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Rupicolous habitats of interest for conservation in the central-southern Iberian peninsula

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Abstract
We studied the *Quercus rotundifolia* Lam. formations in the central-southern Iberian Peninsula, working particularly in areas in the Rondeño and Subbético biogeographical sectors. As a result we propose two new plant associations with an edaphoxeric character: *Bupleuro gibraltarici-Quercetum rotundifoliae*; and J*unipero phoeniceae-Quercetum rotundifoliae* included in habitat 9340. In both formations there is a high number of endemic plants often found in habitat 8210 "Calcareous rocky slopes with chasmophytic vegetation" like *Antirrhinum graniticum*, *Antirrhinum onubense*, *Saxifraga reuteriana*, *Cerastium gibraltaricum*.

Key words: conservation, endemics, phytosociology, *Quercus*, scree, woodlands.

Introduction

The study focuses on the central-southern Iberian Peninsula, characterised by its steep orography comprising large rocky crests, and exemplifying the typical character of the Betic and Sierra Morena mountain ranges. This orography, along with the increase in rainfall in mountain areas, causes certain areas to serve as refugia for endemic flora and for distinctive plant communities. In view of this, our aim is to highlight the important botanical and ecological value of these territories, which have been considered by some authors and government agencies as microreservations. In previous studies, Cano *et al.* (2015, 2016a, 2016b) highlighted the significance of these areas due to their high rate of endemics, and proposed formulas to establish the level of conservation. Cano-Ortiz *et al.* (2015) also noted the importance of these wild territories based on their endemic species and habitats, focusing the study fundamentally on the formations of *Juniperus oxycedrus* L. subsp. *badia* (H. Gay) Debeaux, and attributed the spread of these areas to anthropogenic action. Piñar Fuentes *et al.* (2012, 2013) and del Río *et al.* (2011) studied the diversity of geological substrates and climate trends, and found that rainfall is becoming increasingly concentrated in shorter periods of time, with most rain falling in September and October, and in only March and April in spring, which subjects the vegetation to water stress over long periods and threatens the future survival of these edaphoxerophilous communities.

Other authors have recently carried out comparative analyses between the formations of *Quercus ilex* L. subsp. *ilex* in southern Italy and *Quercus rotundifolia* = *Quercus ilex* L. subsp. *ballota* (IK) in southern Spain (Musarella *et al.* 2012, 2013). A large number of relevés have previously been published on the woodlands in the southern Iberian Peninsula, and particularly holm oak woodlands (Rivas Goday *et al.,* 1959; Rivas-Martínez, 1975; Costa *et al.,* 1982; Costa *et al.,* 1987; Rivas-Martínez, 1987; Nieto *et al.,* 1988; Navarro, 1989; Cano & Valle, 1990; Galán de Mera, 1993; Madrona, 1994; García Fuentes, 1996; Gómez Mercado *et al.,* 2000; Alonso, 2002; Pinto Gomes & Paiva Ferreira, 2007; Molina *et al.,* 2008; Gómez Mercado, 2011), but always following the criterion of not separating the holm oak woodlands on rocky substrates and shallow soils with low water-retention capacity (edaphoxerophilous) from strictly climatophilous woodlands. Subsequently Rivas-Martínez (2011) established a climatophilous and edaphoxerophilous diagnosis for *Quercus rotundifolia* woodlands; and more recently Quinto Canas *et al.* (2012) and Pérez Latorre *et al.* (2015) mooted the possibility of considering these woodlands on scree. As a result of this, our aim is to justify the separation of the climatophilous and edaphoxerophilous aspects of these woodland formations.

The edaphoxerophilous woodland formations of

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Quercus rotundifolia are well represented in several biogeographical units, and appear both in the central and more continentalised eastern zones, and even in more oceanic and siliceous territories. The study area focuses essentially on the Betic, Western Iberian Mediterranean and Central Iberian Mediterranean biogeographical provinces. All these zones share the fact that they contain small mountain chains formed by quartzite, granite, pre-Cambrian slate, limestone and limestone-dolomites with altitudes ranging between 280-1500 m. A study was made of 100 meteorological stations in the central-southern Iberian Peninsula, 29 of which have an ombrothermic index (I_o) between 3.6 and 6.3; meaning that this territory has a humid-humid ombrotype; while the 71 remaining stations have an Ioof between 2.02 and 3.6, implying a dry ombrotype prevailing throughout the whole territory. The continentality values range between 10.8 for Santiago Do Cacen (Portugal) to 21.7 in Vianos (Albacete, Spain). All this explains the presence of a Mediterranean-pluviseasonal-oceanic macrobioclimate in the westernmost areas of the territory in the study, and a Mediterranean-pluviseasonal-continental macrobioclimate in the easternmost territories. The thermotype ranges from thermomediterranean belt in the warmer territories near the Guadalquivir river valley, and supramediterranean belt on the rocky crests of the Subbética range. However the mean values for I_o(3.89), Ic (18.54) and Itc (284) clearly signal the territorial dominance of the dry-subhumid ombrotype, the mesomediterranean thermotype and the Mediterranean-pluviseasonal-oceanic macrobioclimate; with strong evidence of the continental influence of the plateau in the easternmost mountain areas (Jaén, Ciudad Real and Toledo), where there are also indications of the Mediterranean-pluviseasonal-continental macrobioclimate (Cano-Ortiz *et al.*, 2015).

Material and methods

In this work we used 209 relevés from the 13 associations described, including the *typus*, and the two new communities (McQr1-13: *Myrto communis-Quercetum rotundifoliae* Rivas Goday in Rivas Goday, Borja, Esteve, Rigual & Rivas-Martínez 1959; RlQr1-16: *Rubio longifoliae-Quercetum rotundifoliae* Costa, Peris & Figuerola 1982; PbQr1-14: *Pyro bourgaenae-Quercetum rotundifoliae* Rivas-Martínez 1987; HhQr1-14: *Hedero helicis-Quercetum rotundifoliae* Costa, Peris et Stübing 1987; BhQr1-12: *Berberido hispanicae-Quercetum rotundifoliae* Rivas-Martínez 1987; AdQr1-12: *Adenocarpo decorticantis-Quercetum rotundifoliae* Rivas-Martínez 1987; AaQr1-20: *Asparago acutifoliae-Quercetum rotundifoliae* Rivas-Martínez, Cantó, Fernández-González & Sánchez-Mata in Rivas-Martínez *et al.* 2002; Qr1-15: *Quercetum rotundifoliae* Br.-Bl. & O. Bolòs (1956) 1957; RoQr1-38: *Rhamno oleoidis-Quercetum rotundifoliae* Rivas-Martínez 2002; PcQr1-26: *Paeonio coriaceae-Quercetum rotundifoliae* Rivas-Martínez 1964; JlQr1-11: *Junipero lagunae-Quercetum rotundifoliae* Rivas Goday ex 1965 corr. Rivas-Martínez in Rivas-Martínez *et al.* 2011; BgQr1-8: *Bupleuro gibraltarici-Quercetum rotundifoliae* ass. nova *hoc loco*; JpQr1-13: *Junipero phoeniceae-Quercetum rotundifoliae* ass. nova *hoc loco*; RmQr1-7: *Rhamno myrtifoliae-Quercetum rotundifoliae* Pérez-Latorre, Soriguer-Solanas & Cabezudo 2015). The sampling was made over a broad territory in Spain, covering a variety of areas and taking relevés in *Quercus rotundifolia* formations.

These relevés were prepared following the phytosociological methodology of Braun-Blanquet as described in works such as Braun-Blanquet (1979), Géhu & Rivas-Martínez (1981) and Biondi (2011). A variety of statistical treatments were applied to establish a separation between Quercus communities. An Excel table was created with 209 relevés x 512 species, and an ordination cluster analysis was applied using the Bray-Curtis distance with Ward's agglomerative method. A DECORANA, RA and DCA multivariant ordination analysis was also applied. To explain the presence of tree communities of *Quercus rotundifolia* on scree and lithosoils in rainy environments we referred to the new ombro-edaphoxeric index proposed by Cano *et al.* (in press). To obtain information on the diversity of the different plant associations we applied Simpson's dominance indexes and Margalef's diversity index to the characteristic, companion and endemic species. Statistical analyses were made to establish the differences between Margalef's index of the different associations studied by ANOVA analysis of variance.

For the authorship and homogenisation of the taxa obtained from the bibliography we used the works of Flora Ibérica: Castroviejo *et al.* (eds.) (1986, 1990, 1993a, 1993b, 1997a, 1997b); Muñóz-Garmendia & Navarro (eds.) (1998); Talavera & Castroviejo (eds.) (1999, 2000) and Paiva *et al.* (eds.) (2001); Flora de Andalucía Occidental: Valdés *et al.* (eds.) (1987), Flora Europea: Tutin *et al.* (eds.) (1964-80).

For a better visualisation of how these communities of climatophilous holm oak woodlands are related to the edaphoxerophilous formations, we built a network of phytosociological placement for the associations in the study using free software (Pajek 4.10 http://vlado.fmf.uni-lj.si/pub%20/networks/pajek/default.htm). This allows us to see more clearly the floristic affinities between the relevés used. All the taxa present in fewer than 20% of the relevés in each community were eliminated from the table of floristic composition, in addition to taxa that were insignificant in the communities studied.

Results

Phytosociological analysis

In this study we analysed 12 plant associations from holm oak woodlands described previously by their authors (McQr1-13: *Myrto-Quercetum rotundifoliae*; RlQr1-16: *Rubio-Quercetum rotundifoliae*; PbQr1-14: *Pyro-Quercetum rotundifoliae*; HhQr1-14: *Hedero-Quercetum rotundifoliae*; BhQr1-12: *Berberido-Quercetum rotundifoliae*; AdQr1-12: *Adenocarpo-Quercetum rotundifoliae*; AsQr1-20: *Asparago-Quercetum rotundifoliae*; Qr1-15: *Quercetum rotundifoliae*; RoQr1-38: *Rhamno-Quercetum rotundifoliae*; PcQr1-26: *Paeonio-Quercetum rotundifoliae*; JlQr1-11: *Junipero-Quercetum rotundifoliae*), and two new communities of edaphoxerophilous stands (BgQr1-8: *Bupleuro gibraltarici-Quercetum rotundifoliae*; JpQr1-13: *Junipero phoeniceae-Quercetum rotundifoliae*). The 12 holm oak woodland associations have been described by their authors as climatophilous woodlands, corresponding to thermo and supramediterranean thermotypes in dry-subhumid environments.

The formations in Grazalema and Cazorla grow in rainy environments on rocky limestone and limestone-dolomitic substrates. In the case of Grazalema, the edaphoxerophilous holm oak woodland is located in the thermomediterranean thermotype, and may extend to the lower mesomediterranean with high rainfall; it therefore has I_o values of 10.68. In Cazorla the holm oak woodland is located in an I_o of 8.42; between the lower humid to upper humid ombrotype according to Rivas-Martínez *et al.* (2002). These two edaphoxerophilous communities have a different floristic composition from the rest of the climatophilous woodlands of *Quercus rotundifolia*, and do not share the same ecological aspects and catenal contacts. These two communities are therefore perfectly separated in the different statistical analyses (Figs. 1, 2, 3). The new association *Bupleuro gibraltarici-Quercetum rotundifoliae* ass. nova (Tab. 1, rels. 1-8, *typus* rel. 3) is characterised by the constant presence of *Bupleurum gibraltaricum*, *Rhamnus myrtifolia* subsp *iranzoi*, *Hedera hibernica*, *Hedera maderensis* subsp. *iberica*, *Aristolochia baetica* and *Rhamnus oleoides* subsp. *oleoides*. From a catenal standpoint, these edaphoxerophilous holm oak woodlands contact with the pinsapo fir formations of *Paeonio broteroi-Abietetum pinsapo*. This community grows on marble limestone and compact limestone screes in a humid ombrotype in the westernmost territories of the Rondeño biogeographic sector. This association is differentiated from *Rhamno myrtifoliae-Quercetum rotundifolia*e, described by Pérez Latorre *et al.* (2015) in the Almijarense unit, which has greater continentality and a subhumid ombroclimate, and occupies the easternmost part of the Rondeño sector on limestone dolomites and kakirites. The new lower thermo-mesomedi-

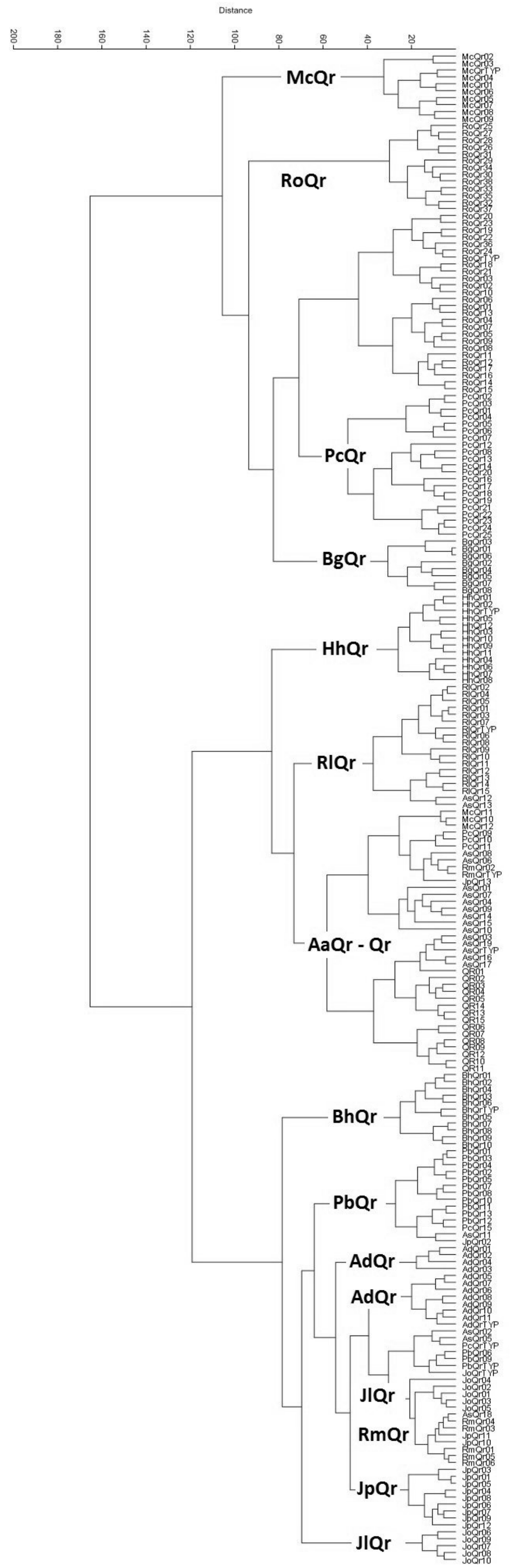

Fig. 1 - Cluster analysis of *Quercus rotundifolia* woodlands in the southern-central Iberian Peninsula.

Tab. 1 - Ass. *Junipero phoeniciae-Quercetum rotundifoliae* and *Bupleuro gibraltarici-Quercetum rotundifoliae*.

Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Nº cluster	BgQr01	BgQr02	BgQr03*	BgQr04	BgQr05	BgQr06	BgQr07	BgQr08	JpQr01	JpQr02	JpQr03*	JpQr04	JpQr05	JpQr06	JpQr07	JpQr08	JpQr09	JpQr10	JpQr11	JpQr12	JpQr13
Area in m^2 1=100 m^2	10	6	6	6	6	6	6	6	6	6	5	6	6	6	4	10	10	4	1.6	10	1
Altitude in m 1=10 m	140	75	120	90	60	90	70	100	110	100	130	100	150	120	90	150	156	91	120	132	142
Covering in %	70	75	60	60	60	70	80	75	75	75	75	70	65	60	75	75	75	75	80	55	80
Orientation	E	E	SE	SW	E	NE	W	S	SW	SW	SE	N	NW	SE	NW	W	W	SE	S	SE	W
Slope in %	60	70	70	50	80	80	15	80	30	25	50	60	45	30	15	60	20	45	18	70	80
Average height of vegetation in m.	7	4	3.5	5	3	5	6	3.5	2.5	2.5	3	5	5	3	4	7	6	6.5	7	3	2
Char. species																					
Quercus rotundifolia Lam.	3	4	3	3	3	3	4	4	4	5	5	5	4	4	5	5	5	3	4	3	4
Juniperus phoenicea subsp. phoenicea L.	1	·	1	·	·	1	·	1	+	1	1	1	1	1	1	1	1	·	·	·	·
Juniperus oxycedrus L. subsp. badia (H. Gay) Debeaux	2	·	1	·	·	2	+	1	1	2	2	·	2	3	2	2	2	·	·	·	·
Hedera hibernica (G. Kirchn.) Bean	1	2	3	2	3	3	2	1	·	·	1	1	·	·	1	1	1	·	·	·	·
Rhamnus myrtifolia subsp. iranzoi Rivas Mart. & J.M. Pizarro	1	1	2	1	·	1	·	1	·	·	·	·	·	2	·	·	·	·	+	2	+
Rubia peregrina subsp. pererina L.	1	·	+	1	·	1	1	+	+	·	1	·	2	1	1	·	·	1	+	·	2
Paeonia broteri Boiss. & Reut.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	·	·	·	1	·
Diff. species of *Bupleuro gibraltaricae-Quercetum Rotundifoliae*																					
Bupleurum gibraltaricum Lam.	+	1	2	1	2	1	+	2	·	·	·	·	·	·	·	·	·	·	·	·	·
Smilax aspera var. aspera L.	·	·	1	1	+	·	2	1	·	·	·	2	·	·	·	·	·	·	·	·	·
Rhamnus oleoides subsp. oleoides L.	·	+	·	1	1	·	1	1	·	·	·	·	·	·	·	·	·	·	·	·	·
Arbutus unedo L.	+	·	1	·	·	+	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Olea europea var. sylvestris (Mill.) Lehr	·	·	·	2	3	·	1	2	·	·	·	·	·	·	·	·	·	·	·	·	·
Aristolochia baetica L.	·	1	1	2	·	·	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Rhamnus velutinus subsp. velutinus Boiss.	·	1	·	·	1	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Asparagus albus L.	·	·	·	+	2	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Hedera maderensis subsp. iberica McAllister	·	·	1	·	·	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Doronicum plantagineum L.	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Diff. species of *Junipero phoeniciae-Quercetum Rotundifoliae*																					
Phillyrea latifolia L.	·	·	·	·	·	·	+	·	·	·	3	2	2	·	3	·	·	1	·	·	·
Jasminum fruticans L.	·	·	2	·	·	·	·	·	·	·	3	·	2	·	3	·	·	+	·	·	·
Acer monspessulanum L.	·	·	·	·	·	·	·	·	·	·	1	·	1	·	1	1	·	+	·	·	·
Buxus sempervirens L.	·	·	·	·	·	·	·	·	·	·	1	·	·	·	1	·	·	1	·	·	3
Char. species of *Quercetalia ilicis*																					
Viburnum tinus L.	·	·	2	·	·	·	1	·	·	·	1	1	·	·	1	·	·	·	·	·	·
Ruscus aculeatus L.	·	·	+	·	·	·	1	·	·	·	·	·	1	·	·	·	·	·	·	·	·
Juniperus oxycedrus subsp. oxycedrus L.	·	·	·	·	·	·	·	·	·	·	2	·	·	·	·	·	·	·	+	·	·
Piptatherum paradoxum (L.) P. Beauv.	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Char. species of *Pistacio lentisci-Rhamnetalia alaterni*																					
Euphorbia characias L.	+	·	·	1	+	+	·	·	·	·	1	·	1	·	1	·	·	·	·	·	·
Pistacia terebinthus L.	·	1	+	+	1	·	1	+	·	·	·	·	·	·	·	·	·	1	·	·	·
Ceratonia siliqua L.	·	1	·	1	·	·	+	+	·	·	·	·	·	·	·	1	·	·	·	·	·
Pistacia lentiscus L.	+	·	+	·	·	·	1	1	·	·	·	1	·	·	·	·	·	·	·	·	·
Bupleurum fruticosum L.	·	·	1	·	·	·	·	·	·	·	·	1	·	·	·	·	·	·	·	·	·
Quercus coccifera L.	·	·	·	·	·	·	·	·	·	·	·	1	1	·	·	·	·	·	·	·	·
Char. species of *Quercetea ilicis*																					
Lonicera implexa Aiton	+	·	+	·	·	+	1	·	·	·	·	·	·	·	·	·	·	+	+	·	2
Carex halleriana Asso	2	·	·	·	·	·	+	·	1	2	·	·	·	·	·	·	·	·	·	1	2
Daphne gnidium L.	·	·	·	1	+	·	+	+	·	·	·	·	·	·	·	·	·	1	+	·	·
Asparagus acutifolius L.	·	·	·	·	1	·	+	·	·	·	·	1	·	·	·	·	·	+	·	·	·
Rhamnus alaternus L.	·	·	·	·	·	·	·	·	·	·	·	2	·	·	·	·	·	·	·	·	+
Transgressive and mesophytic species of *Querco-Fagetea* and *Salici-Populetea*																					
Tamus communis L.	·	·	+	+	·	·	+	+	·	·	·	·	1	·	·	·	·	·	·	·	·
Daphne laureola L.	1	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	+	·	·	·
Hedera helix L.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	2	+	·	·
Sorbus aria (L.) Crantz	1	·	·	·	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Quercus faginea subsp. faginea Lam.	·	·	·	·	·	·	·	·	·	·	·	1	·	·	·	·	·	·	+	·	·
Helleborus foetidus L. (Diff.)	·	·	·	·	·	·	·	·	·	·	1	·	1	·	1	·	·	+	1	·	·
Abies pinsapo Boiss. (Terr.)	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Companions species																					
Ceterach officinarum subsp. officinarum Willd.	·	1	+	+	+	·	+	+	·	·	1	·	1	·	1	·	·	·	·	+	·
Aphyllanthes monspeliensis L.	1	·	+	·	·	·	·	+	+	1	1	·	1	1	1	·	·	·	·	·	2
Ptilostemon hispanicus (Lam.) Greuter	+	·	+	1	·	+	·	·	+	·	·	·	·	·	·	·	1	+	·	+	·
Thymus orospedanus Villar	1	·	·	·	·	·	·	·	+	1	·	·	1	2	·	1	2	·	·	1	·
Echinospartum boissieri (Spach) Rothm.	1	·	·	·	·	·	·	·	+	1	·	·	·	2	·	1	·	·	+	2	+
Chaenorhinum villosum subsp. granatense (Willk.) Valdés	+	·	1	+	1	+	·	+	·	·	·	·	·	·	·	·	·	·	·	+	·
Berberis hispanica Boiss. & Reut.	2	·	·	·	·	·	·	·	1	·	1	·	·	1	1	1	1	·	·	·	·
Asplenium trichomanes L.	+	·	+	·	·	+	+	+	·	·	·	·	1	·	·	·	·	·	·	·	·
Linum suffruticosum L.	+	1	+	·	·	+	·	·	·	·	·	1	·	·	·	·	·	·	·	·	1
Crataegus laciniata Ucria	1	·	·	·	·	·	·	·	1	·	·	1	1	1	·	·	·	·	·	+	·
Lithodora fruticosa (L.) Griseb.	1	·	·	·	·	·	·	·	+	1	·	·	·	1	·	·	1	·	·	·	·
Pinus nigra subsp. salzmannii (Dunal) Franco	1	·	·	·	·	·	·	·	+	·	·	·	·	1	·	·	1	·	·	·	·
Biscutella valentina (Loefl. ex L.) Heywood	1	·	·	·	·	·	·	·	+	1	·	·	·	2	·	·	·	·	·	·	·
Erinacea anthyllis Link,	1	·	·	·	·	·	·	·	+	1	·	·	·	·	·	·	1	·	·	·	·
Rosa micrantha Borrer ex Sm. in Sowerby	1	·	·	·	·	·	·	·	+	·	·	·	1	1	·	·	·	·	·	·	·
Cistus albidus L.	·	·	+	·	·	·	·	·	·	·	·	1	·	·	·	·	·	·	1	·	+
Thapsia villosa L.	·	·	+	+	·	·	·	·	·	·	·	1	·	·	·	·	·	·	·	·	·
Dactylis glomerata L. subsp. hispanica (Roth) Nyman	·	·	+	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·
Anthyllis vulneraria subsp. maura (Beck) Maire	·	+	+	·	·	·	·	·	·	1	·	·	·	·	·	·	·	·	·	·	·
Sedum album L.	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·
Lavandula lanata Boiss.	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+
Juniperus communis subsp. hemisphaerica (C. Presl) Nyman	2	·	·	·	·	·	·	·	1	·	·	·	·	1	·	·	·	·	·	·	·
Phlomis lychnitis L.	1	·	·	·	·	·	·	·	+	·	·	·	·	1	·	·	·	·	·	·	·
Schoenus nigricans L.	1	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·

Antirrhinum graniticum Rothm.	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·
Ficus carica L.	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·
Sedum dasyphyllum L.	+	·	1	1	+	+	1	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Ulex baeticus Boiss.	1	1	+	+	·	+	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Putoria calabrica (L. fil.) DC.	1	·	1	1	·	1	+	1	·	·	·	·	·	·	·	·	·	·	·	·	·
Crambe filiformis Jacq.	+	1	+	+	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Vinca difformis Pourr.	·	2	·	1	+	·	2	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Antirrhinum onubense (Fern. Casas) Fern. Casas	1	·	1	+	1	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Anthyllis polycephala Desf.	1	·	+	1	·	1	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Thymus baeticus Lacaita	1	·	·	+	+	1	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Ballota nigra L.	+	·	+	+	1	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Sedum sediforme (Jacq.) Pau	·	·	+	+	+	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Silene andryalifolia Pomel	1	·	1	·	1	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Asperula hirsuta Desf.	+	·	+	·	2	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Cerastium gibraltaricum Boiss.	+	·	+	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Phlomis purpurea L.	·	·	+	·	·	·	1	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Saxifraga reuteriana Boiss.	+	·	1	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Reichardia tingitana (L.) Roth	+	·	+	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Thymus granatensis Boiss.	+	·	·	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Phlomis crinita malacitana (Pau) Cabezudo, J.M. Nieto & T. Navarro	·	·	+	+	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Asplenium petrarchae subsp. petrarchae (Guérin) DC.	·	·	·	+	+	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Phagnalon saxatile (L.) Cass.	·	·	+	·	+	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Crataegus granatensis Boiss.	·	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Sanguisorba ancistroides (Desf.) Ces.	1	·	·	·	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Arisarum simorhinum Durieu	·	·	1	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Asphodelus macrocarpus rubescens Z. Díaz & Valdés	·	·	+	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Erysimum rondae Polatschek	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Teucrium aureum Schreb. subsp. angustifolium (Willk.) Valdés Berm. & Sánchez Crespo	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Santolina chamaecyparissus L.	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Stipa parviflora Desf.	·	·	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Macrochloa tenacissima (L.) Kunth	·	·	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Distichoselinum tenuifolium García Martín & Silvestre	·	·	·	+	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·
Acinos alpinus subsp. meridionalis (Nyman) P.W. Ball	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Galium lucidum All.	+	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Dianthus broteri Boiss. & Reut.	·	·	+	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Micromeria graeca (L.) Rchb.	·	·	+	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Brachypodium retusum subsp. retusum (Pers.) P. Beauv.	·	·	·	·	·	·	·	·	·	·	1	·	1	·	1	·	·	1	·	·	3
Thymus zygis subsp. gracilis (Boiss.) R. Morales	·	·	·	·	·	·	·	·	·	·	2	1	1	·	2	·	·	·	·	·	·
Festuca scariosa (Lag.) Asch. & Graebn.	·	·	·	·	·	·	·	·	·	1	·	·	·	·	·	1	1	·	·	1	·
Melica minuta L.	·	·	·	·	·	·	·	·	·	·	2	2	·	·	2	·	·	·	·	·	·
Rubus ulmifolius Schott	·	·	·	·	·	·	·	·	·	·	·	1	·	·	·	·	1	·	1	·	·
Crataegus monogyna Jacq.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	·	·	2	·	·
Rosmarinus officinalis L.	·	·	·	·	·	·	·	·	·	2	·	·	·	·	·	·	·	·	·	·	1
Genista cinerea subsp. speciosa Rivas Mart. & al.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	2
Lavandula latifolia Medik.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	·	·	1	·
Rosa canina L.	·	·	·	·	·	·	·	·	·	·	1	·	·	·	1	·	·	·	·	·	·
Sedum mucizonia (Ortega) Raym.-Hamet	·	·	·	·	·	·	·	·	·	·	1	·	·	·	1	·	·	·	·	·	·
Arrhenatherum elatius subsp. bulbosum (Willd.) Schübl. & Martens	·	·	·	·	·	·	·	·	·	·	1	·	·	·	1	·	·	·	·	·	·
Geranium purpureum Vill.	·	·	·	·	·	·	·	·	·	·	1	·	·	·	1	·	·	·	·	·	·
Carduus granatensis Willk.	·	·	·	·	·	·	·	·	·	·	1	·	·	·	1	·	·	·	·	·	·
Amelanchier ovalis Medik.	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	1	·	·	·	+	·

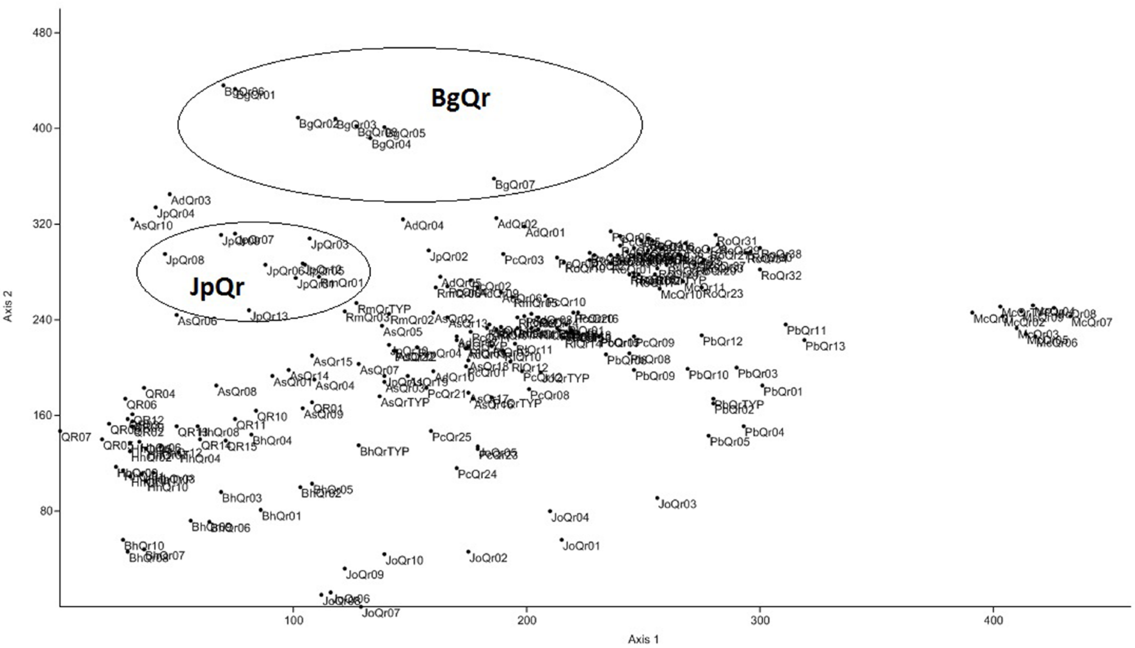

Fig. 2 - DCA analysis of *Quercus rotundifolia* woodlands in the southern-central Iberian Peninsula.

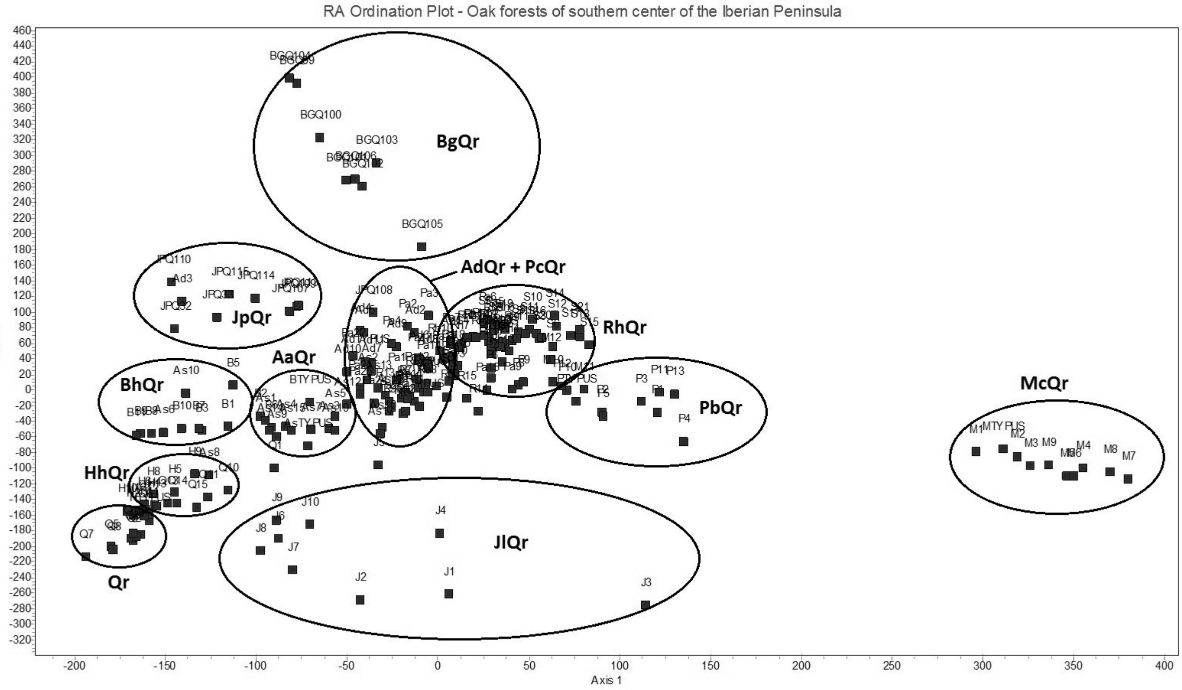

Fig. 3 - RA analysis of *Quercus rotundifolia* woodlands in the southern-central Iberian Peninsula.

terranean association *Bupleuro gibraltarici-Quercetum rotundifoliae* has significant floristic differences with *Rhamno myrtifoliae-Quercetum rotundifoliae*, due to the presence of *Bupleurum gibraltaricum*, *Rhamnus myrtifolia* subsp. *iranzoi* (Rivas-Martínez & Pizarro, 2012), *Hedera maderensis* subsp. *iberica*, *Hedera hibernica*, *Viburnum tinus* and *Aristolochia baetica*; and the absence of species such as *Pinus halepensis*, *Chamaerops humilis*, *Ephedra fragilis* and *Rhamnus myrtifolia* subsp. *myrtifolia*.

The high rainfall in the central part of the Subbética mountain ranges of Cazorla, Segura, Las Villas, Mágina and Pandera caused by the funnel effect of the Guadalquivir valley and the screening effect from the Atlantic squalls, together with the steep orography and limestone and limestone-dolomitic substrates, leads to the growth of an edaphoxerophilous holm oak community which occupies all the rocky crests with a humid ombrotype in the meso and supramediterranean thermotype in the Subbético sector. These edaphoxerophilous formations, *Junipero phoeniceae-Quercetum rotundifoliae* (Tab. 1, rels. 9-21, *typus* rel. 11), are constituted and characterized by *Quercus rotundifolia*, *Juniperus oxycedrus* subsp. *badia*, *Hedera hibernica*, *Juniperus phoenicea*, *Acer monspessulanum*, *Buxus sempervirens* and *Helleborus foetius* like differential of *Querco roboris-Fagetea sylvaticae* undergrowth, and are the basis for our proposal of the new association. It is differentiated from the previous one floristically, biogeographically and catenally, as in this case it contacts with the Baetic oak woodlands of *Viburno tini-Quercetum alpestris* and *Berberido hispanicae-Quercetum alpestris*, and the maple woodlands of *Daphno latifoliae-Aceretum granatensis* (Rivas-Martínez *et al.,* 2011). The floristic differentiation of these two new edaphoxerophilous associations from the rest of the climatophilous associations of *Quercus rotundifolia* can be clearly seen in Tab. 1.

The network analysis of phytosociological placement highlights how these associations are related to each other through their floristic composition. As can be seen in Fig. 4, the associations JpQr (*Junipero phoeniceae-Quercetum rotundifoliae*) and BgQr (*Bupleuro gibraltarici-Quercetum rotundifoliae*) are well characterised by their floristic composition, which is not found in any of the other associations; and there is a greater affinity between them than between the rest of the climatophilous communities. The connection with all the other climatophilous associations is established by means of the central nucleus of characteristic species common to all the communities belonging to *Quercetea ilicis*.

Diversity analysis

The analysis of total diversity (Fig. 5) shows a high value for both the relevés of McQr1-13: *Myrto communis-Quercetum rotundifoliae*, and the relevés of BgQr: *Bupleuro gibraltarici-Quercetum rotundifoliae*. The itemised application of Margalef's diversity index to characteristic, endemic and companion species (Tab. 2) reveals clear differences that do not agree with the total diversity values.

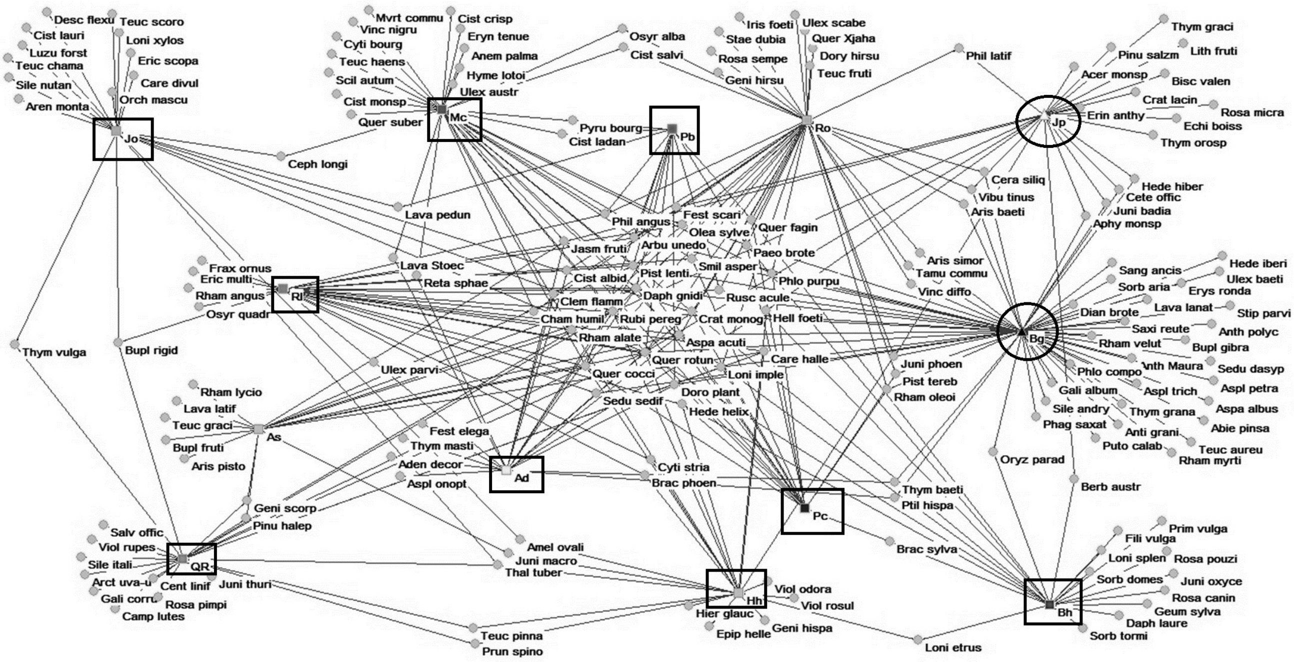

Fig. 4 - Network of the phytosociological placement of the associations studied.

In the case of the diversity of characteristic species, some associations stand out above the mean (McQr, RlQr, PbQr, AaQr, RoQr, PcQr, BgQr, JpQr), whereas all the other associations present low diversity values for characteristic species (Fig. 7). These differences are evident in the analysis of variance of Margalef's index, which shows significant differences between the associations as can be seen in Fig. 6.

The diversity analysis points to significant differences between the values for endemic species in the communities of AdQr, BgQr and JlQr. It is worth noting that the associations with a lower diversity of characteristic species have a greater diversity of companion species. This decline in the number of characteristic species and rise in companion species can be interpreted as an association having a poor state of conservation, and if this process were to continue these associations would be substituted by others. There are six types of associations with zero diversity (Fig. 7) of endemic species; the two new types of edaphoxerophilous formations (BgQr, JpQr) have the maximum diversity, along with AdQr: *Adenocarpo decorticantis-Quercetum rotundifoliae*, which is not an edaphoxerophilous

Tab. 2 - Diversity values for the associations studied considering characteristic, companion and endemic species.

	McQr	RlQr	PbQr	HhQr	BhQr	AdQr	AaQr	Qr	RoQr	PcQr	Rmr	JlQr	BgQr	JpQr
Margalef_C	5.53	6.28	5.14	3.10	2.78	2.98	5.79	3.31	6.96	6.07	1.95	3.71	6.04	4.70
Margalef_Co	3.35	2.66	1.89	2.73	1.46	2.73	5.64	3.13	1.14	3.80	2.62	2.98	3.24	3.38
Margalef_E	0.00	0.00	0.51	0.00	0.91	1.36	0.91	0.00	0.48	0.91	0.00	0.00	1.06	1.08

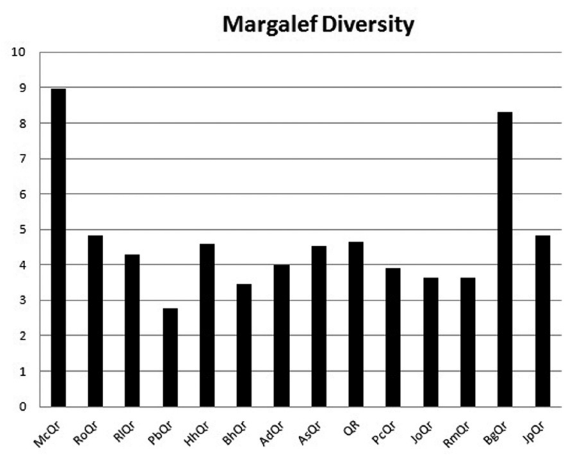

Fig. 5 - Total diversity for the associations studied.

Association	Value	Standard Error	t	P value
AdQr	0,145	0,065	2,222	**0,027**
AsQr	0,063	0,069	0,919	0,359
BgQr	0,313	0,063	4,954	**< 0,0001**
BhQr	0,138	0,065	2,140	**0,034**
HhQr	-0,020	0,066	-0,300	0,764
JoQr	-0,018	0,065	-0,282	0,778
JpQr	0,424	0,066	6,453	**< 0,0001**
McQr	-0,020	0,066	-0,300	0,764
PbQr	-0,020	0,066	-0,309	0,758
PcQr	-0,027	0,071	-0,380	0,704
QR	-0,021	0,067	-0,317	0,752
RlQr	-0,022	0,067	-0,324	0,746
RmQr	-0,015	0,063	-0,234	0,815
RoQr	0,018	0,031	0,601	0,549

Fig. 6 - Analysis of the variance of Margalef diversity of endemic species, bold, significant associations to 95% significance.

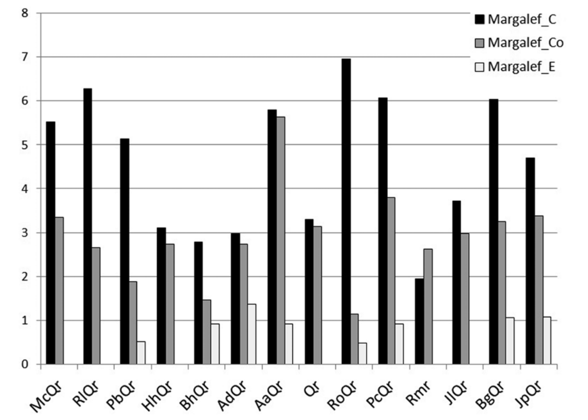

Fig. 7 - Diversity of companion, endemic and characteristics species.

community, but is in the Nevadense sector, one of the Spanish biogeographic units with the greatest rate of endemics. The association BgQr: *Bupleuro gibraltarici-Quercetum rotundifoliae* described for the Rondeño sector and JpQr: *Junipero phoeniceae-Quercetum rotundifoliae* for the Subbético sector have a high rate of endemic taxa due to the particular orography of the territories, which act as a species refugium. These sites are therefore of great interest for conservation. This conservation should be enacted through the Habitats Directive 92/43/EEC, whose Habitat 9340 includes all the *Quercus rotundifolia* associations in this study. In the case of holm oak woodlands on scree there are other habitats of interest such as 8210, which may be located sporadically or not at all in climatophilous holm oak woodlands.

Discussion

Territories behave differently in response to the general climate, the type of substrate and the topography of the terrain. For this reason areas on rocky crests, even though they may be located in rainy environments and surrounded by climactic forests, behave differently from the territories around them due to their reduced capacity for retaining groundwater in the soils. In these circumstances islands evolve that may potentially contain edaphoseries, minoriseries and permaseries (Cano *et al.,* 2016). All plant communities growing on rocky crests, steeply sloping areas with extreme gradients and similar environments are very significantly influenced by the soil, which conditions their existence. The whole territory has a particular type of substrate and an orography which determines its greater or lesser capacity to retain water. For this reason areas with high rainfall behave differently from the rest of the territory, which leads to the installation of edaphoxeric communities that contain a high number of endemic species. These associations should therefore not be considered as climatophilous and edaphoxerophilous concurrently (Rivas-Martínez *et al.*, 2011), as they have different catenal contacts, ecology and flora (See Tab. 3); furthermore, these edaphoseries comprise a high number of endemisms, which are mostly included in EU priority habitats.

Tab. 3 - Analysis of the synthetic table of the different associations of holm oak woodlands in the center and south of the Iberian peninsula, which takes into account the characteristic species of class, endemic companions of interest and other companions with less interest.

	RmQr	McQr	PcQr	AdQr	HhQr	JpQr	RoQr	PbQr	AaQr	BgQr	BhQr	RlQr	JlQr	Qr
Quercetea ilicis class species														
Asparagus acutifolius L.	.	IV	IV	III	I	I	IV	I	III	II	II	IV	I	.
Daphne gnidium L.	I	V	III	III	.	.	V	IV	IV	III	I	III	I	.
Rubia peregrina subsp. peregrina L.	III	.	III	IV	V	III	.	I	III	IV	.	.	III	V
Smilax aspera L. var. aspera	II	IV	III	.	.	I	V	II	I	IV	.	IV	.	.
Rhamnus alaternus subsp. alaternus L.	.	II	I	.	II	I	IV	I	II	.	.	IV	.	III
Carex halleriana Asso	.	.	I	.	V	II	I	.	II	I	I	II	.	V
Lonicera implexa Aiton	II	II	II	.	.	.	III	.	I	III	.	II	.	III
Clematis flammula L.	.	II	II	II	.	I	I	.	I	.	I	III	.	.
Olea europaea L. var. sylvestris (Mill.) Lehr	.	III	I	.	.	.	IV	II	.	III	.	III	.	.
Lonicera etrusca G. Santi	.	.	I	.	III	.	.	.	I	.	II	.	I	.
Vincetoxicum nigrum (L.) Moench	.	II	.	.	.	.	I	I	.	.	.	.	I	.
Rubia peregrina subsp. longifolia (Poir.) O. Bolòs	.	IV	.	.	.	.	V	.	.	.	.	V	.	.
Arisarum simorrhinum Durieu.	.	.	I	.	.	.	IV	.	.	II	.	.	.	.
Colutea hispanica Talavera & Arista	.	.	I	.	.	.	.	.	I	.	.	.	.	.
Quercetalia ilicis order species														
Quercus rotundifolia Lam.	V	V	IV	V	V	V	V	V	V	V	V	V	V	V
Quercus coccifera L.	III	III	II	.	II	II	IV	III	IV	.	.	V	.	V
Ruscus aculeatus L.	I	.	I	.	.	I	II	II	I	II	I	II	I	.
Viburnum tinus L.	.	I	I	.	.	II	I	I	I	II	.	I	.	.
Doronicum plantagineum L.	.	.	.	II	.	.	.	III	.	II	.	.	I	.
Quercus suber L.	.	IV	.	.	.	.	I	.	.	.	.	.	.	.
Carex distachya Desf.	.	.	.	.	.	.	I	.	.	.	.	.	I	.
Juniperus oxycedrus L. subsp. badia (H. Gay) Debeaux	.	.	.	.	.	V	.	.	.	IV	.	.	.	.
Bupleurum rigidum L.	.	.	.	.	.	.	.	.	I	I	I	II	II	III

Quercion broteroi alliance species														
Paeonia broteri Boiss. & Reut.	.	.	IV	.	.	I	III	III	.	.	II	.	I	.
Pyrus bourgaeana Decne.	.	IV	.	.	.	.	V	V	.	.	.	.	.	.
Hyacinthoides hispanica (Mill.) Rothm.	.	.	.	.	.	.	I	I	.	.	.	.	.	.
Asparago albi-Rhamnion oleoidis Alliance species														
Rhamnus oleoides subsp. oleoides L.	.	I	II	.	.	.	V	.	.	IV	.	.	.	.
Aristolochia baetica L.	.	I	.	.	.	.	IV	.	.	III	.	.	.	.
Erición arboreae Alliance														
Phillyrea latifolia L.	.	.	I	.	I	III	II	II	.	I	.	.	.	.
Erica arborea L.	.	.	.	.	.	.	.	I	.	.	.	I	I	.
Arbutus unedo L.	.	III	I	.	.	.	III	II	I	IV	.	II	.	.
Pistacio lentisci-Rhamnetalia alaterni Order														
Juniperus oxycedrus L. subsp. oxycedrus	III	I	.	I	V	I	I	.	II	.	IV	I	I	I
Jasminum fruticans L.	.	III	II	II	.	II	I	I	II	I	.	I	.	.
Pistacia lentiscus L.	I	V	II	.	.	I	V	IV	II	III	.	V	.	.
Phillyrea angustifolia subsp. angustifolia L.	II	IV	I	.	.	.	II	IV	I	.	.	II	I	.
Pistacia terebinthus L.	.	I	IV	I	.	.	II	II	I	IV	.	I	.	.
Juniperus phoenicea L.	I	.	.	.	III	V	III	.	I	III	.	I	.	I
Osyris alba L.	.	II	I	.	.	.	I	.	I	.	.	.	.	I
Chamaerops humilis L.	II	II	.	.	.	.	III	.	.	I	.	III	.	.
Myrtus communis L.	.	IV	.	.	.	.	I	II	.	.	.	I	.	.
Pinus halepensis Mill. var. halepensis	I	.	.	I	.	.	.	.	III	.	.	.	.	II
Bupleurum fruticosum L.	.	.	I	.	.	I	I	.	.	I	.	.	.	.
Ceratonia siliqua L.	.	.	.	.	.	I	IV	.	.	V	.	.	.	.
Rhamnus lycioides L. subsp. lycioides	.	.	.	.	.	.	.	.	II	.	.	I	.	I
Ephedra fragilis Desf.	II	I	.	.	.	.	.	.	.	.	.	.	.	.
Coronilla juncea L.	.	.	.	.	.	.	I	.	.	.	.	I	.	.
Rhamnus myrtifolia subsp. iranzoi Rivas Mart. & J.M. Pizarro	.	.	.	.	.	I	.	.	.	III	.	.	.	.
Asparagus albus L.	.	I	I	.	.	.	.	.	.	II	.	.	.	.
Querco roboris-Fagetea sylvaticae class														
Quercus faginea Lam. subsp. faginea	.	.	III	I	II	I	II	II	I	.	III	.	I	.
Hedera helix subsp. helix L.	II	.	II	I	V	.	I	.	.	.	IV	II	.	.
Helleborus foetidus L.	.	.	I	II	III	II	.	.	.	.	V	.	I	.
Buxus sempervirens L.	.	.	.	.	.	II	I	.	I	.	.	.	.	.
Fraxinus ornus L.	.	.	.	.	.	.	.	.	I	.	.	II	.	.
Daphne laureola L.	.	.	.	.	.	I	.	.	.	.	II	.	.	.
Hieracium murorum L.	.	.	.	.	.	.	.	.	.	.	.	.	I	I
Acer monspessulanum L.	.	.	I	.	.	III	.	.	.	.	.	.	.	.
Hedera hibernica (G. Kirchn.) Bean	.	.	.	.	.	III	.	.	.	V	.	.	.	.
Differential species of class, orders and alliances of *Quercetea ilicis* class														
Ephedra major Host	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Arenaria montana L.	.	.	.	.	.	.	.	.	.	.	.	.	III	.
Pistacia x saportae Burnat	.	.	.	.	.	.	.	.	.	.	.	I	.	.
Asparagus horridus L. in Murray.	.	.	.	.	.	.	.	.	.	.	.	I	.	.
Calicotome spinosa (L.) Link	.	.	.	.	.	.	.	.	.	.	.	I	.	.
Rhamnus oleoides var. angustifolia Lange ex Willk.	.	.	.	.	.	.	.	.	.	.	.	III	.	.
Osyris quadripartita Salzm. ex Decne.	.	.	.	.	.	.	.	.	.	.	.	III	.	.
Rhamnus velutinus Boiss. subsp. velutinus	.	.	.	.	.	.	.	.	.	II	.	.	.	.
Hedera maderensis subsp. iberica McAllister	.	.	.	.	.	.	.	.	.	II	.	.	.	.
Asplenium petrarchae (Guérin) DC	.	.	.	.	.	.	.	.	.	II	.	.	.	.
Bupleurum gibraltarium Lam.	.	.	.	.	.	.	.	.	.	V	.	.	.	.
Clematis cirrhosa L. subsp. cirrhosa	.	.	.	.	.	.	I	.	.	.	.	.	.	.
Quercus x jahandiezii A. Camus	.	.	.	.	.	.	I	.	.	.	.	.	.	.
Calicotome villosa (Poir.) Link	.	.	.	.	.	.	I	.	.	.	.	.	.	.
Asparagus aphyllus L.	.	.	.	.	.	.	I	.	.	.	.	.	.	.
Coronilla glauca L.	.	.	.	.	.	.	I	.	.	.	.	.	.	.
Prasium majus L.	.	.	.	.	.	.	I	.	.	.	.	.	.	.
Ruscus hypophyllum L.	.	.	.	.	.	.	I	.	.	.	.	.	.	.
Colutea arborescens L	.	.	.	.	II	.	.	.	.	.	.	.	.	.
Hieracium glaucinum Jord.	.	.	.	.	III	.	.	.	.	.	.	.	.	.
Asplenium onopteris L.	.	.	.	II	.	.	.	.	.	.	.	.	.	.
Biarum carratracense (Haens. ex Willk.) Font Quer	.	.	I	.	.	.	.	.	.	.	.	.	.	.
Paeonia coriacea Boiss.	.	.	I	.	.	.	.	.	.	.	.	.	.	.
Rhamnus myrtifolia subsp. myrtifolia Willk.	III	.	.	.	.	.	.	.	.	.	.	.	.	.
Teucrium fruticans L.	III	.	.	.	.	.	.	.	.	.	.	.	.	.
Companions differentials species														
Helianthemum myrtifolium (Lam.) Samp.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Festuca rubra L.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Helianthemum marifolium subsp. origanifolium (Lam.) G. López	.	.	.	.	.	.	.	.	.	.	.	.	.	II

Dianthus lusitanus Brot	.	.	.	.	.	.	.	.	.	.	.	.	I	.
Festuca indigesta Boiss. subsp. aragonensis (Willk.) Kerguélen	.	.	.	.	.	.	.	.	.	.	.	.	I	.
Cistus laurifolius L.	.	.	.	.	.	.	.	.	.	.	.	.	II	.
Helianthemum origanifolium (Lam.) Pers. subsp. molle (Cav.) Font Quer & Rothm.	.	.	.	.	.	.	.	.	.	.	.	I	.	.
Genista cinerea subsp. speciosa Losa & Rivas Goday	.	.	.	.	.	.	.	.	.	.	I	.	.	.
Quercus faginea subsp. alpestris (Boiss.) Maire	.	.	.	.	.	.	.	.	.	I	.	.	.	.
Abies pinsapo Boiss.	.	.	.	.	.	.	.	.	.	II	.	.	.	.
Dianthus boissieri Willk.	.	.	.	.	.	.	.	.	.	I	.	.	.	.
Brachypodium sylvaticum var. gaditanum (Talavera) A. Galan de Me	.	.	.	.	.	.	.	.	.	I	.	.	.	.
Celtis australis L.	.	.	.	.	.	.	.	.	.	I	.	.	.	.
Echium albicans Lag. & Rodr.	.	.	.	.	.	.	.	.	.	I	.	.	.	.
Cheilanthes maderensis Lowe in Trans.	.	.	.	.	.	.	.	.	.	I	.	.	.	.
Halimium atriplicifolium (Lam.) Spach	.	.	.	.	.	.	.	.	.	I	.	.	.	.
Erysimum rondae Polatschek	.	.	.	.	.	.	.	.	.	II	.	.	.	.
Antirrhinum graniticum Rothm.	.	.	.	.	.	.	.	.	.	IV	.	.	.	.
Dianthus pungens L. subsp. hispanicus (Asso) O. Bolòs & Vigo	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Cistus creticus L.	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Erysimum mediohispanicum Polatschek	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Fumana laevis (Cav.) Pau	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Genista pumila (Debeaux & É. Rev. ex Hervier) Vierh.	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Festuca capillifolia L.M. Dufour in Roem. & Schult.	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Erica terminalis Salisb.	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Helianthemum apenninum (L.) Mill.	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Helianthemum hirtum (L.) Mill.	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Helianthemum syriacum (Jacq.) Dum. Cours.	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Helianthemum violaceum (Cav.) Pers.	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Helictotrichon filifolium subsp. filifolium (Lag.) Henrard	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Hippocrepis bourgaei (Nyman) Hervier	.	.	.	.	.	.	.	.	I	.	.	.	.	.
Helianthemum cinereum (Cav.) Pers. subsp. rotundifolium (Dunal) Greuter & Burdet	.	.	.	.	.	.	.	.	II	.	.	.	.	.
Cytisus scoparius ssp. bourgaei (Boiss) Rivas Mart. & al.	.	.	.	.	.	.	.	I	.	.	.	.	.	.
Cytisus grandiflorus (Brot.) DC.	.	.	.	.	.	.	.	I	.	.	.	.	.	.
Cistus populifolius L.	.	.	.	.	.	.	.	I	.	.	.	.	.	.
Erophaca baetica subsp. baetica (L.) Boiss.	.	.	.	.	.	.	.	II	.	.	.	.	.	.
Cheirolophus sempervirens (L.) Pomel	.	.	.	.	.	.	I	.	.	.	.	.	.	.
Epipactis lusitanica D. Tyteca	.	.	.	.	.	.	II	.	.	.	.	.	.	.
Genista hirsuta Vahl subsp. hirsuta	.	.	.	.	.	.	III	.	.	.	.	.	.	.
Antirrhinum tortuosum Bosc ex Vent	.	.	.	.	.	I	.	.	.	.	.	.	.	.
Argyrolobium zanonii (Turra) P.W. Ball	.	.	.	.	.	I	.	.	.	.	.	.	.	.
Carduus platypus subsp. granatensis Willk.	.	.	.	.	.	II	.	.	.	.	.	.	.	.
Erinacea anthyllis Link,	.	.	.	.	.	II	.	.	.	.	.	.	.	.
Juniperus communis subsp. hemisphaerica (C. Presl) Nyman	.	.	.	.	.	II	.	.	.	.	.	.	.	.
Crataegus laciniata Ucria	.	.	.	.	.	III	.	.	.	.	.	.	.	.
Acer opalus Mill. subsp. granatense (Boiss.) Font Quer & Rothm.	.	.	.	.	I	.	.	.	.	.	.	.	.	.
Epipactis helleborine (L.) Crantz	.	.	.	.	II	.	.	.	.	.	.	.	.	.
Ferulago granatensis Boiss.	.	.	.	I	.	.	.	.	.	.	.	.	.	.
Cotoneaster granatensis Boiss.	.	.	.	I	.	.	.	.	.	.	.	.	.	.
Centaurea boissieri DC.	.	.	.	I	.	.	.	.	.	.	.	.	.	.
Celtica gigantea (Link) J.M. Vázquez & Barkworth	.	.	.	I	.	.	.	.	.	.	.	.	.	.
Clematis vitalba L.	.	.	.	I	.	.	.	.	.	.	.	.	.	.
Fraxinus angustifolia Vahl	.	.	.	I	.	.	.	.	.	.	.	.	.	.
Festuca elegans Boiss.	.	.	.	II	.	.	.	.	.	.	.	.	.	.
Helichrysum serotinum (DC.) Boiss.	.	.	.	III	.	.	.	.	.	.	.	.	.	.
Adenocarpus decorticans Boiss.	.	.	.	V	.	.	.	.	.	.	.	.	.	.
Biscutella valentina var. variegata (Boiss. & Reut.) Grau & Klingenberg	.	.	I	.	.	.	.	.	.	.	.	.	.	.
Cytisus fontanesii Spach in Bourg.	.	.	I	.	.	.	.	.	.	.	.	.	.	.
Flueggea tinctoria (L.) G.L. Webster	.	I	.	.	.	.	.	.	.	.	.	.	.	.
Halimium halimifolium (L.) Willk. in Willk. & Lange	.	I	.	.	.	.	.	.	.	.	.	.	.	.
Genista triacanthos Brot.	.	I	.	.	.	.	.	.	.	.	.	.	.	.
Cistus crispus L.	.	IV	.	.	.	.	.	.	.	.	.	.	.	.
Thapsia villosa L.	I	.	.	.	.	.	.	.	.	.	.	.	.	.
Companions transgressive species														
Crataegus monogyna subsp. brevispina Kumze	.	II	IV	III	I	I	V	II	I	II	V	I	III	I
Cistus albidus L.	IV	II	II	II	.	I	II	I	I	I	.	II	.	I
Brachypodium retusum (Pers.) P. Beauv.	III	II	II	.	V	II	I	.	III	.	.	IV	.	IV
Brachypodium phoenicoides (L.) Roem. & Schult.	.	I	.	.	II	.	.	.	I	I	.	II	.	I
Aphyllanthes monspeliensis L.	.	.	.	.	I	IV	.	.	I	II	.	I	.	I
Aristolochia pistolochia L.	.	II	I	.	I	.	.	.	II	.	.	.	.	I
Cistus salviifolius L.	.	V	I	.	.	.	II	I	.	.	.	.	I	.
Cistus monspeliensis L.	.	V	.	.	.	.	I	I	.	.	.	I	.	.
Aristolochia paucinervis Pomel	.	II	I	.	.	.	I	.	.	.	I	.	.	.
Genista scorpius (L.) DC. in Lam. & DC.	.	.	I	.	.	.	.	.	III	.	.	.	I	II
Cytisus scoparius subsp. reverchonii (Degen & Hervier) Rivas Goday & Rivas Mart.	.	.	I	.	.	.	.	.	I	.	I	.	.	.

Biscutella valentina (Loefl. ex L.) Heywood	.	.	.	I	.	II	.	.	I	.	.	.	.	.
Cistus ladanifer L.	.	III	.	.	.	.	.	IV	.	.	.	.	I	.
Cytisus scoparius (L.) Link subsp. scoparius	.	II	.	.	.	.	.	I	.	.	.	.	I	.
Helichrysum stoechas (L.) Moench	.	.	I	I	.	.	I	.	.	.	.	.	.	.
Brachypodium sylvaticum (Huds.) P. Beauv.	.	.	II	.	.	.	.	.	.	.	II	.	I	.
Festuca scariosa (Lag.) Asch. & Graebn.	.	.	I	II	.	II	.	.	.	.	.	.	.	.
Arctostaphylos uva-ursi (L.) Spreng.	.	.	.	.	.	.	.	.	I	.	.	.	I	III
Ceterach officinarum subsp. officinarum Willd	.	.	I	.	.	II	.	.	.	IV	.	.	.	.
Juniperus thurifera L.	.	.	.	.	I	.	.	.	.	.	.	.	.	II
Echinospartum boissieri (Spach) Rothm.	.	.	.	.	.	III	.	.	.	.	I	.	.	.
Dianthus broteri Boiss. & Reut	.	.	.	.	.	.	I	.	.	II	.	.	.	.
Erica scoparia L.	.	II	.	.	.	.	.	.	.	.	.	.	II	.
Genista umbellata (L'Hér.) Dum. Cours.	.	II	.	I	.	.	.	.	.	.	.	.	.	.
Cytisus striatus (Hill) Rothm.	.	.	.	.	II	.	.	.	.	.	.	II	.	.
Erica multiflora L.	.	.	.	.	.	.	.	.	I	.	.	III	.	.
Genista valentina (Willd. ex Spreng.) Steud.	.	.	I	.	.	.	.	.	.	.	.	I	.	.
Helianthemum marifolium (L.) Mill.	.	.	.	.	II	.	.	.	I	.	.	.	.	.
Genista hispanica L.	.	.	.	.	V	.	.	.	.	.	.	.	.	I
Berberis hispanica Boiss. & Reut. subsp. hispanica	.	.	.	.	.	IV	.	.	.	.	V	.	.	.
Fumana thymifolia (L.) Spach ex Webb	.	.	.	.	.	.	.	.	I	I	.	.	.	.
Helianthemum apenninum subsp. cantabricum (M. Laínz) G. López	.	.	I	.	.	.	.	.	I	.	.	.	.	.
Cistus clusii Dunal in DC.	II	.	.	.	.	.	.	.	I	.	.	.	.	.
Asplenium trichomanes L.	.	.	.	.	.	I	.	.	.	IV	.	.	.	.

Conclusions

The presence of woodland formations of *Quercus rotundifolia* with an edaphoxerophilous character enables the delimitation of two new associations: *Junipero phoeniceae-Quercetum rotundifoliae* and *Bupleuro gibraltarici-Quercetum rotundifoliae*, which differ from climatophilous holm oak wood formations. Statistical analyses reveal notable differences between holm oak woodlands growing on rocky substrates and climatophilous holm oak woodlands, and the calculation of the diversity of characteristic and companion species reveals the presence of climatophilous woodlands with a low diversity of characteristic species which could potentially lead to their disappearance. It is therefore recommended to separate the climatophilous and edaphoxerophilous concepts. The rate of endemic species for the two large areas studied in the southern Iberian peninsular is extremely high, indicating the need for conservation measures.

Syntaxonomic scheme

QUERCETA ILICIS Br.-Bl. ex A. & O. Bolòs 1950
QUERCETALIA ILICIS Br.-Bl. ex Molinier 1934
Quercion ilicis Br.-Bl. ex Molinier 1934 em. Rivas-Martínez 1975
Quercenion rotundifoliae Rivas Goday in Rivas Goday, Borja, Esteve, Galiano, Rigual & Rivas-Martínez 1960 em. Rivas-Martínez 1975
Hedero helicis-Quercetum rotundifoliae Costa, Peris & Stübing 1987
Asparago acutifoliae-Quercetum rotundifoliae Rivas-Martínez, Cantó, Fernández-González & Sánchez-Mata in Rivas-Martínez *et al.* 2002
Quercetum rotundifoliae Br.-Bl. & O. Bolòs (1956) 1957
Querco rotundifoliae-Oleion sylvestris Barbero, Quézel & Rivas-Martínez in Rivas-Martínez, Costa & Izco 1986
Bupleuro gibraltarici-Quercetum rotundifoliae ass. nova *hoc loco*
Myrto communis-Quercetum rotundifoliae Rivas Goday in Rivas Goday, Borja, Esteve, Rigual & Rivas-Martínez 1960
Rubio longifoliae-Quercetum rotundifoliae Costa, Peris & Figuerola 1982
Rhamno oleoidis-Quercetum rotundifoliae Rivas-Martínez 2002
Quercion broteroi Br.-Bl., P. Silva & Rozeira 1956 em. Rivas-Martínez 1975 corr Ladero 1974
Paeonio broteroi-Quercenion rotundifoliae Rivas-Martínez in Rivas-Martínez, Costa & Izco 1986.
Junipero phoeniceae-Quercetum rotundifoliae ass. nova *hoc loco*
Berberido hispanicae-Quercetum rotundifoliae Rivas-Martínez 1987
Adenocarpo decorticantis-Quercetum rotundifoliae Rivas-Martínez 1987
Pyro bourgaenae-Quercetum rotundifoliae Rivas-Martínez 1987
Paeonio coriaceae-Quercetum rotundifoliae Rivas-Martínez 1964
Junipero lagunae-Quercetum rotundifoliae Rivas Goday ex 1965 corr. Rivas-Martínez in Rivas-Martínez *et al.* 2011
PISTACIO LENTISCI-RHAMNETALIA ALATERNI Rivas-Martínez 1975
Pino acutisquamae-Juniperion phoeniceae Rivas-Martínez 2002
Rhamno myrtifoliae-Quercetum rotundifoliae Pérez Latorre, Soriguer-Solanas & Cabezudo 2015

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Appendix I: Sporadic species

Tab. 1 - rel. 2: 1 Dianthus boissieri Willk., + Rumex scutatus L., + Allium roseum L., + Ferula communis subsp. catalaunica (C. Vicioso) Sánchez Cuxart & Bernal, + Centranthus macrosiphon Boiss; rel. 3: + Quercus faginea subsp. alpestris (Boiss.) Maire, 1 Thymus mastichina subsp. mastichina (L.) L, + Conopodium marianum Lange, + Centaurea pullata subsp. pullata L., + Sedum acre L.; rel. 4: 1 Brachypodium sylvaticum var. gaditanum (Talavera) A. Galán de Mera, 1 Brachypodium phoenicoides (L.) Roem. & Schult., + Ruta angustifolia Pers., + Brachypodium retusum subsp boissieri

(Nyman) Romero García, + Linaria aeruginea (Gouan) Cav.; rel. 5: + Bryonia dioica Jacq., + Celtis australis L., + Campanula mollis L.; rel. 7: 2 Chamaerops humilis L., + Polypodium cambricum L. subsp. cambricum; rel. 8: + Euphorbia nicaeensis subsp. nicaeensis All. , + Fumana thymifolia (L.) Webb, + Polygala rupestris Pourr., + Globularia alypum, + Cheilanthes maderensis Lowe; rel. 12: 1 Clematis flammula L., 1 Lonicera splendida Boiss., 1 Anarrhinum laxiflorum Boiss., 1 Antirrhinum tortuosum Bosc ex Vent; rel. 14: 1 Argyrolobium zanonii (Turra) P.W. Ball; rel. 16: 1 Rubus canescens DC., 1 Saxifraga erioblasta Boiss. & Reut. in Boiss., 1 Leopoldia comosa (L.) Parl.; rel. 19: + Digitalis obscura L. , + Urginea maritima (L.) Baker; rel. 20: 1 Osyris alba L. , + Phillyrea angustifolia L. , + Salvia lavandulifolia Vahl subsp. lavandulifolia , + Asphodelus albus subsp. Albus Mill., + Cytisus scoparius subsp. reverchonii (Degen & Hervier) Rivas Goday & Rivas Mart.; rel. 21: 2 Bupleurum rigidum L. subsp. paniculatum (Brot.) H. Wolff in Engl., + Coronilla juncea L., 1 Festuca capillifolia L.M. Dufour in Roem. & Schult., 1 Thymus membranaceus Boiss., 1 Ulex parviflorus Pourr.

Appendix II: Location of the relevés

Tab. 1 - Rels. 1 and 6, Sierra de Grazalema; rel. 2, Sendero el Santo (Mirador de Grazalema) (30S 278852/2927980); rel. 3 , Sierra de Grazalema (30S 301232/4036702); rel. 4, Prox. Grazalema; rel. 5, Route "Molinos Harineros" (30S 301232/4036702); rel. 7, Prox Benamahoma-Grazalema (30S 303894/4035575); rel. 8, Benamahoma-Grazalema to 5 km of Grazalema (30S 302779/4035301); rels. 9 and 10, Pico Cabañas-Quesada (Cazorla, Jaén); rel. 11, Sierra Valdepeñas de Jaén; rel. 12, Burunchel (Cazorla, Jaén); rels. 13 and 14, "Cerrada del Utrero" (Cazorla, Jaén); rel. 15, Towards Pico Cabañas-Quesada; rel. 16, Descent from Pico Cabañas (30S 8499706/4188275) (Cazorla, Jaén); rel. 17, Ascent to the Cabañas from Tiscar (30S 0503102/4188033) (Cazorla, Jaén); rel. 18, Lower part "Cerrada de Utrero"; near the ponds of the Hydroelectric Power Plant (Cazorla, Jaén); rel. 19, Intersection Fuensanta de Martos-Valdepeñas de Jaén; rel. 20, Sierra de Valdepeñas de Jaén (Jaén); rel. 21, Alto del Calabrial, Sierra de Gádor (Almería), taken from Giménez Luque (2000), Tab. 105, rel. 2, pag 302.