ELSEVIER

FLORA REVIEW

Dolomite flora of the Baetic Ranges glades (South Spain)

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Abstract

The vegetation growing on special types of rocks has long attracted the attention of botanists and ecologists. In this respect, interest in serpentine soils has led to the publication of a number of monographs on their flora and vegetation. The high levels of heavy metals, in particular of Ni, and the low proportion of Ca/Mg are generally held responsible for the severe restrictions limiting flora development on this kind of rocks. Although researchers have also studied other types of unusual bedrocks such as gypsum outcrops, little work has been done on dolomites. This is surprising because dolomites share certain features with serpentines (they are both rocks rich in Mg). This paper deals with the flora peculiar to the dolomites of the Baetic Ranges, one of the richest territories in Europe as far as flora is concerned. A number of botanists with experience in the study of this very particular flora have joined together to make a list of the plants peculiar to the dolomites. Our catalogue includes 144 species with a variable degree of "dolomitophily", the score of which ranging from 1 to 3, the maximal value. A comparison of the taxonomical spectrum of this catalogue with the one found in territories where dolomites are dominant or with other areas of serpentines reveals that there is a given deviation or bias in favour of some families. A similar comparison between biotypes also leads to the observation that, as usually happens on ultramafic rocks, hemicryptophytes tend to be dominant on dolomites. In addition, we show that the proportion of Ca/Mg catalogued for different kinds of soils could be a key element in explaining the

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restrictions which dolomites and serpentines impose on plants. In dolomites this proportion shows an intermediate position (2.19) between soils derived from limestones (11.30) and serpentines (0.84) in the study area.

Introduction

The relationship between type of rock and vegetation has been recognised for a long time. In 1583, referring to *Alyssum bertolonii* Desv., a species which is now known for its ability to store nickel (Brooks and Radford, 1978; Küpper et al., 2001), Andrea Cesalpino recorded the occurrence of endemic species on the Italian serpentines. However, the scientific and systematic study of the relationship between vegetation and the underlying rocks only dates back to the 19th century (Kruckeberg, 2002). Since then, the effect of rocks on the vegetation has been dealt with from two different approaches, depending on the importance given to either the physical or the nutritional role played by soils (Cavers, 1914). Critical physical factors are topography and soil texture. Nutritional factors constitute for example the imbalances in macro- and micronutrients or heavy metals. This dichotomy is seen in Jeffrey's (1987) explanation of the restriction of many flowering plants to serpentines (serpentinophily) and to other substrates (e.g., Parsons, 1976). The occurrence of floras specifically related to serpentines has proved to be a very fruitful field of research in geobotany, with a number of monographs which are essential reference for any scientist dealing with this topic (Baker et al., 1992; Brooks, 1998; Kruckeberg, 1985; Roberts and Proctor, 1992). In the last few years, these and other publications have prompted work on the subject in different parts of the world, such as Reeves et al. (2001), Specht et al. (2001), Changwe and Balkwill (2003), and Freitas et al. (2004).

Although the occurrence in Spain of a flora peculiar to special substrates were already described by several authors in the 19th century (Boissier, 1839–1845; Willkomm, 1852) and the early 20th century (Huguet del Villar, 1925), it was Rivas Goday who initiated the study of plants growing on serpentines (Rivas Goday, 1969, 1973, 1974). This author denoted the condition that often endemic taxa may be restricted to a peculiar kind of substrate as "edaphism". In a more general sense, edaphism is interpreted as a "geobotanical phenomenon giving rise to particular floras on certain substrates" (Font Quer, 1977), or as "those physical and chemical effects induced on living beings by the soil" (Sarmiento, 2001). In this last sense, edaphism tends to agree with the object of research of Kruckeberg's (2002) "geoecology". The term "edaphism" has been used extensively

by European botanists long ago (Cavers, 1914; Géze, 1908; Gola, 1910) and may be of great help in describing the phenomena referred to here in an accurate way.

In the above-mentioned works, Rivas Goday states that not only serpentines but also andesites and dolomites are rocks prone to edaphism. He cautiously attempts to provide a common explanation for the occurrence of a flora which he called comprehensively magnesicolous flora, i.e., plants growing mainly on dolomites and serpentines. As plausible explanation for the occurrence of these special floras Rivas Goday mentioned the xericity of the substrate, the presence of heavy metals and the high proportion of magnesium (Rivas Goday, 1969, 1973).

Although Willkomm (1852) described the occurrence in Spain of vegetation exclusive to dolomites, Quézel (1953) was the first person to study it from a phytosociological point of view when he described the association Convolvulo–Andryaletum. A decade later Rivas-Martínez (1961) established an alliance exclusive to this kind of communities: *Andryalion agardhii*. Despite being stimulated by these initial works, scientific research in Spain on this kind of substrates and their vegetation has never gone beyond the description of associations following the sigmatist method of Braun-–Blanquet (e.g., Lorite et al., 2001; Mota and Valle, 1992; Mota et al., 1993; Rivas Goday and Rivas Martínez, 1969; Sánchez-Gómez and Alcaraz, 1992). As far as dolomites are concerned, this is much the case in other European countries (Quézel, 1952; Ravazzi, 1992; Ritter-Studnička, 1967). In other continents little has been done beyond making floristic lists and catalogues (Allison and Stevens, 2001; Cloutier, 1987; Ludwig, 1999; Siebert and Siebert, 2005).

As serpentine, dolomite is a rock rich in magnesium (Jones, 1951), although its origin is radically different and more related to limestone. However, if limestones are mainly calcium carbonate, in dolomites a good deal of Ca^{2+} has been replaced by Mg^{2+}. By considering this as distinctive, McHale and Winterhalder (1997) assign the terms "dolomitic limestone" to one kind of rock and "calcitic limestone" to the other. In the Baetic Ranges (southern Spain), there are abundant examples of these three kinds of rocks (Vera, 2004). The transition from limestones to dolomites (and their metamorphic versions or marbles) is not quite obvious and geological mapping has paid no serious attention to the issue (different categories are frequently grouped together in

the same unit; e.g., IGME, 1972). However, many botanists (besides those already mentioned) have recognized a flora peculiar to and exclusive to the dolomites (Allison and Stevens, 2001; Braun-Blanquet, 1932; Cloutier, 1987; Csontos et al., 2004; Ludwig, 1999; Neely and Barkworth, 1984; Quézel, 1952; Ravazzi, 1992; Tamás, 2003). This does not only occur in the south of Spain. What Gams (1930) called "Dolomit-phänomen" is found all over the world. However, the outcrops of dolomites are not clearly mapped from a geological point of view and they are not easily distinguishable from pure limestone outcrops. Therefore, it is difficult to identify a "dolomitophilous" flora (Lorite et al., 2001; Ludwig, 1999). Indeed, the distinction between these two kinds of floras is not always precise, because they share a high percentage of species in some territories (e.g., Ludwig, 1999; Nelson and Ladd, 1983). It has been frequently noted that the flora on dolomites only occurs on topographical ridges, on steep mostly south-facing slopes or when the rock is finely crushed (cataclasites, brecciated or kakiritized dolomites) (Lorite et al., 2001; Mota and Valle, 1992; Mota et al., 1993; Valle et al., 1987), but in all other respects the vegetation growing on limestones and dolomites is not very dissimilar. Kakiritisation is an alteration process associated with the intense tectonic fracturation of rocks which renders them megascopically sheared and brecciated with fragments of the original material surrounded by gliding surfaces with intense granulation and some recrystallisation (Carreira et al., 1997). The result is a soil with extremely low soil moisture and a high content of magnesium (Allison and Stevens, 2001). The presence of these high concentrations of magnesium suggests that some of the determining factors postulated for the magnesicolous flora of serpentines could also be acting on the flora growing on dolomites (Krapfenbauer, 1969). In this respect, Duvigneaud (1966) already stated that soil Ca saturation is extremely important on serpentines and that the main feature of serpentinophytes is their ability to grow by obtaining sufficient Ca on soils with extremely low quantities of it, an opinion also supported by Marschner (2002). The above-mentioned monographs dealing with the vegetation on serpentines point in this same direction and ascribe a fundamental role to the Ca/Mg relation. Both the classic (e.g., Proctor, 1971; Walker et al., 1954) and recent surveys (e.g., Brady et al., 2005; O'Dell et al., 2006) on serpentines support this point of view. On the other hand, several experimental works have compared the effect of Ca and Mg on the phosphatase activity in serpentines races and species with the activity in non-serpentines races and species (e.g., Gabbrielli et al., 1989; Johnston and Proctor, 1984). These researches also dealt with the effect of Ni on the acid phosphatase, but also on the growth (Johnston and Proctor, 1981; Nagy and Proctor,

1997a). The previous works have clarified the differences between ultramafic and non-ultramaphic races, especially for the effect of Mg. However, the nutrient limitation (Nagy and Proctor, 1997a) and the soil water retention (Proctor et al., 1999) must be also added to the possible causes of the serpentinophily. The ability of some serpentinophytes to store nickel has given rise to other hypotheses to account for their occurrence (e.g., Brooks, 1998). However, this feature could be better related to a protective mechanism against herbivores (Boyd and Martens, 1998; Proctor, 1999; but Martens and Boyd, 2002) than to an inescapable adaptation to live on serpentines.

Jeffrey's (1987) excellent summary of the factors present in a serpentine soil environment includes shallow and overdrained soils and calcium–magnesium relationships as shared by dolomites and serpentines. Toxicity due to heavy metals does not seem to be a general problem in dolomites (cf. Genova et al., 2000), and a limiting supply of nitrogen, phosphate and potassium as inhibitory factors would not be exclusive to these two kinds of soils, at least in Mediterranean environments (e.g., Lamont, 1983, 1994).

Considering these aspects, we assume that dolomites may be interpreted as a crossroad between serpentines and limestones, with a peculiar flora which occasionally overlap with the flora observed on the other kinds of rocks. Based on this, the aims of our paper are as follows:

1. Provide a checklist of the species exclusive (or almost exclusive) to dolomites in the south of Spain, a region extremely rich from a floristic point of view.
2. Describe the relationship between the flora of dolomites and the taxonomical groups, the spectrum of life forms, and establish the richness and rarity of the respective phytogeographical units of the Baetic Ranges.
3. Make comparisons with other magnesicolous floras (serpentines and peridotites) according to the taxonomical spectrum and the proportion of biotypes.
4. Compare those basic characteristics of dolomite soils which may explain their peculiar flora with the properties of other closely related soils, such as those of limestones and serpentines, on which special floras also occur.

In order to achieve these aims, a number of botanists with experience in the flora growing on dolomites have brought together their energy and knowledge. We aim at reviewing and updating the issue of "dolomitophily" (a term coined in the same way as the widely used "halophily" and "gypsophily") in order to encourage investigation into this interesting edaphic phenomenon or edaphism.

Material and methods

Study area

The Baetic Ranges are the principal orographical and geological unit of the S and SE of the Iberian Peninsula (Fig. 1). They include the mountains located to the S of the Guadalquivir River and those which, extending towards the NE, reach the Eastern Iberian coast, covering some 45,000 km². Although to the SW, S and SE the boundaries of these ranges coincide with the Atlantic and Mediterranean coasts, they extend under the sea to eventually connect with other alpine domains: the North African Rif and the Balearic Islands (Vera, 2004). The Baetic Ranges have been recognized as one of the great plant diversity centres in the Mediterranean basin (Médail and Quézel, 1997) and Europe (Molero Mesa, 1994). The richness in endemic species is very high, with percentages comparable to those observed on some islands in the Mediterranean or in extremely mountainous peninsulas (Peñas et al., 2005). A large part of this endemic flora tends to concentrate on the territories of high altitude mountains (Mota et al., 2002) and is usually related to particular edaphic substrates. From a geological point of view, the Baetic Ranges are extremely complex, indeed (Vera, 2004). Their rugged topography, crowned by Sierra Nevada (Mulhacén, 3482 m above sea level), is accompanied by a motley lithology ranging from the siliceous metamorphic core of Sierra Nevada, through the world's largest peridotitic range originating in the lower lithosphere (Sierra

Bermeja), to the dominant limestones, dolomites and marbles. The geographical location of these ranges, in the south of a peninsula, has allowed them to act as a refuge for many species during the glaciations (Blanca et al., 1998) while, at the same time, they interchanged biotas with the northern Africa through the primeval pathways already mentioned (Quézel, 1985). In past the climate fluctuated enormously, and nowadays temperature and precipitation ranges are still very great, although the area shows a clear Mediterranean character with a long period of summer drought.

Methods

First we made a list of dolomitophytes based on the species considered by Rivas-Martínez et al. (2002a, b) as characteristic of the order *Convolvuletalia boissieri* and those of the alliances Omphalodion commutatae and Triseto velutini-Brachypodion boissieri and Andryalo-Crambion filiformis, that is, four syntaxa exclusively defined for dolomites. This initial catalogue contained 107 taxa and kept growing with the addition of other species also considered as dolomitophytes according to the observations of the research team. Our experience in the different phytogeographical units covers the whole Baetic territory. Many of these opinions on the subject had already appeared in publications (e.g., Benavente, 2005; Gámez et al., 2000; Lorite et al., 2001; Mota and Valle, 1992; Mota et al., 1993; Navarro et al., 1998; Pérez Sánchez and Pérez Latorre, 1998; Sánchez-Gómez and Alcaraz, 1992). A list with a total of 209 taxa was
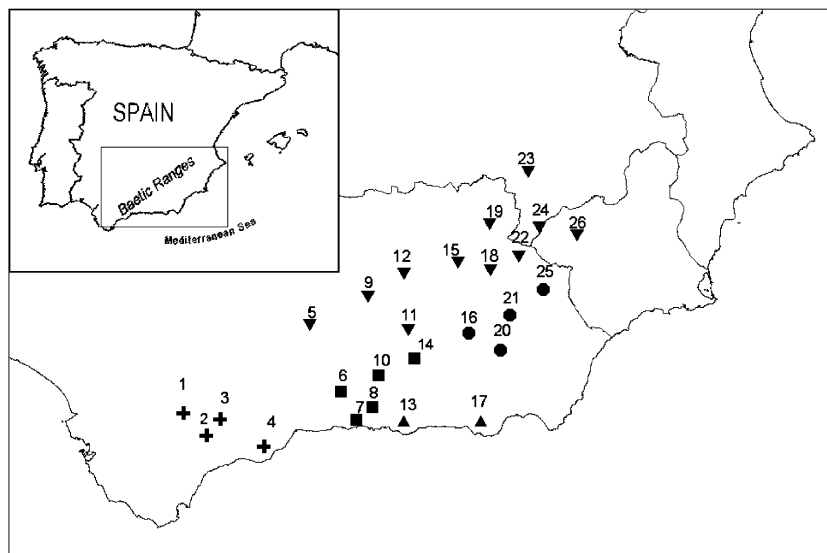
Fig. 1. Baetic sierras and localities mentioned in the text: 1: 1 – Grazalema, 2 – Bermeja, 3 – Las Nieves, 4 – Blanca de Ojén, 5 – Horconcera, 6 – Tejeda, 7 – Almijara, 8 – Guájares, 9 – La Pandera, 10 – Sierra Nevada, 11 – Harana, 12 – Sierra Mágina, 13 – Lújar, 14 – La Peza, 15 – Cazorla-Pozo, 16 – Baza, 17 – Gádor, 18 – Empanada–Castril–Cabrilla–Guillimona, 19 – Segura–Banderillas, 20 – Los Filabres, 21 – Estancias, 22 – La Sagra, 23 – Calar del Mundo, 24 – Taibilla–Revolcadores, 25 – María and 26 – Villafuerte. Symbols used related to biogeographical sector: ▲, Alpujarrean-Gadorensean Sector; ●, Guadician-Bacensean Sector; ■, Malacitan-Almijarensean Sector; +, Rondean Sector and ▼, Subbaetic.

sent to all researchers for them to judge the degree of "dolomitophily" (in a scale ranging from 3 to 1) of each taxon. Species considered as strict dolomitophytes were given a 3, 2 to preferential species (i.e., species which clearly prefer dolomites although occasionally found on other kinds of substrates), 1.5 to species growing on dolomites and on some other particular substrate (e.g., gypsum soil, serpentines), and 1 to those species able to thrive indistinctly on dolomites and on other kinds of soil. Both the number of times that each taxon was included as a dolomitophyte and the median value of the scores obtained are considered as indicators of dolomitophily, i.e., as a degree of restriction to dolomites (Annex 1). Here we must clarify that any one taxon could only be considered eight times as a maximum and, consequently as, the five researchers resident in Almería agreed on a common opinion. Annex includes not only the taxonomical status (family) and life form of each taxon, but also their respective presence in the biogeographical units (sectors) suggested by Rivas-Martínez et al. (2002a). These data were later used in the subsequent analyses and cross-checked with other floras and territories (Gutiérrez, 1986; López González, 1975; Pérez-Raya, 1987) and to determine the richness and continuous rarity of each phytogeographical unit using the methods described by Medina-Cazorla et al. (2005). The rarity is the inverse of the number of sector where this species is present and the continuous rarity is the sum of the rarity of each species present in the sector. We have also recorded the number of endangered taxa present in each of the chorological units according to Bañares et al. (2003).

We have also compared the dolomite soils with the soils of serpentines and limestones by using the pH values and the Ca/Mg proportions. As already mentioned, special floras have frequently been recorded on serpentines all over the world and the Ca/Mg proportion is one of the parameters being responsible for these particular plant arrangements (Brady et al., 2005; Chiarucci et al., 2001; O'Dell et al., 2006). On the other hand, the soils on limestones are a priori most similar to those occurring on dolomites, since the distinguishing feature between both kinds of rocks relies on the Ca and Mg contents. For comparative purposes, we have used 15 dolomite soils (Aguilar et al., 1986; Delgado et al., 1988; García-Fernández et al., 1983; Ortega et al., 1988; Sierra et al., 1986, 1990, 1992), 14 limestone soils (Delgado et al., 1988; Ortega et al., 1988; Sierra et al., 1986, 1990, 1992) and 10 soils of ultramafic rocks (Aguilar et al., 1998; García-Fernández et al., 1987; Hoyos and González Parra, 1971). With the exception of two serpentine soils (Guitián Ojea and López López, 1980), all the soils included in the analyses are located in the Baetic Ranges and, as far as the soils developed on limestones are concerned, we always tried to sample sites close to dolomite soils. The analyses included the A and, in most cases, B horizons. However, they did not include C horizons, in which the differential values of Ca and Mg contents for the three kinds of rock tend to be even more noticeable. In this paper, the substrate concentrations of Ca and Mg are given in cmol $(+)$ kg^{-1}. To help the data meet the distributional and variance assumptions (Quinn and Keough, 2002), it was necessary to transform the Ca/Mg $(\log x + 1)$ proportional values prior to the comparative analysis of the means. After execution of ANOVA, an unplanned pairwise comparison (a posteriori or multiple comparisons) was performed, since we compare all possible pairs of group means (i.e., each group to every other group) in a post hoc exploratory fashion. All the statistical analyses were carried out by means of SPSS 13.0 for Windows.

The botanical nomenclature is in accordance with *Flora Iberica* for the published families (Castroviejo (coord.), 1989) and, for the rest of taxa, with Rivas-Martínez et al. (2002a, b). The syntaxonomical and phytogeographical nomenclature follows these two last references too.

Results

Annex shows the 144 taxa considered as taxa peculiar to dolomites, i.e., with dolomitophily values higher than 1. It shows not only how many experts included each of them as a dolomitophyte, but also how many times each taxon was listed by each expert (N votes) and how many times the score was higher than 1 (N votes > 1). This Annex also shows the sum of all the scores, the average values, the corresponding families of the taxa, their life forms, the biogeographical sectors in which they occur and their vulnerability according to Bañares et al. (2003). Sixty-five percent of the taxa were considered as dolomitophytes by at least four experts and over 75.7% of them scored a median value higher than 1.5. One hundred and six taxa (73.6%) obtained median values of 2 or higher, whereas 57 scored 2.5 or higher, i.e., almost 39.6% of the list. The median value for the 144 taxa was 2 (average 2.2). *Thymus granatensis* (including its two subspecies), *Convolvulus boissieri* subsp. *boissieri* and *Pterocephalus spathulatus* obtained 20 or higher in the accumulated values. *Rothmaleria granatensis*, *Lomelosia pulsatilloides* subsp. *pulsatilloides*, *Santolina elegans*, *Hippocrepis eriocarpa*, *Lithodora nitida* and *Andryala agardhii* (Annex 1) scored values very close to those of the above-mentioned taxa. Fifty-three taxa, almost 37% of the list, accumulated values over 11.

The best represented families in our list of dolomitophytes are Fabaceae (16%), Brassicaceae (14.6%), Asteraceae (12.5%), Caryophyllaceae (10.4%), Scrophulariaceae (9.7%) and Lamiaceae (4.9%) [family

delimination in conventional sense]. In Fig. 2, this taxonomical spectrum is compared with that of other territories. In some of these territories dolomites are dominant, as in the rim of Sierra Nevada and Sierra de la Peza, in the S of Spain (Gutiérrez, 1986; Pérez-Raya, 1987), whereas in other areas peridotites or serpentines tend to be the most abundant rocks, as in the Sierra de Aguas in the S of Spain (López González, 1975), the outcrops in the NE of Portugal (Menezes de Sequeira and Pinto da Silva, 1992) or in Rhodopes, Bulgaria (Pavlova et al., 2003). Tabernas, in the Spanish SE, has been used because it is one of the most arid territories in Europe (Mota et al., 2003). There is an obvious disharmony between the floras of the territories under consideration and our checklist of plants exclusive to dolomites. Curiously, the arid territory of Tabernas Desert exhibits a similar taxonomical profile, in which the six already mentioned families represent over 70% of the flora.

As far as biotypes are concerned, hemicryptophytes are dominant, with 48.6% of the species, whereas chamaephytes represent 36.1%. As is usual in Mediterranean areas (Fig. 3), therophytes, with 13.9%, have a less important role. Phanerophytes and geophytes are, however, unusually rare.

As far as chorological areas are concerned, the Malacitan-Almijarensean Sector is extremely rich, with 72.9% of the taxa. This territory has also the largest
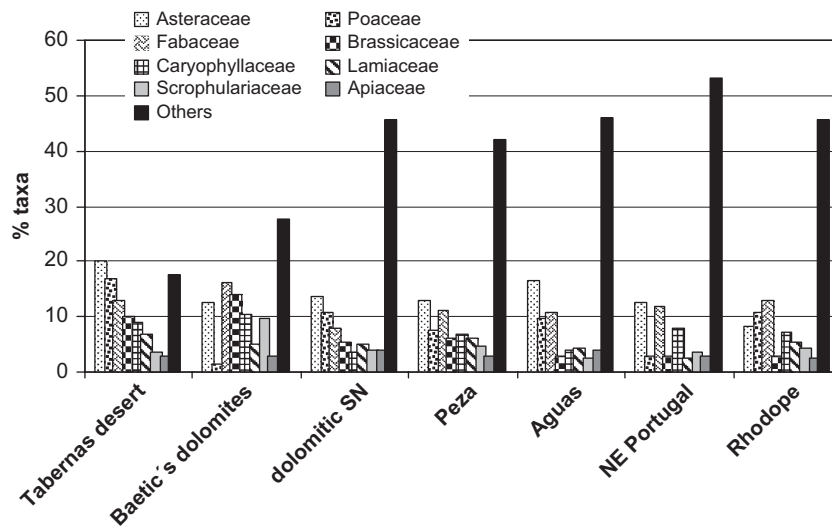
Fig. 2. Families proportion of the dolomitic flora of the Baetic Ranges compared to the proportion of other territories included in these ranges (dolomitic SN, Peza and Aguas) and exterior to these ranges (Tabernas, NE Portugal and Rhodope).

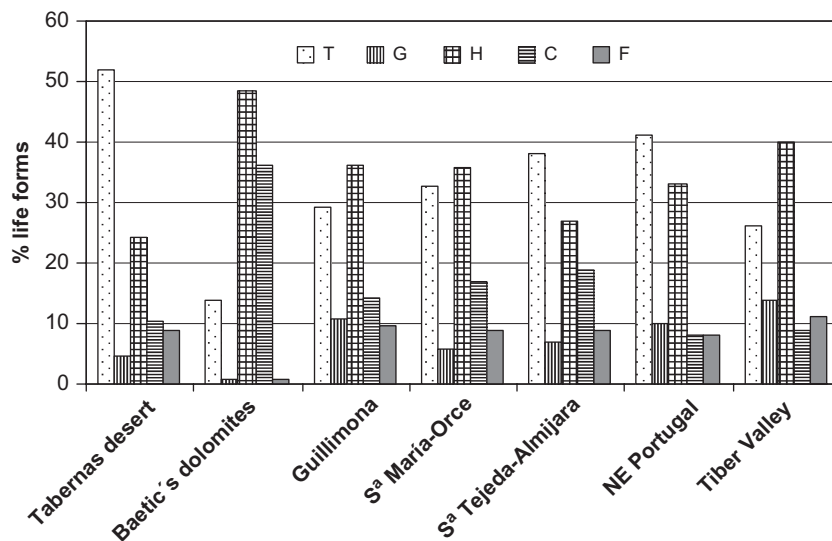**Fig. 3.** Most relevant life forms present in the dolomitic flora of the Baetic Ranges and other territories included in these ranges (Guillimona, María-Orce and Tejeda-Almijara) and exterior to these ranges (Tabernas Desert, NE Portugal and Tiber Valley); T, therophyte; G, geophytes; H, hemicryptophyte; C, chamaephyte and F, phanerophyte.

number of exclusive species (105), i.e., species which are not be found elsewhere (Table 1). The Subbaetic territories stand out for these same reasons, with 16 exclusive taxa. The Sierra de Lújar and the Sierra de Gádor, which form the Alpujarrean-Gadorensean Sector, are the poorest territories, with only 36 dolomitophytes, none of them endemic, except *Alyssum gadorense*. The Rondean and Guadician-Bacensean Sectors occupy an intermediate position. The values of continuous rarity are also maximal for the Malacitan-Almijarensean and Subbaetic territories. These last sectors are also notable for conservation policies (Table 1), since, according to Bañares et al. (2003), they have 39 and 34 threatened taxa, respectively. In this respect, the Alpujarrean-Gadorensean Sector has only six threatened taxa, while the Rondean and Guadician-

Bacensean sectors have a few more. The continuous rarity also shows a similar pattern, with maximal values in the Malacitan-Almijarensean Sector, followed by the Subbaetic, Rondean, Guadician-Bacensean and Alpujarrean-Gadorensean sectors.

From the edaphic point of view and as far as the Ca/Mg proportion is concerned, dolomites exhibit an intermediate position between limestones and serpentines, with an average value of 2.19, while limestones have 11.30 and ultramafic 0.84 (Table 2). Considering the three types of substrates (Table 3), this is a significant difference. Scheffé test (Waite, 2000) was used for multiple significant testing across the means. Means were significantly different in all cases (Table 3). A value of 1.96 (Neely and Barkworth, 1984) was recorded for dolomites in the Bear River Range (Utah)

Table 1. Richness and rarity of the dolomitic flora of the biogeographic sectors of the Baetic Ranges

Sector	N	N endemic taxa	Rc	Rc/N	CR	EN	VU	DD	Threatened
Alpujarrean-Gadorensean Sector	36	1	10.87	0.30	0	0	5	1	6
Guadician-Bacensean Sector	57	3	19.28	0.34	0	0	10	0	10
Malacitan-Almijarensean Sector	105	26	51.62	0.49	2	4	31	2	39
Rondean Sector	54	6	21.78	0.40	0	2	11	2	15
Subbaetic Sector	91	16	40.45	0.44	1	4	28	1	34

N, number of taxa; Rc, continuous rarity; CR, critically endangered; EN, endangered; VU, vulnerable; DD, data deficient. Number of taxa included in these IUCN threat categories.

Table 2. Chemical characteristics of the soils studied

Soils	N	Ca means	Mg means	Ca/Mg means	pH means
Ultramafic	10	8.21	12.32	0.84	6.81
Dolomite	15	10.92	5.98	2.56	7.94
Limestone	14	24.28	2.89	11.30	7.73
Total	39	15.02	6.50	5.26	7.57

N, number of samples; Ca, calcium; Mg, magnesium; Ca/Mg, calcium–magnesium ratio.

Table 3. Results of the statistical analyses of the soils by applying two different techniques

ANOVA						Scheffé test		
	SS	d.f.	MS	F	p	p	Ultramafic	
$\log[(Ca/Mg)^{+1}]$								
Between-groups	3.74	2	1.87	37.43	–	Dolomite	>0.02[*]	Dolomite
Within groups	1.80	36	0.05			Limestone	>0.005[*]	>0.005[*]
Total	5.54	38						
pH								
Between-groups	8.21	2	4.10	24.96	–	Dolomite	>0.005[*]	Dolomite
Within groups	5.92	36	0.16			Limestone	>0.005[*]	0.39
Total	14.13	38						

and 3.38 (Wright and Mooney, 1965) for the forests of Bristlecone Pine in the White Mountains, both very similar to ours. As far as pH values are concerned, serpentines show the lowest values (6.80), with no significant differences between limestones and dolomites (7.72 and 7.96, respectively). In the ANOVA, the pH tests revealed significant differences and the pH of serpentines differed from the records obtained both for dolomites and limestones. However, the latter two revealed no significant differences (Table 3).

Discussion and conclusion

Although for many taxa the experts' evaluation tends to coincide, the survey clearly suggests that the category of dolomitophyte is far from being clear. The average difference between the maximal and minimal values given to the 144 taxa under consideration was 1.1 and this difference was only zero in 24 cases. Despite these understandable discrepancies, the average value given to the 144 species was 2.2, the standard deviation was 0.5 and in 40 cases the experts' opinions differed enormously. Probably, the same variability would be recorded if a similar procedure were applied to other kinds of edaphisms, such as those of serpentines and gypsum outcrops. However, in these cases the issue has never been approached as it has been here, i.e., different experts have never been asked to evaluate the same group of species. A vast majority of the evaluations available on the restriction of the corresponding species to a particular type of soil are based on the opinions provided by one or two researchers on very limited territories. If the species restricted to the type of soil in one area does not react differently to such substrates elsewhere along their range, it is possible that the conclusions derived from surveys of this kind of flora may be incomplete or incorrect.

There are, obviously, more objective ways than these to determine the preference of a species for a certain kind of substrate, although it would be difficult to cover the whole geographical scope of all the Baetic Ranges. Thus, soil analyses would be of great help for this purpose, in particular if the soils and flora of the dolomites were compared with those of the adjoining territories with a different flora developed on other kinds of rocks (e.g., Duvigneaud, 1966). From the nutritional point of view, it is also possible to distinguish between plants living in dissimilar edaphic environments, as is the case of halophytes and gypsophytes (e.g., Merlo et al., 2001). In the case of serpentines, phosphorus has been reported as the key major nutrient (Nagy and Proctor, 1997b). Physiological, morpho-anatomical and phenomorphological surveys which could reveal special adaptations of this kind of floras to their environment (Brady et al., 2005) would be even more helpful. In the case of gypsophytes, for example, the germination on gypsum has been extensively studied with no clear conclusions as yet (Merlo et al., 1997). The experimental researches in serpentines have reported relevant results, so presumably stress-tolerant species respond in an opportunistic way when the nutrients limitation is removed (Nagy and Proctor, 1997b). In all the above-mentioned aspects dolomites and their flora have been rarely studied. Despite their great interest, all these investigations require an enormous amount of work in sampling and subsequent analyses. All this work cannot easily be undertaken unless we previously determine which species, out of many hundreds, are to be given top priority. Our approach may help both to concentrate attention on certain species and to establish research priorities.

As far as the dominant families are concerned, the taxonomical spectrum of the strictly dolomiticolous flora is the usual one. Perhaps the most remarkable observation is that only six families represent almost 70% of the total species. In this respect, this spectrum is similar to that of Tabernas, a territory located in the semiarid Spanish SE (Fig. 2). This fact supports the comments of Baskin and Baskin (2004) that glade species are often typical of hotter and drier conditions than their surrounding environment. Asteraceae and Fabaceae are among the families with a larger number of species, although the latter family is slightly over-represented. The most striking observation is the reduced number of Poaceae that can be considered exclusive to the dolomites, in contrast to other territories, as USA, where as these habitats are commonly known as "prairies", a term often reserved for grasslands that are extensive and essentially devoid of woody species (Ludwig, 1999). There may be cryptotaxa which have still not been described and great effort should be made to explain this striking fact (Gauthier et al., 1998). Poaceae occur frequently in very stressful environments (Baskin and Baskin, 2000) and, consequently, it is hard to understand why there is such a low number of them which can be considered peculiar to dolomites. Perhaps, as with the *Armeria* genus, many of these taxa are being described as peculiar to dolomites (Nieto-Feliner et al., 2001). Taxonomical investigation will eventually reveal greater variability than at present, as Allison and Stevens (2001) have shown. On the other hand, some species of the Poaceae are relatively sensitive to Mg presence in the substrate (Proctor, 1971), although with important exceptions (Dixon and Tood, 2001). Besides, Poaceae are very well represented in serpentine environments (Nelson and Ladd, 1983). An alternative explanation, however, could be that for this family there is little difference between the floras of dolomites and those of limestones. Poaceae with a wide ecological range in the south of Spain, such as *Helictotrichon filifolium* or *Stipa tenacissima*, like

numerous *Festuca* species, grow well on both dolomites and limestones. Other conspicuous families in the floristic spectrum of dolomites are Cistaceae, Caryophyllaceae and Brassicaceae. All of them are found in arid Mediterranean environments and, therefore, it is not surprising to find them so well represented here. However, the dominance of Brassicaceae is similar for dolomites and serpentines (Proctor, 1999). The large number of serpentinicolous hyperaccumulator species which belong to this family (Brooks and Radford, 1978; Küpper et al., 2001) such as *Alyssum* species, are also peculiar to dolomites (Quézel, 1952). On the other hand, *Arenaria* (Caryophyllaceae) is the genus with the largest number of species growing on dolomites. Finally, the importance of the presence of Scrophulariaceae is also striking. This family has several very well represented genera, with *Linaria* and *Chaenorrhinum* as the most prominent examples.

Dwarf procumbent scrubs usually with small leaves covered by a dense sericeous indument are dominant in the Baetic dolomites (Mota and Valle, 1992). Most such species are hemicryptophytes and nanochamaephytes. The intense exposure to sunshine of these environments, the microclimatic effects (Csontos et al., 2004; Tamás, 2003) and the shortage of water and nutrients (Carreira et al., 1997) are probably responsible for these modifications which produce the remarkable adaptive convergence and poor growth of these plants, as on serpentines (Chiarucci et al., 2001). Phanerophytes peculiar to dolomites are probably so infrequent for these same reasons. On top of these factors, the intense erosion of these environments could also explain the strikingly low proportion of geophytes, since their roots could become exposed (LaMarche, 1968). Other surveys also reflect the low proportion of phanerophytes and the exclusive dominance of hemicryptophytes, which represent almost 75% of the species on the site (Neely and Barkworth, 1984). The abundance of therophytes may be explained by the substrate texture, which tends to be sandy or gravely with little or no capacity to retain water (García-Fernández et al., 1983). Thus, annual plants can be favoured by drought (Archibold, 1995; Merlo et al., 2003).

In accordance with the dominant biotype, the Rosmarinetea scrubs show the largest number of dolomitophytes. The thyme pastures of the Convolvuletalia order are probably the best expression of the dolomiticolous flora, a feature clearly different from other surrounding types of vegetation. In this respect, a detailed investigation should be made into how small environmental variations, e.g., in the substrate, slope and wind exposure induce the occurrence of these striking sericeous vegetal pads, especially when they are dominated by *Convolvulus boissieri* subsp. *boissieri* and/or *Pterocephalus spathulatus*. The whitish colour both of these plants and the rock has led to these communities being called *blanquizar* or *blanquizal* (literally "white-land"). The scarce vegetal cover and the sterility of the soil have also given rise to a series of Spanish topological terms which describe these areas as "pelaos" (bald) that is low-fertility areas with low-growing and intermittent vegetation. These terms can be compared to those of "barrens" or "glade" used in the USA (Ludwig, 1999).

The existence of a rich endemic flora with remarkable ecomorphological adaptations, the relict character of some taxa, the speciation phenomena apparently induced and the description of new taxa in the dolomite glades fully justify the conservation of these outcrops. In addition, many of the plant taxa of conservational concern occur in these glades (Table 1) and these habitats have been included by the EU in the "Habitats" Directive 92/43/CEE. Most of the best sites are currently under protection, but some areas have not yet been included in the network of nature reserves (Medina-Cazorla et al., 2005). Table 4 shows the most valuable sites in the study area under the aspect of flora and vegetation. Of all of them only the dolomitic outcrops of Guájares, La Peza and la Hoya Alazor are not under effective protection.

We have already commented on the differences between the three kinds of soils as far as the Ca/Mg proportion is concerned, with dolomites showing an intermediate position between soils derived from limestones and serpentines. However, if we consider only the edaphic profiles made on kakiritized dolomites, i.e., those in which the authors specifically mention this kind of crushed dolomites (Delgado et al., 1988; García-Fernández et al., 1983), the six soils obtain a ratio of 0.82. This ratio is identical to that of the serpentine soils included in this survey and within the range reported by Proctor (1971, 2003) for serpentines. We must not forget either that the dolomitic limestone Mg can constitute between 3 and $15\,\mathrm{me}\,100\,\mathrm{g}^{-1}$ (Dixon and Tood, 2001),

Table 4. The most valuable sites of dolomitophilous flora of the Baetic Ranges and the Sierras they belong to

Sierra	Sites
S. Nevada	Cerro Trevenque and Alayos de Dílar
S. Tejeda and Almijara	Cerro Lucero and Navachica
Los Guájares	The whole sierra
Calar del Mundo	The summit area
La Peza	Dolomitic area
S. Mágina	Dolomitic area
S. Cazorla	Puerto de los Tejos
S. Villafuerte	Hoya Alazor
S. Baza	Cerro Quintana and Calar de Santa Bárbara
S. Las Nieves	Cañada del Hornillo
S. Blanca of Ojén	The whole sierra

whilst estimates for serpentine vary between 4.1 and 19.7 (Walker, 1954), 14.9 and 34.8 me $100\,g^{-1}$ (Proctor, 1971) and 1.1–38.5 me $100\,g^{-1}$ (Proctor, 2003). The Mg range lies within 4.02 and 30.15 me $100\,g^{-1}$ for the serpentine soils included in this survey and corresponds to the values previously reported. For dolomites, the range varies from 2 to 23.67 me $100\,g^{-1}$. However, if within dolomites, soils on kakirites are considered separately from those developed on non-kakiritized dolomites, the respective ranges are very different: 12–23.67 me $100\,g^{-1}$ for the first and 2–13 me $100\,g^{-1}$ for the second type. These ranges are very close to those reported by Dixon and Tood (2001), but very different from the values for kakiritized dolomites, which are very similar to those of serpentines. Although the number of data from soils developed on kakiritized dolomites (3) is insufficient to adequately compare means with any statistical significance, they reveal that a study of soils developed on dolomites and their impact on the vegetation would be of great interest.

Our work is only a preliminary step in determining what we could call the "dolomite syndrome" and to better understand plant mechanisms of tolerance to these environments (Ca/Mg proportion, nutrient shortage, severe droughts, growth constrictions, ecomorphological features), genetic adaptation, speciation and other evolutive mechanisms (e.g., preadaptation to these kinds of soils). Likewise, the checklist of dolomitophytes should contribute to a better understanding of the autoecology and synecology of rare species. Data of rare species are handled before a management (recovery) plan is made. Therefore, few studies have investigated the factors involved in the maintenance of rare early successional species (Walck et al., 1999). It is important to remember that dolomites are mined (Pérez Sánchez and Pérez Latorre, 1998) and the restoration of these special edaphic environments requires a sound knowledge of this type of area and its flora. Otherwise, as Mota et al. (2004) have already pointed out in relation to gypsum outcrops, there is a serious risk of irreversible destruction of a priority habitat. These restoration activities must also take into account the genetic adaptations to a local environment by means of the "home site advantage" (Mattner et al., 2002). New taxa are still being found in the dolomites and other special edaphic environments (Nieto-Feliner et al., 2001; Rajakaruna, 2004), taxa which have not yet been described or are insufficiently known. In addition, differentiated populations or provenances need to be protected as separate entities. Conservation aims at protecting as many diverse populations as possible (Mattner et al., 2002). Paraphrasing Goethe "we only see what we already know", and so far we know very little about dolomites compared with our understanding of other special substrates such as serpentines or gypsum outcrops.

Acknowledgement

Annex. 1. Checklist of dolomitic plant species of the Baetic Ranges

Taxon	N votes	N votes >1	SUM	MEAN	Family	Life form	AG	GB	MA	Ro	Sb	N sectors	Threaten
Alyssum gadorense	1	1	2	2.00	BRASSIC	C	1	0	0	0	0	1	VU
Alyssum montanum	5	3	8	1.60	BRASSIC	C	1	0	1	1	1	4	NL
Alyssum serpyllifolium	6	3	8	1.33	BRASSIC	C	1	1	1	1	1	5	NL
Anarrhinum laxiflorum	7	2	9	1.29	SCROPH	H	1	1	1	1	1	5	NL
Andryala agardhii	7	7	17	2.43	ASTERA	C	1	1	1	0	1	4	VU
Andryala ragusina ramosissima	6	6	16	2.67	ASTERA	C	0	0	1	1	0	2	NL
Anthyllis montana hispanica	6	1	7	1.17	FABACE	H	0	1	0	0	1	2	NL
Anthyllis podocephala	4	2	6	1.50	FABACE	H	1	0	1	1	0	3	NL
Anthyllis ramburii	5	3	9	1.80	FABACE	H	0	0	1	0	1	2	VU
Anthyllis rupestris	5	4	10	2.00	FABACE	H	0	0	0	0	1	1	EN
Anthyllis tejedensis plumosa	5	5	15	3.00	FABACE	H	0	0	1	0	0	1	VU
Anthyllis tejedensis tejedensis	6	6	15	2.50	FABACE	H	0	0	1	1	0	2	NL
Anthyllis vulneraria arundana	6	5	12	2.00	FABACE	H	1	1	1	1	1	5	NL
Anthyllis vulneraria maura	5	3	8	1.60	FABACE	H	0	1	1	1	1	4	NL

Anthyllis vulneraria reuteri	3	2	5	1.67	FABACE	T	0	1	1	1	1	4	NL
Arenaria alfacarensis	6	5	12	2.00	CARYOP	C	0	0	1	0	1	2	VU
Arenaria armerina armerina	7	2	11	1.57	CARYOP	C	1	1	1	0	1	4	NL
Arenaria armerina caesia	4	4	11	2.75	CARYOP	C	1	1	1	0	1	4	NL
Arenaria arundana	6	6	16	2.67	CARYOP	T	0	0	1	1	0	2	NL
Arenaria delaguardiae	5	5	15	3.00	CARYOP	C	0	0	1	0	0	1	VU
Arenaria erinacea	4	2	6	1.50	CARYOP	C	0	0	1	1	0	2	NL
Arenaria modesta tenuis	7	6	14	2.00	CARYOP	T	0	0	0	0	1	1	VU
Arenaria racemosa	5	5	12	2.40	CARYOP	C	0	0	1	0	0	1	VU
Arenaria tetraquetra murcica	7	5	15	2.14	CARYOP	C	1	1	0	0	1	3	NL
Arenaria tomentosa	5	5	12	2.40	CARYOP	C	1	1	0	0	1	3	NL
Armeria filicaulis filicaulis	4	3	8	2.00	PLUMBA	H	0	0	1	1	1	3	NL
Armeria filicaulis trevenqueana	4	4	10	2.50	PLUMBA	H	0	0	1	0	0	1	EN
Armeria villosa carratracensis	4	1	5	1.25	PLUMBA	H	0	0	0	1	0	1	EN
Armeria villosa longiaristata	7	3	12	1.64	PLUMBA	H	1	1	1	1	1	5	NL
Asplenium celtibericum celtibericum	3	3	8	2.67	ASPLEN	H	0	0	0	0	1	1	NL
Astragalus granatensis	6	1	7	1.17	FABACE	C	1	0	1	1	1	4	NL
Athamanta hispanica	4	2	6	1.50	APIACE	H	0	1	0	0	0	1	VU
Brachypodium boissieri	6	6	16	2.67	BRASSIC	H	1	0	1	0	0	2	NL
Brassica repanda almeriensis	4	3	9	2.25	BRASSIC	H	1	1	0	0	0	2	VU
Brassica repanda blancoana	4	4	10	2.38	BRASSIC	H	1	0	1	0	1	3	NL
Brassica repanda confusa	3	2	6	1.83	BRASSIC	H	0	0	1	1	1	3	NL
Brassica repanda latisiliqua	4	4	10	2.50	BRASSIC	H	1	0	1	1	1	4	NL
Centaurea alpina	3	1	4	1.33	ASTERA	H	0	0	0	0	1	1	NL
Centaurea boissieri funkii	4	4	11	2.75	ASTERA	H	0	0	1	0	0	1	NL
Centaurea bombycina bombycina	5	4	12	2.40	ASTERA	H	0	0	1	0	0	1	VU
Centaurea bombycina xeranthemoides	4	4	12	3.00	ASTERA	H	0	0	1	0	0	1	NL
Centaurea granatensis	6	5	12	2.00	ASTERA	H	1	1	1	0	1	4	NL
Centaurea haenseleri epapposa	3	3	8	2.67	ASTERA	H	0	0	1	0	0	1	VU
Centaurea mariana	4	4	8	2.00	ASTERA	H	0	1	0	0	0	1	VU
Centaurea prolongoi	4	4	7	1.63	ASTERA	H	0	0	1	1	0	2	VU
Chaenorhinum macropodum degenii	7	6	15	2.14	SCROPH	T	1	1	1	0	1	4	NL
Chaenorhinum macropodum macropodum	8	4	13	1.63	SCROPH	T	0	1	1	0	1	3	NL
Chaenorhinum minus	5	2	7	1.40	SCROPH	T	0	1	1	0	1	3	NL
Chaenorhinum rubrifolium raveyi	4	4	12	3.00	SCROPH	T	0	0	1	1	0	2	NL
Chaenorhinum rubrifolium rubrifolium	5	4	8	1.60	SCROPH	T	0	1	1	1	1	4	NL
Chamaespartium undulatum	4	4	12	2.88	FABACE	C	0	0	1	0	0	1	VU
Convolvulus boissieri boissieri	7	7	21	3.00	CONVOL	C	0	1	1	1	1	4	NL
Daphne oleoides hispanica	7	1	8	1.07	THYMEL	C	0	1	1	0	1	3	NL
Draba hispanica hispanica	6	1	7	1.17	BRASSIC	C	1	1	1	1	1	5	NL
Echinospartum boissieri	7	4	12	1.71	FABACE	C	1	1	1	1	1	5	NL
Echium albicans	6	6	16	2.67	BORAGI	H	1	1	1	1	1	5	NL
Erodium astragaloides	5	5	15	3.00	GERANI	H	0	0	1	0	1	2	VU
Erodium boissieri	5	5	15	3.00	GERANI	H	0	0	1	0	0	1	VU
Erodium cazorlanum	6	4	11	1.83	GERANI	H	0	0	0	0	1	1	NL
Erodium daucoides	4	3	7	1.75	GERANI	H	1	0	1	0	0	2	NL
Erodium recoderi	2	2	4	2.00	GERANI	T	0	0	0	1	0	1	VU
Eryngium grosii	4	4	10	2.50	APIACE	H	0	0	1	0	0	1	VU
Erysimum cazorlense	5	5	10	2.00	BRASSIC	H	0	1	0	0	1	2	VU

Erysimum fitzii	4	4	8	2.00	BRASSIC	H	0	0	0	0	1	1	VU
Erysimum myriophyllum	6	4	12	2.00	BRASSIC	H	0	1	1	0	1	3	VU
Erysimum rondae	5	4	9	1.80	BRASSIC	H	0	0	1	1	0	2	VU
Fumana paradoxa	6	5	12	2.00	CISTAC	C	1	1	1	0	1	4	NL
Fumana procumbens baetica	7	6	15	2.14	CISTAC	C	0	1	1	0	1	3	VU
Galium baeticum	4	4	10	2.50	RUBIAC	H	1	0	0	1	0	2	NL
Galium erythrorrhizon	6	6	14	2.33	RUBIAC	C	0	0	1	0	1	2	EN
Galium pulvinatum	3	3	7	2.33	RUBIAC	C	0	0	0	1	0	1	DD
Genista haenseleri	4	4	9	2.25	FABACE	NF	1	0	0	1	0	2	VU
Genista longipes longipes	5	4	11	2.20	FABACE	C	1	1	1	0	1	4	NL
Genista longipes viciosoi	5	5	13	2.60	FABACE	C	0	0	1	1	1	3	VU
Genista pumila	4	2	7	1.75	FABACE	C	0	1	0	0	1	2	NL
Geranium cazorlense	6	4	10	1.58	GERANI	H	0	0	0	0	1	1	CR
Globularia spinosa	6	2	9	1.50	GLOBUL	H	0	1	1	0	1	3	NL
Hedysarum boveanum costaetalentii	4	3	8	2.00	FABACE	C	0	0	0	0	1	1	VU
Helianthemum apenninum estevei	4	4	12	3.00	CISTAC	C	0	0	1	0	0	1	VU
Helianthemum marifolium frigidulum	5	4	12	2.40	CISTAC	C	0	0	0	0	1	1	VU
Helianthemum pannosum	5	5	15	3.00	CISTAC	C	0	0	1	0	0	1	VU
Helianthemum viscidulum raynaudii	4	4	11	2.75	CISTAC	C	1	1	1	0	1	4	NL
Helianthemum viscidulum viscidulum	5	5	14	2.80	CISTAC	C	0	0	1	0	0	1	NL
Helictroticum filifolium velutinum	6	4	12	2.00	CISTAC	H	1	1	1	1	1	5	VU
Hieracium baeticum	3	1	4	1.33	ASTERA	H	0	1	0	1	1	3	NL
Hieracium texedense	5	4	10	2.00	ASTERA	H	0	0	1	0	0	1	CR
Hippocrepis eriocarpa	6	6	17	2.83	FABACE	H	0	0	1	0	0	1	VU
Hippocrepis nevadensis	2	1	3	1.50	FABACE	H	0	0	1	0	0	1	VU
Hormathophylla baetica	5	4	12	2.40	BRASSIC	C	0	0	0	0	1	1	VU
Hormathophylla lapeyrousiana	5	4	8	1.50	BRASSIC	C	0	1	1	0	1	3	NL
Hormathophylla longicaulis	8	5	12	1.50	BRASSIC	H	0	1	1	0	1	3	NL
Hormathophylla reverchonii	5	5	11	2.20	BRASSIC	H	0	0	0	0	1	1	VU
Iberis fontqueri	3	3	6	1.83	BRASSIC	T	0	0	0	1	0	1	VU
Iberis grossii	4	4	8	2.00	BRASSIC	C	0	0	1	0	0	1	VU
Iberis nazarita	6	3	9	1.50	BRASSIC	C	1	0	1	1	1	4	DD
Jasione crispa segurensis	4	4	11	2.63	CAMPAN	H	0	0	0	0	1	1	VU
Jasione penicillata	4	3	10	2.50	CAMPAN	T	0	0	1	1	0	2	NL
Jurinea pinnata	6	6	9	1.50	ASTERA	C	0	1	1	1	1	4	NL
Kernera boissieri	5	4	9	1.80	BRASSIC	H	0	0	1	0	1	2	VU
Koeleria dasyphylla	3	1	4	1.33	POACEA	H	0	0	1	1	1	3	EN
Lavandula lanata	6	1	8	1.33	LAMIAC	C	1	1	1	1	1	5	NL
Leucanthemopsis pallida spathulifolia	5	5	14	2.80	ASTERA	H	0	1	0	0	1	2	NL
Leucanthemum arundanum	5	4	10	2.00	ASTERA	H	0	0	0	1	1	2	NL
Linaria aeruginea	3	1	4	1.17	SCROPH	H	0	1	1	1	1	4	NL
Linaria amoi	2	2	6	3.00	SCROPH	H	0	0	1	0	1	2	VU
Linaria clementei	2	2	6	3.00	SCROPH	H	0	0	1	1	0	2	VU
Linaria huteri	2	2	6	3.00	SCROPH	T	0	0	0	1	0	1	VU
Linaria oblongifolia	3	2	7	2.33	SCROPH	T	0	0	1	1	1	3	NL
Linaria salzmannii	4	4	11	2.75	SCROPH	T	0	0	1	1	1	3	NL
Linaria saturejoides	5	5	14	2.70	SCROPH	T	0	0	1	1	1	3	NL
Lithodora nitida	6	6	17	2.83	SCROPH	C	0	0	1	0	1	2	EN

Lomelosia pulsatilloides pulsatilloides	6	6	18	3.00	DIPSAC	H	0	0	1	0	0	1	VU
Moehringia tejedensis	5	5	11	2.10	CARYOP	H	0	0	1	0	0	1	CR
Omphalodes commutata	5	4	11	2.10	BORAGI	T	0	0	1	1	0	2	NL
Onobrychis argentea argentea	4	3	6	1.38	FABACE	H	0	1	1	0	1	3	NL
Ononis cephalotes	3	2	6	2.00	FABACE	H	0	1	1	0	1	3	NL
Orchis cazorlensis	4	3	7	1.63	ORCHID	G	0	0	0	0	1	1	NL
Paronychia aretioides	5	4	8	1.50	CARYOP	C	0	1	1	0	1	3	NL
Paronychia kapela baetica	6	3	9	1.50	CARYOP	H	0	1	0	0	1	2	NL
Pimpinella tragium litophylla	5	2	8	1.60	APIACE	H	1	1	1	1	1	5	NL
Plantago asperrima	4	3	7	1.75	PLANTA	H	0	0	1	0	1	2	NL
Platycapnos tenuiloba parallela	4	4	10	2.50	PAPAVE	T	0	0	1	1	0	2	VU
Prolongoa hispanica	2	1	3	1.50	ASTERA	T	0	1	1	1	1	4	NL
Pseudoscabiosa grosii	5	5	15	3.00	DIPSAC	C	0	0	1	0	0	1	DD
Pterocephalus spathulatus	7	7	21	3.00	DIPSAC	C	1	1	1	0	1	4	NL
Reseda paui almijarensis	4	4	10	2.50	RESEDA	H	0	0	1	0	0	1	NL
Rothmaleria granatensis	6	6	18	3.00	ASTERA	H	0	0	1	0	0	1	VU
Santolina elegans	6	6	18	3.00	ASTERA	C	0	0	1	0	1	2	VU
Saxifraga erioblasta	7	5	14	2.00	SAXIFR	H	1	1	1	0	1	4	NL
Scorzonera albicans	5	5	14	2.80	DIPSAC	H	0	1	0	0	1	2	NL
Seseli granatense	3	1	4	1.33	APIACE	H	0	1	1	0	1	3	NL
Sideritis incana occidentalis	5	4	10	2.00	LAMIAC	C	1	0	1	1	0	3	NL
Sideritis incana virgata	6	4	11	1.83	LAMIAC	C	0	1	1	0	1	3	NL
Sideritis stachydioides	4	4	8	2.00	LAMIAC	C	0	1	0	0	0	1	VU
Silene germana	5	5	14	2.80	CARYOP	T	1	1	1	1	1	5	NL
Silene psammitis lasiostyla	4	4	10	2.50	CARYOP	T	0	1	1	1	1	4	NL
Thymelaea angustifolia	6	6	15	2.50	THYMEL	C	0	1	1	0	0	2	NL
Thymus funkii sabulicola	5	5	14	2.80	LAMIAC	C	0	0	0	0	1	1	VU
Thymus granatensis granatensis	8	8	23	2.88	LAMIAC	C	0	1	1	1	1	4	VU
Thymus granatensis micranthus	7	7	20	2.86	LAMIAC	C	0	0	0	0	1	1	VU
Trisetum velutinum	4	3	10	2.50	POACEA	H	0	0	1	0	1	2	NL
Ulex baeticus	5	4	9	1.80	FABACE	C	0	0	0	1	0	1	NL
Ulex parviflorus rivasgodayanus	5	5	11	2.20	FABACE	C	0	0	1	0	0	1	NL
Viola cazorlensis	6	6	13	2.17	VIOLAC	H	0	0	0	0	1	1	VU

N votes, number of votes; *N* votes >1, number of votes above 1. Biogeographic sectors key: AG, Alpujarrean-Gadorensean; GB, Guadician-Bacensean; MA, Malacitan-Almijarensean; Ro, Rondean; Sb, Subbaetic. Life forms key: T, therophyte; G, geophytes; H, hemicryptophyte; C, chamaephyte; F, phanerophyte. Threat categories: CR, critically endangered; EN, endangered; VU, vulnerable; NL, not listed; DD, data deficient).

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