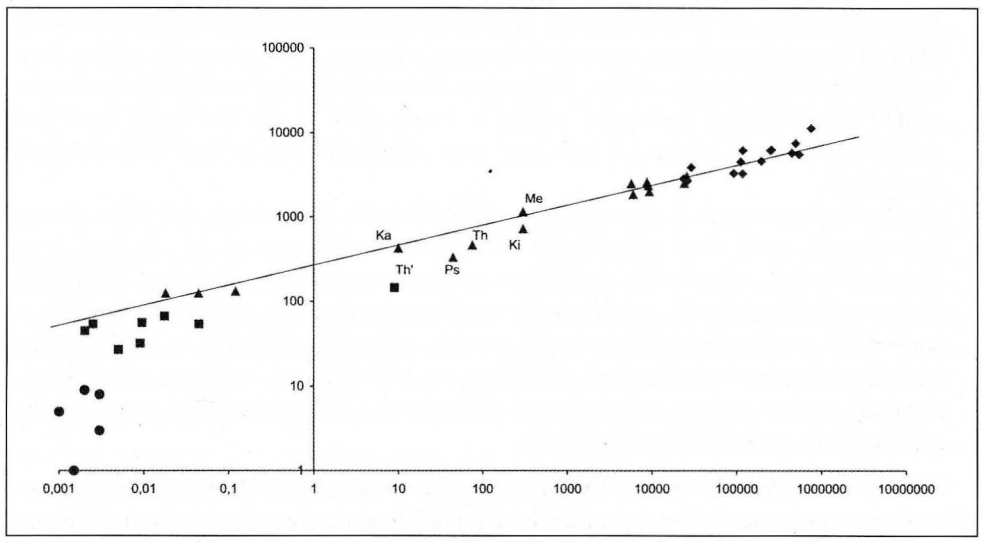

Fig. 2. A double logarithmic plot of taxon numbers (ordinate) against surface area (abscissa: km^2): left, islets near Karpathos (from Fig. 4); right, Med-Checklist territories (from Greuter & al. 1984-1989, see Greuter 1991; predominantly desertic territories [Sn, Eg, Li, Tn, Ag] are omitted); centre, selected islands: Ka = Kastellorizo (Greuter 1979), Ki = Kithira (Giannitsaros 1969), Me = Malta (Greuter 1991), Ps = Psara (Greuter 1976), Th = Thira and Th' = Thirasia (Hansen 1971). – Mainland areas (◆); insular areas regularly (▲), occasionally (■), and hardly affected by Man (●).

isolation by surrounding water, especially sea water, while certainly the most obvious, most effective and most durable form of isolation, is by no means the only one. Biologists have long taken to speak of "islands" when discussing special habitats surrounded by a "sea" of quite different conditions of life, which being more or less impermeable to "island life" constitutes an isolating barrier of varying strength and durability. Think of mountains surrounded by lowlands, swamps or lakes in the midst of dry areas, forest stands in a steppic environment, local serpentine outcrops or limestone cliffs or canyons, and you have it. The Mediterranean flora owes its richness to many such isolation phenomena, often prominently linked with endemism, so that terms like cliff endemics, serpentine endemics, and mountain endemics are current notions in Mediterranean plant geography.

This symposium, hence this paper, concentrates on islands in the strict sense. It is nevertheless important to realise that island and isolation phenomena are of general occurrence in mainland areas, too; and also, that within any and all of the larger Mediterranean islands internal compartmentalisation and "sub-insularity" can be observed. Let me ask and briefly try to answer the question: is insularity proper substantially different from other isolating situations? and, if so, what makes the difference? I shall argue that island confinement has a certain number of qualities that does make it unique.

- Islands are easily defined and circumscribed, and can be found on any map. They have a sharp outer edge. Literature data can be more easily and more confidently linked to individual islands than to any other kind of isolated habitats, except perhaps lakes (which are in a way "negative islands").
- Islands show much more permanence over time than other kinds of isolated biota. Although islands are known at times to have fused among themselves and with continents in the geological past, or to have become submerged or have newly arisen, these are slow or rare processes, which furthermore in some cases can be reliably documented and dated through geological evidence. Coast lines do far less easily shift than boundaries between habitats, which may react dramatically to perhaps minor climate fluctuations.
- Finally, the open sea is a more impermeable barrier for all kinds of land plants than is solid ground, even when inhospitable. On the swell and surge of the sea there is no chance for small, ephemerous stepping-stone populations to get established, no way for diaspore-carrying animals to cross unless they choose to swim, no perches for migrating birds to shorten flight distances (or, speaking of genetic isolation: no resting places for pollen-carrying insects either). Salt water will kill off most swimming propagules in a matter of hours or days, and those that might survive will be deposited in saline habitats hostile to most non-littoral species.

Perhaps we should add a point that is mainly psychological. Islands, true islands I mean, have always had a particular appeal for biologists. They are closed systems, definite and clearly delimited targets for research, and are furthermore in many a way natural laboratories in which a number of questions related to biogeography, general biology and evolution can be studied. In the Mediterranean the choice is yours: there are about 5000 of them, varying in size from a few metres square to the extent of Sicily, with any degree of complexity, diversity, age, geological structure, whatever. Just define your problem and choose the island or islet tailored to your needs. And remember: you may need a boat to get there!

Islands and plant evolution

The study of adaptive radiation has been at the forefront of the island biogeographers' endeavours ever since Darwin brought up the example of the Galapagos finches. Yet, fascinating as it is, adaptive radiation is by no means a universal island phenomenon. On the contrary, it is virtually absent from Mediterranean islands, at least as far as plants are concerned. Whenever you look closely at examples of variable, polymorphic groups you are likely to find mosaic patterns of geographical vicariance rather than sympatric niche differentiation concomitant with speciation, as is thought to be characteristic of genuine adaptive radiation. To find good examples of the latter, in higher plants, you will have to go to remote volcanic islands and island groups in the width of the oceans.

As I have found many years ago (Greuter 1979a), the floras of islands split off from a mainland (chersogenous islands) do not lend themselves to creative evolution to the same degree as the sea-born (thalassogenous) islands do. In the latter, initially, empty space offers itself for a few newcomers to expand and adapt. The chersogenous islands, to which all Mediterranean islands of an appreciable size belong, already carried their own, fully adapted and diversified flora when they became insular. No empty space could they offer, no special challenges to new colonists, no new horizons.

It turns out, on closer inspection, that chersogenous islands differ fundamentally in their properties from the thalassogenous ones. They are conservative systems, remarkably well buffered against the effects of climatic and evolutionary change. When on the mainland climatic changes of seemingly trivial amplitude may result in sweeping changes of the flora and vegetation, in large-scale migrations due to shifting balances of competitiveness,

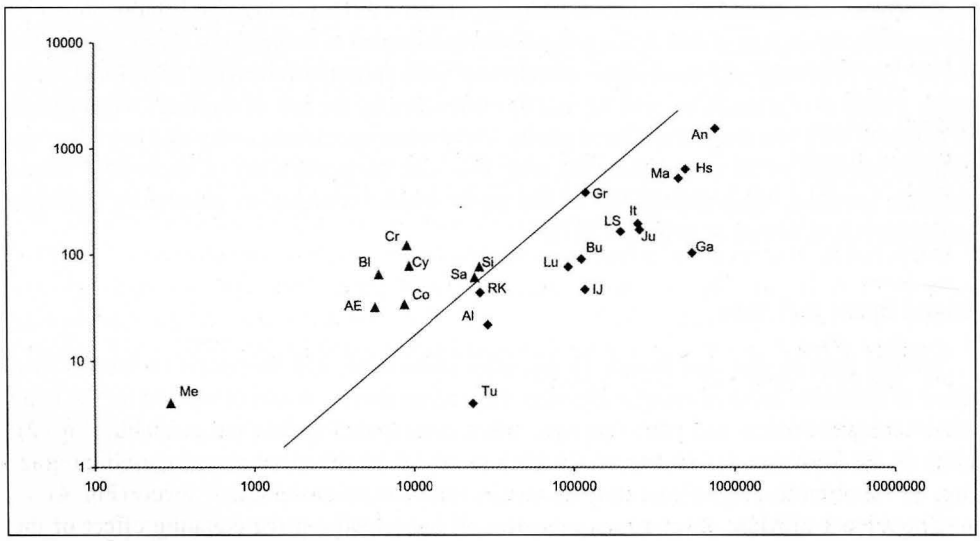

Fig. 3. A double logarithmic plot of numbers of taxa endemic to single Mediterranean territories (ordinate) against surface area (abscissa: km^2); only taxa treated in the published volumes of Med-Checklist (Greuter & al. 1984-1989; see Greuter 1991) are considered; predominantly desertic territories (Sn, Eg, Li, Tn, Ag) are omitted. — Mainland areas (◆) and insular areas (▲) are distinguished.

and in the replacement and loss of whole floras, the effects of these same changes on island floras are apparently minimal. This is easily explained when one compares the wide range of physiological tolerance of plants with the often very narrow and specialised ecological niches to which they are confined in nature, under competitive stress. Just compare the rich array of plants happily growing in your rockery (provided you don't neglect weeding) with the completely different, much poorer selection of species growing outside in the wild.

What is the conclusion? Ideally, the flora of each island can be considered to be a reflection, perhaps impoverished but otherwise little changed, of the plant cover it was bearing at the time when it became insular. Under this assumption, and since islands budded off from the continents at various times of the past and in different parts of the Mediterranean region, we would expect that they are nowadays the sanctuaries in which much of the floras of the past, extinct elsewhere, may have survived.

Reality is not, of course, quite so ideal. Even on islands species go extinct when they are no longer adapted to environmental conditions that change profoundly over the aeons. The Mediterranean islands are no Jurassic Parks (quite apart from the fact that they are much younger than Jurassic in origin). Still they host a conservative flora, rich in old relic elements that did not survive elsewhere.

Looking at present plant distribution in much-fragmented insular areas such as the Aegean archipelago, notably at patterns of geographical differentiation and vicariance, one cannot escape the conclusion little if any evolutionary change has taken place since these islands were formed. The examples of plant taxa that have remained identical on either side of old isolation barriers, or that show patterns of variation that take no account of the present distribution of land and sea, are too numerous to be explained away as resulting from recent long-range migration. Statistical models (Runemark 1969), supported by the scant observations that have been made so far (e.g., Höner 1991), predict that establishment of newcomers on an island following long-distance dispersal is an unlikely if not impossible event. The offspring of a newcomer, which may have sprouted following occasional long-range transport of a diaspore, will be readily eliminated by the law of numbers when forced to compete with seedlings from local plants. Only when species diversity and overall competitive strength of an island flora are very low will the probability of successful immigrations increase significantly, up to the point when immigration eventually balances extinction (MacArthur & Wilson 1967).

Island floras and Man

Models thus predict that islands floras, after some time, will be poorer in species than those of mainland areas of comparable size. This, remember, is not what we find for the large Mediterranean islands and island groups, when corresponding data are available (Fig. 2). Only on the most minute of islets, which are not only uninhabited but not even used for grazing, do we observe a significant drop of species numbers below "normal" levels (Fig. 4).

The advent of Man, we must assume, has all but wiped out the isolating effect of the sea. By the shipping trade of goods, plants and animals Man has, accidentally and sometimes purposely, introduced large quantities of alien propagules into suitably cleared, man-made new habitats, or at least into a degraded, unbalanced environment. The effect may perhaps, to some extent, have been the elimination of vulnerable old relic species. If such

losses did happen, it must have been long before reliable botanical records were made. There are some cues (Greuter 1994) pointing to a – rather unspectacular – prehistoric or early historical wave of extinctions in the Mediterranean area, that may most likely have happened in those habitat types which were immediately suitable for agro-pastoral purposes. It is clear, however, that Man has essentially enriched the Mediterranean island floras, has greatly added to its variety if also, at the same time, to its becoming more trivial

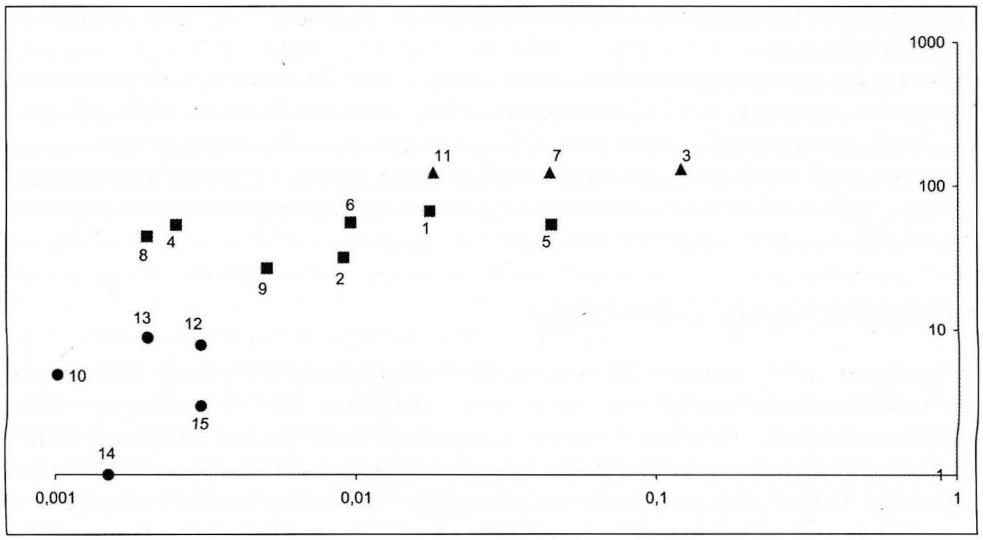

Fig. 4. A double logarithmic plot of numbers of species observed on 15 islets around Karpathos (ordinate; data and islet numbering as in Höner 1991) against their surface area (abscissa: km^2). – Islets regularly (▲), occasionally (■), and hardly affected by Man (●) are distinguished.

It is difficult to quantify the anthropic contribution to Mediterranean island floras. No direct proof exists or is ever likely to be found. Estimates that have been made are, avowedly, sophisticated guesses. That portion of the flora that is at the same time widespread and mainly found in man-made or degraded habitats is likely, at least for the most part, to be archaeophytic. It is would be hopeless, though, to try and classify each individual taxon in this way. Some old introductions may have become so perfectly integrated in the wild flora that they cannot be told apart from the members of the native stock, while conversely some autochthonous elements may have spread into secondary habitats where they behave like recent weedy invaders. Yet most botanists nowadays would agree that estimates of one third (Crete: Greuter 1971) or almost one half (Psara: Greuter 1976) of the vascular flora of an island having been brought in by Man are by no means shockingly high.

The human impact on Mediterranean island floras, from the early prehistoric settlements through antiquity to the Middle Ages, has been profound but I dare say rather benign. Things have been changing for the worse in the last few decades. The speed of deterioration of natural habitats has increased manifold. Traditional habits are becoming

lost, the scales and standards of the past are no longer valid. Man's attitude toward life alters, his consciousness of being part of an old, traditional, natural and social ecosystem is fading. Comparing the island of Crete of 38 years ago when I first got to know it with the Crete of today is a shocking experience. A modern road network has been built; motor traffic has conquered the remotest areas; garbage production (when formerly every tin and old tire was saved, re-used or re-cycled) is at its peak; agriculture is being mechanised and intensified in suitable areas, abandoned in others; tourism (which includes millions from within Greece) has conquered and spoilt every bit of sandy shore and large stretches of land along the coast.

So far, the deterioration mostly concerns aesthetic and cultural quality. The irremediable species extinctions, the documented ones at least, are exceedingly few. Nothing virtually has been irretrievably lost, most valuables can still be saved or mended. Will we succeed? There are two basic requirements which I believe must be met before we may begin to hope: increased awareness (which is a political and social problem) and improved knowledge. The latter is our own, the biologists', business.

Island plants: what do we know (ignore)

Ignorance is not a problem that is particular to island plants. If anything, island floras are better known than comparable ones from the continents. Yet this point is too fundamental to be ignored in an island context. The political world has just discovered, thanks to the Rio Conference in 1992, that the safeguard of biological diversity world-wide is a vital issue. To their great amazement decision-makers begin to realise what biologists have long known and voiced (e.g., Greuter 1979b): that inadequate knowledge is one of the major problems hampering the development and realisation of rational policies. Research, including basic research into species diversity (or biological taxonomy and floristics, to use more traditional terms) made its way, timidly still, into the text of the Rio Convention. Barely five years later a new term is born, officialised by the Third Conference of Parties to the Convention of Biological Diversity: the "taxonomic impediment", which a Global Taxonomic Initiative is now designed to remove.

Our own scientific discipline must stand ready to face new challenges of an unprecedented scale. Taxonomy, when you listen, is presently buzzing as a bee-hive with new plans and activities. Few months ago a workshop on "Removing the Taxonomic Impediment" was held in Darwin, Australia, which resulted in the *Darwin declaration* (Anonymous 1998): a concise and powerful set of statements and recommendations that illustrates for the world at large the promises and present shortcomings of biological taxonomy. The strategic action plan for Mediterranean island plants by Delanoë & al. (1996), just mentioned, highlights the need for scientific research in our own area and was thus in many ways premonitory of the Darwin conclusions.

The fact that every year new plant species are being described from Mediterranean islands, and sometimes genera (Egli & al. 1990), proves that not even the basic inventory of island floras has so far been achieved. Detailed data on within-island distribution are either lacking or incomplete, and few that exist are readily available. The ecological requirements of most species, rare endemics in particular, are not or poorly known. Data on demography, population structure, reproductive biology, vulnerability to pests, diseases

or predation are limited to a few choice species, even though they are of prime importance for conservation managers (see Greuter 1991b). The task ahead is immense (and, as for all science, unending), so let us get started!

Islands: problems and priorities

Since as I have just explained so little is known and so much remains to be done, any attempt do draw conclusions now is hazardous. Let me nevertheless try to flesh out some points of particular concern which, judging from my experience of many years, would seem to deserve some priority action.

My first choice is for the smallest of islands. They are of interest in many ways, first of all as natural laboratories in which to study the processes of island colonisation and species turnover. They have also, in some parts of the Mediterranean, given rise to a peculiar set of specialised, mostly endemic taxa that depend on the particular conditions of small-island life such as low competition and absence of grazing. Dwarf islets are usually short-lived, bound to become submerged or fused to larger islands at the slightest fluctuation of sea level. In order to survive, their inhabitants must therefore be fit to leap on any newly emerging land fragment. Islet ecosystems are known to be extremely vulnerable. Not for nothing, half of the documented extinctions of Mediterranean island endemics concern minute islets (Greuter 1995), which is a horrendous proportion given the small number of small island specialists. One postulate which should, at an early stage, be linked to a research campaign on small-island biota is to restrict the right of visiting the unspoilt, ungrazed ones to local fishermen and scientists, to the exclusion of tourists.

A second, perhaps less obvious and certainly less appetising suggestion is a comparative overview of garbage dumping sites. This idea originates from the hideous experience to see Hania's garbage slowly filling up a coastal canyon with a highly original flora that I had explored ten years earlier, in 1966. Among other rarities, a peculiar local variant of *Hypericum aegypticum* L. was growing in this place, which had been described from there as a distinct species (*Hypericum maritimum* Sieber) and may well have gone extinct. Garbage dumps are among the major environmental problems on Mediterranean islands (and not of them alone), and it is important to make sure that their negative effects be minimised.

Much more ambitious, and perhaps more appealing, is the idea to promote a comparative study of the reproductive biology of endemic island taxa. The way in which rare plants reproduce is critical for their survival, yet desperately little is presently known on this topic. Besides, a good overall knowledge of breeding systems has theoretical value for understanding the constraints of island life and possible evolutionary pathways. A study as I would fancy it would have pollination and pollinators as one of its basic targets, and also seed set and seed predation. I would like to see a workshop organised in which common standards of study and of presentation of the results could be defined, whereupon young taxonomists in many Mediterranean countries could set to work independently but in a co-ordinated fashion.

The spiny, perhaps hopeless problem of the shores I have left to the end. Is there any hope to get at least a representative sample of sandy beaches and coastal dunes protected before they are all ruined? We are up against economy in this struggle, but at least an attempt must be made, today rather than tomorrow. In some cases it may be politically

impossible to save some of the more local endemic species by conserving their habitat. If so, and before they vanish completely, ex-situ conservation should be used as a last resort.

Let me not finish on a pessimistic note. Awareness of conservation problems is growing in many Mediterranean countries, and if powerful help can be generated, if sufficient good-will and know-how can be found, we are still in time to prevent major losses. Let us hope that we can hand down unspoilt, to the generations to come, that incredibly rich and valuable natural patrimony: the biota of the islands in the Mediterranean Sea.

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