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Orophilous plant communities of Baetic range in Andalusia (south-eastern Spain): priority altitudinal-islands for conservation

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with 2 figures, 5 tables and 2 appendices

Abstract. The present work compares several localities in the high-mountain of the Baetic Cordilleras on the basis of plant communities, to establish priorities for conservation. The main objectives of the work are: 1) Identification of the whole set of plant communities described in the study area. 2) Analysis of the phytogeographical relationships between the summit areas. 3) Characterize a sere of ecological and management variables for each syntaxon that led us establish the main "conservation-value" groups, and the weight of each variable. 4) Calculation of values such as richness, continuous or discontinuous rarity, and complementarity. 5) Establish conclusions relevant to conservation purposes at community level in these areas.

For this, 17 mountain areas have been selected, occupying a surface area of 2197.5 km^2 and represented by 65 syntaxa. For each area, information has been compiled to construct two data matrices, which have been analysed with multivariate techniques of classification (cluster analysis) and ordination (correspondence analysis) as well as non-linear methods (categorical principal-component analysis; CATPCA). The priority areas for conservation have been determined by applying the concepts of richness, continuous rarity, discontinuous rarity and complementarity. In the 17 mountain areas, a series of aspects related to community ecology were analysed, such as types of habitats represented, distribution, thermotypes, ombroytpes and substrate, in addition to others related to diversity and conservation, including type of rarity, richness in endemic and/or endangered species, protection level, conservation status, and threat factors. The data analysis of presence/absence in the different massifs resulted in 4 groups: the first composed of Tejeda-Almijara, calcareous Sierra Nevada, and Gádor; the second of Grazalema, las Nieves, Loja, Lújar, Estancias, and Huétor-Harana; the third of Baza, María-Orce, Cazorla, the Subbetic, Mágina, and la Sagra; the fourth of Filabres and siliceous Sierra Nevada. The CATPCA quite clearly separated the groups with well-differentiated conservation needs on the basis of their ecology and degree conservation (this being a combination of different factors). Finally, the work concludes by discussing the results and making a series of recommendations for conservation at community level.

Keywords: syntaxa, high-mountain communities, priority areas, conservation.

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Introduction

Although the first geobotanical observations on Baetic mountains may date to the 19th century (*e. g.* Clemente 1864, Boissier 1839–1845) the vegetation did not constitute a prime objective of botanical studies until much later. Sierra Nevada attracted a good portion of the early efforts in this sense (Quèzel 1953).

In this same period, other sierras attracted the attention of different botanists, as in the case of the Sierra Mágina (Cuatrecasas 1930, Melchior & Cuatrecasas 1935), the Sierras of Tejeda and Almijara (Laza-Palacios 1946, 1956), the Sierra of Ronda (Laza-Palacios 1936) and the Sierra of Baza (Rivas-Goday 1941). This latter author vigorously promoted phytosociological studies of the Baetic Cordilleras in a series of major works interpreting orophilous vegetation (Rivas Goday & Mayor 1966, Rivas-Goday 1968, Rivas-Goday & Borja 1961, Rivas-Goday & Rivas-Martínez 1963, 1969, Rivas-Goday & Rivas- Martínez 1971).

However, the interest of Professor Rivas-Martínez for Baetic vegetation began earlier. At the beginning of the 1960s Rivas-Martínez (1960) analysed the rupicolous communities of the Iberian Peninsula, with reference to the Baetic alliance Saxifragion camposii. This author's interest for Andalusian mountains began to be concentrated in a publication concerning the vegetation belts in the Sierra Nevada (Rivas-Martínez 1961), relationships between soil and vegetation, focused on the altitudinal cliserie of the Baetic mountains (Rivas-Martínez 1964, Rivas-Martínez 1972), comparisons between vegetation of the Central System and the Sierra Nevada (Rivas-Martínez et al. 1986). Afterwards, with the publication of the syntaxonomical checklist of vascular plant communities of Spain and Portugal (Rivas Martínez et al. 2001, 2002a, 2002b) that should be considered a mandatory reference for the study of any Spanish or Portuguese territory, together with a classic reference such as the map of the vegetation series of Spain (Rivas-Martínez 1987). Apart from these studies, it also bears mentioning here two of the most cited works of this author in relation to the flora and vegetation of the Betic Cordilleras, a study on endemic vascular species of Andalusia (Rivas-Martínez et al. 1991), and a biogeographical synthesis of the same area (Rivas-Martínez et al. 1997).

Besides these works, it is also worth highlighting studies of local botanists on this subject, mainly completed after 1980 (more information can be found in Mota 1990 and Valle et al. 2003 and Appendix 1).

Recent works (Mota et al. 2002, Peñas et al. 2005, Lorite et al. 2007) have examined the orophilous flora of the Baetic Cordilleras, taking into account the discontinuous character of the high-mountain zones (oro- and cryoromediterranean belts). This geographic isolation has led these to be considered "altitude islands" (Whittaker 1998) and this is one of the features responsible for the great richness in endemic species, together with the great variety of habitats that can be recognized in these mountains (Mota 1990). However, to date, no study has considered this great diversity of biotopes, expressed in the form of phytosociological associations. If the floristic richness should be taken into account in conservation planning, it is no less true that the great European strategy of protection is based on habitats (Rivas-Martínez et al. 1993), and in this context the Mediterranean high-mountain presents a great diversity of habitats, many considered priorities.

This antecedents, led us to address the following issues: 1) Identification of the whole set of plant communities described in the study area. 2) Analysis of the phytogeographical relationships between the summit areas. 3) Characterize a sere of ecological and management variables for each syntaxon that led us establish the main "conservation-value" groups, and the weight of each variable. 4) Calculation of values such as richness, continuous or discontinuous rarity, and complementarity. 5) Establish conclusions relevant to conservation purposes at community level in these areas.

Study area

The Baetic Sierras are located in the south-eastern Iberian Peninsula, covering a surface area of some 45,000 km^2. They present a particularly complex orography, where they reach a highest altitude of the peninsula (Mulhacén peak, 3,482 m a.s.l.). The dominant geology is calcareous, although siliceous zones constitute authentic islands in the surrounding matrix. The climate is

Table 1. Sites studied, predominant lithology, abbreviation used in the analysis, maximum altitude (a.s.l.), surface area (in ha) above 1,600 m a.s.l. (sur.), protected surface area above 1,600 m a.s.l. (Prot. sur.) and % of protected surface area of each site (% Prot. sur.).

Lithology	Areas	Abbr.	Max. Alt.	Sur.	Prot. sur.	% Prot. sur.
Calcareous	Grazalema	GR	1665	11.0	11.0	100.0
	Nieves	NI	1918	1137.1	1137.1	100.0
	Loja	LO	1671	174.6	0.0	0.0
	Lújar	LU	1824	750.9	0.0	0.0
	Gádor	GA	2240	11339.9	0.0	0.0
	Tejeda-Almijara	TEA	2065	2649.0	2649.0	100.0
	Estancias	ES	1722	92.5	0.0	0.0
	calcareous Sierra Nevada	SNC	2450	3484.5	2496.6	71.6
	Huétor-Harana	HUH	1943	2661.7	678.8	25.5
	Mágina	MA	2167	3604.1	3604.1	100.0
	Cazorla-Segura	CA	2028	44587.1	35833.2	80.4
	La Sagra	SA	2383	1813.7	0.0	0.0
	Córdoba and Jaén Subbaetics	SB	1872	743.9	0.0	0.0
	María-Orce	MAO	2045	3316.8	2370.7	71.5
	Baza	BA	2236	12929.4	12611.5	97.5
Siliceous	Filabres	FI	2168	31686.7	9985.6	31.5
	siliceous Sierra Nevada	SNS	3482	98769.2	94074.7	95.2
				219752.1	**165452.4**	**75.3**

Mediterranean, with a wide range of precipitation, from 300 to 1,200 mm annually (Rivas-Martínez et al. 1997).

For this work, we selected areas that presented typically oro- and cryoromediterranean vegetation, according to Rivas-Martínez et al. (2002a) and Valle et al. (2003), usually above 1,600 to 1,800 m a.s.l. To calculate the total surface areas and the protected surface areas, we used ArcGis 8.3, over a vectorial layer of protected natural areas in Andalusia (source: REDIAM; Red de Información Ambiental de Andalucía, www.juntadeandalucia.es/medioambiente/site/web/) (see Table 1).

Methods

Data Collecting

First, we reviewed all the syntaxonomical literature since 1953, selecting the works referring totally or partially to the Baetic Sierras and their orophilous components (for a review, see Rivas-Martínez et al. 2001). For the 65 syntaxa represented (see Appendix 1), we have compiled a series of data (see Table 2), such as: the distribution in the different orophilous areas, type of habitat, distribution range, thermotype, ombrotype, substrate, species richness, presence of endangered (Cabezudo et al. 2005) and/or endemic species (Rivas-Martínez et al. 1991, Melendo et al. 2003), rarity (adapted from Izco 1998), protection level, conservation status or threats. With the data compiled, two matrices were performed, the first for presence/absence of syntaxa by orophilous areas of 65 rows and 17 columns (available from authors), and for the second were a matrix of syntaxa by variables with 65 rows and 11 columns (Appendix 2).

Multivariate analysis

For the analysis of the presence/absence data by orophilous areas, a correspondence analysis (CA) was used as a basic ordination method (indirect gradient-analysis methods, non-transformed data). Two cluster analyses were used, the first by the Ward's method (hierarchical and agglomerative) in order to make a visual-preliminary exploration of groups in the data matrix, the second by the Fuzzy C-means method (diffuse partition). The diffuse partition was made with 3, 4 and 5 groups, suggested by the Ward's cluster, and 4,000 random runs in all cases. At the end, we had 4 groups, based on the normalized partition coefficient and normalized entropy. The result is shown in the form of three-dimensional graph that combines the CA and the Fuzzy C-means (Graph 1). The combination of ordination and classification techniques enabled us to show graphically all the information that was masked in the correspondence analyses. In all these analyses, the Ginkgo module of the Vegana package was used (Font & De Caceres: see Bouxin 2005). To analyse the second matrix of categorical variables, we used a non-parametric principal-component analysis (Gifi 1991) integrated

Table 2. Variables and categories used in the Categorical Principal-Component Analysis (CATPCA).

Abbrev.	**Variable**	**Categories**
HAB	Habitat type	**1.** Aquatic, amphibious, or hygrophilous vegetation; **2**. Chasmophytic and scree vegetation; **3**. Synanthropic and megaforbic vegetation; **4**. Orophilous scrubs perennial pasturelands; **5**. Forests and shrublands.
DIS	Distribution	**1**. Broad; **2**. Iberian (Iberian high-mountains); **3**. Widely Baetic endemic (more than two massifs); **4**. Narrowly Baetic endemic (present in one or two massifs)
TH	Thermotypes	**1**. Strictly cryoromediterranean; **2**. Strictly oromediterranean; **3**. Strictly oro-cryoromediterranean; **4**. Broad (present in other supramediterranean zones or lower)
OM	Ombrotypes	**1**. Hyperhumid; **2**. humid; **3**. Subhumid; **4**. Hyperhumid-humid; **5**. Subhumid; **6**. Broad; **7**. Hygrophilous
SUBS	Substrate	**1.** Calcareous; **2**. Dolomites; **3**. Serpentines-peridotites; **4**. Siliceous; **5**. Indifferent
RICH	Species richness (mean no. sp per inventory)	**1**. Low (<5 taxa); **2**. Medium(5-15); **3**. High (>15)
TH_EN	Presence of Threatened and/or endemic species	**1**. Low (0-1 taxa); **2**. Medium (2-5); **3**. High (>5)
RAR	Rarity	**1**. Not rare; **2**.Broad geographic area, low frequency of appearance, large fragment size; **3**. Broad geographic area, high frequency of appearance, small fragment size; **4**. Broad geographic area, low frequency of appearance, small fragment size **5**. Small geographic area, high frequency of appearance, large fragment size; **6**. Small geographic area, low frequency of appearance, large fragment size; **7**. Small geographic area, high frequency of appearance, small fragment size; **8**. Small geographic area, low frequency of appearance, small fragment size
PROT_LE	Protection level	**1.** Without conservation interest; **2**. With interest but without protection; **3**. Legally protected (Directive 92/43); **4**. Included, at least partially, in protected areas; **5**. Legally protected and included, at least partially, in protected areas
CON_STA	Conservation status	**1**. Good; **2**. Acceptable; **3**. Worrying; **4.** Alarming
THRE	Threats	**1**. Not threatened; **2**. Natural causes; **3**. Human causes; **4**. Combination of natural and human causes

in the CATPCA 1.1 module of the statistical software package SPSS 12.0. This method has been used in certain ecological and environmental studies (for a review, see Ellis et al. 2006), as well as in works on vascular plants conservation (Domínguez et al. 2003). However, it has not been used for any syntaxonomical study, although it presents great potential because different types of variables (ordinal, binomial, single nominal and multiple nominal) can be analysed.

Selection of priority areas

To establish important zones for conservation of the plant communities, we have used the following concepts: Richness (Ri): number of communities present in each sierra, as representative of diversity (Usher 1986). ii)

Continuous rarity (Rc) (Rabinowitz 1981; Mota et al. 2003): this is based in the level of endemicity of each syntaxa. Thus, a community that is found at a single locality will have a greater degree of rarity than one found at various localities. The inverse of the number of localities gives a good estimate of this degree. Following this procedure and adding together the values for each syntaxon of those present in a territory, we get an overall value (criterion of discontinuous rarity). iii) Discontinuous rarity or threshold rarity (Rd): In the first step we recorded the number of localities in which each of the syntaxa considered are present, in the second step we have taken the 25 % of the rarest communities (present in the lowest number of localities). As a simpler estimation, it can be considered that the rarity value of a locality coincides with the number of rarest taxa present there (Rabinowitz, 1981; Mota et al. 2003). iv) Principle of complementarity (Com) (Kirpatrick 1983, Margules et al. 1988): this takes into account how the addition of a new locality influences the total number of elements (syntaxa in this work) compiled (Vane-Wright et al. 1991; Colwell & Coddintong 1994).

This type of analysis enables us to evaluate the relative importance of each of the areas selected and how each of these areas contributes to the conservation at the community level. In short, how a maximum of elements (syntaxa in this case) can be conserved on a minimum of surface area. In principle, these elements are not placed in opposition to those mentioned earlier (Ri, Rc o Rd), since these can serve as the basis for selecting the first locality. Thus, on beginning the iterative process required by the complementarity criterion, we can use both richness (Kirpatrick 1983) as well as rarity (Margules et al. 1988).

Results

Of the 17 high-mountain areas delineated within the Baetic Sierras, covering a surface area of 2,197.5 km^2, most were calcareous mountain zones, except for Sierra Filabres and part of the Sierra Nevada, which are siliceous in nature. Of the 2,197.5 km^2, protected spaces covered 1,654.5 km^2 (75.3 %). We should highlight zones such as the Sierras Mágina, Tejeda-Almijara, Las Nieves and Grazalema, which have 100 % of their orophilous surface protected, and siliceous Sierra Nevada, with 95.2 % protection. In the extreme opposite are Sierras Gádor and Sagra, with a large surface area above 1,600 m, but without any protection figure (Table 1). A total of 65 orophilous syntaxa described for the Baetic sierras have been compiled (see Appendices 1 and 2), mostly scrub and perennial grassland orophilous communities (20 syntaxa); aquatic, amphibious, or hygrophilous vegetation (20), or chasmophytic and scree vegetation (19). Of these syntaxa, most are narrow endemic species of the Baetic sierras (37), *i. e.* they occupy one or two massifs, or they are wide endemic Baetic species, *i. e.* present on more than two massifs (23). Almost half of the communities (32) are present not only in the high-mountain (oro- and cryomediterranean belts) but also at lower altitudes (supra-, meso-, or even thermomediterranean), although 33 communities are exclusively orophilous (3 strictly cryoromediterranean, 15 strictly oromediterranean, and 15 oro- and cryoromediterranean). With respect to the ombrotype, most inhabit humid or subhumid areas (36), although with a strong presence of hygrophilous communities (17). The majority of the communities were linked to siliceous (29), or calcareous substrate (22), although there was also a significant presence of 9 communities linked to dolomites. Aspects such as rarity indicated that most of the communities had a small geographical areas (55) and most of these (46) had a low frequency of appearance. The rarest communities (type 8; see Table 2 for a more detailed explanation) numbered 37. In terms of richness, measured as the mean number of species per relevé analysed, most of the communities (57 syntaxa) presented a medium number (5–15 taxa per relevé) while only 5 communities presented more than 15 taxa per relevé. Similarly, among endangered species and/or endemic species, 37 syntaxa presented a medium number (2–5), although 10 syntaxa presented a high number (> 5). The level of protection indicated that 59 communities had some protection (of these 54 were legally protected and also included at least partially in protected areas), while 5 were included in protected areas but did not appear on any protection list at community level. Only two communities were of interest for conservation and were not protected. From the stand-

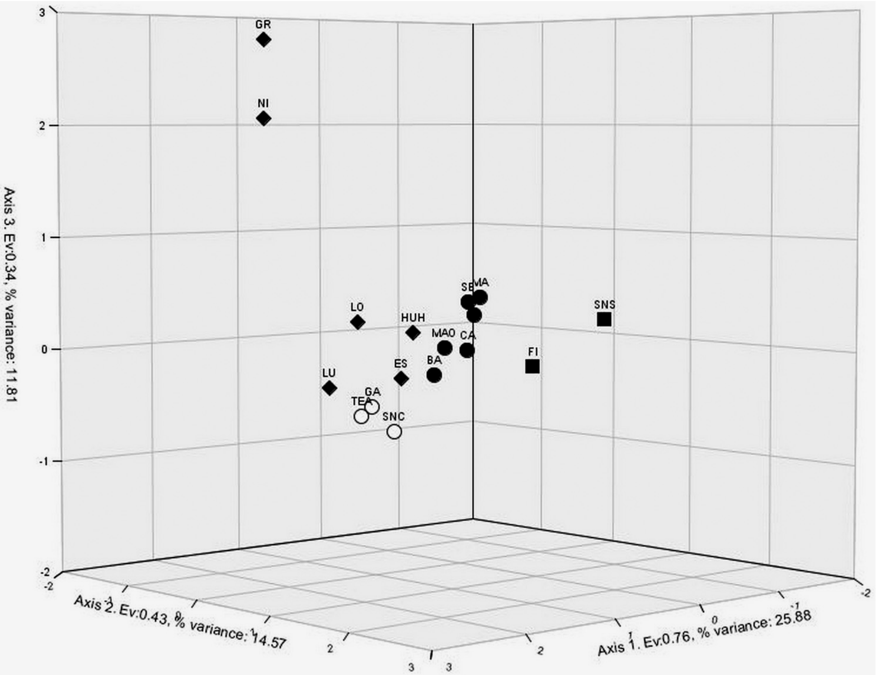

Fig. 1. Three-dimensional plot showing the results of the correspondence analysis with the Fuzzy C-means superimposed.

Table 3. Results of the fuzzy C-means; probability of the different elements belonging to the 4 proposed groups (g-1 a g-4). The elements assigned to each group are in bold.

	g-1	g-2	g-3	g-4
TEA	**0.99**	0.01	0.00	0.00
SNC	**0.99**	0.00	0.00	0.00
GA	**0.93**	0.07	0.00	0.00
GR	0.00	**1.00**	0.00	0.00
NI	0.00	**1.00**	0.00	0.00
LO	0.00	**1.00**	0.00	0.00
LU	0.00	**1.00**	0.00	0.00
ES	0.01	**0.99**	0.00	0.00
HUH	0.02	**0.91**	0.07	0.00
MA	0.00	0.00	**1.00**	0.00
SA	0.00	0.00	**1.00**	0.00
CA	0.01	0.00	**0.99**	0.00
MAO	0.00	0.02	**0.98**	0.00
SB	0.04	0.04	**0.92**	0.00
BA	0.07	0.01	**0.92**	0.00
FI	0.00	0.00	0.00	**0.99**
SNS	0.00	0.00	0.00	**1.00**

point of conservation status, 18 presented a worrying state of conservation, and 1 alarming. The main causes of threat were a combination of natural and human causes (46) or fundamentally natural (12).

Fig. 1 shows the result of the correspondence analysis. The first three axes represented explain 52.17 % of the total variance. The diffuse partition of the Fuzzy C-means shows 4 groups with a high level of congruence (see Table 3). The first group is constituted by Tejeda-Almijara, calcareous Sierra and las Nieves with notable singularity, and by a group of sierras (Loja, Lújar, Estancias and Huétor-Harana) with little oromediterranean surface area and therefore quite poor. The following group, very compact, is formed by Baza, María-Orce, Cazorla, Subbaetic, Mágina, and la Sagra. The last group, composed of Filabres and siliceous Sierra Nevada, had the most singular elements, especially in the latter case.

The results of the CATPCA are shown in Table 4 and Fig. 2. The table shows the factor loadings for two dimensions with 11 variables over 65 syntaxa. The eigenvalues, which reflect the reliability of the analysis, explained 57.79 % of the total sample variance. The variables HAB, PROT_LE, THREATS, RAR, and DIS were the ones that most contributed to explaining the variance. Fig. 2 shows the position of the 65 syntaxa in the first two dimensions of the analysis. We find the segregation in the lower left corner of the communities of relatively broad distribution, not

Table 4. Analysis values in the CATPCA for 65 syntaxa.

	Component loadings		Total variance
Variable	Dimension 1	Dimension 2	
HAB	.028	-.892	0.842
DIS	.600	-.344	0.721
TH	-.495	.049	0.370
OM	-.047	.921	0.674
SUBS	-.806	.051	0.622
RICH	.113	.401	0.443
TH_EN	.746	-.051	0.618
RAR	.883	-.163	0.749
PROT_LE	.771	-.010	0.801
CON_STA	.473	.648	0.435
THREATS	.698	.257	0.783
Eigenvalues	3.913	2.445	

very rare, and not endangered, such as Artemisio-Santolinetum canescentis, Verbasco-Onopordetum acauli, or Artemisio-Santolinetum rosmarinifoliae, of clearly nitrophilous-colonizing behaviour. Following this first dimension, we next find communities of more restricted areas, but of relatively broad distribution, such as Thymo-Cistetum laurifolii, at the end of this axis being the Baetic communities restricted to one or two massifs. Meanwhile, the second axis separates the hygrophilous communities situated in the upper part from the climatic ones situated preferentially in the lower part. In the upper part of the graph appears behaviour very similar to the one described above: at the left are the communities of broad distribution, and not endangered, such as Cirsio-Juncetum inflexi, followed by communities of broad distribution but rarer, such as Acrocladio-Eleocharidetum palustris, Ranunculetum hederacei, or Juncetum nanae. To the right, we find communities exclusive to one or two massifs and very rare, such as Achilleo-Astragaletum tremolsiani or Aconito-Senecionetum elodis.

The analysis to determine the important areas in plant communities is presented in Table 4. We highlight that siliceous Sierra Nevada occupies the first position in richness, with 33 communities in continuous rarity (21.7), in discontinuous rarity (18), and in complementarity with more than half of the total orophilous Baetic communities (33). The second position in complementarity is occupied by the calcareous Sierra Nevada, followed by Mágina, Gádor, and Tejeda-Almijara. In addition, there is a group (positions 9–17) that provided no new communities, many of these massifs having a small high-mountain surface area (see Table 1).

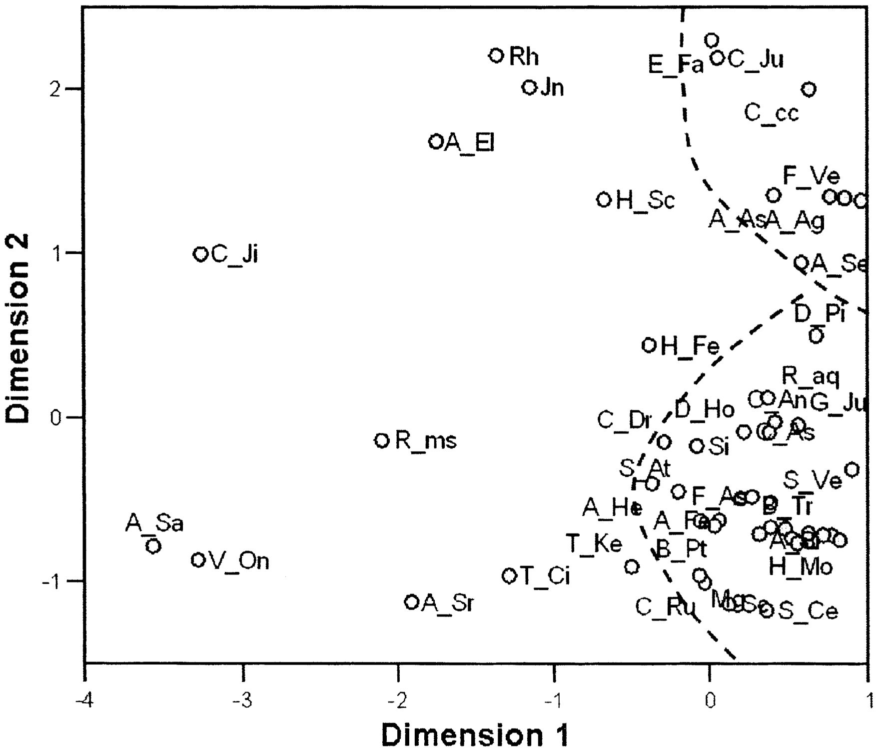

Fig. 2. Scores for 65 syntaxa (not all labelled). See abbreviation in Appendix 1. The broken lines mark the two groups referred to in the text.

Discussion

The syntaxonomic checklist of the high-mountain zones of the Baetic Cordilleras offers 65 syntaxa, with more than half of these endemic, implying great diversity, comparable with the diversity at taxonomic level (e.g. Médail & Quézel 1999).

Phytogeographical patterns

In general, the groups found with the matrix analysis of presence/absence coincide quite well with the phytogeographic units described by other authors for the Baetic sierras (e.g. Rivas-Martínez et al. 1997, Mota et al. 2002). Differences can be explained by the fact that some units present very low syntaxonomic richness, having a very restricted high-mountain surface area. Sierra Nevada and Filabres, the two siliceous units are noteworthy for being the most syntaxonomically original, coinciding with findings of other authors for endemic flora (Peñas et al. 2005) as well as for endangered flora

(Lorite et al. in press). The group of calcareous sierras has three subgroups, the first including the sierras considered by other authors to be Subbaetic (Rivas-Martínez et al. 1997), such as Cazorla, Mágina, la Sagra, or the Córdoba and Jaén Subbaetics, together with other sierras nearby such as María-Orce and Baza. Another subgroup is comprised of southern sierras, including the calcareous part of Sierra Nevada, Tejeda-Almijara, and Gádor. Finally, a group is composed of sierras that are very poor in elements (Grazalema, las Nieves, Loja, Lújar, Estancias, and Huétor-Harana) and that do not have geographic continuity. The lack of richness in these sierras is undoubtedly due to the low altitude, implying that typically oromediterranean communities appear marginally in these areas for topographical reasons (summit effect)(Mota et al. 2002). These are therefore poor in the context of the present study, although some of them (particularly Grazalema and las Nieves) harbour singular flora not reflected in this work (Peñas et al. 2005).

Priorities for conservation

From the standpoint of conservation the syntaxa, we can conclude that CATPCA accurately identifies the associations that should be treated as conservation priorities. The syntaxa that should receive priority in conservation are those of two groups indicated by dotted lines in Fig. 2. The group in the upper part is comprised of hygrophilous communities and the lower one is composed of climatic communities. Another fact that deserves to be highlighted is that 1 syntaxon present an alarming state of conservation, and 18 worrying, this plant communities are mainly endangered for natural causes, such as climatic change, to which Mediterranean mountains are especially sensitive (Hódar & Zamora, 2004). For the set of factors that we call “natural causes”, conservation measures in many cases are difficult to prescribe, although the combination of human and natural factors act synergetically in most cases. These factors unquestionably include the strong pressure of herbivores in high-mountain zones, especially in hygrophilous communities, and therefore the control of overgrazing should be a major priority.

In terms of priority zones for conservation, the complementarity analysis, whether considering richness or the two types of rarity, renders very similar results (Tab. 5). The most important areas would be siliceous Sierra Nevada and calcareous Sierra Nevada, a conclusion that coincides with the findings of other authors (*cf.* Gómez-Campo 1985; Blanca et al. 2002; Del Valle et al. 2003). In this sense, the declaration of the Sierra Nevada as a national park should be considered one of the most important milestones in plant conservation to be achieved in recent years. This sierra is followed in importance by the Sierras Mágina and Gádor. The importance of this latter massif, for conservation, has been pointed out in numerous works (*e. g.* Gómez-Campo 1985; Mota et al. 2003; Del Valle et al. 2003), though no such protection has ever been granted. The future declaration of Special Areas of Conservation (SACs; inside the Natura 2000 Network at

Table 5. Selection of priority areas according to richness (Ri), continuous rarity (Rc), discontinuous rarity (Rd), and complementarity (Com) of the syntaxa studied (see abbreviations of localities in Table 1).

Order	Loc	Ri	Order	Loc	Rc	Order	Loc	Rd	Order	Loc	Com
1	SNS	33	1	SNS	21.748	1	SNS	18	1	SNS	33
2	FI	21	2	FI	7.429	2	SNC	3	2	SNC	17
3-4	SNC	19	3	SNC	5.988	3-6	GA	1	3	MA	7
	CA	19	4	CA	4.513		TEA	1	4	GA	3
5-6	MA	16	5-6	MA	3.204		CA	1	5	TEA	2
	SA	16		SA	3.204		FI	1	6-8	NI	1
7	BA	15	7	TEA	2.938	7-17	GR	0		MAO	1
8	SB	14	8	SB	2.871		NI	0		FI	1
9-11	GA	12	9	GA	2.723		LO	0	9-17	BA	0
	TEA	12	10	BA	2.279		LU	0		GR	0
	MAO	12	11	MAO	1.787		ES	0		LO	0
12	HUH	8	12	ES	1.009		HUH	0		LU	0
13	ES	6	13	HUH	0.833		MA	0		ES	0
14	LU	5	14	NI	0.800		SA	0		HUH	0
15	NI	4	15	LU	0.783		SB	0		CA	0
16-17	GR	3	16	GR	0.633		MAO	0		SA	0
	LO	3	17	LO	0.258		BA	0		SB	0

European level) would address this omission. Similarly, the Sierra Sagra offers major syntaxonomic richness, though without exclusive communities, having 16 syntaxa. The sierra of Cazorla (s.l.) does not rank with the former massifs from the standpoint of complementarity because, despite its richness and continuous rarity, it has no exclusive communities. In addition, we find that 8 of the 17 massifs guarantee the representation of all the syntaxa present in the Baetic high-mountain, and thus the effective protection of these zones would favour the conservation of a multitude of endangered and/or endemic species (LORITE et al. in press).

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Appendix 1. Alphabetical list of the associations described for the Baetic sierras.

	Abbrev.	Syntaxa
1	A_El	*Acrocladio cuspidati-Eleocharidetum palustris* O. Bolòs & Vigo in O. Bolòs 1967
2	A_As	*Achilleo odoratae-Astragaletum tremolsiani* Gómez, F. Valle & Mota 1995
3	A_Se	*Aconito burnatii-Senecionetum elodis* Quézel 1953 *nom. mut.* Rivas-Martínez, T. E. Díaz, Fernández-González, Izco, Loidi, Lousã & Penas 2002
4	A_Fe	*Arenario frigidae-Festucetum indigestae* Rivas-Martínez 1964 corr. Rivas-Martínez, T. E. Díaz, Fernández-González, Izco, Loidi, Lousã & Penas 2002
5	A_Ag	*Armerio splendentis-Agrostietum nevadensis* Quézel 1953
6	A_Sa	*Artemisio glutinosae-Santolinetum canescentis* Peinado & Martínez-Parras 1984
7	A_Sr	*Artemisio glutinosae-Santolinetum rosmarinifoliae* Costa 1975 *subass. helichrysetosum serotini* Valle Mota & Gómez 1987
8	A_Si	*Athamantho hispanicae-Sideritidetum stachydioidis* Rigual, Esteve & Rivas Goday 1963
9	A_He	*Avenulo pauneroi-Helictotrichetum cazorlensis* Gómez & F.Valle 1991 corr. Rivas-Martínez, T. E. Díaz, Fernández-González, Izco, Loidi, Lousã & Penas 2002
10	B_Tr	*Brachypodio boissieri-Trisetetum velutini* Martínez Parras, Peinado & Alcaraz 1987
11	B_Pt	*Brassico almeriensis-Pterocephaletum spathulati* Peñas, Mota & Cabello 2000
12	C_Po	*Campanulo willkommii-Polystichetum lonchitidis* (Esteve & Fernández Casas 1971) Molero Mesa 1984
13	C_cc	*Caricetum camposii-cuprinae* Salazar, Lorite, Cano & F. Valle *in* Salazar, Lorite, A. García, J. A. Torres, Cano & F. Valle 2001
14	C_Da	*Cirsio gregarii-Dactyletum juncinellae R*ivas-Martínez, T. E. Díaz, Fernández-González, Izco, Loidi, Lousã & Penas 2002
15	C_Ju	*Cirsio micranthi-Juncetum effusi* Salazar, Cano & F. Valle in Salazar, A. García, Torres, Melendo, F. Valle & Cano 1999
16	C_Ji	*Cirsio paniculati-Juncetum inflexi* Vigo 1968 *corr.* Rivas-Martínez, T. E. Díaz, Fernández-González, Izco, Loidi, Lousã & Penas 2002
17	C_An	*Convolvulo nitidi-Andryaletum agardhii* Quézel 1953
18	C_As	*Coronillo minimae-Astragaletum nummularioidis* Pérez Raya & Molero 1987
19	C_Ib	*Crepido granatensis-Iberidetum granatensis* Quézel 1953
20	C_Ru	*Crepido oporinoidis-Rumicetum indurati* Rivas-Martínez, Fernández-González & Sánchez-Mata 1986
21	C_Dr	*Cryptogrammo crispae-Dryopteridetum oreadis* Rivas-Martínez *in* Rivas-Martínez & Costa 1970 *corr.* Rivas-Martínez, Báscones, T. E. Díaz, Fernández-González & Loidi 1991
22	D_Pi	*Daphno hispanicae-Pinetum nevadensis* Rivas-Martínez 1965 *corr.* Rivas-Martínez, T. E. Díaz, Fernández-González, Izco, Loidi, Lousã & Penas 2002
23	D_Se	*Digitali nevadensis-Senecionetum granatensis* Quézel 1953
24	D_Ho	*Drabo lutescenti-Hohenackerietum exscapae* Mota, Peñas & Cabello 1987
25	E_Fe	*Erigeronto frigidi-Festucetum clementei* Quézel 1953

	Abbrev.	Syntaxa
26	E_Sa	*Erodio daucoidis-Saxifragetum erioblastae* Pérez Raya & J. M. Losa in J. M. Losa & Pérez Raya 1986
27	E_Fa	*Euphrasio willkommii-Festucetum amplae* Martínez-Parras, Peinado & Alcaraz 1987
28	F_mp	*Festucetum moleroio-pseudoeskiae* Quézel 1953 *corr.* Rivas-Martínez, T. E. Díaz, Fernández-González, Izco, Loidi, Lousã & Penas 2002
29	F_As	*Festuco hystricis-Astragaletum boissieri* Quézel 1953 *nom. mut. et inv. propos.* Rivas-Martínez, T. E. Díaz, Fernández-González, Izco, Loidi, Lousã & Penas 2002
30	F_Ve	*Festuco rivularis-Veronicetum nevadensis* Quézel 1953
31	F_He	*Festuco scariosae-Helictotrichetum arundani* Asensi, Díez-Garretas & Martín 1993
32	G_Tr	*Galio pyrenaici-Trisetetum glac ialis* Martínez Parras, Peinado & Alcaraz 1997
33	G_Ju	*Genisto baeticae-Juniperetum hemisphaericae* Quézel 1953 *corr.* Rivas-Martínez, Fernández-González & Loidi 1999
34	H_Pt	*Helianthemo frigiduli-Pterocephaletum spathulati* Martínez Parras & Peinado 1987
35	H_Fe	*Helictotricho filifolii-Festucetum scariosae* Martínez Parras, Peinado & Alcaraz 1984
36	H_Br	*Helictotricho sarracenorum-Brachypodietum boissieri* Pérez-Raya & Molero 1988
37	H_Mo	*Hieracio texedensis-Moehringietum tejedensis* Mota, Gómez & F. Valle 1989
38	H_Pt	*Hippocrepido eriocarpae-Pterocephaletum spathulati* (Quézel 1953) Rivas Goday & Mayor 1966
39	H_Sc	*Hyperico caprifolii-Schoenetum nigricantis* Gómez & F. Valle 1992
40	L_Sa	*Linario cuartanensis-Saxifragetum rigoi* Boucher *ex* Martínez-Parras & Peinado 1990 (= *Jasiono minutae-Saxifragetum rigoi* Mota, Gómez & Valle 1991)
41	Jn	*Juncetum nanae* Rivas-Martínez 1963
42	Mg	*Moehringietum giennensis* Fernández Casas 1972 *corr.* Mota, Gómez & F. Valle 1991
43	N_Fe	*Nardo strictae-Festucetum ibericae* Quézel 1953
44	O_Le	*Omalotheco pusillae-Lepidietum stylati* Martínez-Parras, Peinado & Alcaraz 1987
45	P_Fe	*Plantagini granatensis-Festucetum ibericae* Gómez, F. Valle & Mota 1995
46	Rh	*Ranunculetum hederacei* (Tüxen & Diemont 1936) Libbert 1940
47	R_Va	*Ranunculo acetosellifolii-Vaccinietum uliginosi* Quézel 1953
48	R_ca	*Ranunculo alismoidis-Caricetum intricatae* Martínez-Parras, Peinado & Alcaraz 1987
49	R_ms	*Rosetum myriancantho-siculae* Ríos, P. Sánchez & Alcaraz *in* Alcaraz, P. Sánchez, De la Torre, Ríos & J. Álvarez 1991
50	R_aq	*Rumici scutati-Aquilegietum cazorlensis* Fernández Casas 1972
51	Si	*Sarcocapnetum integrifoliae* Fernández Casas & Molero Briones *in* Fernández Casas 1972
52	S_Ve	*Saturejo intricatae-Velletum spinosae* Rivas Goday 1968 *corr.* Alcaraz, P. Sánchez, De la Torre, Ríos & J. Álvarez 1991
53	Sn	*Saxifragetum nevadensis* Litardière *ex* Quézel 1953
54	S_Pt	*Scorzonero albicantis-Pterocephaletum spathulati* Martínez Parras & Peinado 1987

	Abbrev.	Syntaxa
55	S_Ce	*Sedo brevifolii-Centranthetum nevadensis* Quézel 1953
56	S_Sa	*Sedo melanantheri-Saxifragetum alpigenae* Martínez Parras, Peinado & Alcaraz 1987
57	S_Fe	*Seseli granatensis-Festucetum hystricis* Martínez Parras, Peinado & Alcaraz 1987
58	S_Ar	*Sideritido glacialis-Arenarietum pungentis* Quézel 1953
59	S_Ge	*Sideritido virgatae-Genistetum longipedis* F. Valle, Mota & Gómez 1989
60	Sc	*Saxifragetum camposii* Cuatrecasas *ex* Martínez-Parras & Peinado 1990
61	S_At	*Sileno lasiostylae-Arenarietum tenuis* Gómez, E. Giménez & F. Valle 2006
62	T_Ke	*Teucrio rotundifolii-Kerneretum boissieri* Quézel 1953
63	T_Ci	*Thymo gadorensis-Cistetum laurifolii* Martínez-Parras, Peinado & Alcaraz 1987
64	V_On	*Verbasco gigantei-Onopordetum acauli* Mota, Peñas & Cabello 1997
65	V_Li	*Violo crassiusculae-Linarietum glacialis* Quézel 1953 *nom. mut.* Rivas-Martínez, T. E. Díaz, Fernández-González, Izco, Loidi, Lousã & Penas 2002

Appendix 2. Categorical variables assigned to the syntaxa present in the Baetic sierras (see abbreviations in Appendix 1 and Table 2).

Abrv	HAB	DIS	TH	OM	SUBS	RICH	TH_EN	RAR	PROT_LE	CON_STA	THREATS
A_El	1	2	4	7	5	1	1	4	5	2	4
A_As	1	4	2	7	1	2	2	8	2	3	4
A_Se	1	4	3	7	4	2	2	8	5	2	4
A_Fe	4	4	2	3	4	2	1	5	5	2	4
A_Ag	1	4	3	7	4	2	2	8	5	3	4
A_Sa	3	3	4	6	5	2	1	1	1	1	1
A_Sr	3	3	4	6	4	2	1	5	1	1	1
A_Si	2	4	4	5	1	2	2	8	5	2	2
A_He	4	3	4	5	1	2	1	5	5	2	4
B_Tr	4	4	4	5	2	2	3	8	5	2	4
B_Pt	4	4	4	5	2	2	2	8	2	2	4
C_Po	2	4	2	4	4	2	2	8	5	2	2
C_cc	1	4	4	7	4	3	2	8	5	3	4
C_Da	2	4	3	5	4	2	2	7	5	2	2
C_Ju	1	3	4	7	4	3	2	7	4	3	4
C_Ji	1	2	4	7	5	2	1	3	4	1	1
C_An	2	3	4	5	2	2	3	7	5	4	2
C_As	4	3	2	5	1	2	1	8	5	3	4
C_Ib	4	3	4	5	2	2	2	8	5	3	4
C_Ru	2	4	3	6	4	2	2	7	5	2	1
C_Dr	2	2	3	2	4	2	2	4	5	2	4
D_Pi	5	3	2	5	1	3	2	6	5	3	4
D_Se	2	4	2	5	4	2	2	8	5	2	4
D_Ho	4	3	2	5	1	2	1	8	5	3	4
E_Fe	4	4	1	5	4	2	3	6	5	2	4
E_Sa	2	4	4	5	1	2	2	8	5	2	4
E_Fa	1	3	4	7	4	3	2	4	5	3	4
F_mp	2	4	3	4	4	2	2	8	5	2	4
F_As	4	3	2	5	1	2	2	5	5	2	4
F_Ve	1	4	3	7	4	2	3	8	5	3	4
F_He	4	4	4	2	1	2	1	6	5	2	4
G_Tr	2	4	3	5	4	2	3	8	5	2	4
G_Ju	4	4	3	5	4	3	2	5	5	2	3
H_Pt	4	4	4	5	2	2	2	8	5	2	4
H_Fe	1	3	4	6	1	2	1	5	5	2	4
H_Br	4	4	4	5	2	2	2	8	5	2	4
H_Mo	2	4	2	2	1	1	2	8	5	2	2
H_Pt	4	3	4	5	2	2	2	8	5	2	4
H_Sc	1	3	4	7	1	2	1	4	5	2	4
L_Sa	2	4	4	5	1	2	2	8	5	2	2
Jn	1	2	4	7	4	2	1	4	4	3	4
Mg	2	3	4	5	1	2	2	8	5	1	2
N_Fe	1	4	3	7	4	2	2	8	5	3	4
O_Le	2	4	1	3	4	2	3	8	5	2	4
P_Fe	1	4	2	7	1	2	2	8	5	3	4

Abrv	HAB	DIS	TH	OM	SUBS	RICH	TH_EN	RAR	PROT_LE	CON_STA	THREATS
Rh	1	1	4	7	4	1	1	4	4	3	4
R_Va	1	4	1	7	4	2	3	8	5	3	4
R_ca	1	4	3	7	4	2	3	8	5	3	4
R_ms	5	3	4	5	5	2	1	3	4	2	4
R_aq	1	4	4	5	1	2	2	8	5	2	4
Si	1	3	4	5	1	2	2	8	5	1	2
S_Ve	4	3	2	5	1	2	2	6	5	2	4
Sn	2	4	3	5	4	2	3	8	5	2	2
S_Pt	4	4	4	5	2	2	2	8	5	2	4
S_Ce	2	4	2	5	4	2	2	8	5	1	2
S_Sa	1	4	3	7	4	2	2	8	5	3	4
S_Fe	4	3	2	5	1	2	2	5	5	2	4
S_Ar	4	4	3	5	4	2	2	8	5	2	4
S_Ge	4	3	2	5	1	2	2	5	5	2	4
Sc	2	4	4	5	1	2	2	8	5	1	2
S_At	4	3	4	5	2	2	1	8	5	2	4
T_Ke	2	3	4	5	1	2	1	7	5	1	2
T_Ci	5	4	2	5	4	2	1	5	1	2	1
V_On	3	3	4	6	5	2	1	3	1	1	1
V_Li	2	4	3	5	4	2	3	8	5	3	4