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Minuartio valentinae-Quercetum pyrenaicae: a new Iberian broad-leaved oak forest in the eastern coastal mountains and their seral plant communities

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Abstract: Vilches de la Serna, B., Merle, H., Ferriol, M., Sánchez-Mata, D. & Gavilán, R.G. *Minuartio valentinae-Quercetum pyrenaicae: a new Iberian broad-leaved oak forest in the eastern coastal mountains and seral plant communities. Lazaroa 34: 209-217 (2013).*

The study of *Quercus pyrenaica* forests in eastern areas of the Iberian Peninsula has differentiated a set of relevés from Castellón. They are located in subhumid sites in the upper mesomediterranean to low supramediterranean thermotype territories of Sierra de Espadán, in the Valenciano-Tarraconense biogeographical sector. A new forest *Minuartio valentinae-Quercetum pyrenaicae* is therefore described here, together with its main seral communities.

Keywords: broad-leaved oak forests, Mediterranean vegetation, new association, community ecology, Sierra de Espadán.

Resumen: Vilches de la Serna, B., Merle, H., Ferriol, M., Sánchez-Mata, D. & Gavilán, R. G. *Minuartio valentinae-Quercetum pyrenaicae: una nueva serie de vegetación de los melojares de las montañas levantinas costeras y sus comunidades seriales. Lazaroa 34: 209-217 (2013).*

El estudio de los bosques de *Quercus pyrenaica* del centro y este ibérico ha discriminado un conjunto de inventarios procedentes de Castellón. Están situados en emplazamientos de termotipos mesomediterráneo superior-supramediterráneo inferior y ombrotipo subhúmedo de la Sierra de Espadán, incluidos en el sector biogeográfico Valenciano-Tarraconense. Así, se describe la nueva asociación de melojares *Minuartio valentinae-Quercetum pyrenaicae* y las comunidades seriales que forman una nueva serie de vegetación para la Península Ibérica.

Palabras clave: Bosques marcescentes, melojares, vegetación mediterránea, nueva asociación, ecología de las comunidades, Sierra de Espadán.

INTRODUCTION

The distribution of the marcescent Pyrenean oak on the Iberian Peninsula is concentrated mainly in sites with a sub-Mediterranean climate (moderate or compensated summer drought) in the northwest. This, together with its preference for siliceous soils (less common in the east), means that only reduced samples remain in eastern mountain zones, and usually in protected areas surrounded by evergreen (generally basophile) vegetation. They appear over 1000 m asl and have traditionally been included in the supra-mediterranean association *Cephalanthero rubrae-Quercetum pyrenaicae*. All are at risk of local extinction due to their level of isolation (mainly edaphic) and fragmentation (Pérez Badía, 2003). The Prades mountains in Catalonia, Pina, Penyagolosa, Castielfabib, and Tuéjar in Valencia are sites for which there is bibliographic evidence of the presence of this oak forest (Braun-Blanquet, 1934; Font Quer, 1934; Bolòs, 1967; Vigo, 1968; Costa & *al*., 1985; Herreros, 2010; Roselló, 1994; Mateo & Aguilella, 1990), and Prades and Penyagolosa are its best representations in the eastern Iberian peninsula. Its composition is high in ne-

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moral herbs, and often includes other phanerophytes in the arboreal stratum with which it is in contact, mainly *Pinus sylvestris s.l.*, in addition to *Juniperus communis*. Different *Cytisus* and *Erica* appear frequently in the shrub layer, also accompanied by the typical spiny border shrubs *Crataegus monogyna* or *Prunus spinosa*.

Although the vegetation of the Sierra de Espadán has been studied, as a whole, by various authors (BELTRÁN, 1911; RIVAS GODAY & BORJA, 1961; BOLÒS, 1967, 1975; BOLÒS & VIGO, 1979; MATEO & AGUILELLA, 1990), its oak forests are the least studied of all those on the eastern Iberian Peninsula. This can be explained by its isolated location and relatively difficult access, and partly because historically this has been a managed area, as it is located in cooler locations that are ideal for farming (MERLE & FERRIOL, 2008), reducing the forest area, currently under regeneration.

The Espadán Triassic mountain range, although not very high in altitude (highest peak: La Rápita at 1106 m asl) captures more rain and humidity than nearby territories. Its NW-SE orientation leads to an annual average rainfall of over 600 mm on the lower slopes, in addition to the contribution of the frequent mists in the area. Espadán soils comprise mainly Buntsandstein sandstones and argilites, characterized by neutral pH, and locally by the formation of deep argillic horizons that allow good water reserves. Both these factors are instrumental in making cork oak the main vegetation in the mountain range, with a predominance of maritime pine (*Pinus pinaster s.l.*) in drier areas. Heathlands are found on the forest fringes; they are the main substitution shrubs for cork oak forests (COSTA & *al*., 1985) in sites with a cooler microclimate and for *Quercus pyrenaica* formations. Several authors have highlighted the special floristic character of this site where Temperate, Iberian-Moroccan and endemic species converge (RIVAS GODAY & BORJA, 1961; MATEO & AGUILELLA, 1990); some have also delimited an independent chorologic element inside the Valenciano-Tarraconense sector, supported by endemics such as *Minuartia valentina*, *Centaurea paui, Dianthus multiaffinis* or *Biscutella calduchii* (O. Bolòs & Masclans) Mateo & M.B. Crespo (ROSELLÓ, 1994; COSTA & *al*., 1985).

The main aim of our paper is to describe a new association of broad-leaved oak forests in the Sierra de Espadán. This objective was developed as part of a larger study of all the *Quercus pyrenaica* forests on the Iberian Peninsula. The results of this study emphasised the significant floristic difference between the forests described here and the rest, even when they appear at similar altitudes and bioclimatic belts. We have also analysed –from a purely phytosociological point of view– the following main seral plant communities: heathlands appearing as forest fringes or as a substitution plant community when the forest is destroyed; and shrublands representing a more degraded stage.

MATERIALS & METHODS

We compiled a data set of published relevés on *Quercus pyrenaica* forests in eastern areas of the Iberian Peninsula (Table 1). These relevés were pre-

Table 1
Summary of data gathering according to the locations studied

No.	Original assignment	Locality	Province	Distance to coast	Altitude	References
1	Luzulo forsteri-Quercetum	Guadarrama	Madrid	480 km	1170-1500 mosl	FERNÁNDEZ-GONZÁLEZ, 1991
2	*Luzulo forsteri-Quercetum*	Ayllón	Guadalajara	430 km	960-1350 mosl	FUENTE, 1985
3	*Luzulo forsteri-Quercetum*	Albarracín	Teruel	235 km	1500-1700 mosl	BARRERRA, 1983
4	*Luzulo forsteri-Quercetum*	Boniches	Cuenca	170 km	1000-1200 mosl	LÓPEZ, 1976
	Luzulo forsteri-Quercetum	Ranera		120 km	1280-1380 mosl	MATEO, 1983
5	*Cephalanthero-Quercetum*	Penyagolosa	Castellón	58 km	1250-1500 mosl	VIGO, 1968
6	*Cephalanthero-Quercetum*	Prades	Tarragona	27 km	950-1050 mosl	BRAUN-BLANQUET, 1934; FONT QUER, 1934, BOLÒS, 1967
7	*Cephalanthero-Quercetum s.l.*	Espadán	Castellón	35 km	900-1106 mosl	MERLE & FERRIOL, 2008

viously analysed to check the relationships between central and eastern *Quercus pyrenaica* forests (VILCHES & *al*., 2013). We used Principal Components Analysis (PCA) on the site-by-species matrix containing presence-absence values to display the compositional variation among the *Quercus pyrenaica* woodlands in the study. Using indicator species analyses with site group combinations ('multipatt' function of the R package 'indicspecies') we determined the indicator species of each massif, in addition to the common species in forests belonging to those different massifs. The number and identity of the indicators suggest how the different geographical locations could be related.

For the seral communities we studied the data published in the Catalano-Valenciano biogeographical subprovince (Valenciano-Tarraconense sector), which includes: BRAUN-BLANQUET (1940),ZELLER (1959), BOLÒS (1967) MATEO (1983), MATEO & MANSANET (1982), COSTA & *al*. (1985), GARCÍA-FAYOS (1991), MERLE & FERRIOL (2008).

We have followed the taxonomic nomenclature proposed by the published volumes of *Flora Iberica* (CASTROVIEJO & *al*., 1986-2013) if the authority is not indicated; and the compilation of the *Euro+Med PlantBase* (2006-2013) for the rest. In addition we have followed RIVAS-MARTÍNEZ & *al*. (2007, 2011b) proposals for the biogeographical and bioclimatological characterisation of the studied forest.

RESULTS & DISCUSSION

Minuartio valentinae-Quercetum pyrenaicae *ass. nova hoc loco*
[Holotypus ass. Table 2, rel. 2; (Merle & Ferriol, 2008)]

The first axis of the PCA (Figure 1) separated the pre-coastal relevés with the lowest altitudes – Sierra de Espadán (downward triangles)– in the most positive part of the diagram, with the most central relevés –Sierra de Guadarrama (solid circles) and Sierra de Ayllón (upward triangles)– in the negative part. The relevés assigned to *Cephalanthero-Quercetum pyrenaicae* O. Bolòs & Vigo in O. Bolòs 1967 and Luzulo-Quercetum pyrenaicae Rivas-Martínez 1964 in the eastern localities of Cuenca, Teruel, Valencia and Catalonia appeared only in the middle, leaving Penyagolosa, the highest peak in the upper section. Thus the first

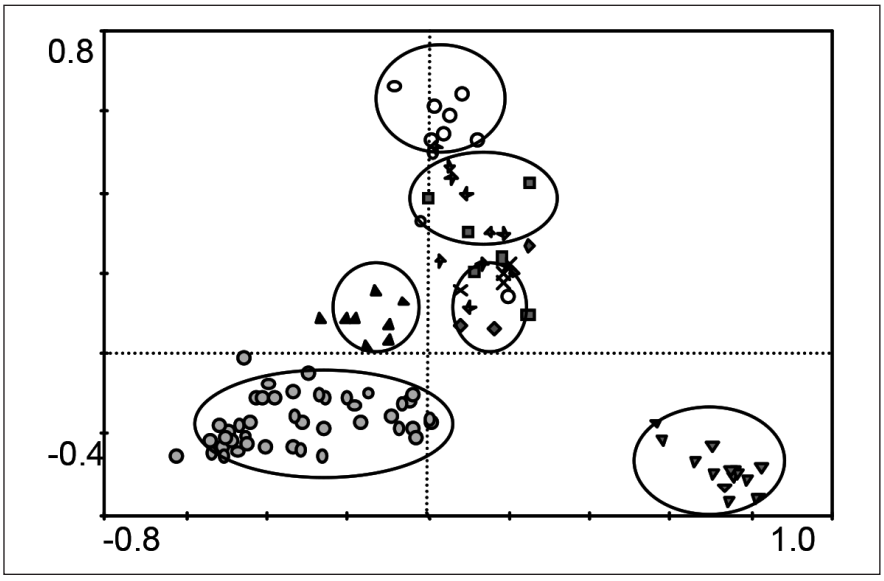

Figure 1. – First two axes of the Principal Component Analysis carried out with data from Sierra de Espadán (downward triangles), Sierra de Prades (solid boxes), Sistema Ibérico: Penyagolosa (open circles), Albarracín Massif (stars) and Serranía de Cuenca: Boniches (X-marks), Ranera (diamonds), Sistema Central: Ayllón (upward triangles), Guadarrama (solid circles).

Table 2
Minuartio valentinae-Quercetum pyrenaicae ass. nova
(*Quercion pyrenaicae, Quercetalia roboris, Querco-Fagetea*)

Cover (%)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Slope (%)	40	30	35	35	35	20	30	30	30	30	30	30	30	30	30
Exposure	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Area (m^2)	100	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Characteristics															
Quercus pyrenaica	5	5	5	5	5	5	5	4	5	5	5	5	3	5	4
Quercus pyrenaica shrub	5	3	2	3	4	4	5	4	5	4	3	3	5	3	2
Hedera helix	+	1	+	1	+	1	+	1	.	+	1	.	2	1	4
Hieracium glaucinum	2	+	+	.	.	.	+	1	.	.	+	.	.	.	.
Luzula forsteri	+	1	.	.	.	+	.	1	+	.	1	.	+	+	+
Moehringia trinervia	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.
Biscutella calduchii	1	1	1	1	1	+	+	+	+	+	+	+	+	+	.
Minuartia valentina	5	4	3	5	+	+	+	.	1	2	2	3	3	3	2
Polypodium cambricum	+	+	.	.	.	.	.	.	+	+	.	+	.	+	+
Hieracium amplexicaule	+	.	.	.	.	.	+	.	+	.	.	.	.	+	+
Erica arborea	2	2	1	2	2	3	2	1	1	2	2	1	+	+	+
Asplenium onopteris	1	1	1	1	+	+	1	1	1	1	1	1	1	1	3
Rubia peregrina	+	+	1	+	1	1	1	1	1	+	+	+	+	+	+
Galium maritimum	+	+	+	+	+	+	+	1	1	+	1	1	+	+	+
Quercus suber	1	1	1	.	1	1	1	2	+	+	.	1	+	.	1
Quercus rotundifolia	.	.	.	1	1	.	1	2	+	.	.	+	+	.	.
Daphne gnidium	.	.	.	.	.	+	.	+	1	1	+	+	.	.	.
Lonicera implexa	+	+	.	+	.	.	.	.	.	.	.	.	.	+	+
Companions															
Brachypodium retusum	3	3	3	4	3	2	2	2	3	3	1	2	3	.	+
Rubus ulmifolius	+	1	+	+	+	+	+	+	+	+	+	+	+	.	+
Rosa pouzinii	1	1	1	+	.	+	+	+	+	+	+	+	+	.	.
Ulex parviflorus	2	1	+	+	+	+	.	.	1	1	.	+	+	+	.
Helianthemum origanifolium *	+	+	+	+	+	+	.	.	+	+	+	+	.	+	.
Carex muricata	+	+	.	1	+	1	+	1	+	.	.	.	+	+	.
Euphorbia flavicoma	+	+	+	+	+	+	.	+	.	+	+	+	.	.	.
Prunus spinosa	1	1	1	1	.	3	+	+	.	1	+	+	.	.	.
Pinus pinaster s.l.	2	1	2	2	2	1	2	1	.	1	2	.	.	.	.
Teucrium chamaedrys	+	+	+	+	+	+	+	+	.	+	+	.	.	.	.
Crataegus monogyna	1	.	1	.	.	+	.	+	.	1	+	.	.	+	1
Geranium robertianum	.	.	+	.	.	.	+	+	+	.	.	.	+	+	+
Cistus albidus	+	+	.	.	+	+	.	.	+	+	.	+	.	.	.
Phleum phleoides	.	.	.	.	.	.	+	+	+	.	.	+	+	.	+
Viola alba	+	.	.	.	.	+	.	.	.	+	+	+	+	.	.
Festuca durandoi	.	.	.	.	.	.	.	+	+	.	.	+	.	+	1
Sedum sediforme	.	.	.	+	+	.	+	.	.	.	.	+	.	+	.
Vicia tenuifolia	.	.	.	1	.	+	.	.	.	.	.	.	+	.	1
Silene inaperta	.	+	.	.	.	.	+	.	+	.	.	+	.	.	.
Orobanche alba	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.
Cephalanthera rubra	.	.	.	.	+	.	.	.	.	+	1	.	.	.	.
Thapsia villosa	.	.	.	.	+	+	.	.	.	+	.	.	.	.	.
Hieracium sabaudum	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.
Pteridium aquilinum	.	.	.	.	.	.	2	.	.	.	+	.	.	.	.

Other species: *Asplenium trichomanes, Antirrhinum barrelieri, Cistus salviifolius* + in 9; *Dactylis glomerata* + in 12; *Galium idubedae* + in 13 and *Scrophularia sciophila* + in 14.
Localities: All relevés from Sierra de Espadán between 900-1106 m asl. *Holotypuss ass.* rel. 2
* *Helianthemum origanifolium: H. marifolium* subsp. *origanifolium*

PCA axis could be interpreted as a continentality-oceanity gradient, with relevés from the Sierra de Espadán near the coast, and clearly separated from the relevés of the central Iberian Peninsula. The second axis could be related to a Mediterranean (aridity) gradient, with relevés with shorter or compensated summer drought located in the most positive part, clearly separated from the Sierra de Espadán and Sistema Central, which undergo higher summer dryness. Most of these forests are located at higher altitudes than the coastal Sierra de Espadán (Figure 1), where retention of clouds formed by evaporation from the Mediterranean Sea becomes a factor of vital importance to compensate aridity. Precipitation and fog increase the atmospheric humidity of these mountains, where it is common to find ferns and other cryptogrammic species such as *Asplenium onopteris, Polypodium cambricum* or *Polypodium vulgare* (Mateo & Aguilella, 1991).

The Sierra de Espadán generated the maximum number of exclusive indicator species, including a high number of endemisms that separated it from relevés ascribed to *Cephalanthero-Quercetum pyrenaicae* from Penyagolosa and Prades (Vilches & *al*., 2013). Both mountains have almost three months of frost risk in winter, and both *Quercus pyrenaica* forests are related to *Pinus sylvestris s. l.* and *Cistion laurifolii* seral communities. Only the pre-coastal location of Prades (Catalonia) shares certain species with Espadán –such as *Rosa pouzinii, Cistus albidus* or *Asplenium onopteris*– in addition to some thermophilous and calcareous species, although the analysis (Figure 2) confirmed a differentiated floristic composition of the latter. In fact this difference was also apparent when this community was compared to the whole Iberian Peninsula (Vilches & *al*., in press).

Minuartio valentinae-Quercetum pyrenaicae corresponds to silicicolous subhumid forests of *Quercus pyrenaica,* appearing over rodenos in the upper mesomediterranean to lower supramediterranean belts of the Sierra de Espadán (Castellón). It is found in sites with reduced continentality and increased humidity due to crypto-precipitations and also to the deep limy soils. Its distribution is thus reduced and localized, specifically on the northern slope of the highest peak: La Rápita (as indicated by Mateo & Aguilella, 1990; Roselló, 1994). The territory has been cultivated for centuries, and some individuals of *Quercus pyrenaica* can be found growing on abandoned terraces. The forests have a strong level of regeneration and usually include evergreen phanerophytes from the forests with which they are in contact, such as *Quercus suber, Quercus rotundifolia* and *Pinus pinaster s. l.*, in addition to shrubs (*Erica arborea, Ulex parviflorus, Prunus spinosa*). *Quercetea ilicis* species are widely represented in these forests, in contrast with the *Quercus pyrenaica* locations of the supramediterranean *Cephalanthero-Quercetum pyrenaicae* (Penyagolosa or Prades), which have an increased Eurosiberian species composition (Vilches & *al*., 2013). Thus the absence of some species such as *Astragalus glycyphyllos, Primula veris* subsp. *columnae, Veronica officinalis, Poa nemoralis, Campanula trachelium* and *Lapsana communis,* together with its chorology and dynamism, differentiate it from *Cephalanthero-Quercetum pyrenaicae*.

As is known, Pyrenean oak requires a minimum annual rainfall of 600 mm to become established, as well as a site that compensates the Mediterranean summer drought (costa, 1997). The timing of the rainfall in this area (autumn-spring-winter-summer) facilitates a faster recovery of water reserves (Roselló, 1994), enough for *Minuartio-Quercetum pyrenaicae* to grow in the most humid sites throughout the entire Sierra de Espadán, specifically sub-humid locations (Vall de Almonacid, 670 mm; Bolòs & Vigo, 1979; Ninyerola & *al*., 2005). There is an absence of most of the drought tolerant species of the Valenciano-Tarraconense sector such as *Phillyrea angustifolia* (including the subhumid *Ph. latifolia*), *Rhamnus alaternus* or *Pistacia lentiscus*; but also a lack of thermophilic shrubs frequent in other mesomediterranean *Quercus pyrenaica* forests (*Arbutus unedo, Viburnum tinus*).

On southern slopes or in more exposed areas, these forests come into contact with the Valencian cork forests of *Asplenio onopteridis-Quercetum suberis*, and also with *Hedero-Quercetum rotundifoliae* in drier areas. Our community shares more species with the former, mainly in the understory, where the rocky silicicolous substrate allows the

Table 3
Hedero helicis-Ericetum arboreae (Costa, Peris, Figuerola & Stübing 1985) Rivas-Mart. & al. 2011 (*Pistacio lentisci-Rhamnetalia alaterni, Ericenion arboreae, Quercetea ilicis*)

Cover (%)	100	100	100	100	100	100	100
Slope (%)	30	30	30	30	30	30	30
Exposure	N	N	N	N	N	N	N
Area (m^2)	50	50	50	50	50	50	50
Relevé N.	1	2	3	4	5	6	7
Characteristics							
Erica arborea	4	5	5	5	4	4	4
Asplenium onopteris	+	+	+	+	+	+	+
Rubia peregrina	.	+	+	+	+	1	+
Quercus rotundifolia	.	1	+	1	1	.	1
Quercus suber	1	.	1	+	1	+	1
Galium maritimum	1	+	+	.	+	+	.
Lonicera implexa	.	.	+	1	.	2	.
Daphne gnidium	1	1	.	.	.	.	.
Companions							
Brachypodium retusum	3	4	4	3	3	+	1
Rosa pouzinii	1	+	+	+	+	1	+
Biscutella calduchii	+	+	+	+	+	+	+
Crataegus monogyna	+	.	+	1	+	1	+
Euphorbia flavicoma	+	+	+	+	+	.	+
Minuartia valentina	.	+	1	1	.	+	+
Rubus ulmifolius	2	.	.	1	+	+	1
Cistus albidus	1	1	.	1	.	1	+
Ulex parviflorus	2	2	1	.	+	1	.
Prunus spinosa	.	1	1	1	+	1	.
Helianthemum origanifolium *	.	+	+	+	.	+	.
Hedera helix	.	.	.	.	1	+	1
Polypodium cambricum	.	.	+	.	.	+	+
Pinus pinaster s.l.	1	.	+	.	2	.	.
Quercus pyrenaica shrub	.	.	+	.	.	.	+
Vicia tenuifolia	.	.	+	.	.	.	+
Luzula forsteri	.	.	.	.	+	+	.
Hieracium glaucinum	.	.	+	.	+	.	.
Galium idubedae	.	.	+	+	.	.	.
Viola alba	.	.	+	+	.	.	.
Quercus pyrenaica	.	1	1	.	.	.	.
Phleum phleoides	+	+	.	.	.	.	.

Other species: *Sedum sediforme* and *Thapsia villosa* + in 2; *Cistus salviifolius* 1 in 4; *Asplenium trichomanes, Scrophularia tanacetifolia, Geranium robertianum, Hieracium amplexicaule* and *Antirrhinum barrelieri* + in 6.
Localities: All relevés from Sierra de Espadán (Pico La Rápita) between 900-1106 m.a.s.l.
* *Helianthemum origanifolium: H. marifolium subsp. origanifolium*

inclusion of *Minuartia valentina* and other related Espadán endemisms such as *Biscutella calduchii* or *Scrophularia tanacetifolia*; it also shares the heathland fringe community described below.

Hedero helicis-Ericetum arboreae (Costa, Peris, Figuerola & Stübing 1985) Rivas-Mart. & al. 2011 (=*Cytiso villosi-Ericetum arboreae* Costa, Peris, Figuerola & Stübing 1985 non Zéller 1959)

We agree with Costa & *al*. (1985) regarding the floristic composition of seral scrub plant communities that form part of the vegetation series of *Minuartio-Quercetum pyrenaicae*. *Hedero-Ericetum* is not only the first degraded plant community of *Asplenio-Quercetum suberis* in the Sierra de Espadán; it is also present as a seral state of *Minuartio-Quercetum*, although impoverished in scrubs such as *Cytisus villosus* or *Ruscus aculeatus* (Merle & Ferriol, 2008). It is found in shady areas where soils retain enough water, and has a coastal influence in the upper mesomediterranean to lower supramediterranean bioclimatic belt. They are included in *Quercetea ilicis* and not in *Cytisetea* as it could be expected (Rivas-Martínez & *al*., 2011; Gavilán & *al*., 2011).

We followed the criteria of Rivas-Martínez & *al*. (2011) to distinguish Espadán heathlands (*Cytiso villosi-Ericetum arboreae* Costa, Peris, Figuerola & Stübing 1985), from the species reported by Zeller (1959) to describe a similar plant community in Catalonia dominated by *Erica arborea* and *Cytisus villosus*, together with other brooms such as *Teline monspessulana* and *Cytisus scoparius* subsp. *reverchonii*. Espadán heathlands are lacking most of these species, although may include *Cytisus villosus*. Moreover, as mentioned above, in the territory of *Minuartio-Quercetum pyrenaicae* there is an absence of drought-tolerant and thermophilic species inside the *Hedero-Ericetum*, such as *Ruscus aculeatus, Smilax aspera, Clematis flammula*, etc. (Table 2).

Ulici parviflorae-Cistetum albidi *ass. nova hoc loco* [*Holotypus ass*. Table 4, rel. 1; (Merle & Ferriol, 2008)]

They represent rockrose-gorse shrublands that appear in a more degraded stage than *Hedero-Ericetum arboreae*. Of all the associations des-

Table 4
Ulici parviflorae-Cistetum albidi ass. nova
(*Cistion ladaniferi, Lavanduletalia stoechadis, Cisto-Lavanduletea*)

Cover (%)	100	100	100	100	100	100	100	100
Slope	20	30	30	30	30	30	30	30
Exposure	N	N	N	N	N	N	N	N
Area (m^2)	100	50	50	50	50	50	50	50
Relevé N.	1	2	3	4	5	6	7	8
Characteristics								
Ulex parviflorus	2	4	4	3	5	4	3	2
Cistus albidus	2	3	3	4	3	3	3	4
Cistus salviifolius	+	1	1	.	1	.	.	.
Companions								
Asplenium onopteris	+	+	+	+	+	+	+	+
Biscutella calduchii	.	+	+	+	+	+	+	+
Galium maritimum	.	+	+	+	+	+	+	+
Trifolium campestre	+	.	1	+	+	+	+	+
Sedum sediforme	+	.	+	+	+	+	+	+
Brachypodium retusum	5	4	3	4	3	4	.	3
Euphorbia flavicoma	+	+	+	+	.	.	+	1
Prunus spinosa	1	+	.	1	+	1	.	1
Helianthemum origanifolium *	+	+	+	.	+	+	+	.
Trifolium arvense	+	.	+	.	.	+	1	1
Rubus ulmifolius	1	1	1	.	.	.	1	1
Geranium robertianum	1	.	+	.	.	+	+	+
Dactylis glomerata	+	.	+	.	+	+	.	+
Quercus rotundifolia	.	1	+	.	+	+	1	.
Rosa pouzinii	2	+	.	.	+	1	.	.
Thapsia villosa	2	2	1	1	.	.	.	.
Senecio lividus	1	+	+	+	.	.	.	.
Daphne gnidium	1	+	+	+	.	.	.	.
Galium idubedae	.	.	.	.	.	+	+	1
Hedera helix	.	.	.	.	+	.	+	2
Minuartia valentina	.	+	1	.	.	.	.	1
Quercus suber	+	.	.	.	+	1	.	.
Phleum phleoides	.	.	+	.	+	+	.	.
Vicia tenuifolia	.	.	.	.	.	.	+	2
Lonicera implexa	.	.	.	.	.	.	1	+
Silene inaperta	.	.	.	+	.	.	.	+
Rubia peregrina	+	.	.	.	.	.	.	+
Antirrhinum barrelieri	.	.	.	.	.	+	1	.
Erica arborea	.	2	.	.	.	+	.	.
Polypodium cambricum	.	.	+	.	1	.	.	.
Hieracium amplexicaule	+	.	+	.	.	.	.	.

Other species: *Crataegus monogyna* 1 in 1; *Pteridium aquilinum* + in 3; *Quercus pyrenaica* 1 in 5; *Pinus pinaster* 1, *Asplenium trichomanes* + in 6; *Festuca durandoi* 1 in 7; *Scrophularia sciophila* and *Carex muricata* + in 8.
Localities: All relevés from Sierra de Espadán (Pico La Rápita) between 900-1106 m asl. *Holotypus ass.* rel. 4.
* *Helianthemum origanifolium: H. marifolium* subsp. *origanifolium*

cribed in the area, the relevés included in the new association *Ulici-Cistetum* are close to those of *Pino pinastri-Cistetum salvifolii* Bolòs 1967 given by Costa & *al.* (1985) and recently synonymized by Rivas-Martínez & *al.* (2002) to *Calicotomo spinosae-Cistetum crispi* Br.-Bl. 1940. The original relevés given by Braun-Blanquetin 1940 showed the dominance of *Calicotome spinosa, Cistus crispus*, and even *Erica cinerea* in Catalonia (on granitic soils). Bolòs (1967) included maritime pine (*Pinus pinaster s. l.*), *Lavandula stoechas* and *Erica arborea* to the set, and indicated in a previous work the enormous local variability of this association, in which he suggested including gorse bushes with various *Cistaceae* that appeared in Espadán and neighbouring mountains (Bolòs, 1957; Rivas-Martínez, 1979). In our case, the community lacks these species (*Calicotome spinosa, Cytisus villosus* or *Lavandula stoechas*) and is particularly enriched with *Rosmarinetea* species such as *Cistus albidus* and *Ulex parviflorus*.

The absence of thermophilous taxa such as *Calicotome spinosa* or *Cistus crispus* in *Ulici-Cistetum* can be also explained in terms of altitude (900-1106 masl), with the latter found at higher altitudes than taxa of *Calicotomo-Cistetum*. Frequent fires also favour the dominance of *Ulex parviflorus* and *Cistus albidus*, which are quite common in some areas of the Sierra de Espadán such as La Rápita (Merle & Ferriol, 2008).

CONCLUSIONS

Minuartio valentinae-Quercetum pyrenaicae can be framed perfectly in the *Quercion pyrenaicae alliance*, which includes mesophytic *Quercus pyrenaica* forests from the meso- to supramediterranean bioclimatic belts. Previous studies (Herreros, 2010; Vilches & *al.*, 2013) already reflected a clear distinction between this and the adjacent communities, specifically *Luzulo forsteri-Quercetum pyrenaicae* and *Cephalanthero rubrae-Quercetum pyrenaicae*.

The series 'Minuartio valentinae-Querco pyrenaicae sigmetum' corresponds to silicicolous subhumid forests of *Quercus pyrenaica*, appearing

on rodenos in the upper mesomediterranean to lower supramediterranean bioclimatic belts of the Sierra de Espadán (Valenciano-Tarraconense biogeographical sector). *Hedero helicis-Ericetum arboreae* and *Ulici parviflorae-Cistetum albidii* are their main seral plant communities.

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SYNTAXONOMICAL SCHEME

QUERCO-FAGETEA SYLVATICAE Br.-Bl. & Vlieger in Vlieger 1937
Quercetalia roboris Tx. in Barner 1931
Quercion pyrenaicae Rivas Goday ex Rivas-Mart. 1964
Minuartio valentinae-Quercetum pyrenaicae ass. nova
QUERCETEA ILICIS Br.-Bl. ex A. & O. Bolòs, 1950
Pistacio lentisci-Rhamnetalia alaterni Rivas-Mart. 1975
Ericion arboreae (Rivas-Mart. ex Rivas-Mart. & al. 1986) Rivas-Mart. 1987
Hedero helicis-Ericetum arboreae Costa & al. 1985 in Rivas-Mart. 2011
CISTO-LAVANDULETEA Br.-Bl. in Br.Bl., Molinier &Wagner 1940
Lavanduletalia stoechadis Br.-Bl. in Br.Bl., Molinier &Wagner 1940 em. Rivas-Martínez 1968
Cistion ladaniferi Br.-Bl. ex A. & O. Bolòs 1950
Ulici parviflorae-Cistetum albidi ass. nova

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