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Patterns and correlates of exotic and endemic plant taxa in the Balearic islands

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ABSTRACT

We analysed the taxonomy and biogeography of endemic and exotic plants in the Balearic Islands (Spain), one of the "hot-spots" of the Mediterranean Basin. Richness, diversity and density (number of taxa/$\log_{10}$ area) of exotic taxa (species and subspecies) is higher than that of endemic taxa. Mallorca is the island with the highest number of endemic and exotic taxa. On average, exotic and endemic taxa are little abundant or rare and represent 8.4% and 6% of the total flora, respectively. The taxonomic distribution of both exotic and endemic species is not random: Solanaceae, Amaranthaceae, Iridaceae and Euphorbiaceae are over-represented families within the exotic taxa. Plumbaginaceae, Labiatae and Rubiaceae are over-represented among endemics. While most exotic taxa are therophytes, chamaephytes are the dominant life-form among endemics. Exotics are mainly found in cultivated areas, in disturbed and ruderal communities, while most endemics are located in rocky habitats. Coastal communities display a great proportion of endemic taxa (35.94 %), and are little represented by exotic taxa (5.94 %). It is in this habitat where most effort should be addressed in order to preserve both endemic and non-endemic native vegetation.

Key words: commonness, conservation of islands, endemism, Mallorca, Pithyusic Islands, rarity

RESUME

Nous avons analysé la taxonomie et la biogéographie des plantes endémiques et exotiques des îles Baléares (Espagne), l'un des "hot-spots" du bassin méditerranéen. La richesse, la diversité et la densité (nombre de taxa/$\log_{10}$ zones) des taxa exotiques (espèces et sous-espèces) sont plus élevées que celles des taxa endémiques. Majorque est l'île ayant le plus grand nombre de taxa endémiques et exotiques. En moyenne, les taxa exotiques et endémiques sont peu abondants ou rares, et représentent respectivement 8,4% et 6% de la flore totale. La répartition taxonomique des espèces exotiques et endémiques n'est pas aléatoire : les Solanaceae, Amaranthaceae, Iridaceae et Euphorbiaceae sont les familles sur-représentées parmi les exotiques. Les Plumbaginaceae, Labiatae et Rubiaceae sont sur-représentées parmi les endémiques. Tandis que la plupart des taxa exotiques sont des thérophytes, les chamaephytes constituent la forme de vie dominante parmi les endémiques. Les espèces exotiques se rencontrent principalement dans les zones cultivées et les communautés perturbées et rudérales, alors que la plupart des endémiques s'observent dans les habitats rocheux. Les communautés côtières affichent une grande proportion de taxa endémiques (35,94 %), mais peu de taxa exotiques (5,94 %). Ce sont dans ces biotopes littoraux que la plupart des efforts devraient être entrepris afin de préserver la végétation indigène, endémique et non-endémique.

Mots-clés : fréquence, conservation des îles, endémisme, Majorque, îles Pithyuses, rareté

INTRODUCTION

There is a great interest in understanding the processes that shape the ecology of endemic and introduced species (e.g. Gaston, 1994; Drake *et al.*, 1989, respectively). This concern requests a strong previous knowledge of the diversity and abundance patterns of these taxa (McIntyre, 1992; Schwartz, 1993; Cowling & Samways, 1995). On the other hand, preservation of endemic species and control of introduced species are two main goals of conservation programmes world-wide that often are simultaneously carried out (Usher, 1986; Houston & Scheiner, 1995; Schierenbeck, 1995). Thus research on the distribution patterns of endemics and exotics at the regional level and taxonomic, biological and ecological affinities of both groups of taxa is imperative to highlight hypothesis to be experimentally tested, and also to advance on basic knowledge for conservation practices.

Islands have high levels of plant endemism. The best examples are found in big isolated islands such as Madagascar with 12.000 species 80 % of wich are endemic or New Zealand with 82 % endemic species. Endemics are also common in small islands: Canary Islands (612 endemics), Mauricio Island (280 endemics), Madeira Islands (129 endemics) (Lean & Hinrichsen, 1990). In the Mediterranean Basin, the Tyrrhenian Islands are one of the 10 "hot-spots" of species diversity and have almost 20 % of endemic plant taxa (Médail & Quézel, 1997).

Endemic plant species are especially vulnerable in islands (Eliasson, 1995). For example, more than 90 % of endemic plants in Sta. Elena, Ascension Island and Lord Howe island are endangered (Lean & Hinrichsen, 1990). Intrinsic causes of vulnerability are related to the characteristics of insular species such as biological simplicity and reduced dispersal (Carlquist, 1965; Eliasson, 1995; Cody & McCoverton 1996; Schiffman 1997). However, the main causes of such vulnerability are overexploitation, deforestation, habitat destruction, alteration of regional hydrological cycles, water pollution and species introductions.

Islands are very vulnerable to biological invasions (Loope & Mueller-Dombois, 1989; Atkinson & Cameron, 1993; McDonald & Cooper, 1995). The percentage of exotic plant species is very high in islands, i.e. Hawaii (44 %), New Zealand (40 %), British Islands (43 %), Ascension Island (83 %) (Vitousek *et al.*, 1997). This high fraction of exotic species may be related to higher invasibility of islands due to higher number of releases and propagules per unit area, a lack of biotic mechanisms controlling invasion, the existence of unsaturated communities, high disturbance regimes, higher susceptibility to the effects of invaders than similar mainland areas (D'Antonio & Dudley, 1995) and also to a large perimeter-area ratio than that for continents (Lonsdale, 1999).

The Balearic Islands have a high species diversity (Simon, 1994) and are rich in endemic taxa (Gómez-Campo *et al.*, 1984). Endemic plants have been studied with regard to evolutionary origin based on cytotaxonomy analysis (Cardona & Contandriopoulos, 1979; Contandriopoulos & Cardona, 1984). However, the diversity and distribution of endemic taxa has not been quantified and compared to that of the exotic component. In this study we analyse several aspects of the diversity and distribution of both the endemic and the exotic component of the Balearic flora. The questions are: 1) Are endemic and exotic taxa similarly abundant? 2) Are there taxonomic and life-history similarities between endemic and exotic taxa? 3) In which communities are endemic and exotic taxa located? The biogeographic origin of exotics is also commented. We base our study on a bibliographic survey.

METHODS

Area of study

The Balearic Islands are the most eastern islands of the Mediterranean Basin and belong together with Corsica, Sardenia and Sicily to the Tyrrhenian Islands. They originated after the geologic drift and posterior rotation of 30º of the Cyrno-Sardinian plate at the end of the Oligocene and early Miocene from the adjacent coast of Provence, Languedoc and NE Catalonia. Materials are calcareous from the Triassic to the tertiary except in Menorca, where the geology is more heterogeneous and contains silicic esquists. The flora is typically Mediterranean dominated by evergreen sclerophyllous shrubs and forests. The Balearic Islands form two different groups in terms of their geology and endemism. The eastern Balearic Islands or Gymnesias Islands (Mallorca and Menorca) that have Tyrrhenian affinities, and the western Balearic Islands or Pithyusic Islands (Eivissa and Formentera) that have an Iberian and North African affinity.

Bibliographic survey

A data base with species and subspecies (taxa hereafter) was created with all endemic and exotic taxa of the Balearic Islands according to "Flora Manual del Països Catalans" (Bolòs *et al.*, 1993). We chose this flora because it is the most complete and modern of this region. Screening a single flora guaranties homogeneity in nomenclature and homogeneous taxonomic treatment between endemics and exotics. Furthermore, using this flora instead of detailed taxonomic monographies minimises author's effects in subdividing genera into more or fewer species according to the taxonomic approach. It is for this reason that we did not use the following references: Bonafé (1977-1980), Contandriopoulos & Cardona (1984), Pla *et al.* (1992) or Romo (1994).

Endemic taxa were easily identified, although taxa listed as endemic may not be exclusively endemic to the Balearic Islands but also endemic in adjacent NE continental regions (Catalonia or Valencia) and Corsica or Sardenia Islands.

Exotic taxa were those considered in the flora as subspontaneous, adventicious, introduced or naturalised. Species listed as "cultivated" or "planted" were excluded, as well as those that were rarely found as subspontaneous or their naturalisation status was uncertain. Thus our list is not over-represented in exotics. The following information for each taxon was gathered: family, life-form (Raunkiaer, 1934), habitat and origin if exotic.

Bolòs *et al.* (1993) considers three biogeographic regions: Mallorca, Menorca and Pithyusic Islands. For each biogeographic region and for the Balearic Islands in general, we calculated: 1) richness of endemic and exotic taxa as the absolute number of endemic and exotic taxa respectively, 2) percentage of exotic and endemic taxa from the total, 3) density of endemic and exotic taxa as the ratio of endemic and exotic taxa to $\log_{10}$ area (Rejmánek & Randall, 1994) and 4) family diversity of endemic and exotic taxa calculated by the Shannon index: $S = -Epi \times \log_e pi$ where *pi* is the number of endemic or exotic taxa in family *i* divided by the total number of endemic or exotic taxa, respectively (Solbrig, 1994). The number of taxa per family was compared by a t-test after ln transformation of data and evenness expressed by the CV.

To test whether endemics were taxonomically random assemblages, over-representation of main endemic families was assessed by comparing the ratio p_{en} = (endemic taxa within a family/total number of endemic taxa) with the ratio p_{nn}= (native non-endemic taxa within a family/total number of native non-endemic taxa) performing a X^2 test (Cowling & Hilton-Taylor, 1997). Likewise, over-representation of main exotic families was assessed by comparing the ratio p_{ex} = (exotic taxa within a family/total number of exotic taxa) with the ratio p_n = (native taxa within a family/total number of native taxa).

For each biogeographic region and for the Balearic Islands in general we calculated an abundance index for endemic and exotic taxa by assigning the following values to the abundance nomenclature used by Bolòs *et al.* (1993): 1= RRR (very rare), 2 = RR (rare), 3 = R (not abundant), 4 = C (relatively common), 5 = CC (common) and 6 = CCC (very common). This abundance index is an estimation of the geographic range of the taxa within the Balearic Islands.

RESULTS

Diversity of endemic taxa

In the Balearic Islands there are 89 endemic taxa distributed in 29 families that represent 6 % of the total number of taxa. One species is a Pteridophyte, 5 monocotyledons and 23 dicotyledons. Density of endemics is 24 taxa per 10 km² and family diversity is 2.92 (Table 1).

Families with endemics have in average 3 taxa per family (Figure 1). The families with more endemic taxa are Plumbaginaceae (14), Fabaceae (12), Compositae (9), Labiatae (7), Umbelliferae (6), Scrophulariaceae (4) and Rubiaceae (4). Plumbaginaceae, Labiatae and Rubiaceae are over-represented among native taxa (Table 2).

Most endemic taxa are chamaephytes (44.94 %) followed by hemicryptophytes (26.97 %), nanophanerophytes (13.48 %), geophytes (7.87 %) and therophytes (5.62 %). Macrophanerophytes (1.12 %) is the less represented life-form (Table 3).

Region	Area (km2)	No. endemics (%)	No. endemics/log_{10} area	Family diversity[a]	Abundance[b]
Balearic Islands	5014	89 (6)	24	2.9	2.2
Mallorca	3655.9	70 (5.8)	19.6	2.6	2.3
Menorca	701.8	39 (4.4)	13.7	2.5	2.6
Pithyusic Islands	623.3	26 (2.3)	9.3	2.9	2.4

Pithyusic Islands = Eivissa and Formentera.

[a]Calculated as the Shannon index = $-\Sigma p_i x \ln p_i$ where p_i is the number of endemic taxa in family *i* divided by the total number of endemic taxa.

[b] Median value of 1= RRR (very rare), 2 = RR (rare), 3 = R (not abundant), 4 = C (relatively common), 5 = CC (common) and 6 = CCC (very common) according to Bolòs et al (1993) nomenclature.

Table 1. Numbers of endemic taxa of the Balearic Islands

Family	No. endemic taxa (%)1	No. native non-endemic taxa (%)1	X^2
Plumbaginaceae	14 (15.7)	18 (1.3)	627.7 *
Fabaceae	12 (13.5)	132 (9.7)	1.5 ns
Asteraceae	9 (10.1)	151 (11.1)	0.0 ns
Labiatae	7 (7.8)	46 (3.4)	6.5 *
Umbelliferae	6 (6.7)	52 (3.8)	2.5 ns
Scrophulariaceae	4 (4.5)	46 (3.4)	0.3 ns
Rubiaceae	4 (4.5)	24 (1.8)	4.2 *
Caryophyllaceae	3 (3.4)	59 (4.3)	0.3 ns
Euphorbiaceae	3 (3.4)	26 (1.9)	1.0 ns
Ranunculaceae	3 (3.4)	29 (2.1)	0.65 ns

[1] *number of taxa in the family/total number of taxa of the respective group*

* $p < 0.05$, ns = not significant. X^2 compares the no. endemic taxa (%) with the no. native non-endemic taxa (%). If significant, the family is over-represented.

Table 2. The ten largest families of endemic taxa in the Balearic Islands

Lifeform	% endemics	% exotics
Therophytes	5.6	37.9
Hemicryptophytes	27.0	17.7
Nanophanerophytes	13.5	5.6
Macrophanerophytes	1.1	11.3
Phanerophytes	-	5.6
Chamaephytes	44.9	12.1
Geophytes	7.9	9.7

Table 3. Percentage of lifeforms of endemic and exotic taxa in the Balearic Islands

Distribution and abundance of the endemic taxa

Of the 89 endemic taxa, 5 are also endemic in other north-eastern regions of Spain: *Medicago arborea* subsp. *citrina* (Papilionaceae) also endemic to Columbretes islands (Valencia), *Asplenium petrarchae* subsp. *majoricum* (Polypodiaceae), *Asperula cynanchica* subsp. *paui* (Rubiaceae) and *Saxifraga corsica* subsp. *cossoniana* (Saxifragaceae) are also present in Valencia and *Limonium gobertii* (Plumbaginaceae) is also endemic to Catalonia.

Mallorca is the island with most endemic taxa, and with the highest density and family diversity of endemic taxa. Endemic taxa have low abundance (R) or are rare (RR) in all islands (Table 1).

Most endemic plants occur on rocky habitats (64 %) in the mountaintops mainly in non coastal sites (39.36 %). Coastal communities also display a great proportion of endemic plants (35.11 %). Only 7 taxa are located in ruderal communities. There are 10 endemic taxa in shrublands and only two in forests (Table 4).

Diversity and origin of the exotic taxa

The Balearic Islands display 124 exotic taxa distributed in 46 families that represent 8.4% of the total flora. Only one exotic species is a gymnosperm, 17 are monocotyledons and 106 are dicotyledons. Density and family diversity for exotics are 33.5 and 3.31 respectively (Table 5).

Habitat	No. endemic taxa (%)	No. exotic taxa (%)
Non-littoral rocks	37 (39.4)	6 (4.9)
Coastal	33 (35.1)	6 (4.9)
Shrublands	10 (10.6)	2 (2.0)
Ruderal	7 (7.4)	52 (51.5)
Grasslands	3 (3.2)	3 (3.0)
Forests	2 (2.1)	2 (2.0)
Ponds, riparian	2 (2.1)	11 (10.9)
Crops, fallows	-	19 (18.8)

Table 4. Habitat classification of endemic and exotic taxa from the Balearic Islands

Region	Area (km2)	No. exotics (%)	No. exotics/$\log_{10}$ area	Family diversity[a]	Abundance[b]
Balearic Islands	5014	124 (8.4)	33.5	3.3	2.6
Mallorca	3655.9	117 (8.8)	32.8	3.3	2.6
Menorca	701.8	62 (6.6)	21.8	3.1	3.1
Pithyusic Islands	623.3	65 (5.3)	23.2	3.2	3.1

Pithyusic Islands = Eivissa and Formentera.

[a] Calculated as the Shannon index = $-Ep_i x \ln p_i$ where p_i is the number of exotic taxa in family i divided by the total number of exotic taxa.

[b] Median value of 1= RRR (very rare), 2 = RR (rare), 3 = R (not abundant), 4 = C (relatively common), 5 = CC (common) and 6 = CCC (very common) according to Bolòs et al (1993) nomenclature.

Table 5. Numbers of exotic taxa of the Balearic Islands

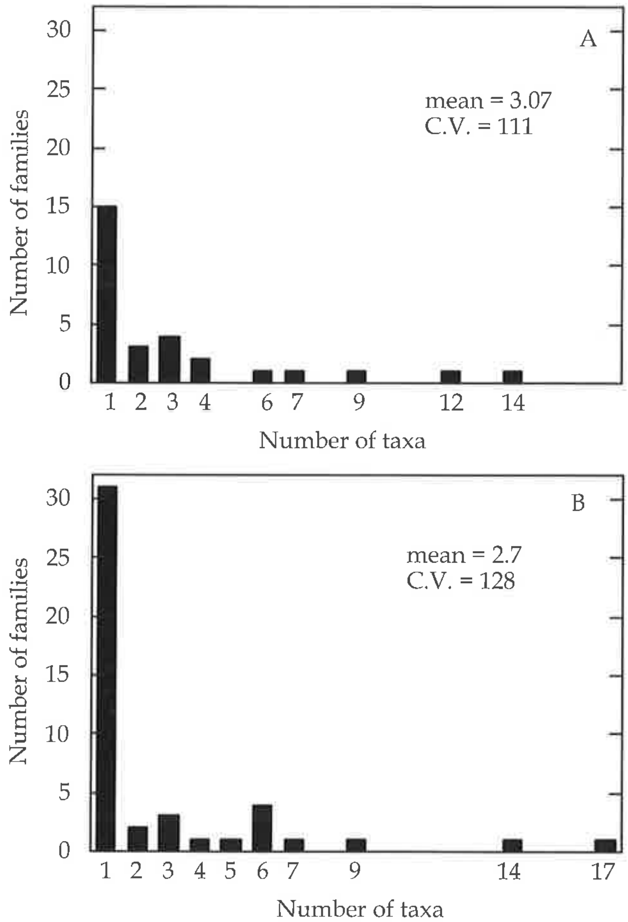

Figure 1. Frequency distribution of the number of endemic (A) and exotic (B) taxa (species and subspecies) per family

As for endemics, distribution of taxa among families is strongly skewed with most families having only one taxon (Figure 1). The number of taxa per family was not significantly different between endemics and exotics (t-value = 0.831, p = 0.409, data ln transformed). The families with more exotic taxa are: Asteraceae (17), Fabaceae (14), Solanaceae (9), Poaceae (7), Amaranthaceae (6), Brassicaceae (6), Euphorbiaceae (6), Iridaceae (6), Labiatae (5);, Solanaceae, Amaranthaceae, Iridaceae and Euphorbiaceae are over-represented exotic families (Table 6).

Most exotic taxa are therophytes (37.90 %), followed by hemicryptophytes (17.74 %), chamaephytes (12.10 %) and macrophanerophytes (11.29 %). Geophytes (9.68 %), nanophanerophytes (5.65 %) and phanerophytes (5.65 %) are the least represented life-forms (Table 3).

Most exotics have an American (32.83 %) or Mediterranean (19.40 %) origin. Asia is also well represented. Unfortunately, almost 15 % of taxa have an unknown origin (Table 7).

Distribution and abundance of the exotic taxa

Within the archipelago, more than 90 % of exotic taxa are found in Mallorca. Only two exotic taxa are exclusively found in Menorca (*Lepidium spinosum* and *Hedysarum coronarium*) and five in Pithyusic Islands are not present in Mallorca. Menorca is the island with the lowest number of exotic taxa. Density and family diversity follow the same pattern (Table 5).

Exotic taxa in the Balearic Islands have low abundance (R) or are rare (RR), especially in Mallorca. Exotics are significantly less rare than endemics (t-value = 2.096, p = 0.037). In Menorca and Pithyusic Islands exotic taxa are mostly little abundant (R) but relatively common (C). The 7 most abundant exotic taxa in the Balearic Islands are: *Amaranthus retroflexus* subsp. *retroflexus* (Amaranthaceae), *Aster squamatus*, *Conyza bonariensis*, *C. sumatrensis* (Asteraceae), *Arundo donax* (Poaceae), *Oxalis pes-caprae* (Oxalidaceae) and *Ulmus minor* (Ulmaceae).

Most exotic plants are found in ruderal communities (51.48 %) such as old fields, wasting areas, dumps and roadsides. Cultivated fields are also very invaded by exotic taxa (18.81 %). Fifty eight percent of the taxa that invade cultivated areas are also found in ruderal communities. Exotic taxa are also well represented in coastal communities (5.94 %), mainly in dunes and salt marshes (Table 4).

DISCUSSION

Although mediterranean climate regions occupy only 2 % of the world surface, they have high family diversity which conservation status needs to be explored (Cody, 1986; Cowling *et al.*, 1996). This study is the first attempt as far as we know to combine patterns of diversity and abundance of endemic and exotic taxa at the regional level. We found that richness, density and family diversity of exotic taxa is higher than for endemic taxa.

Density of endemic taxa is similar to that of adjacent islands: Corsica (32.98 sp/$\log_{10}$ area) and Sardenia (24.19) (Médail & Verlaque, 1997). Density of exotic taxa is also similar than in other Mediterranean islands. For example, in Corsica there are 473 exotic taxa wich represent a 17% of the total flora. Most of these species set up in the last 20 years (Jeanmonod, 1998). Weber (1997) found that the Flora Europea (1964-1980) listed only 71 exotic species, a value which is less than half of the total number of exotics presented in the present study. Thus, immigration rates of exotic species are extremely high in these islands.

Mallorca is the Balearic island with the highest number of endemic and exotic taxa. The richness of exotic taxa may be related to island area, thus being higher in Mallorca and lower in Menorca. Instead, endemic taxa richness is more related to the geological and evolutionary formation of islands (Contandriopoulos & Cardona, 1984). Mallorca and Menorca with the highest number of taxa have a different origin than Pithyusic Islands.

Our regional survey is consistent with the general assessment that the endemic (Prance & Elias, 1977; Cowling & Hilton-Taylor, 1997) and the exotic (Pysek, 1998; Daehler, 1998) components of a flora are not randomly assemblages of taxa. However, causes underlying these taxonomical patterns are different for both flora components. Endemism of the Balearic Islands is the result of the geologic and insular origin of the islands (Contandriopoulos & Cardona, 1984). In contrast, the exotic component depends on their geographic origin and the equilibrium between propagule pressure and extinction rate (Lonsdale, 1999).

Family	No. exotic taxa (%)[1]	No. native taxa (%)[1]	X^2
Asteraceae	17 (13.7)	160 (10.8)	1.2 ns
Fabaceae	14 (11.3)	144 (9.9)	0.3 ns
Solanaceae	9 (7.2)	16 (1.1)	99.0 ***
Poaceae	7 (5.6)	160 (10.8)	2.8 ns
Amaranthaceae	6 (4.8)	9 (0.6)	78.6 ***
Brassicaceae	6 (4.8)	59 (4)	0.3 ns
Euphorbiaceae	6 (4.8)	29 (2.2)	5.0 *
Iridaceae	6 (4.8)	11 (0.7)	60.7 ***
Labiatae	5 (4)	53 (3.4)	0.1 ns
Chenopodiaceae	4 (3.2)	30 (2.0)	0.9 ns

[1] *number of taxa in the family/total number of taxa of the respective group*
*** $p< 0.001$, * $p< 0.05$, ns = not significant. X^2 compares the no. exotic taxa (%) with the no. native taxa (%). If significant, the family is over-represented.

Table 6. The ten largest families of exotic taxa in the Balearic Islands

Region	No. taxa	% taxa
Non tropical America	26	19.4
Tropical America	18	13.4
Mediterranean region	26	19.4
Africa	13	9.7
Asia	10	7.5
Middle East	10	7.5
Submediterranean region	5	3.7
Tropical	4	3.0
Oceania	2	1.5
Macaronesia	1	0.7
Unknown	19	14.2

Table 7. Biogeographic origin of exotic taxa of the Balearic Islands

In the Balearic Islands, the most represented exotics have an American origin like for other Mediterranean Basin regions (Di Castri, 1989; Groves & Di Castri, 1991), and the families with the largest number of exotic taxa belong also to the largest families world-wide i.e. Asteraceae, Fabaceae, Poaceae (Weber, 1997; Daehler, 1998; Pysek, 1998). However, some families were over-represented. This may partly be explained by deliberate and reiterated introductions of certain taxa and by specific features of these taxa, making them more invasive. It may also reflect the identity of naturalised plants, e.g. the Amaranthaceae contain many weeds in agroecosystems.

There is not a strong overlap of habitats occupied by endemic and exotic taxa. While endemic taxa are located in more isolated pristine habitats, exotic taxa are located in most disturbed habitats, except for coastal communities where an important proportion of both taxa co-occur. These habitats, are the ones where endemics will be most threatened by invasion by exotics. For example, invasion of *Carpobrotus edulis* is very high in the Mallorcan coast and is threatening several endemic *Limonium* spp. (PANDION, 1997). Moreover, in coastal habitats the human influence is the strongest, and this increases the rate of species introduction and threat to endemics.

Isolated edaphic systems appear to be major endemic centres (Gómez-Campo *et al.*, 1984). Besides crop fields, most exotic taxa were found in anthropogenic habitats (dumps, roadsides). Water courses are especially prone to invasion by exotic plants because they act as effective corridors providing a route for the dispersal of water-borne propagules (de Waal *et al.*, 1994). Very few exotics succeed in closed forest and shrublands. Low disturbance levels may prevent invasion of closed forest and shrublands (Hobbs & Huenneke, 1992).

Often the term rarity is confused with that of endangered taxa but they are not synonyms (Kruckeberg & Rabinowitz, 1985). It is important to notice that in average both endemic and exotic taxa are rare. However, putative mechanisms of rarefaction are different in both group of taxa and their fate may also discourse in opposite directions. At the human scale, we have witnessed changes from common to rare in native taxa and from rare to common in exotic taxa (Kruckeberg & Rabinowitz, 1985). The rarity status of exotic taxa does not prevent their invasion status either. Because rarity depends on geographical range, habitat specificity and population size, one exotic taxa can be restricted to a small geographical area but be very abundant or vice-versa, have widespread small populations. In both cases its presence may be considered invasive and may have an impact on the native biota and ecosystem functioning (Rabinowitz *et al.*, 1986).

Endemics and exotics are two faces of the same coin because management of both taxa have strong conservation implications. Five percent of the overall flora of the Balearic Islands is seriously endangered (Mus & Mayol, 1993). In addition, new introduced species are becoming naturalised (Fraga & Pallicer, 1998). Because low-altitude areas are both fairly rich in threatened endemic taxa and exotic taxa there is a need to tackle conservation priorities in these habitats and to reduce main threats which are from more to less important: tourism, fire, overgrazing, urbanisation and cropping (Médail & Quézel, 1997).

Conservation priorities should be strongly enforced to those taxa that are evolutionary unique (Williams *et al.*, 1994). In the Balearic Islands, relict taxa (paleoendemics) should be conserved because they are those that have gone through major disturbances and environmental changes. Paleoendemics include species represented by monospecific genera (*Naufraga balearica*), morphologically isolated species (*Pimpinella bicknellii*, *Daphne rodriguezii*), and those without clear affinities (*Helichrysum ambiguum*, *Hypericum balearicum*, *Paeonia cambessedesii*) some of which are located in coastal habitats also invaded by exotic species.

More studies like this one should be conducted at other regions in order to have a global assessment of the diversity and distribution of endemic and exotic taxa. Next research step should focus on the experimental study of the ecological mechanisms that control the establishment of plants of conservation interest (Mack, 1996), such as the studies undertaken with *Cyclamen balearicum* (Affre *et al.*, 1995) or the ones currently analysed by Traveset *et al.* (unp. data) on endemics, in order to have ecological bases for conservation efforts as for example the *Ligusticum huteri* Porta reintroduction program (Vicens, 1998).

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