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Different biodiversity components of a nature reserve in southern Spain

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Abstract

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Biodiversity has often been considered to be the same as species richness and is often assessed both of flora and fauna. In this article we suggest a procedure which can be used to quantify biodiversity at plant community level implementing indices similar to those commonly used in the quantification of species biodiversity, i.e., richness of plant community, Shannon diversity of plant community, abundances, endemicity of the plant community and syntaxonomical singularity. As a case study, we have chosen the plant communities of a natural reserve in southern Spain, the Paraje Natural Punta Entinas-Sabinar. The technique provides a useful and relevant indicator of the environmental quality of an area.

Key words: Habitat directive, habitat diversity, plant community richness, coastal vegetation.

Introduction

One of the main objectives in monitoring natural areas is to preserve or if necessary restore their biodiversity. In order to achieve this goal, it is necessary to quantify the effects of human intervention by means of accurate biodiversity estimates (Chiarucci et al. 2001).

Biodiversity estimates have been developed mostly at species level. The difficulties involved in measuring plant community biodiversity have to do with the disputed definition and classification of plant communities. However, once this question is settled, it is relatively easy to obtain an estimate of plant community biodiversity using indices similar to those available to assess species richness (Magurran 1988). In order to preserve natural areas, it is of great importance to correctly estimate their habitat biodiversity.

The index of plant community biodiversity usually mirrors the structural complexity of the environment. At an elementary level, it corresponds to the number of plant communities of a given geographical area. In order to obtain this index, it is necessary to use a priori-stated classification system enabling a homogeneous sampling of the areas. As stated in Annexe I of the Directive 92/43 of the CEE Council (Anon. 1992), it is possible to use the phytosociological typology to work out this classification. In this respect, Izco (1998) prompts a research line aiming at the quantification biodiversity above genetic and taxonomical levels, particularly, at plant community level, these being interpreted according to the hierarchical classification systems of the sigmatist phytosociology (Géhu and Rivas Martínez 1981). In our study we are going to identify habitat with plant community or association, as in the above-mentioned directive in Spain.

In this work we quantify plant community biodiversity using four biodiversity factors: richness of plant communities, Shannon diversity of plant communities, endemicity rate and syntaxonomical singularity. The accurate assessment of these parameters provides a useful tool with which to find the most suitable preservation policy for the natural areas to be protected. As a case study, we concentrate on the plant communities of the Paraje Natural Punta Entinas-Sabinar, a nature reserve in the south of Spain.

Area under study

The Paraje Natural Punta Entinas-Sabinar encompasses a narrow coastal fringe at the western limit of the Bahía de Almería (Spain), from 36° 40' 45" to 36° 43' 58" N latitude and from 2° 46' 37" and 2° 38' 22" W longitude (Fig. 1). Of a total area of 1960 ha, 785 ha have been declared Reserva Natural (Anon. 1989). The territory presents interesting, variously preserved coastal ecosystems, both terrestrial and aquatic. The ever increasing populations of the neighbouring towns and villages, together with the aggressive growth of the intensive greenhouse agriculture most commonly implemented in the area have turned these ecosystems into natural islands surrounded by a manmade landscape which seriously menaces their preservation (Giménez Luque and Gómez Mercado 1999).

Materials and Methods

In order to quantify habitat biodiversity, our starting point has been the list of habitats of Annexe I of the Habitat Directive (Anon. 1997) supplemented by the work of Rivas Martínez et al. (2001). The biodiversity factors (see below) have been estimated in each of the cartographical units of a previously arranged (Gómez Mercado et al. 2001) vegetation map (Fig. 1).

In each of the map units we assessed the vegetation types in five randomly selected 10 × 10 m homogeneous plots. Then, we calculated the percentage of area covered by each plant community (association). Table 1 shows the 33 types of plant communities recorded in the total of 105 sampled.

Four main broad ecological environments can be distinguished in the vegetation map. In the key these are named with capital letters. A, B and C are series or geoseries,

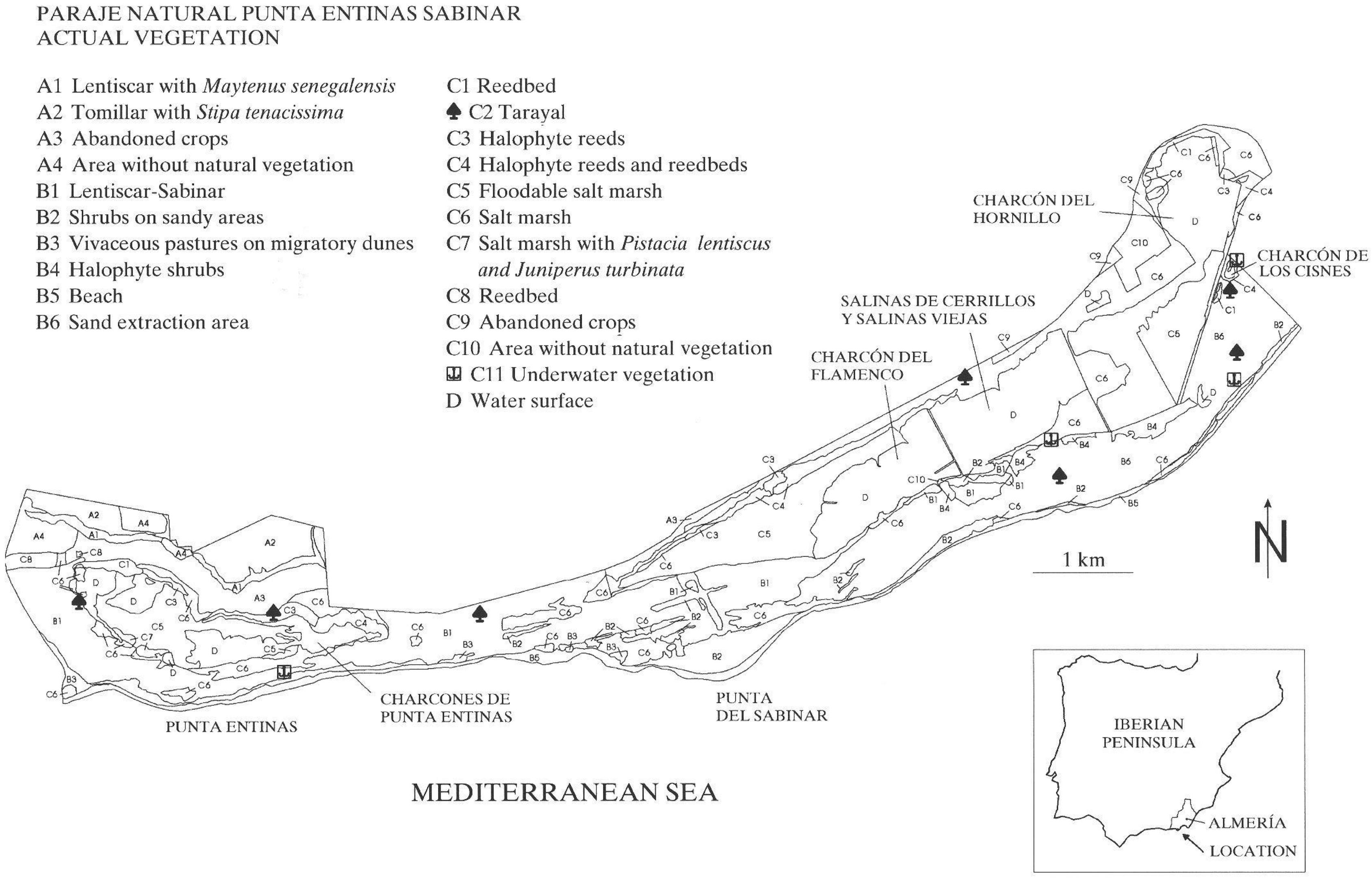

Fig. 1. Location map of the study area and actual vegetation map.

Tab. 1. List of plant communities recorded in the study area.

Plant communities
Asphodelo fistulosi-Hordeetum leporini A. & O. Bolòs in O. Bolòs 1956
Atriplicetum glauco-halimi Rivas Martínez & Alcaraz in Alcaraz 1984
Atriplici glaucae-Suaedetum pruinosae Rigual 1972
Cistancho phelypaeae-Arthrocnemetum fruticosae Géhu ex Géhu & Géhu Franck 1977
Frankenio corymbosae-Arthrocnemetum macrostachyi Rivas Martínez, Alcaraz, Belmonte, Cantó & Sánchez Mata 1984
Comunidad de Arundo donax
Comunidad de Cynodon dactylon
Comunidad de Potamogeton pectinatus y Najas marina
Comunidad de Salicornia ramosissima
Cypero mucronati-Agropyretum juncei Kühnholtz ex Br.-Bl. 1933
Elymo elongati-Juncetum maritimi Alcaraz, Garre, Peinado & Martínez Parras 1986
Enteromorpho intestinalis-Ruppietum maritimae Westhoff ex Tüxen & Böckelmann 1957
Eryngio ilicifolii-Plantaginetum ovatae Esteve 1973
Gasouletum cristallino-nodiflori O. Bolòs 1957
Gymnosporio europaei-Ziziphetum loti F. Casas 1970
Helianthemo almeriensis-Sideritidetum pusillae Alcaraz, T.E. Díaz, Rivas Martínez & P. Sánchez 1989
Inulo crithmoidis-Tamaricetum boveanae Izco, Fernández González & A. Molina 1984
Inulo viscosae-Oryzopsietum miliaceae O. Bolòs 1957
Lapiedro martinezii-Stipetum tenacissimae Rivas Martínez & Alcaraz in Alcaraz 1984
Limonietum angustibracteato-delicatuli Rivas Martínez & Alcaraz in Alcaraz 1984
Loto cretici-Crucianelletum maritimae Alcaraz, T.E. Díaz, Rivas Martínez & P. Sánchez 1989
Medicagini marinae-Ammophiletum australis Br.-Bl. 1921 corr. F. Prieto & T.E. Díaz 1991
Parapholido incurvae-Frankenietum pulverulentae Rivas Martínez ex Castroviejo & Porta 1976
Rhamno angustifoliae-Juniperetum turbinatae Rivas Martínez ex Freitag 1971 corr. Alcaraz, T.E. Díaz, Rivas Martínez & P. Sánchez 1989
Salsolo kali-Cakiletum aegyptiacae Costa & Mansanet 1981
Salsolo oppositifoliae-Thymelaeetum hirsutae Rivas Goday & Bellot ex Rivas Goday & Rivas Martínez 1959
Sisymbrio irionis-Malvetum parviflorae Rivas Martínez 1979
Suaedo fruticosae-Salsoletum oppositifoliae Rivas Goday & Rigual 1958
Teucrio belionis-Helianthemetum scopulorum Peinado, Martínez Parras, Alcaraz, Garre & Cruz 1985
Triplachno nitentis-Silenetum ramosissimae Peinado, Martínez Parras, Alcaraz, Garre & Cruz 1985
Triplachno nitentis-Vulpietum alopecuroris Peinado, Alcaraz & Martínez Parras 1992
Typho-Schoenoplectetum glauci Br.-Bl. & O. Bolos 1958
Wahlenbergio nutabundae-Loeflingietum pentandrae Alcaraz, Díez Garretas & Asensi in Ferré, Díez Garretas & Asensi 1984

whereas D is the aquatic environment. A Termomediterránea inferior almeriense semiárida del arto series (*Maytenus senegalensis*): Gymnosporio-Zisipheto loti Series. B Sabulícola litoral murcian-almerian geoseries (dunes and seacoast sandy areas): Rubio longifoliae-Junipereto lyciae Series. C Edafohigrófila halófila murcian-almerian geoseries (saltmarsh and salinas). D Aquatic vegetation (under-water vegetation). Each of these broad environments was later subdivided into vegetation types which were assigned the capital letter of the corresponding environment and a particular number up to a total of 22. The units were established basically according to the criterion of uniformity of vegetation types. In fact, there are only 21 in this paper, since, for practical purposes, we integrated unit C11 (under-water vegetation) with D (water surface). The names and some dominant plant species of these 21 landscape units are given in Figure 1.

Many authors (Branch et al. 1999, Qian et al. 1998, Samant et al. 1998, Kutiel 1997) have estimated species richness as the total number of identified species in a given area. In our case, plant community richness (absolute richness) corresponds with the number of types of associations identified in all the samples of each map unit. This value has also been estimated for each of the four series mentioned in the key.

In order to estimate proportional abundance, a number of methods have been suggested. Of all of these, Magurran (1988) already mentions Shannon Index as one of the most commonly accepted as far as structural diversity is concerned and declares it suitable for expressing the proportional abundance of plant communities in a given area. This index is defined here as:

$$H = -\Sigma \, p_i \ln p_i$$

p_i being the surface proportion of the cartographical unit which is encompassed by each plant community.

In order to estimate endemicity rates, we first determined the distribution types of each plant community (association) occurring in the study area. Seven types could be distinguished: Local endemism, Murcian-Almerian, Iberolevantine, Iberian, western Mediterranean, Holartic and Subcosmopolitan. The following step was to compute the number of plant communities of each distribution type in every map unit and the total amount of them for each of the four series comprising the 21 units mentioned in the key.

The taxonomical singularity of a given area is defined by Jaccard 1929, Ojeda et al. 1995, 1996, Díaz et al. 1999, etc, as the inverse of the average of infrageneric diversity of the species in each community. In other words, the inverse of the number of species which, belonging to the same genus, occur in that area. In our case, we define syntaxonomical singularity as the inverse of the syntaxonomical richness of each phytosociological class both in the Iberian Peninsula and Balearic Islands (Rivas Martínez et al. 2001). The range of the values so computed and the average of each map unit are represented by means of a histogram.

Results and Discussion

Figure 2 shows the number of associations in each landscape unit and series. Generally speaking, absolute numbers tend to increase in all the series along with the degradation. The same pattern arises as far as syntaxonomical richness is concerned: the heterogeneity of landscape grows as the rate of man-induced alteration increases. Degradation has caused a mosaic scenery where small remnants of climax vegetation and first substitution communities alternate with larger areas characterised by invading nitrophilous communities. It is only at the highest level of degradation (e. g. B6,

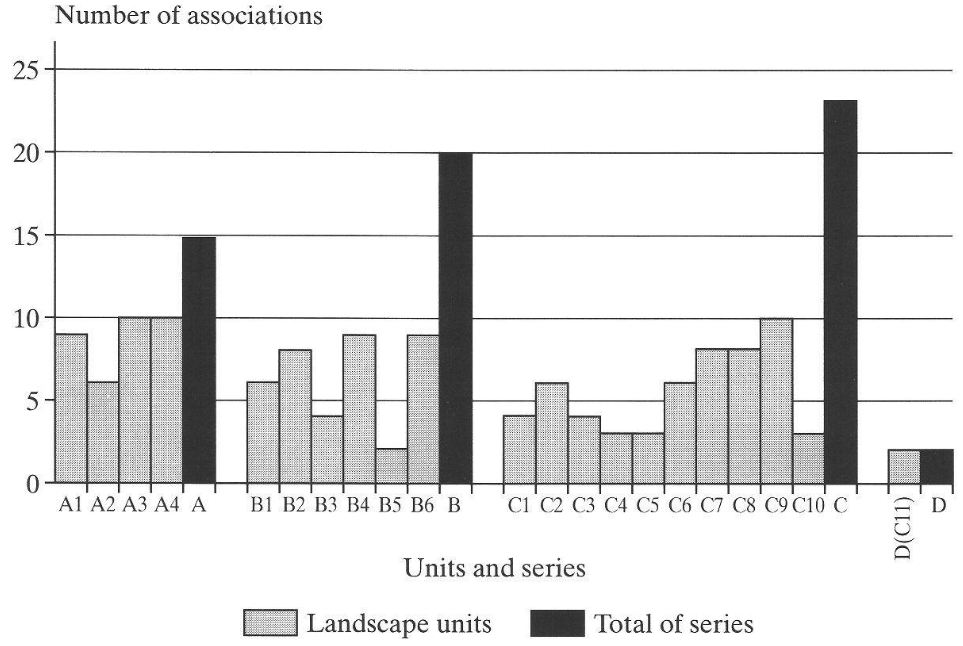

Fig. 2. Plant community richness per unit and series.

where sand extraction takes place, or A4 and C10, where farming has already caused the extinction of natural vegetation) that landscape complexity and plant community richness decrease dramatically. The comparative analysis of the series leads to the following conclusions: sandy areas (B) have a higher diversity record than the arto series (A), although the well-developed arto formations (A1) are still more diverse than the lentiscar-sabinar (B1). As moisture increases, the complexity of well-preserved units tends to decrease (from C1 to C6 richness records are low), although the accumulated value (C) is higher than that of the non-hygrophilous series, if altered communities are also taken into consideration (C8 to C10). As already expected, marshy areas show a considerably low rate of diversity as far as cormophyte communities are concerned. In this last case, the rate would have been very different if microphytes had also been considered.

The proportional abundance index (Tab. 2, Fig. 3) mirrors the sample homogeneity. Consequently, in our case it tends to increase along with cartographic unit heterogeneity. As a general pattern, records tend to be higher in terrestrial series as compared to marshy areas, where it is only in the mixed or most altered units (C7 to C9) that proportional abundance is high. The low record of occasionally floodable salty areas (C5) is most remarkable. Habitats are not only sparse here but just one of them (Cistancho-Arthrocnemetum fruticosae) coincides with almost the whole surface unit too. Once more, the comparative analysis of the units of each series clearly shows an increase in diversity as alteration becomes more and more apparent, in the same way as habitat richness.

The endemicity rates of each map unit are shown in Table 3 and have been graphically summarised in series in Figure 3. Terrestrial series clearly present higher records, especially so in the sabulicolous series (local endemisms and Murcian-Almerian), than

Tab. 2. Proportional abundance index of plant communities recorded in the study area.

Unit	Proportional abundance index
A1	1,439304
A2	1,507643
A3	1,671897
A4	1,743259
B1	0,948273
B2	0,413103
B3	1,134456
B4	1,400451
B5	0,562335
B6	1,428696
C1	0,267107
C2	0,829216
C3	0,472168
C4	0,803713
C5	0,151700
C6	0,592260
C7	1,544485
C8	1,262398
C9	1,539347
C10	0,873900
D(C11)	0,677494

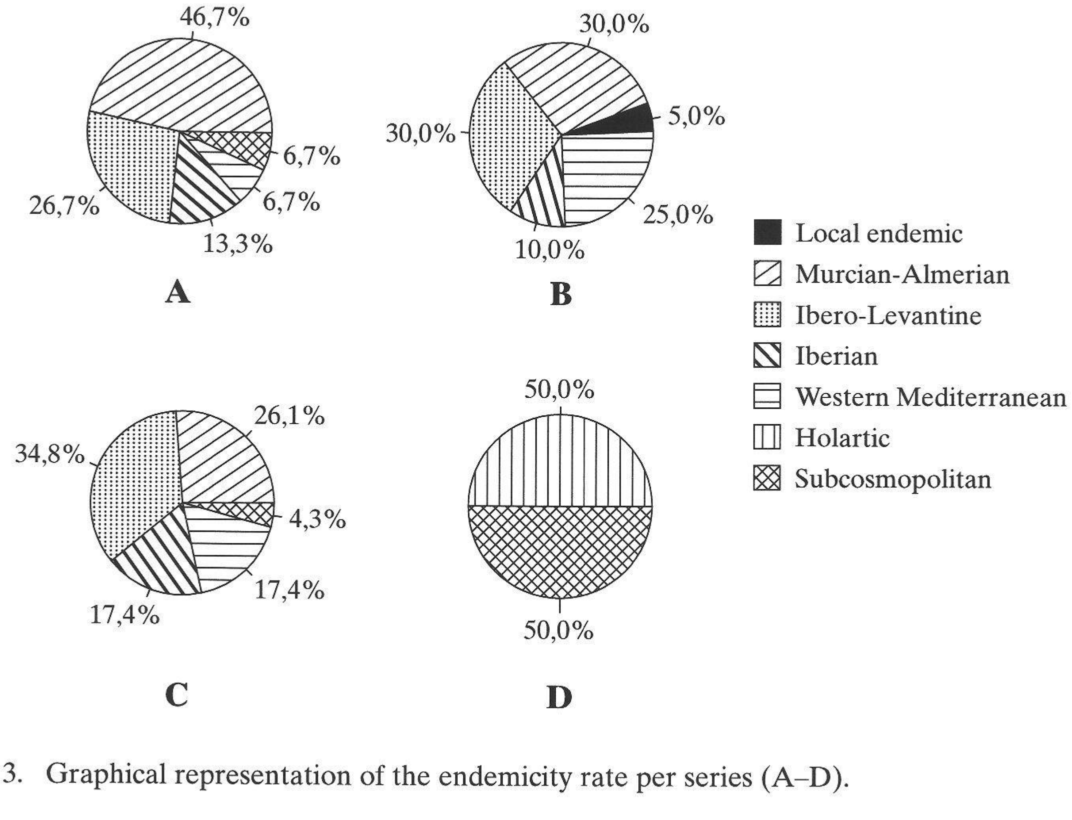

Fig. 3. Graphical representation of the endemicity rate per series (A–D).

Tab. 3 Number of plant communities of each type of distribution per landscape unit (A1–D).

Types of distribution of plant communities	Landscape units																				
	A1	A2	A3	A4	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	D(C11)
Local endemic species	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Murcian-Almerian	6	5	5	5	2	1	0	4	0	2	3	2	2	1	1	3	3	2	5	1	0
Iberolevantine	0	0	4	3	3	4	2	2	1	3	2	3	1	2	0	1	4	4	2	2	0
Iberian	1	1	1	0	0	1	0	2	0	0	1	1	1	0	1	0	1	0	1	0	0
Western Mediterranean	1	0	0	2	0	1	2	0	1	4	1	0	0	0	1	2	0	1	2	2	0
Holarctic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Subcosmopolitan	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1

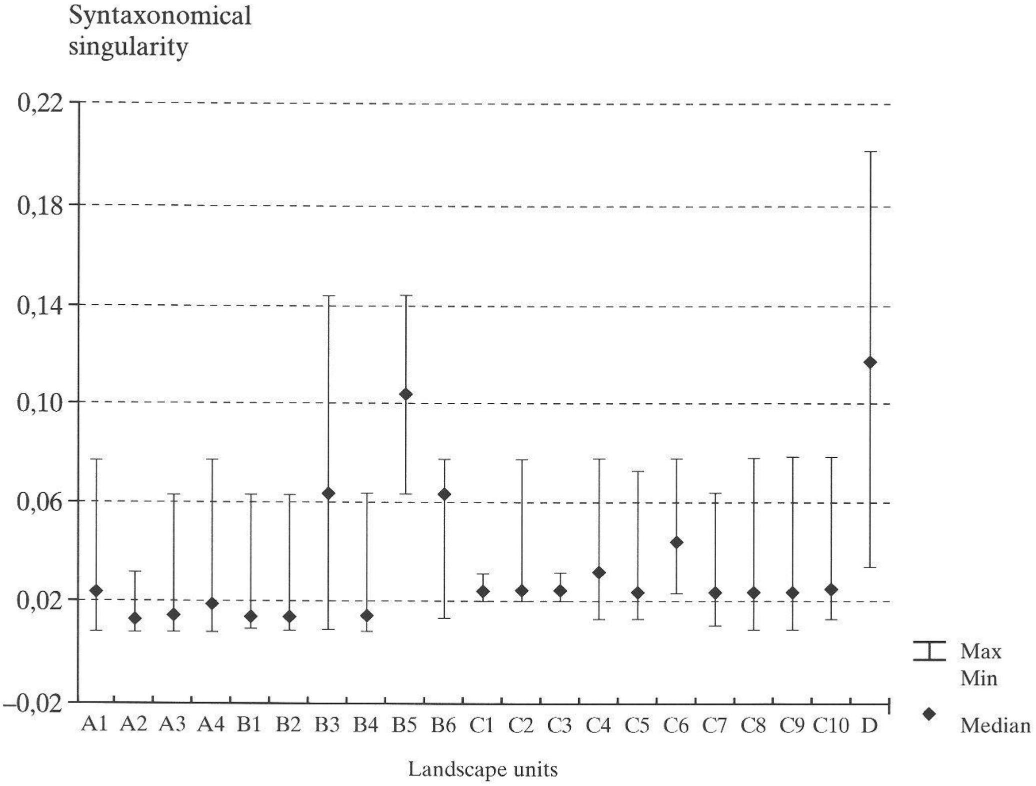

Fig. 4. Graphical analysis of the syntaxonomical singularity of each map unit (A1–D).

marshy areas, where Iberolevantine taxa are dominant. Under-water vegetation exhibits a broad distribution (Holarctic and Subcosmopolitan).

The range of syntaxonomical singularity of each map unit is given in Figure 4. As can be seen, uniformity, both as regards average and extreme values, is apparent. This means that both well-developed communities and those considerably altered belong to highly diversified phytosociological classes (Quercetea ilicis, Rosmarinetea, Helianthemetea, Sarcocornietea, Pegano-Salsoletea, etc.). Some units such as B3 (grassland on sandy soils), B5 (seashore) and D (under-water vegetation), exhibit remarkably high records, which clearly suggests that the phytosociological classes (Ammophiletea, Cakiletea, Potametea and Ruppietea) comprising these communities have little variability in the Iberian Peninsula (as in the rest of Europe).

As some studies on species biodiversity have already shown (Díaz et al. 1999), high records of syntaxonomical singularity (associations of classes which are little diverse in the Iberian Peninsula) coincide with the lowest endemicity rates, since the most diverse classes, at least at a local level, tend to be more original, i. e., tend to have a larger number of endemic taxa.

Conclusions

The comparative analysis of the ingredients of plant community diversity is a powerful tool with which to assess the environmental quality of a region and it yields valuable conclusions which can contribute to better monitor and preserve nature reserves.

As already suggested by Arroyo (1997), conventional diversity indices, either absolute (plant community richness) or relative (proportional abundance index), increase along with environmental alteration, except in those cases where alteration has been extremely high. These indices must be used in combination with either other indicators of environmental quality, such as the endemicity rate, or methods of naturalistic assessment (Loidi 1994) which take into account other relevant parameters such as naturalness, replaceability, rarity, etc.

As an index of naturalistic assessment suggested by Loidi (1994), anthropic pressure must also be given due attention, especially in the Mediterranean ecosystems, where the impact of human action on the landscape has not only been taking place for a long time but it has also had dramatic effects on the vegetation (Pausas 1999).

The comparative analysis of the map units of the Paraje Punta Entinas-Sabinar leads to the conclusion that the terrestrial series present the highest diversity records, both of richness and proportional abundance, and even more so as far as endemicity rates are concerned. However, the efforts aiming at the preservation of the Paraje deal mostly with the monitoring of the marshy areas, where ornithological diversity is concentrated.

So far, the conclusions of this paper can only serve to comparatively and more accurately assess the different ecosystems and areas of the Paraje and, hopefully, to better monitoring. If, in the future, other surveys in different territories or countries provide similar results, then the conclusions could be used to more accurately select the areas worthy of preservation.

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