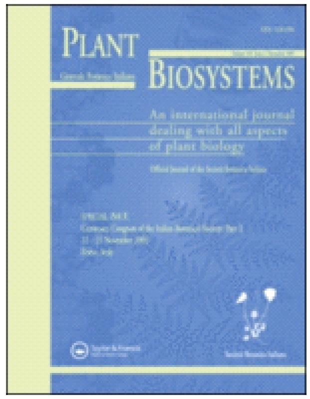

Phytosociological analysis of the endemic Quercus faginea forests on the Iberian Peninsula

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Phytosociological analysis of the endemic *Quercus faginea* forests on the Iberian Peninsula

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Abstract

A phytosociological analysis of the Iberian *Quercus faginea* forests is carried out. For this purpose, 291 relevés were studied. A multivariate analysis consisting of a numerical classification process based on the floristic characters of the relevés, and an ordination from the bioclimatic data associated with each one, is performed. The coherence and explanatory value of the current syntaxa are reviewed. As a result, the diversity of Iberian gall-oak groves is resolved into 15 associations characterised according to their floristic, biogeographical, bioclimatic and synecological data supported by the statistical analyses. Thirteen have been described previously and two new associations are proposed: *Glandoro diffusae-Quercetum fagineae* and *Helianthemo mollis-Quercetum fagineae*. A new combination, a lectotypification and a nomenclatural correction are also proposed. The Ios_2 (ombrothermic index of the warmest bimonth of the summer quarter), Itc (compensated thermicity index) and Ic (continentality index) indexes proved to be fundamental to explain the syntaxonomic differentiation of the forests in the study. We consider that the differentiation and precision in the definition of clear syntaxonomic entities is vital to prioritize objectives in the conservation of these singular forests, and to ensure their adequate management in the context of the Habitats Directive.

Keywords: bioclimatology; B-VegAna; gall-oak forests; Habitat Directive; Iberian Peninsula; *Quercus faginea*; synchorology; vegetation classification.

Introduction

The gall oak *Quercus faginea* Lam. is an oak species belonging to the subsection *Gallifera*. The taxonomic position of this species has been the subject of much unresolved controversy (Bussotti and Grossoni 1998; Vila-Viçosa et al. 2017), largely due to the high degree of intraspecific polymorphism and the high frequency of hybridisation. Two subspecies of *Q. faginea* have usually been differentiated (Amaral 1990): *Q. faginea* subsp. *faginea* and *Q. faginea* subsp. *broteroi* (Cout.) A. Camus. However, it has become increasingly common to separate the two taxa at the species level (Rivas-Martínez and Sáenz 1991), since they inhabit different coenotopes (basophilic versus acidophilic), are parapatric (*broteroi* occupies the southwestern Iberian quadrant and North Africa, while *faginea* is widespread in the rest of the Peninsula), and have different morphological features (indumentum, floral characters and the size and shape of the leaf blade). The segregation at the species level is consistent with the reduced geographic overlap of both taxa and the expansion of *Q. faginea* s.str. towards the NW Iberian Peninsula during the Middle Holocene (Vila-Viçosa et al. 2020b). In this paper we refer to *Q. faginea* ("Iberian gall oak") as a separate species, differentiated from *Q. broteroi* (Cout.) Rivas Mart. & Sáenz de Rivas ("Lusitanian oak"). The plant communities dominated by *Q. faginea* sensu stricto that are endemic to the Iberian Peninsula are therefore considered.

It is also necessary to consider the role of the taxon *Quercus alpestris* Boiss. (=*Q. faginea* subsp. *alpestris* (Boiss.) Maire, =*Q. lusitanica* subsp. *alpestris* (Boiss.) Malag.). *Quercus alpestris* was described by Boissier (1838, p. 83) in Sierra de Las Nieves at altitudes between 914 and 1828 metres next to *Abies pinsapo* Boiss. The differentiation of this taxon is based mainly on the secondary nervation and hairiness of the lower side of the leaves (Boissier 1838; Cano et al. 2001*;* Pérez-Latorre 2011). *Q. alpestris* is considered very rare (Pérez-Latorre 2011), so much so that is included in the regional (Cabezudo et al. 2005) and national (Cabezudo et al. 2003) Red Lists as "Endangered" on the basis of its reduced extension and area of occupancy.

The interpretation of the taxon *Quercus alpestris* has moved towards diametrically opposed positions. Some researchers postulate that there is no taxonomic differentiation and consider it a synonym of *Q. faginea s.str.* (Amaral 1990; Aissi et al. 2020; Gómez-Navarro 2011; Tschan and Denk 2012) or a nothospecies resulting from the hybridisation of *Q. suber* and a taxon of the *Q. lusitanica* group (Vázquez and García 2018), while others interpret *Q. alpestris* as the majority species distributed throughout the Bética province, relegating the appearance of *Q. faginea s.str* to the Subbética sector as a result of a disjunction from a supposed central Iberian core (Molero and Marfil 2017). Since this is a problem of taxonomic interpretation that has not yet been adequately resolved, we have also decided to include the syntaxa described for the *Q. alpestris* communities in the study.

The marcescence of *Quercus faginea*, shared with other Iberian oak species such as *Q. pyrenaica* Willd. or *Q. humilis* Mill., together with its subcoriaceous character, seems to be a combined physiological-ecological strategy between deciduous and evergreen (Peinado et al. 2017) that confers certain advantages in the transition zone between the domains of both physiological forms. This ecotonal or transition zone between the broadleaved deciduous and evergreen domains is represented in the Iberian Peninsula in the bands of proximity between the territories in the Temperate (without summer aridity: $Ios_2 \geq 2$) and Mediterranean macrobioclimate (with at least two months of drought in summer: $Ios_2 < 2$). The contact occurs mainly along the line that separates the northern third of the Iberian Peninsula from east to west: in the southern foothills of the Pyrenean-Cantabrian-Montes de León axis, and in the temperate islands within the Mediterranean biogeographical region, mainly associated with inland mountain ranges (Iberian or Central System).

These transition zones between the two macrobioclimates represented on the Iberian Peninsula often have their own character, defined by the submediterranean bioclimatic variant. In these submediterranean areas with $Ios_2<2$, the phenomenon of water compensation reduces summer aridity to one month, meaning it is considered a Temperate macrobioclimate in its submediterranean variant. It is in these areas where marcescent forest communities reach their physiological optimum (García-Mijangos et al. 2015; Rivas-Martínez et al. 2017a). While *Q. pyrenaica* forests prevail in acidic submediterranean ecotones, *Q. faginea* communities do so on basic substrates, mainly associated with limestone outcrops and loamy areas in a subhumid ombrotype.

From the combined model using climate data and ecosystem functional attributes (EFAs) (Vila-Viçosa et al. 2020a), it can be estimated that 16.17% of the territory on the Peninsula corresponds to tesserae potentially headed by gall oak. However, according to the statistics for the Spanish territory (MITERD 2020), only 3214 km^2 are occupied by these forests (0.63% of the territory). Their preference for more or less deep basic soils with good moisture retention has led to their historical occupation by cereal crops or forestry plantations of resinous species. As a result, the gall oak has often been relegated to suboptimal manifestations, in areas of contact with edaphophilous tesserae.

Slope and terrain heterogeneity (average topographic ruggedness index) are the most important variables in modelling gall-oak distribution (Vila-Viçosa et al. 2020a), perhaps because of the close interspecies competition and anthropogenic pressure that often relegates gall-oak communities to narrow foothills, ravines and steep areas unsuitable for cultivation.

There is a constant and close relationship with holm-oak (*Q. rotundifolia* Lam.) groves that prevail in edaphoxerophilous soils but do not tolerate the hygromorphism – albeit temporary – typical of loamy-clay soils where they are replaced by gall-oak communities. The contact between the two communities is repeated throughout the Iberian Peninsula, and small orographic variations mean that one replaces the other. In these contacts, there have been frequent descriptions of subassociations of *quercetosum fagineae* holm-oak groves, which in coherence with current phytosociological systematics (Rivas-Martínez and Penas 2003) must be considered edaphophilic contact variants.

In recent years, in places where the pressure of small livestock has decreased, there has been a parallel soil development and therefore an advance and densification of the gall-oak groves. In many cases this recovery has developed from the longitudinal bands of the foothills immediately adjacent to the limestone escarpments, into terrain previously dominated by xeric chamaephytic scrub dotted with open xerophytic juniper or holm-oak copses. This allows a better phytosociological characterisation, as the relevés taken in subserial or paraclimate conditions follow the concept of "groupement fragmentaire" or "groupement basal" (Meddour 2011) and do not adequately reflect the floristic cast of the mature communities, as we have observed in old relevés or in relevés taken in disturbed stations.

Acer sp. pl. maples are frequent alongside the gall oak, accompanied by a group of species typical of the thorny mesofruticose groves of *Rhamno catharticii-Prunetea spinosae*. In conditions of greater edaphoxericity, the gall-oak groves are replaced by basophilic thorny microfruticose groves, mainly of different gorse communities (dominated by *Genista hispanica* L., *G. scorpius* DC., *G. legionensis* (Pau) M.Laínz or *Ulex parviflorus* Pourr., among others) and in certain areas by boxwoods (practically single-layer communities of *Buxus sempervirens* L.). Broadleaved perennial grasslands dominated by species of the genus *Brachypodium* ("fenalares") appear in the tesserae headed by gall-oak groves with a degree of hygromorphism.

The bioclimatic, synchorological and floristic singularity of the Iberian gall-oak forests has led to their inclusion in the List of Habitats of Community Interest (code 9240, Annex I of Directive 92/43/EEC), which obliges Member States to establish a network of special areas that guarantee their conservation or restoration to a favourable state (Council Directive, 1992). It is therefore the responsibility of the Member States to adopt the appropriate management and preservation measures, so it is a necessity and a priority to correctly characterise this particular type of Iberian vegetation.

This study consists of a phytosociological revision of the Iberian gall-oak groves included mainly in the *Aceri granatensis-Quercion fagineae* alliance (*Querco roboris-Fagetea sylvaticae* class). A statistical analysis of these communities has been done to review their syntaxonomy, analyse their statistical coherence and characterise the different associations and subassociations.

Material and Methods

Study area

The Iberian Peninsula (Figure 1) is located at the southwestern edge of the European continent and includes the territories of Spain and Portugal, covering an area of about 500,000 km². The Temperate and Mediterranean macrobioclimates converge on the Iberian Peninsula. The intricate orography, lithological variety and differential thermal range also offer a heterogeneity of biotopes that partly explain its high floristic and vegetational biodiversity in the European context. The Iberian Peninsula also played a key role as a refuge for species during glacial periods (Gómez and Lunt 2007) and is an important centre of diversification and speciation. It is estimated that this territory (including the Balearic Islands) has 6196 species of vascular plants with endemicity percentages of 25-30% (Sainz and Moreno 2002).

Data collection and preparation

All the available literature on the Iberian gall-oak communities, included mainly in the *Aceri granatensis-Quercion fagineae* alliance (*Querco-Fagetea sylvaticae* class), was reviewed. 550 relevés were initially collected, although for various reasons some were not taken into consideration. First, any relevés where *Quercus faginea* was not dominant (or at least codominant) were eliminated. One exception was *Fraxino orni-Quercetum fagineae*, naturally dominated by the manna ash *Fraxinus ornus* but with a varying participation of *Q. faginea*. Additionally, after studying the species richness of the 550 initial relevés, those with low richness values (<20 taxa, corresponding to the first quartile) were also discarded in order to guarantee a sufficient and representative floristic combination of the plant community.

After this filtering process, 291 phytosociological relevés from 15 associations were studied, with an accumulated richness of 931 vascular plant taxa. A large proportion of the relevés analysed were extracted from the SIVIM database (Font et al. 2010; Campos et al. 2020), and 13 new relevés in the southern Orocantabrian territory were also sampled, following the Zürich-Montpelier or Braun-Blanquetist Sigmatist method (Braun-Blanquet 1964, 1979; Meddour 2011). The bibliographic references for the relevés are listed in Appendix 1.

The plant taxonomy follows Castroviejo (1986-2019), The Plant List (2013) and, in some specific cases, Rivas-Martínez et al. (2011a). The syntaxonomy follows Rivas-Martínez et al. (2011c). The biogeographic classification corresponds to Rivas-Martínez et al. (2017b). The syntaxonomic process of phytocoenosis follows the 4th edition of the International Code of Phytosociological Nomenclature (Theurillat et al. 2020).

The relevés were compiled and processed with the computer software "QUERCUS"

(Font 2003), included in the "B-VegAna" software package (Font et al. 2003). A raw table was obtained with 291 columns (relevés) and 931 rows (taxa), where each cell contains the corresponding abundance-coverage index.

The main bioclimatic indexes that characterize each relevé were calculated using the raster information for the precipitation and temperature variables (mean, maximum and minimum) of each month (Fick and Hijmans 2017), with a spatial resolution close to 1 km. The following bioclimatic parameters and indexes (Rivas-Martínez et al. 2017a) were calculated from this data using the software ArcGIS® (ESRI 2010): average annual temperature in degrees centigrade (T), mean annual precipitation in millimetres (P), annual positive temperature (Tp), annual positive precipitation (Pp), average temperature of the warmest month of the year (Tmax), annual ombrothermic index (Io), ombrothermic index of the warmest bimonth of the summer quarter (Ios_2), compensated thermicity index (Itc) and continentality index (Ic). The precision in the location of the relevés is usually $\leq 1\ km$. When the accuracy is lower (11.68% of relevés), each parameter is interpolated by taking the average values of the 10 x 10 km grid containing the relevé.

Statistical analysis

Classification

In order to test the coherence of the syntaxonomic associations, the relevés were subjected to multivariate analysis. The abundance-coverage index of each relevé was transformed according to $x' = x^y$ choosing $y = 0.25$ ($r = 0;\ += 1; 1 = 1.19; 2 = 1.31; 3 = 1.41; 4 = 1.50; 5 = 1.57$). This transformation expresses the qualitative view while also sufficiently considering the quantitative aspect (Wildi 2013). We obtain a rectangular matrix where each relevé is interpreted as a vector in a space with S dimensions, where S corresponds to the number of taxa in our relevés.

Following the K-means classification algorithm (MacQueen 1967), we grouped the relevés looking for the minimum dispersion (minimum total quadratic error TESS) around the coordinates that act as centroids of each group *ci*. The “QUERCUS” software (Font 2003) tests the number of groups *c* according to the heterogeneity of the sample by optimizing the average cluster silhouette (Rousseeuw 1987).

The previously generated regular matrix was imported in the "GINKGO" software (Cáceres et al. 2003). The Euclidean distance between relevés was calculated from the transformed matrix. A diagonal distance matrix was obtained and submitted again to a K-means classification for *c* groups. The agglomerative hierarchical clustering initiation mode following Ward’s minimum variance method (Ward 1963) was selected for Bray-Curtis dissimilarity (Bray and Curtis 1957). The results of the process are a regular matrix detailing the distance from each relevé to each group, a symmetric matrix of distances between the groups, and a binary classification matrix defining the relevés that make up each group.

A distance dendrogram was represented from the interdistance symmetric matrix to facilitate the analysis of the affinities between the groups.

An analysis of species fidelity was carried out using the Ochiai index (Ochiai 1957) and IndVal index (Dufrêne and Legendre 1997), and was useful in identifying the diagnostic species and subspecies of each cluster in the classification obtained.

Ordination

From the information on the values of the parameters and bioclimatic indexes of all the relevés, we studied the minimum correlation between variables, then selected the bioclimatic indexes Itc, Ic and Ios_2 to submit our relevés to a Principal Components

Analysis (PCA) with the "GINKGO" application (Cáceres et al. 2003). We excluded 11 relevés that act as outlier objects (four relevés related to climate descriptor values and seven relevés for the distance value between the relevé and the group to which it belongs greater than 6.4). Original descriptors were standardized. Principal components and variable loadings were plotted together in a correlation biplot.

Results and Discussion

We obtained 11 clusters in the classification process. These groups are described according to the dendrogram of hierarchical relationships (Figure 2), the inter-cluster distances, the spatial distribution of the relevés in each group (Figure 3) in relation to the biogeographical units, the bioclimatic data (Appendix 2), and the diagnostic value of the taxa for each cluster (Appendix 3).

In the ordination process, the scatter plot resulting from the two-axis representation of the PCA (Figure 4) shows certain patterns in the distribution of the relevés in terms of the environmental gradients defined by the bioclimatic variables Ios_2, Ic and Itc. The total cumulative variance is 95.27%, of which 61.96% corresponds to the X-axis and 33.31% to the Y-axis (Table 1).

The variable Ios_2 shows a high correlation (0.71) with the X-axis (with the highest cumulative variance) and null correlation with the Y-axis (Table 2). The relevés are therefore distributed from left to right following a gradient of decreasing summer xericity (mediterraneity) (Figure 4). At the extremes of variation are the relevés in Group 8 (severe mediterraneity) on the left, and the members of Groups 1 and 2 on the right (temperate relevés).

The descriptors Itc and Ic show a higher correlation with the Y-axis. Observing the scatter plot we infer that Itc is effective in separating Groups 3 and 5 or Groups 10 and 11, while the descriptor Ic differentiates the relevés in Groups 4 and 5.

Groups 3, 4, 5, 6 and 10 have more concentrated groupings compared to groups 1, 2, 7 and 8, whose more dispersed elements generally denote a smaller range of variation of the environmental parameters, which define the biplot components (Figure 4).

Groups 1 and 2 have a high affinity, with the smallest inter-cluster distance ($d = 2.589$). They group the Northern Iberian relevés, which are more oceanic and humid, with scant mediterranean influence. The differential taxa that are exclusive to both groups and absent or rare in the rest, and with a strong Atlantic character, are: *Erica vagans*, *Rosa arvensis*, *Fraxinus excelsior*, *Melittis melissophyllum*, *Potentilla montana* and *Pteridium aquilinum*, among others.

Group 1 (n = 43)

Comprising strongly euoceanic ($Ic = 14.47 \pm 0.96$), subhumid to humid meso and supratemperate Cantabrian-Atlantic and Castilian-Cantabrian relevés, with abundant species such as *Pulmonaria longifolia, Acer campestre* and *Vicia sepium.* It integrates the relevés of the *Pulmonario longifoliae-Quercetum fagineae* association (*Pl)* and some of the relevés corresponding to the *Spiraeo obovatae-Quercetum fagineae* association (*So*) of the Cantabrian Castilian sector.

Group 2 (n = 51)

Northern Oroiberian, Castilian-Cantabrian and Northern Orocantabrian relevés. Very close to the previous group, although there is some Mediterranean influence ($Ios_2 = 1.86 \pm 0.33$) which is manifested by the presence of taxa such as *Genista scorpius* together with *Genista hispanica* subsp. *occidentalis, Teucrium pyrenaicum, Spiraea* *hypericifolia* subsp. *obovata, Anthericum liliago* or *Lactuca perennis.* It includes the relevés of the *Berberido cantabricae-Quercetum fagineae* association (*Bc*), the northern Oroiberian relevés of the *So* association and a large part of the Castilian-Cantabrian relevés of the *So*.

The relevés of the north-western Iberian gall-oak groves *Bc*, *Pl* and *So* therefore form Clusters 1 and 2 of the classification. The *Pl* relevés are grouped in Cluster 1, together with part of the *So*, mainly those of the Cantabrian Castilian sector. This indicates the strength and internal coherence of the Cantabrian-Basque association *Pl,* and the close relationship with the more northerly *So* gall-oak groves. However, most of the *So* relevés appear in Cluster 2. Both syntaxa can be differentiated in the confluence or transition zones (northern half of the Cantabrian Castilian sector) based on the dominance of oceanic-Eurosiberian or continental-Mediterranean elements. Species such as *Pulmonaria longifolia*, *Erica vagans*, *Rosa arvensis, Hedera helix*, *Cornus sanguinea*, *Vicia sepium*, *Rubus* sp. or *Acer pseudoplatanus* are more frequent and abundant in the gall-oak groves of *Pl* (and in Cluster 1). Species such as *Genista hispanica* subsp. *occidentalis*, *Spiraea hypericifolia* subsp. *obovata*, *Teucrium pyrenaicum* or *Sesleria argentea*, which are also characteristic taxa of Cluster 2, are more frequent in the relevés of *So*.

Finally, the relevés of *Bc* are also included in Cluster 2. It shares Atlantic-European floristic elements with the previous associations, but its edaphoxerophilic character allows its individualisation through the presence of taxa such as *Berberis vulgaris* subsp. *cantabrica, Laserpitium latifolium, Vincetoxicum hirundinaria* or *Crepis albida* subsp. *asturica,* together with other accompanying Orocantabrian species typical of the humid mesotemperate such as *Tilia platyphyllos* or *Sorbus intermedia.*

Group 3 **(*n* = 21)**

It comprises the Somontano and Eastern Catalan relevés in semi-continental areas ($Ic = 17.28 \pm 0.79$) with low altitude ($604.17 \pm 103.19\, masl$), at the confluence between the Mediterranean and Temperate macrobioclimates ($Ios_2 = 1.86 \pm 0.22$). The bioclimatic belts represented are mesomediterranean, supramediterranean and mesotemperate, always with a subhumid ombrotype. Floristically, this group is characterised by the presence of *Cytisophyllum sessilifolium*, *Pinus nigra* subsp. *salzmannii*, *Quercus ilex*, *Polygala calcarea* and *Festuca heterophylla.* It clearly corresponds to the *Violo willkommii-Quercetum fagineae* association (*Vw*).

The classification confirms the aptness of differentiating the Somontano gall-oak woods of *Vw* from the Valencian-Tarraconese ones, which were sometimes named as belonging to the same association *Vw* (Vigo 1968; Roselló 1994; Villaescusa 1998; Pitarch 2002; Royo 2006). The classification separates these Valencian-Tarraconese relevés into Cluster 4 ($distance\ 3 - 4 = 3.861$) as will be discussed later. Undoubtedly, the shared presence of the endemic *Viola willkommii* has contributed to this artificial grouping, despite the floristic, climatic and chorological differences.

As a whole, the relevés of the northernmost Iberian Peninsula appear in Clusters 1, 2 and 3, and correspond to the associations *Bc*, *Pl*, *So* and *Vw*, well defined by the presence of *Acer campestre*, *Mercurialis perennis* and *Euphorbia amygdaloides.*

Group 4 **(*n* = 20)**

It is constituted by Valencian-Tarraconese relevés in the confluence areas between the Mediterranean pluviseasonal oceanic and Temperate oceanic bioclimates, often in semicontinental submediterranean areas ($Ios_2 = 1.66 \pm 0.28$). It groups high altitude relevés ($average\ altitude = 1122 \pm 213\ masl$) in relatively dry areas ($P = 493 \pm 58\ mm$). It occupies the supramediterranean and supratemperate submediterranean dry-subhumid bioclimatic belts. As mentioned in the previous group, these relevés were initially ascribed to *Vw*, although both groups show floristic, bioclimatic and chorological differences. Floristically, Group 4 differs in the presence of *Galium maritimum*, *Coronilla minima* subsp. *lotoides* and *Helianthemum marifolium* subsp. *molle,* among others, and the absence of *Cytisophyllum sessilifolium, Quercus ilex, Polygala calcarea* and *Festuca heterophylla.* At the bioclimatic level, *Vw* appears at lower altitudes, in the meso-supramediterranean and mesotemperate with submediterranean variant thermotypes. *Vw* develops mainly in the Somontano sector.

For all these reasons, we propose for this group of Valencian-Tarraconese relevés (Vigo 1968; Roselló 1994; Villaescusa 1998; Pitarch 2002; Royo 2006) the new association *Helianthemo mollis-Quercetum fagineae ass. nov. hoc loco,* whose *holotypus* is relevé 2 in Table 85 (Roselló 1994). This association is characterised by *Helianthemum marifolium* subsp. *molle, Galium maritimum, Teucrium chamaedrys* subsp. *pinnatifidum* and *Coronilla minima* subsp. *lotoides,* among other taxa.

Five relevés used in this work (Royo 2006, Table 162, rels. 3, 6, 12-14) are located in the dry mesomediterranean bioclimatic belt. The author resolved this bioclimatic peculiarity by creating the subassociation *asparagetosum acutifolii*, but instead of subordinating it to the syntaxon *Vw*, it should belong to the new association *Helianthemo mollis-Quercetum fagineae asparagetosum acutifolii comb. nov. hoc loco*. Characteristic taxa of the subassociation are the "transgressive" species in the class *Quercetea ilicis* (*Asparagus acutifolius, Smilax aspera* or *Pistacia lentiscus*), more frequent as Itc increases and Ios_2 decreases in the distribution gradient of the Iberian gall-oak groves.

Group 5 (n = 31)

It gathers the relevés of the southern slopes of the Orocantabrian subprovince, in areas of the subhumid and humid submediterranean supratemperate bioclimatic belts. These are euoceanic territories ($Io = 16.39 \pm 0.78$) with a certain Mediterranean influence ($Ios_2 = 2.05 \pm 0.45$). Floristically, it is characterised by the abundant presence of *Glandora diffusa*, *Anthyllis vulneraria*, *Juniperus thurifera* subsp. *orocantabrica*, *Helianthemum oelandicum* subsp. *incanum*, *Achillea odora* and *Chamaespartium sagittale*, among others.

The classification process therefore highlights the differentiation of the gall-oak groves on the southern slopes of the Cantabrian range, which form a coherent and independent unit in Cluster 5. These relevés correspond to ten surveyed by Romero (1983) [sub *Querco-Juniperetum thuriferae*] in the Comarca de Luna (León), together with others studied in the upper basin of the Esla river (León): seven of Alonso-Redondo (2003) [sub *So*] and 13 new unpublished relevés we have taken for this study. Cluster 5 is related to Cluster 2 ($d = 2.948$), which groups *So* and *Bc* associations; and with Cluster 6 ($d = 3.227$) that basically groups the Castilian-Duriense gall-oak groves. Indeed, the gall-oak groves in Cluster 5 appear in the transitional supratemperate submediterranean band that gives way in the south to the gall-oak groves of the Tertiary plateau and in the north to the edaphoxerophilous communities of *Bc*.

The floristic, chorological and ecological coherence of these relevés has led us to propose a new association for the subhumid and humid submediterranean supratemperate southern Orocantabrian gall-oak groves belonging to the Picos de Europa and Ubiña sector: *Glandoro diffusae-Quercetum fagineae ass. nov. hoc loco* (Table 3), *holotypus* rel. 16) (*Gd*). It is characterised by the abundance of taxa such as *Glandora diffusa, Anthyllis* *vulneraria, Helianthemum oelandicum* subsp. *incanum, Silene vulgaris* and *Achillea odorata,* among others.

With decreasing soil potency, the *Gd* gall-oak groves are replaced by the relict southern Orocantabrian holm-oak groves of *Lithodoro diffusae-Quercetum rotundifoliae*, or more often by the southern Orocantabrian juniper forests of *Juniperetum sabino-orocantabricae.* These catenary contacts are unique to the southern Orocantabrian territory. The first stage of substitution is the spiny basophilic mesofruticose grove of *Pruno spinosae-Berberidetum cantabricae*, common to the Northern Orocantabrian gall-oak groves of *Bc*. Aulagares accompanying or serially replacing *Gd* gall-oak groves are dominated by *Genista hispanica* subsp. *occidentalis, Glandora diffusa* and in the southernmost areas, *Genista scorpius.* The vegetation series of the *Gd* gall-oak groves typically clearly reveal the transition *Lithodoro diffusae-Genistetum occidentalis/Lithodoro diffusae-Genistetum scorpii.*

Group 6 (n = 19)

Geographically, it is divided into two nuclei: the relevés carried out at the confluence of the Castilian-Duriense and Planileonese biogeographical sectors, and those at the confluence of the La Mancha and South Oroiberian sectors. It groups supramediterranean subhumid relevés ($Io = 3.76 \pm 0.48$) with marked summer aridity ($Ios_2 = 1.05 \pm 0.28$). There are bioindicator taxa such as *Carlina corymbosa* subsp. *hispanica*, *Elymus hispidus*, *Halimium umbellatum* subsp. *viscosum*, *Cistus laurifolius* and *Centaurea langei*, among others. All relevés were determined as belonging to the *Cephalanthero rubrae-Quercetum fagineae* association (*Cr*). *Cr* includes the gall-oak groves of the interior of the Iberian Peninsula, in the Castilian (Castilian Duero, Celtiberia and Alcarria and La Mancha sectors), Carpetania and León (Planileonés and Guadarrama Sierran sectors) and Oroiberian (South Oroiberian sector) biogeographic subprovinces.

Group 7 ($n = 31$)

Made up mainly of Castilian relevés and those of neighbouring territories, in semicontinental ($Ic = 18.49 \pm 0.94$) and dry areas ($Io = 3.15 \pm 1.09$) with a marked Mediterranean character ($Ios_2 = 0.80 \pm 0.46$) in the upper mesomediterranean and supramediterranean thermotypes ($Itc = 219.58 \pm 36.51$). This group is characterised by the xerothermophilous taxa *Helianthemum cinereum* subsp. *rotundifolia*, *Rosmarinum officinalis*, *Aristolochia pistolochia*, *Bupleurum fruticescens*, *Quercus coccifera* and *Rhamnus lycioides*. Most of the relevés in this group were ascribed by their authors to the syntaxon *Cr*.

The classification process therefore splits the *Cr* relevés into Clusters 6 and 7. Cluster 7 is the closest to Cluster 6 ($d = 3.243$), but the former appears grouped with Cluster 8 in the dendrogram due to the higher affinity between the two clusters ($d = 2.855$). The characteristic taxa common to both groups (6-7) are: *Festuca trichophylla*, *Agrostis castellana*, *Juniperus communis* subsp. *hemisphaerica, Dorycnium pentaphyllum* and *Daphne gnidium*.

The extensive synchorological breadth of the *Cr* association manifests in biotope variability, especially with regard to bioclimatic variables. The PCA classification process allows the two clusters (6-7) to be differentiated: the *Cr* relevés corresponding to Cluster 6 are grouped in the centre of the biplot, while those corresponding to Cluster 7 are located on the left, in an area indicating conditions of greater summer aridity (lower Ios_2). The relevés in Cluster 6 are mostly subhumid and supramediterranean, while Cluster 7 shows a predominance of relevés in the dry mesomediterranean and supramediterranean bioclimatic belt.

This bioclimatic differentiation is supported by the xerophytic profile of the taxa characterising Cluster 7 (see above), and explains its proximity to the thermo-xerophilic mainly Baetic relevés (Cluster 8). These inland xeric gall-oak groves correspond basically to the Celtiberia and Alcarria and La Mancha biogeographical sectors (Castilian subprovince), although with disjunctions in the nearby Guadarramic and Southern Oroiberian territories, hence the subassociation of the dry mesomediterranean gall-oak groves *Cr-quercetosum cocciferae* (Casas et al. 1989) appears to be a good fit. It was described in the district of Morata de Tajuña (La Mancha sector, Castilian subprovince) and groups together a large part of the taxa that define Cluster 7.

Group 8 (n = 47)

This group mainly comprises the Betic and Lusitanian-Durian relevés, including the most Mediterranean and thermic ones, with the greatest summer aridity. They have the lowest Ios_2 values ($Ios_2 = 0.18 \pm 0.32$) and the highest T, M and m, Tmax, Tmin and Itc values, with variable but relatively high precipitation data ($P = 561.75 \pm 263.67\ mm$). This group is defined by some thermophilic taxa such as *Smilax aspera*, *Asparagus acutifolius*, *Geranium purpureum*, *Paeonia broteroi*, *Spartium junceum*, *Daphne latifolia* and *Osyris alba*, corresponding to various associations: the Mediterranean pluviseasonal oceanic mesomediterranean *Vinco difformis-Quercetum fagineae* (*Vd*) and *Hedero hibernicae-Quercetum fagineae* (*Hh*), and the supramediterranean *Cytiso reverchonii-Quercetum fagineae* (*Cy*), *Berberido hispanicae-Quercetum alpestris* (*Bh*) and *Daphno latifoliae-Aceretum granatensis* (*Dl*) gall-oak groves, with dry-subhumid ombrotypes (even humid in the case of *Hh*).

Despite the relative homogeneity of the cluster, we can distinguish four subgroups with ecological and biogeographical significance, whose solvency and differential species we ratify by subjecting Cluster 8 to a new running K-means partitioning (dissimilarity measure: Bray Curtis distance, hierarchical clustering method: Ward's, best partition at four groups (max. average silhouette between 2-7)).

Firstly, subgroup 8.1 differentiates the subhumid to humid mesomediterranean Lusitanian-Durian gall-oak groves of the *Hh* association by the presence of taxa such as *Hedera hibernica, Sedum forsterianum, Phillyrea angustifolia, Asplenium onopteris, Rhus coriaria, Genista falcata, Laurus nobilis* and *Lavandula pedunculata.* Although these are locations with marked summer aridity ($Ios_2 = 0.85 \pm 0.06$), the annual rainfall is high ($P = 1164.25 \pm 197.07mm$) with peak values during the winter.

The remaining relevés in Group 8 are located in the Bética province (extreme south of the Iberian Peninsula), where the thermo and mesomediterranean thermotypes and the dry ombrotype predominate. In order to compensate for thermoxericity, the Baetic gall-oak groves are relegated to elevations where precipitation increases in shady areas and ravines with less sunshine, and areas with calcareous-clay soils that allow some water retention (Gómez-Mercado and Valle 1988).

Subgroup 8.2 includes the dry-subhumid mesomediterranean relevés of the mountain range in the N-NE of Málaga (Camarolos and Alhama) in the contact between the Granada and Almijara Sierran and Ronda sectors. It differs from the rest of the Betic (and Iberian) gall-oak groves in the presence of the taxa *Vinca difformis, Cytisus arboreus, Ranunculus spicatus* subsp. *blepharicarpos, Tamus communis, Aristolochia baetica,* among others, which characterise and individualise the *Vd* association and are rare or absent in the other associations in this Group 8.

Subgroup 8.3 is mainly formed by the supramediterranean subhumid relevés corresponding to the *Dl* association described by Rivas-Martínez (1965) in the Subbética sector (Cazorla, Segura and Sierra de Alcaraz). This association perfectly defines the Betic plant communities where gall oak appears, associated with other Atlantic-European optimum elements. The gall oak is not usually dominant in these communities, but rather the Granada maple *Acer opalus* subsp. *granatense*. These are therefore maple woods with a greater or lesser participation of gall oak. This could be due to the fact that these sites represent suboptimal conditions for *Quercus faginea*, although it is more likely that its scarcity and the degradation of the populations in which it appears is caused by anthropic reasons, repeatedly denounced in the literature consulted: logging, pine plantations, abusive grazing, replacement by crops, etc. (Gómez-Mercado and Valle 1992; López 1996; Olmedo 2011).

These communities of maple woods with gall oaks are distributed over a large part of the Betic sectors: Hoyas of Guadix and Baza (Gómez-Mercado and Valle 1988; Olmedo 2011), Alpujarras and Gador Sierran (Madrona 1994; Giménez 2000) and Ronda (Cabezudo et al. 1998; Pérez-Latorre et al. 2012); although their best representation is in the Subbética sector (Rivas-Martínez 1965; Herranz et al. 1986; Gómez-Mercado and Valle 1990 1992; López 1996; Inocencio et al. 1998, Gómez-Mercado et al. 2000; Pavón and Pérez 2010; Gómez-Mercado 2011). The characteristic plants of this association, confirmed by the partitions, are as follows: *Daphne latifolia, Acer opalus* subsp. *granatense, Primula acaulis, Helleborus foetidus, Catananche caerulea, Pinus nigra* subsp. *salzmannii, Ilex aquifolium, Pteridium aquilinum, Berberis vulgaris* subsp. *australis, Prunella vulgaris* and *Agrimonia eupatoria,* among others.

The same subgroup includes the *Bh* association described by Rivas-Martínez et al.

(2011b) in the Subbética sector (Sierra de Cazorla), which represents the Betic supramediterranean climatophilic oak groves dominated by *Quercus alpestris.* These forests are in contact with the temporihygrophilous *Dl* maple woods, which occupy the mesophytic foothills and valleys. Although they share some species such as *Berberis vulgaris* subsp. *australis, Helleborus foetidus* and *Daphne latifolia*, the presence of *Quercus alpestris* and *Crataegus granatensis* in *Bh*, as well as the absence of *Fraxinus angustifolia, Corylus avellana* and *Acer opalus* subsp. *granatense*, allow the two associations to be differentiated.

Finally, Subgroup 8.4 includes relevés with the highest participation of *Quercetea ilicis* elements (*Viburnum tinus, Pistacia lentiscus, Pistacia terebinthus, Smilax aspera, Clematis flammula, Quercus coccifera, Phillyrea latifolia, Chamaerops humilis, Asparagus acutifolius,* etc). They correspond to the *Vt* association (the only association of gall-oak forests included in the *Quercetea ilicis* class) which represents the dry-subhumid Subbetic mesomediterranean forests of *Quercus alpestris*. These relevés are similar to those described by Gómez-Mercado and Valle (1990) as the thermoclimatic subassociation of mesomediterranean optimum *Dl-pistacietosum terebinthi*. The presence of *Quercus alpestris* together with *Viburnum tinus* and *Bupleurum fruticosum* differentiates both forests. In our opinion, the abovementioned relevés on which the subassociation is based need further study as their subordination to *Dl* is not sufficiently justified.

Finally, the *Cy* provisional community described by Inocencio et al. (1998) in meso-supramediterranean valley floor soils, in the contact between the La Mancha and Subbética sectors, appears in the same classification subgroup due to the presence of the thermophilic species *Rhamnus alaternus, Quercus coccifera, Jasminum fruticans* and

Asparagus acutifolius, together with others present in the *Dl* association: *Sorbus aucuparia, Prunus spinosa, Daphne gnidium, Quercus rotundifolia, Rubia peregrina,* etc. The absence of characteristic plants and the scarce representation of *Cytisus reverchonii*, also present in some relevés of *Dl* (Lopez 1996), has led us to disregard this association. We consider that the relevés analysed should be adscribed to *Dl*.

Group 9 (n = 7)

This group brings together relevés of the South Oroiberian sector in cold and elevated areas corresponding to the subhumid supratemperate bioclimatic belt. It has a certain hygrophilous or at least mesophytic character, as indicated by the diagnostic taxa of the group: *Corylus avellana*, *Ranunculus ficaria* or *Poa nemoralis*. In addition to *Corylus avellana*, the following taxa are also characteristic of the cluster: *Saxifraga granulata, Arenaria montana* subp. *intricata* and *Vicia pyrenaica.* This cluster corresponds to the association *Corylo avellanae-Quercetum fagineae* (*Ca*) for which we propose Relevé 3, Table 16 as *lectotypus* (Rivas-Goday et al. 1960).

Some more thermic and lower altitude relevés were defined as subassociation *genistetosum patentis* (Rivas-Goday et al. 1960, Table 16, rels. 7-9), characterised by the presence of *Teline patens*, *Rubia peregrina* and *Daphne gnidium*. A year later, these authors interpreted it as an association. Rivas-Martínez et al. (2011b) subsequently corrected and lectotypified it as *Telino patentis-Quercetum fagineae* (*Tp*). However, we consider it more appropriate to maintain the original category of subassociation since the classification analysis shows that there are no significant floristic differences to justify granting the status of association. *Telino patentis-Quercetum fagineae* becomes a synonym for Ca *telinetosum patentis nom. mut. propos. hoc loco,* and the type proposed by Rivas-Martínez et al. (2011b) is retained.

Group 10 **($n = 9$)**

It groups the dry-subhumid supramediterranean and supratemperate Southern Oroiberian relevés. There is a geographical overlap with the relevés of the previous group, although these in Group 10 show a marked Mediterranean character ($Ios_2 = 1.83 \pm 0.27$), are at a lower altitude and have a climatophilous character. It corresponds to the *Sileno melliferae-Quercetum fagineae* (*Sm*) association. Floristically, the confluence of the Iberian endemism *Silene mellifera*, together with the Eastern Iberian endemisms *Scabiosa turolensis* s.str., *Linum salsoloides, Berberis vulgaris* subsp. *seroi*, as well as *Silene otites, Rosa pimpinellifolia* var. *myriacantha* and *Stachys heraclea,* serve to individualize this group (and to characterize the *Sm* association).

Group 11 **($n = 12$)**

This is a very different group from the rest, although with certain affinities with the previous one. It is mainly composed of relevés of dry mesomediterranean locations in the Játiva sector. They develop in shady areas and cool soils to compensate for low precipitation ($P = 386 \pm 24\ mm$) and summer aridity ($Ios_2 = 0.55 \pm 0.13$), as shown by the dominance of *Fraxinus ornus,* accompanied by the South-Eastern Iberian endemisms *Leucanthemum gracilicaule, Festuca capillifolia, Saxifraga corsica* subsp. *Cossoniana, Iberis carnosa* subsp. *granatensis* and *Erysimum gomezcampoi*, together with *Ptychotis saxifraga*, *Ononis minutissima* and *Viburnum tinus*, among other. All these taxa perfectly characterise this grouping that corresponds to the highly original gall-oak groves of the association *Fraxino orni-Quercetum fagineae* (*Fo*).

Syntaxonomical scheme of the studied plant communities

QUERCO-FAGETEA SYLVATICAE Br.-Bl. & Vlieger in Vlieger in Ned. Kruidk. Arch. 47: 349. 1937

Quercetalia pubescenti-petraeae Klika in Beih. Bot. Centralb. (Dresden) Arb. 50: 759. 1933

Aceri granatensis-Quercion fagineae (Rivas Goday, Rigual & Rivas-Martínez in Rivas Goday, Borja, Esteve, Galiano, Rigual & Rivas-Martínez 1960) Rivas-Martínez in Mapa Series Veg. España: 160. 1987

1. ***Berberido cantabricae-Quercetum fagineae*** T.E. Díaz, F. Prieto & Rivas-Martínez in Rivas-Martínez & al. 2011
2. ***Berberido hispanicae-Quercetum alpestris*** Rivas-Martínez in Rivas-Martínez & al.2011
3. ***Cephalanthero rubrae-Quercetum fagineae*** Rivas-Martínez in Rivas Goday, Borja, Esteve, Galiano, Rigual & Rivas-Martínez 1960 corr. Rivas-Martínez 1972 [*Cephalanthero rubrae-Quercetum valentinae* Rivas-Martínez in Rivas Goday, Borja, Esteve, Galiano, Rigual & Rivas-Martínez 1960 (art. 43), *Arctostaphylo crassifoliae-Quercetum valentinae* Rivas Goday & Rivas-Martínez in Rivas Goday & al. 1960 (syntax. syn.), *Dictamno Arctostaphylo-Quercetum valentinae* Rivas Goday & Rivas-Martínez in Rivas Goday & al. 1960 (art. 10)
   subass. *typicum*
   subass. ***quercetosum cocciferae*** Casas, Díaz, Echevarría & Gavilán 1989
4. ***Corylo avellanae-Quercetum fagineae*** Rivas Goday & Borja in Rivas Goday, Esteve, Galiano, Rigual & Rivas-Martínez 1960 corr. Rivas-Martínez 1972 [*Corylo-Quercetum valentinae* Rivas Goday & Borja in Rivas Goday, Esteve, Galiano, Rigual & Rivas-Martínez 1960 (art. 43)]
   subass. *typicum*
   subass. ***telinetosum patentis*** Rivas Goday & Borja in Rivas Goday, Esteve, Galiano, Rigual & Rivas-Martínez 1960 *nom. mut. propos. hoc loco* [*Genisto patentis-Quercetum fagineae* Rivas Goday & Borja (1960) 1961; *Telino patentis-Quercetum fagineae* Rivas Goday & Borja (1960) 1961 corr. Rivas-Martínez in Rivas-Martínez & al. 2011]
5. ***Daphno latifoliae-Aceretum granatensis*** Rivas-Martínez 1965
   subass. *typicum*
   subass. ***pistacietosum terebinthi*** Gómez-Mercado & Valle 1990
6. ***Fraxino orni-Quercetum fagineae*** Rivas Goday & Rigual in Rivas Goday, Borja, Esteve, Galiano, Rigual & Rivas-Martínez 1960 corr. Rivas-Martínez 1972 [*Fraxino orni-Quercetum valentinae* Rivas Goday & Rigual in Rivas Goday, Borja, Esteve, Galiano, Rigual & Rivas-Martínez 1960 (art. 43)]
7. ***Glandoro diffusae-Quercetum fagineae*** *ass. nov. hoc loco*
8. ***Hedero hibernicae-Quercetum fagineae*** Monteiro-Henriques, J.C. Costa, A. Bellu & Aguiar in J.C. Costa & al. 2012
9. ***Helianthemo mollis-Quercetum fagineae*** *ass. nov. hoc loco*
   subass. *typicum*
   subass. ***asparagetosum acutifolii*** (Royo 2006) *comb. nov. hoc loco*
10. ***Pulmonario longifoliae-Quercetum fagineae*** Loidi & Herrera 1990

11. Sileno melliferae-Quercetum faginae Rivas Goday & Borja in Rivas Goday, Borja, Esteve, Galiano, Rigual & Rivas-Martínez 1960 corr. Rivas-Martínez, T.E. Díaz, Fernández-González, Izco, Loidi, Lousã & Penas 2002
[*Sileno melliferae-Quercetum valentinae* Rivas Goday & Borja in Rivas Goday, Borja, Esteve, Galiano, Rigual & Rivas-Martínez 1960 (art. 43)]

12. Spiraeo obovatae-Quercetum fagineae O. Bolòs & P. Montserrat 1984

13. Vinco difformis-Quercetum fagineae Pérez Latorre & Cabezudo in Pérez Latorre, Caballero, Casimiro-Soriguer, Gavira & Cabezudo 2009

14. Violo willkommii-Quercetum fagineae Br.-Bl. & O. Bolòs 1950 corr. Rivas-Martínez 1972
[*Violo-Quercetum valentinae* Br.-Bl. & O. Bolòs 1950 (art. 43)]

QUERCETEA ILICIS Br.-Bl. ex A. & O. Bolòs, Vegetación Comarcas Barcelonesas: 146. 1950

Quercetalia ilicis Br.-Bl. ex Molinier in Ann. Mus. Hist. Nat. Marseille 27, Mém. 1: 63. 1934

Quercion broteroi Br.-Bl., P. Silva & Rozeira in Agron. Lusit. 18(3): 197. 1956 corr. Rivas-Martínez in Anales Inst. Bot. Cavanilles 29: 125.1972

Quercenion broteroi Rivas-Martínez, Mapa Series Veg. España: 152. 1987

15. Viburno tini-Quercetum alpestris Torres & Cano in Cano & al. 2002 corr. Rivas-Martínez in Rivas-Martínez & al. 2011
[*Viburno tini-Quercetum fagineae* Torres & Cano in Cano & al. 2002 (art. 43)]

Conclusions

The diversity of the Iberian gall-oak groves is resolved by 15 phytosociological associations characterised according to the floristic, biogeographical, bioclimatic and synecological data, supported by the multivariate analysis of classification and ordination. Thirteen of these plant communities have been described previously: *Berberido cantabricae-Quercetum fagineae, Pulmonario longifoliae-Quercetum fagineae, Spiraeo obovatae-Quercetum fagineae* and *Violo willkommi-Quercetum fagineae* cluster the northern gall-oak forests; *Cephalanthero rubrae-Quercetum fagineae* represents the *Quercus faginea* forests of the interior of the Iberian Peninsula; and the Levantine gall-oak groves belong to *Corylo avellanae-Quercetum fagineae, Sileno melliferae-Quercetum fagineae* and *Fraxino orni-Quercetum fagineae.* Finally, *Hedero hibernicae-Quercetum fagineae, Daphno latifoliae-Aceretum granatensis, Berberido* *hispanicae-Quercetum alpestris, Viburno tini-Quercetum alpestris* and *Vinco difformis-Quercetum fagineae* cluster the Lusitanian-Durian and Baetic gall-oak forests.

Two new associations are proposed: *Glandoro diffusae-Quercetum fagineae* which represents the subhumid and humid supratemperate submediterranean *Quercus faginea* forests of the southern Picos de Europa and Ubiña biogeographical sector (Orocantabrian subprovince); and *Helianthemo mollis-Quercetum fagineae*, which includes the dry-subhumid supramediterranean and supratemperate submediterranean gall-oak forests of the Valencian-Tarraconense sector (Valencian subprovince).

The new combination *Helianthemo mollis-Quercetum fagineae asparagetosum acutifolii,* the lectotypification of the association *Corylo avellanae-Quercetum fagineae* and the correction of the subassociation *Corylo avellanae-Quercetum fagineae telinetosum patentis* is also proposed. We reject the association *Cytiso reverchoni-Quercetum fagineae* and accept *Telino patentis-Quercetum fagineae* as synonymous with *Corylo avellanae-Quercetum fagineae telinetosum patentis.*

The combination of the bioclimatic variables Ios_2 (xericity of the warmest two-month period), Itc (compensated thermicity index) and to a lesser extent Ic (continentality index) allow the associations of the Iberian gall-oak groves to be individualised. It is also worth noting that the steppic bioclimatic variant is frequent in the associations of the NE quadrant of the Iberian Peninsula (*Violo willkommi-Quercetum fagineae, Corylo avellanae-Quercetum fagineae, Sileno melliferae-Quercetum fagineae* and *Helianthemo mollis-Quercetum fagineae*), characterising at least semi-continental areas ($Ic > 17$) with more abundant precipitation in the summer period than in the winter, among other characteristics.

The conditions of thermoxericity associated mainly with the dry mesomediterranean belt favour the greater participation of floristic elements related to the class *Quercetea ilicis*. These situations are satisfactorily resolved by means of the syntaxonomic level of thermo-climatic subassociation, subordinated to the association corresponding to the territorial unit: *Cephalanthero rubrae-Quercetum fagineae quercetosum cocciferae*, *Helianthemo mollis-Quercetum fagineae asparagetosum acutifolii* and *Daphno latifoliae-Aceretum granatensis pistacietosum terebinthi.*

The floristic differentiation resulting from the statistical processes of multivariate analysis reinforces the bioindicator value (biocoenotic and territorial) of the characteristic taxa, and therefore of the syntaxa they define. The K-means statistical classification method allows us to observe grouping patterns and test the internal coherence of the groups, proving to be an effective tool for phytosociological taxonomy. IndVal and Ochiai indexes ratify the ecological value of certain taxa, which is especially useful in phytosociological classification.

The differentiation and precision in the definition of clear syntaxonomic entities is vital to prioritise objectives in the conservation of Iberian gall-oak groves, and to achieve an adequate management of these types of habitat in the context of the Habitats of Community Interest Directive and its transposition into national and regional legislation. Their correct characterisation is therefore a priority in order to adopt the correct management and conservation measures for their preservation.

Declaration of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could be seen to influence the work reported in this paper.

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Figure captions

Figure 1. Study area map.

Figure 2. Dendrogram of distances between clusters.

Figure 3. Distribution of the relevés and biogeographic units at sector level.

Figure 4. Correlation biplot. Descriptors are plotted together with the cartesian position of each relevé, grouped according to the hierarchical classification.

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Appendix 2. Average of the bioclimatic values analysed for each cluster

Group	Io	Ios_2	Itc	Ic	T	P
1	6.02±0.77	2.29±0.41	193.03±29.02	14.47±0.96	10.91±0.80	787.45±116.37
2	5.53±1.11	1.86±0.33	163.31±33.19	15.58±1.09	10.26±1.03	677.36±136.08
3	4.35±0.51	1.86±0.22	218.90±20.38	17.28±0.79	12.57±0.60	654.50±64.49
4	4.12±1.00	1.66±0.28	149.60±42.27	17.49±0.39	10.26±1.35	493.05±57.81
5	7.28±1.67	2.05±0.45	131.66±18.91	16.39±0.78	9.45±0.70	813.26±138.20
6	3.76±0.48	1.05±0.28	193.86±16.28	17.66±0.83	11.83±0.57	531.33±44.23
7	3.15±1.09	0.80±0.46	219.58±36.51	18.49±0.94	12.74±1.34	466.71±108.32
8	3.29±1.70	0.18±0.32	275.95±52.55	17.69±2.47	14.40±1.52	561.75±263.67
9	5.66±0.68	2.06±0.27	77.04±33.33	18.09±0.38	7.92±1.07	598.65±46.86
10	4.62±1.32	1.83±0.27	116.86±51.72	18.16±0.19	9.27±1.73	516.46±85.88
11	2.35±0.33	0.55±0.13	250.07±25.57	18.23±0.60	13.84±0.84	386.08±23.97

Appendix 3. Diagnostic species and subspecies of each cluster. The ten taxa with the highest values of Ochiai Index and IndVal ($p\ value\ \leq 0.05$) of each cluster are shown.

Diagnostic taxa	IndVal	P_{val}	Ochiai Index values in each cluster										
			1	2	3	4	5	6	7	8	9	10	11
Diagnosis taxa of cluster 1													
Rosa arvensis	0.679	0.001	0.66	0.23	0	0	0	0	0	0	0	0	0
Pulmonaria longifolia	0.647	0.001	0.63	0.16	0	0	0	0	0	0	0	0	0
Erica vagans	0.594	0.001	0.58	0.42	0	0	0	0	0.05	0	0	0	0
Ligustrum vulgare	0.579	0.001	0.64	0.22	0.29	0.07	0.2	0.03	0.02	0.03	0.04	0	0
Acer campestre	0.545	0.001	0.57	0.24	0.2	0	0	0	0	0	0	0	0
Lonicera periclymenum	0.539	0.001	0.53	0.22	0	0	0.03	0	0	0	0	0	0
Cornus sanguinea	0.536	0.001	0.62	0.22	0.42	0.03	0.04	0	0.02	0.02	0.09	0	0
Brachypodium pinnatum	0.527	0.001	0.51	0.56	0	0	0.07	0.06	0	0	0	0	0
Hedera helix	0.482	0.001	0.55	0.28	0.28	0.18	0.02	0.02	0.1	0.25	0	0	0.24
Vicia sepium	0.448	0.005	0.45	0.07	0	0	0.05	0	0	0	0	0	0
Diagnosis taxa of cluster 2													
Genista hispanica subsp. *occidentalis*	0.509	0.001	0.28	0.55	0.03	0	0.31	0	0	0	0	0	0
Teucrium pyrenaicum	0.505	0.002	0	0.5	0	0	0	0	0	0	0	0	0
Primula veris subsp. *columnae*	0.462	0.002	0.14	0.56	0.08	0.23	0.18	0.09	0.02	0	0	0	0
Bromus erectus	0.434	0.007	0.12	0.53	0	0	0.32	0.2	0.11	0	0	0.04	0
Melampyrum pratense	0.397	0.007	0.15	0.41	0	0	0.04	0	0	0	0	0	0
Sesleria argentea	0.386	0.011	0.15	0.41	0.05	0	0	0	0	0	0	0	0
Spiraea hypericifolia subsp. *obovata*	0.372	0.014	0.2	0.4	0.05	0	0	0	0.04	0	0	0	0
Melittis melissophyllum	0.358	0.022	0.13	0.36	0	0	0	0	0	0	0	0	0
Prunus mahaleb	0.326	0.035	0.03	0.38	0.08	0.12	0.2	0.04	0	0.05	0	0	0
Fagus sylvatica	0.321	0.039	0.27	0.34	0	0	0.04	0	0	0	0	0	0
Diagnosis taxa of cluster 3													
Cytisophyllum sessilifolium	0.690	0.001	0	0	0.69	0	0	0	0	0	0	0	0
Daphne laureola	0.589	0.001	0	0.09	0.55	0	0	0	0	0	0	0	0
Pinus nigra subsp. *salzmannii*	0.553	0.001	0	0	0.54	0.2	0.03	0.16	0.1	0.1	0	0.06	0
Quercus ilex	0.517	0.001	0.06	0	0.49	0	0	0	0	0	0	0	0
Viola alba	0.503	0.001	0.16	0.24	0.43	0.23	0	0	0.07	0.17	0	0	0.08
Buxus sempervirens	0.502	0.002	0.16	0.25	0.41	0.13	0	0	0.26	0.02	0	0	0
Aegonychon purpurocaeruleum	0.472	0.004	0.08	0	0.42	0	0.05	0.06	0	0.08	0	0	0
Polygala calcarea	0.459	0.002	0	0	0.54	0.06	0	0	0	0	0.31	0	0
Acer monspessulanum	0.449	0.003	0.27	0.21	0.36	0.03	0	0	0.08	0.15	0	0.05	0
Euphorbia amygdaloides	0.444	0.001	0.34	0.14	0.36	0	0	0	0	0	0	0	0
Diagnosis taxa of cluster 4													
Galium maritimum	0.696	0.001	0	0.04	0	0.67	0	0	0	0	0	0	0
Teucrium chamaedrys subsp. *pinnatifidum*	0.681	0.001	0	0.22	0.24	0.59	0	0	0.17	0.02	0	0	0
Genista hispanica subsp. *hispanica*	0.650	0.001	0	0.03	0.16	0.69	0	0	0.03	0.03	0	0.3	0.05
Sorbus domestica	0.590	0.001	0.06	0.03	0.22	0.54	0	0	0.07	0.09	0	0	0
Coronilla minima subsp. *lotoides*	0.567	0.001	0	0	0.07	0.57	0	0.07	0	0	0	0	0
Helianthemum marifolium subsp. *molle*	0.560	0.001	0	0	0.08	0.55	0	0	0	0	0	0	0
Asperula aristata subsp. *scabra*	0.558	0.001	0	0	0	0.54	0.05	0.07	0.05	0	0	0	0
Globularia vulgaris	0.534	0.001	0	0	0	0.5	0.05	0	0.2	0	0	0	0
Euphorbia nicaeensis	0.525	0.003	0	0	0	0.49	0	0.19	0.43	0.02	0	0	0.1
Satureja montana	0.500	0.002	0	0	0	0.5	0	0	0	0	0	0	0
Diagnosis taxa of cluster 5													
Glandora diffusa	0.768	0.001	0.03	0.17	0	0	0.73	0.04	0	0	0	0	0
Anthyllis vulneraria	0.576	0.001	0	0.06	0	0	0.59	0.15	0.04	0	0	0	0
Juniperus thurifera subsp. *orocantabrica*	0.568	0.001	0	0	0	0	0.57	0	0	0	0	0	0
Trifolium campestre	0.520	0.001	0	0	0	0	0.54	0.07	0	0	0	0	0
Helianthemum oelandicum subsp. *incanum*	0.508	0.001	0	0	0	0	0.51	0	0	0	0	0	0
Cynosurus echinatus	0.477	0.001	0	0	0	0	0.47	0	0.05	0.08	0	0	0
Cytisus scoparius subsp. *scoparius*	0.471	0.001	0.03	0.09	0	0	0.45	0.1	0	0.15	0	0	0
Quercus pyrenaica	0.467	0.003	0.16	0.03	0	0	0.46	0.15	0	0.03	0	0	0
Trisetum flavescens	0.464	0.003	0.04	0.15	0	0	0.43	0	0	0	0	0	0
Carlina vulgaris subsp. *spinosa*	0.449	0.003	0	0	0.06	0.06	0.47	0	0.05	0	0	0	0
Diagnosis taxa of cluster 6													
Carlina corymbosa subsp. *hispanica*	0.559	0.001	0	0	0	0	0.12	0.54	0	0	0	0	0
Elymus hispidus	0.513	0.001	0	0	0	0	0	0.51	0	0	0	0	0
Halimium umbellatum subsp. *viscosum*	0.513	0.001	0	0	0	0	0	0.51	0	0	0	0	0
Hypericum perforatum	0.502	0.001	0.03	0.03	0	0	0.16	0.4	0	0.22	0	0	0
Dactylis glomerata	0.492	0.002	0.04	0.24	0.05	0.08	0.46	0.37	0.06	0.22	0	0	0
Cistus laurifolius	0.471	0.002	0.04	0	0	0.06	0	0.46	0.18	0	0	0.17	0
Teucrium expassum	0.470	0.002	0	0	0	0.09	0	0.47	0	0	0	0	0
Thymus zygis	0.466	0.002	0	0.04	0	0	0.22	0.42	0	0	0	0	0

Diagnostic taxa	IndVal	P_{val}	Ochiai Index values in each cluster										
			1	2	3	4	5	6	7	8	9	10	11
Centaurea langei	0.459	0.002	0	0	0	0	0	0.46	0	0	0	0	0
Iris sp.	0.459	0.011	0	0	0	0	0	0.46	0	0	0	0	0
Diagnosis taxa of cluster 7													
Helianthemum cinereum subsp. *rotundifolium*	0.596	0.001	0	0	0	0	0	0	0.6	0	0	0	0
Rosmarinus officinalis	0.528	0.001	0	0	0.15	0.05	0	0	0.55	0.03	0	0	0
Aristolochia pistolochia	0.502	0.002	0.05	0	0	0	0	0	0.49	0.04	0	0	0
Bupleurum fruticescens	0.502	0.002	0	0	0.07	0	0	0	0.51	0	0	0	0
Quercus coccifera	0.439	0.003	0	0	0.32	0.1	0	0	0.5	0.17	0	0.15	0.13
Rhamnus lycioides	0.402	0.011	0	0	0	0	0	0	0.4	0	0	0	0
Lavandula latifolia	0.388	0.005	0	0.06	0.05	0.15	0.04	0	0.41	0.03	0	0	0.07
Genista pumila subsp. *pumila*	0.359	0.011	0	0	0	0	0	0	0.36	0	0	0	0
Dorycnium pentaphyllum	0.356	0.024	0.03	0.06	0	0	0.04	0.21	0.36	0.1	0	0	0
Thymus vulgaris	0.332	0.026	0	0.2	0.13	0.18	0.04	0	0.33	0	0	0	0
Diagnosis taxa of cluster 8													
Smilax aspera	0.521	0.001	0.09	0	0.08	0	0	0	0.03	0.56	0	0	0.06
Asparagus acutifolius	0.491	0.001	0	0	0	0	0	0.08	0.09	0.62	0	0.11	0.19
Geranium purpureum	0.485	0.002	0.04	0	0	0	0	0	0.05	0.49	0	0	0
Paeonia broteri	0.474	0.004	0	0	0	0	0.05	0	0	0.49	0	0	0
Spartium junceum	0.438	0.007	0	0	0	0	0	0	0	0.44	0	0	0
Daphne latifolia	0.413	0.010	0	0	0	0	0	0	0	0.41	0	0	0
Clematis flammula	0.396	0.007	0	0	0	0.05	0	0	0	0.48	0	0	0.2
Primula acaulis	0.386	0.011	0	0	0	0	0	0	0	0.39	0	0	0
Vinca difformis	0.386	0.012	0	0	0	0	0	0	0	0.39	0	0	0
Osyris alba	0.369	0.013	0.03	0.06	0.1	0	0	0.05	0	0.42	0	0	0.06
Diagnosis taxa of cluster 9													
Saxifraga granulata	0.845	0.001	0	0	0	0	0	0	0	0	0.85	0	0
Vicia pyrenaica	0.756	0.001	0	0	0	0	0	0	0	0	0.76	0	0
Agrimonia procera	0.738	0.001	0	0	0	0	0	0	0	0	0.71	0.25	0
Rosa pimpinellifolia	0.737	0.001	0.37	0.2	0	0.18	0.06	0	0	0	0.43	0	0
Galium verum	0.732	0.001	0.07	0.19	0	0.05	0.04	0.15	0	0	0.51	0.07	0
Poa nemoralis	0.721	0.001	0.03	0	0	0.05	0.08	0.15	0.04	0	0.56	0	0.43
Arabis hirsuta	0.687	0.001	0	0	0	0.08	0.14	0	0	0	0.57	0	0
Arenaria montana subsp. *intricata*	0.655	0.001	0	0	0	0	0	0	0	0	0.65	0	0
Ranunculus ficaria	0.639	0.002	0	0	0	0	0	0	0	0.07	0.57	0	0
Corylus avellana	0.636	0.001	0.44	0.37	0	0	0.03	0	0	0.04	0.33	0	0
Diagnosis taxa of cluster 10													
Scabiosa turolensis subsp. *turolensis*	0.816	0.001	0	0	0	0	0	0	0	0	0	0.82	0
Silene otites subsp. *otites*	0.816	0.001	0	0	0	0	0	0	0	0	0	0.82	0
Linum salsoloides	0.804	0.001	0	0	0	0	0	0	0	0	0	0.77	0.33
Rosa pimpinellifolia var. myriacantha	0.789	0.001	0	0	0.21	0.22	0	0	0.04	0	0	0.65	0
Aster aragonensis	0.759	0.001	0	0	0	0	0	0	0	0.05	0	0.71	0.1
Rumex intermedius	0.692	0.001	0	0.11	0	0.12	0.14	0	0	0	0	0.53	0
Silene legionensis	0.683	0.001	0	0	0	0	0	0.17	0	0	0	0.63	0
Berberis vulgaris subsp. *seroi*	0.654	0.001	0	0.06	0	0	0	0	0	0	0	0.6	0
Rhamnus infectoria	0.651	0.001	0	0	0.06	0.06	0	0	0	0	0.42	0.65	0
Arenaria serpyllifolia	0.644	0.001	0	0	0	0	0.08	0	0	0	0	0.6	0
Diagnosis taxa of cluster 11													
Fraxinus ornus	0.951	0.001	0	0	0	0	0	0	0.09	0.07	0	0	0.87
Leucanthemum gracilicaule	0.937	0.001	0	0	0	0	0	0	0	0.08	0	0	0.88
Ptychotis saxifraga	0.913	0.001	0	0	0	0	0	0	0	0	0	0	0.91
Ononis minutissima	0.866	0.001	0	0	0	0	0	0	0	0	0	0	0.87
Festuca capillifolia	0.863	0.001	0	0	0	0	0	0	0	0.04	0	0.25	0.87
Viburnum tinus	0.837	0.001	0	0	0.08	0	0	0	0.03	0.38	0	0	0.64
Lonicera pyrenaica subsp. *pyrenaica* var. *paui*	0.816	0.001	0	0	0	0	0	0	0	0	0	0	0.82
Saxifraga corsica subsp. *cossoniana*	0.806	0.001	0	0	0	0	0	0	0	0.05	0	0	0.77
Iberis carnosa subsp. *granatensis*	0.804	0.001	0	0	0	0	0	0	0	0.05	0	0	0.77
Erysimum gomezcampoi	0.766	0.001	0	0	0	0.38	0	0	0	0	0	0	0.7

Table 1. Eigen Values of PCA

Component	Eigen Values	Total Variance %	Cumulative Total variance %
Pc-1	1.8590	61.9668	61.9668
Pc-2	0.9992	33.3082	95.2750

Table 2. Component matrix. Weight to each variable for extracted components

	Pc-1	Pc-2
Itc	-0.46	0.76
Ic	-0.54	-0.65
Ios_2	0.71	0.00

Table 3. *Glandoro diffusae-Quercetum fagineae ass. nov*. (*holotypus* relevé nº 16). Cantoral, Alonso-Redondo & García-González (Alliance: *Aceri granatensis-Quercion fagineae*, Order: *Quercetalia pubescenti-petraeae*, Class: *Querco-Fagetea sylvaticae*). Rels. 1-7: variant with *Juniperus thurifera* subsp. *orocantabrica, Juniperus sabina* and *Arctostaphylos uva-ursi.* Rels. 8-30: *typicum*

Altitude (1=10 m.a.s.l.)	130	125	124	130	121	123	124	125	120	119	95	100	99	122	98	102	110	98	101	101	112	117	110	107	129	122	107	107	115	108
Land inclination (%)	25	35	50	15	35	50	45	30	8	10	30	30	30	40	20	35	25	50	60	40	50	20	30	50	20	30	30	30	50	35
Exposure	SW	W	S	S	S	S	S	S	SW	SW	NE	SW	SW	SE	SW	S	S	E	S	S	S	SE	SW	NE	S	S	SW	S	N	S
Cover (%)	100	100	80	100	60	80	100	100	100	100	100	100	100	100	100	90	70	100	100	60	75	95	100	100	100	80	90	70	10	90
Area (m²)	20	50	80	80	89	40	80	80	50	50	150	150	200	80	60	100	100	30	40	30	30	50	150	30	80	110	150	100	120	100
Richness (taxa number)	32	40	27	31	26	29	23	23	37	33	27	46	42	21	36	35	48	43	19	17	34	23	25	26	36	34	28	30	27	25
Sequence number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16***	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Differential of the association																														
Quercus faginea	3	2	3	3	4	4	3	2	5	5	5	4	4	4	5	4	3	4	4	4	3	4	3	4	4	4	4	3	3	4
Glandora diffusa	3		1	1		1	1	2	+	+	2	+	2	1	2	1	+		+	1	1	+	+		1		+		+	2
Anthyllis vulneraria s.l.	1	2		+	2	1	+		+	+						+	1	2		+	+						+			
Achillea odorata		+						1				1	+			+	+	+							+			+		
Acinos alpinus	1		+						+		1			1		1	+								+			+		
Carlina vulgaris subsp. *spinosa*					1	+	+	+	+									+			+					+		+		
Quercus x *welwitschii*	2	+				1	+	+	1	2											+		+							
Silene vulgaris		+									1	1	2	1							+			+		+	+			
Cynosurus echinatus					+												+	+		+	+	+			+	+				
Helianthemum oelandicum subsp. *incanum*	2	+				+								+			1	+			+									+
Galium aparine			+			+		2	1	+														+		+				
Coronilla scorpioides			+	+	+	1	1									+														
Characteristic of variant																														
Juniperus thurifera subsp. *orocantabrica*	2	+	2	2	2	2	2	1	+	+										(+)										
Juniperus sabina	5	5			+																									
Arctostaphylos uva-ursi			+						+																					
Characteristic of Order and Alliance																														
Tanacetum corymbosum				+						1	+		+				+			1	+		+		+	+	+		+	1
Saponaria ocymoides			1	+	+	+	1	+						1		1			r		+					+				
Helleborus foetidus		1			+		+	1		+		+	1											+			+			1
Viburnum lantana			+				+		1		+		+		+							+							1	+
Primula veris subsp. *columnae*					+	+		+	+	+												+	+						+	
Lonicera etrusca												+	1	1	1		1		+											
Prunus mahaleb									+	+			+		+							+								+
Viola riviniana																			+					+			+			1
Hypericum montanum				+					+	+																				

Lathyrus niger							+			+	1																			
Lathyrus latifolius													+																	+
Luzula forsteri subsp. *forsteri*																							+	+						
Viola hirta								+	1																					
Characteristic of Class																														
Crataegus monogyna						+			1	1	1	1	1		1	1	+	+	+		+	+		+	+		1	+		1
Brachypodium sylvaticum	3	(+)	1		2	1	1	2	2	2		1	3		2											2	+			2
Geum sylvaticum	+								+		1	1		1	+			+				+	+	+	+	+	+		+	
Prunus spinosa				+								2	1	1	+		+					+	+		+	+		+	+	1
Quercus pyrenaica	2					1	+	1	2	2					+								1	+	1			+	1	
Ligustrum vulgare											2	+	1		1		+			+		+	+	+						
Helleborus viridis subsp. *occidentalis*									+	+	+				+				+			+				+			+	
Lonicera xylosteum												1	1		1				+			+	+							
Catananche caerulea														+			1								+	+	1			
Sorbus aria			+						+	+													+						1	
Stellaria holostea															1							+		+			+		+	
Quercus rotundifolia												2				2			+									+		
Potentilla sterilis											2		+											+						
Stachys officinalis		1							+	1																				
Clematis vitalba													+			+														
Cornus sanguinea												+			+															
Poa nemoralis													1		1															
Polygonatum odoratum																						+							+	
Companions																														
Dactylis glomerata	+	1	+		+	+		1	1	+	1	1		1		1	+	+		+	+		+			+	+	+		
Teucrium chamaedrys	2	2				(+)		1			1	2	+		+	2			+	+	+				+	+				+
Bromus erectus		1	+	1		+						1				1	1	1	+	+					1	1	2	2		
Genista hispanica subsp. *occidentalis*									2	3				1			+		2	+		2	+	2	1	+	3		+	+
Cytisus scoparius subsp. *scoparius*			1	2	+	+	1	1	1			+	+		+	1		r		r										
Clinopodium vulgare					+				1		1		1	1	1					+			+	+	+		+			+
Sanguisorba minor s.l.	+	1	+	+								1			+	+	+								+	+	+			
Coronilla minima		+		+	+												1	2		+	+						+			
Silene nutans				+								+	+	+	1						+				+					+
Thymus mastichina		1		(+)												+	+	+			+							+		+
Berberis vulgaris subsp. *cantabrica*	1	1		+		+				+		+	+																	
Daucus carota							+					+	+							+					+	+		+		
Galium mollugo	1		+		1		1												+	+					+					
Aristolochia paucinervis												+	+									+			+	+		+		
Arrhenatherum elatius subsp. *bulbosum*		2		+															+						+	+	+			
Origanum vulgare subsp. *virens*											1	1	1		+													+		+
Rubia peregrina											+	2	+	2		1			1											
Trifolium campestre		+			+	+		+										+		+	+					+		+		
Trisetum flavescens	1			+												+				+	+			+	+	1		+		

Arenaria montana subsp. *montana*	+								+	+													+		+					
Bryonia dioica						1	+		+	+														+						
Eryngium campestre																+	+	+							+			+		
Helianthemum apenninum subsp. *cantabricum*	1		(+)	1			+							+																
Leucanthemum pallens		1										+	+		+												+			
Lotus corniculatus														1	+			+			+					+				
Phleum bertolonii											+									+					+	+		+		
Pilosella sect. *Pilosellina*		1														+		+		+								+		
Pimpinella tragium subsp. *lithophila*						2	1					1				1											+			
Plantago lanceolata																+		+			+					+		+		
Potentilla verna	1	1		+	+																					+				
Rosa canina	2	2							1	1					+															
Rosa sp.																			+			+		+		+				1
Bituminaria bituminosa					2	1	+									+														
Brachypodium pinnatum											1		1						+		1									
Carex flacca																	+						+				+		+	
Chamaespartium sagittale								+															+		+				+	
Galium lucidum													1		+	1	1													
Genista scorpius	3	3															2										+			
Hypericum perforatum		+										+	+														+			
Medicago sativa		+								+				+				+												
Ononis spinosa																1	+			+						+				
Thymus zygis												+				1	+	+												
Agrimonia eupatoria										+													+							+
Anthoxanthum odoratum				+																			+						+	
Arenaria grandiflora		1			+									+																
Cerastium arvense			1			+	+																							
Crepis vesicaria				+	+	+																								
Cruciata laevipes																							+			+			+	
Crupina vulgaris	(+)	+														+														
Euonymus europaeus												2	+		1															
Fragaria vesca		1							+	+																				
Geranium pyrenaicum			+							1	1																			
Helianthemum nummularium	1	1																							+					
Helichrysum stoechas																+	+	+												
Helictotrichon bromoides																1	1				+									
Helictotrichon cantabricum					+	+	2																							
Hippocrepis comosa				+									+							+										
Linum appressum																	1			+					+					
Myosotis alpestris	+								+	+																				
Phleum phleoides												1				+								+						
Physospermum cornubiense								1	+	1																				
Poa compressa												+			+					+										

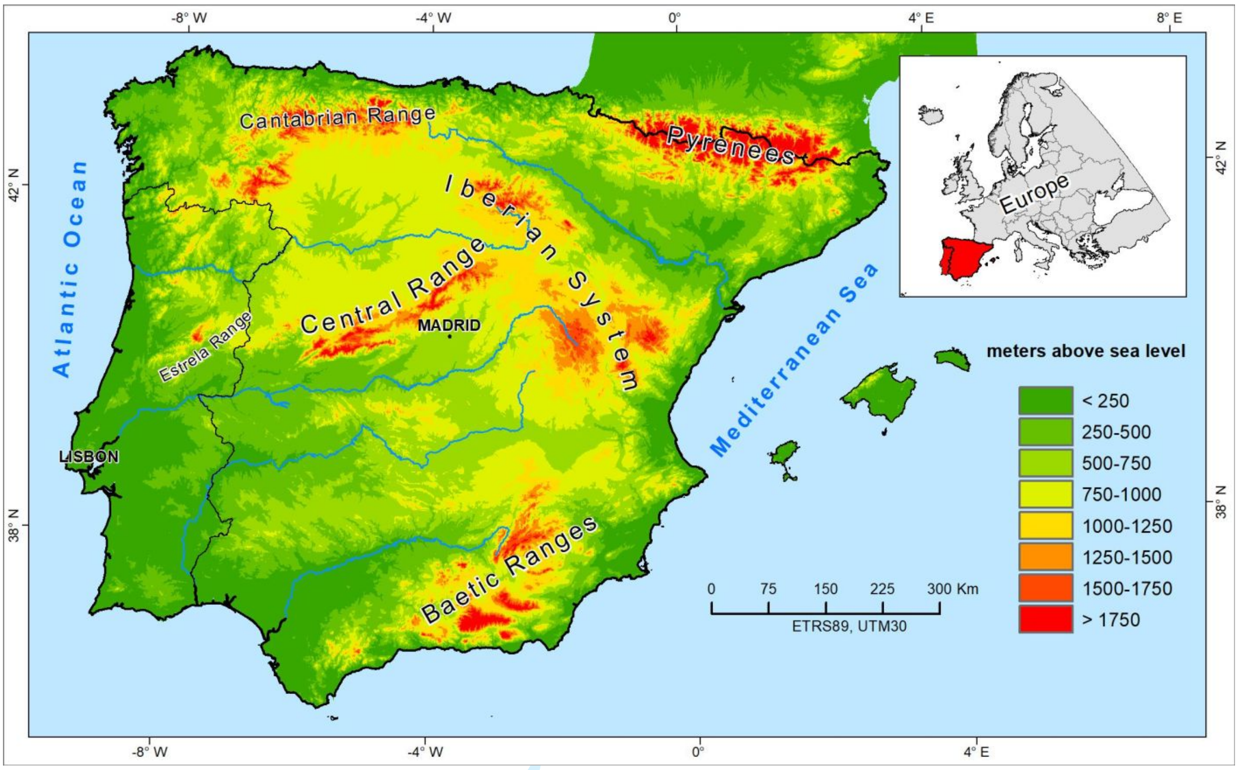
Poa pratensis													+											+		+				
Rumex intermedius																		+							+	+				
Santolina semidentata		1														+		(+)												
Sedum acre				+			1		+																					
Sedum forsterianum						2		+				+																		
Vicia orobus				+					+	+																				
Viola odorata		+						+	+																					
Allium sphaerocephalon								+													+									
Aphyllanthes monspeliensis																	1		+											
Arabis hirsuta												1						+												
Asplenium adiantum-nigrum											2				2															
Brachypodium distachyon																	+	+												
Briza media																	+										+			
Campanula rapunculus																										+		+		
Carlina corymbosa subsp. *hispanica*											+	1																		
Crepis taraxacifolia																									+			+		
Crucianella angustifolia												+						+												
Dianthus hyssopifolius																					+									+
Festuca rubra								+										+												
Filipendula vulgaris																		+											+	
Galium parisiense subsp. *divaricatum*		+		+																										
Genista florida											+				+															
Geranium robertianum									+	+																				
Helictotrichon marginatum																							+					+		
Inula montana																		+			+									
Jasminum fruticans																						+								+
Jurinea humilis	+		+																											
Koeleria vallesiana		1																+												
Lactuca tenerrima					+							+																		
Laserpitium eliasii subsp. *eliasii*																						+							+	
Linum narbonense																		+		+										
Malus sylvestris											+				+															
Medicago lupulina																				+						+				
Muscari neglectum																		+				+								
Polygala vulgaris	+																								+					
Potentilla crantzii												1					1													
Rhaponticum coniferum																		+		+										
Rosa deseglisei																+	+													
Rosa pimpinellifolia																					+			+						
Rubus lainzii												1	+																	
Sedum album												+									+									
Thapsia villosa			+																		+									
Thrincia hispida																									+			+		

Rels. 1-10: Romero (1983: table 7, rels. 5, 7, 20, 23-26, 30-32) sub *Querco-Juniperetum thuriferae* [rectum *Juniperetum sabino-orocantabricae*]**Rels. 11-17:** Alonso-Redondo (2003: table 99, rels. 1-7) sub *So.* **Rels. 18-30:** novum hic.

Additionally: Order and alliance characteristic taxa present in one relevé: 11: *Lonicera periclymenum* +. **13:** *Prunus avium* +. **15:** *Teucrium scorodonia* 1. **20:** *Epipactis kleinii* +. **22:** *Aegonychon purpurocaeruleum* +. **28:** *Quercus x salcedoi* +. **29:** *Melica uniflora* +. **Class characteristic taxa present in one relevé: 1.** *Daphne laureola* subsp. *cantabrica* 1. **2:** *Conopodium majus* +. **15:** *Epipactis helleborine* +. **19:** *Cephalanthera rubra* +. **20:** *Fagus sylvatica* +. **21:** *Carex hallerana* +. **22:** *Paeonia mascula* subsp. *mascula* +. **23:** *Cephalanthera longifolia* +. **29:** *Aquilegia vulgaris* subsp. *vulgaris* +, *Euphorbia hyberna* subsp. *hyberna* +, *Lilium martagon* +, *Paeonia officinalis* subsp. *microcarpa* +. **Companion taxa present in one relevé: 1:** *Taraxacum* gr. *officinale* +, *Micropyrum tenellum* +, *Menta suaveolens* +, *Euphorbia exigua* +. **2:** *Phleum pratense* 1, *Tragopogon pratensis* +, *Asplenium trichomanes* subsp. *trichomanes* +, *Arabis glabra* +. **3:** *Juniperus oxycedrus* 1, *Leontodon hispidus* subsp. *hispidus* +, *Geranium sanguineum* +, *Festuca hystrix* +, *Erinus alpinus* +, *Asplenium ruta-muraria* +. **4:** *Thalictrum minus* +, *Hypochaeris radicata* +, *Hieracium mixtum* +, *Biscutella valentina* +, *Arabis alpina* +. **5:** *Pritzelago alpina* subsp. *auerswaldii* +, *Petrorhagia prolifera* +, *Arenaria erinacea* +. **6:** *Legousia scabra* +, *Cirsium acaulon* subsp. *acaulon* +. **9:** *Vincetoxicum hirundinaria* +, *Rosa micrantha* +. **10:** *Pteridium aquilinum* +. **11:** *Leucanthemum vulgare* 1. **12:** *Rosa squarrosa* 1, *Rosa corymbifera* 1, *Vicia cracca* +, *Mantisalca salmantica* +, *Galium verum* +. **13:** *Trifolium medium* +, *Rhamnus cathartica* +, *Lathyrus pratensis* +, *Knautia arvensis*+. **14:** *Trifolium ochroleucon* +. **15:** *Hypericum humifusum* **+,** *Astragalus glycyphyllos* **+. 16:** *Matthiola fruticulosa* +. **17:** *Scorzonera angustifolia* 1, *Fumana procumbens* 1, *Thymus mastigophorus* +, *Thesium humifusum* +, *Sideritis hirsuta* +, *Salvia verbenaca* +, *Prunella hyssopifolia* +, *Ophrys scolopax* +, *Logfia minima* +, *Linum strictum* +, *Globularia vulgaris* +, *Cuscuta nivea* +, *Carduncellus monspelliensium* +, *Acinos arvensis* +. **18:** *Aegilops geniculata* +, *Aira caryophyllea* +, *Arenaria serpyllifolia* +, *Asperula aristata* subsp. *scabra* +, *Dorycnium pentaphyllum* +, *Festuca rivas-martinezii* subsp. *rectifolia* +, *Galium estebanii* var. *leioclados* +, *Himantoglossum hircinum* +, *Poa bulbosa* +, *Podospermum laciniatum* +, *Polygala monspeliaca* +, *Sedum amplexicaule* +, *Sherardia arvensis* +, *Vicia lathyroides* +. **19:** *Rumex scutatus* +. **20:** *Anacamptis pyramidalis* +, *Ophrys tenthrendinifera* +, *Vicia onobrychioides* +. **21:** *Carduncellus mitissimus* +, *Centaurea ornata* +, *Lepidium hirtum* +, *Ononis pusilla* +, *Trifolium scabrum* +. **22:** *Ulmus minor* +. **23:** *Vicia sepium* 1, *Melampyrum pratense* subsp. *latifolium* +. **24:** *Digitalis parviflora* +, *Festuca rivas-martinezii* subsp. *rivas-martinezii* +, *Ligusticum lucidum* subsp. *lucidum* +, *Ranunculus paludosus* +, *Saxifraga canaliculata* +. **25:** *Cirsium pannonicum* +, *Dianthus pungens* +, *Myosotis arvensis* +, *Trinia glauca* +. **26:** *Centaurea cephalariifolia* +. **27:** *Allium oleraceum* +, *Prunella vulgaris* +, *Tragopogon dubius* +. **28:** *Brachypodium phoenicoides* +, *Carduus nutans* +, *Jasione laevis* +, *Luzula multiflora* subsp. *multiflora* +, *Vicia parviflora* +. **29:** *Corylus avellana* +, *Narcissus triandrus* subsp. *triandrus* +, *Polypodium vulgare* +. **30:** *Centaurea nigra* subsp. *nigra* +, *Cirsium monspessulanum* +, *Ribes alpinum* +.

Locations (León, ES): 1-2. Mirantes de Luna, 30TTN6652; **3-10.** Mallo de Luna, 30TTN6451; **11.** Near Cistierna, 30TUN2539, 1997 Aug 9; **12.** Near Cistierna 30TUN2744, 1997 Aug 31; **13.** Near Cistierna (Cistierna road, detour to Santa Olaja de la Varga), 30TUN2644, 1998 Aug 31; **14.** Díez Valley, Valmartino, 30TUN2840, 1997 May 31; **15.** Cistierna-Santa Olaja de la Varga, 30TUN2644, 1998 Aug 26; **16*.** Cistierna-Aleje, 30TUN2744, 1997 Jun 17 (***holotypus***); **17.** Valmartino, 30TUN2740, 1996 Jun 15; **18.** Vegamediana, Sabero, 30TUN2643, 2012 Jun 21; **19.** Valdetorno, Sabero, 30TUN2543, 2012 Jun 21; **20.** Sobremonte, Crémenes, 30TUN2553, 2012 Jun 23; **21.** La Jana de la Cogolla, Cerecedo, 30TUN1251, 2012 Jul 13; **22.** Yugueros, 30TUN2342, 2011 May 11; **23.** Yugueros, 30TUN2342, 2011 May 18; **24.** Peña Tensora shade, Las Bodas, 30TUN1245, 2013 Jun 16; **25.** El Artiello, Adrados, 30TUN1549, 2013 Jun 22; **26.** Las Canalinas, Adrados, 30TUN1549, 2013 Jun 22; **27.** Yugueros, 30TUN2441, 2014 Jun 30; **28.** Cerecedo, 30TUN1251, 2014 Jun 29; **29.** Sobrepeña, 30TUN1642, 2012 May 31; **30.** Condobrín, Argovejo, 30TUN2653, 2015 Aug 24.

Figure 1



-8° W
-4° W
0°
4° E
8° E
42° N
38° N
Cantabrian Range
Pyrenees
Iberian System
Central Range
MADRID
Estrela Range
Atlantic Ocean
LISBON
Mediterranean Sea
Baetic Ranges
Europe
meters above sea level
< 250
250-500
500-750
750-1000
1000-1250
1250-1500
1500-1750
> 1750
0 75 150 225 300 Km
ETRS89, UTM30

Figure 2

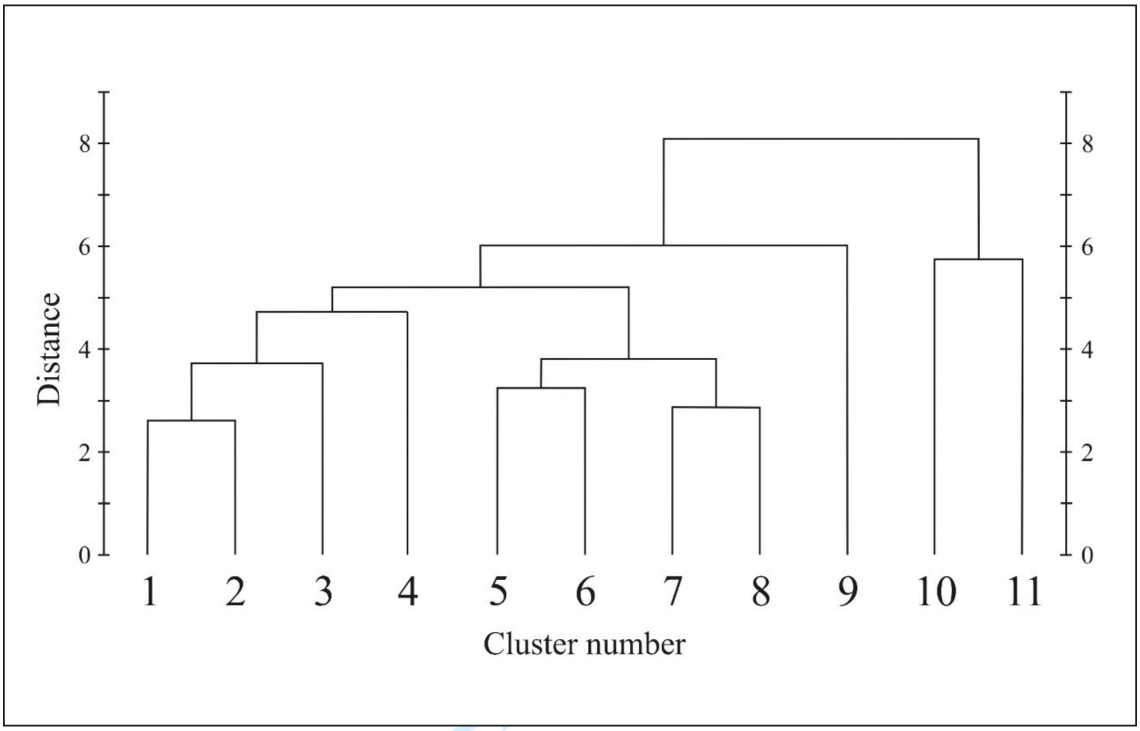
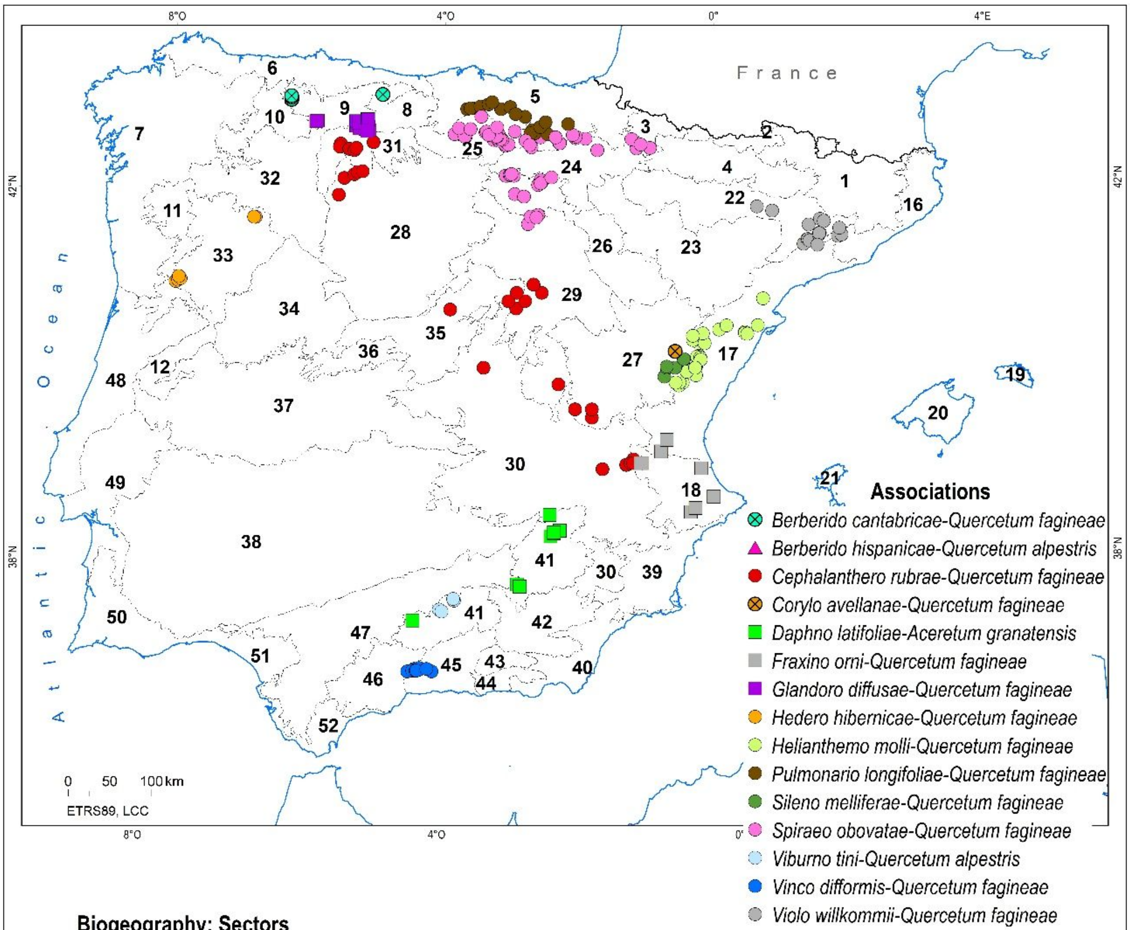


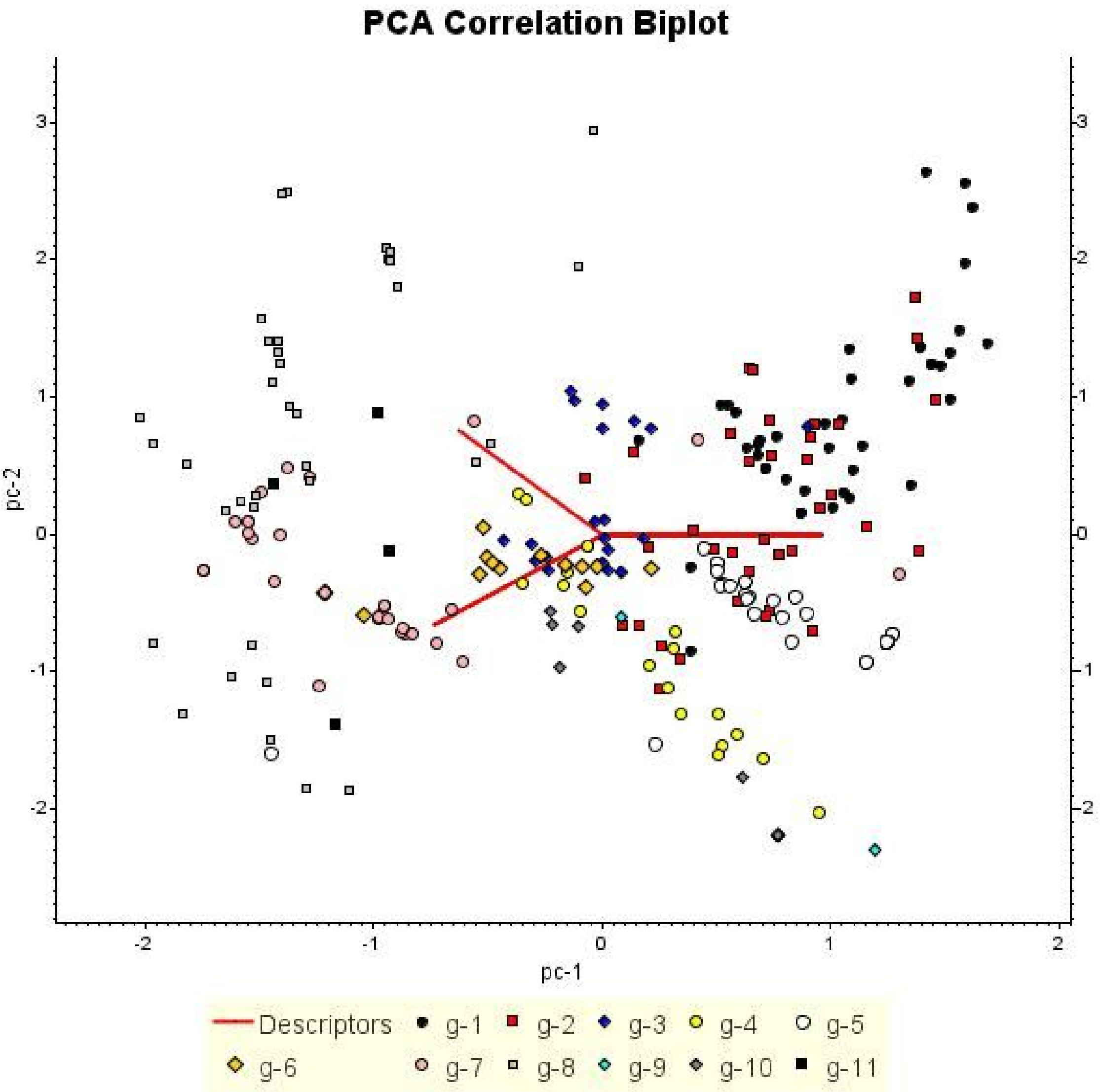
Figure 3



Biogeography: Sectors

1, East Pyrenean Sector
2, Central Pyrenean Sector
3, West Pyrenean Sector
4, Aragón Prepyrenean Sector
5, Cantabrian and Basque Sector
6, North Galicia and Asturias Sector
7, Galicia and North Portugal Sector
8, High Campoo and Carrion Sector
9, Picos of Europa and Ubiña Sector
10, Laciana and Ancares Sector
11, North Lusitania Sierran Sector
12, Montemuro and Estrela Sierras Sector
16, East Catalonian Sector
17, Valencia and Tarragona Sector
18, Játiva Sector
19, Menorca Sector
20, Mallorca Sector
21, Pitiusas Sector
22, Somontano Sector
23, Bardenas and Monegros Sector
24, Rioja and Estella Sector
25, Cantabrian Castilian Sector
26, North Oroiberian Sierran Sector
27, South Oroiberian Sector
28, Castilian Duero Sector
29, Celtiberia and Alcarria Sector
30, Mancha Sector
31, León Plain Sector
32, Bierzo and Sanabria Sector
33, Lusitanian Douro Sector
34, Salamanca Sector
35, Guadarrama Sierran Sector
36, Béjar and Gredos Sierran Sector
37, Oretana Range and Tajo Sector
38, Mariánica Range Sector
39, Alicante and Murcia Sector
40, Almería Sector
41, Subbética Sector
42, Hoyas of Guadix and Baza Sector
43, Nevada Sierran Sector
44, Alpujarras and Gádor Sierran Sector
45, Granada and Almijara Sierran Sector
46, Ronda Sector
47, Campiña of Guadalquivir Sector
48, Divisorio Portuguese Sector
49, Ribatejo and Sado Sector
50, Algarve and Monchique Sector
51, Cádiz and Littoral Huelva Sector
52, Algeciras and Aljibe Sector

Figure 4


PCA Correlation Biplot
pc-2
pc-1
3
2
1
0
-1
-2
-2
-1
0
1
2
Descriptors
g-1
g-2
g-3
g-4
g-5
g-6
g-7
g-8
g-9
g-10
g-11