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New plant communities to define the southern boundary of the European Atlantic Province in mainland Portugal

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Abstract

This study identifies and analyzes the plant communities that allow the definition of the geographic limits between Temperate and Mediterranean macrobioclimates, for the center of Portuguese mainland. The altitude of Serra da Estrela, Açor and Lousã, combined with the increase in atmospheric humidity, allows the presence of vegetation typical of a Temperate macrobioclimate. Thus, based on the phytosociological methodology, floristic relevés were carried out in order to identify the series of vegetation existing in these territories. Through these relevés carried out, four new plant associations were identified: *Cytisetum grandifloro-striati* ass. nova, *Scrophulario grandiflorae-Sambucetum nigrae* ass. nova, *Pruno lusitanicae-Coryletum avellanae* ass. nova that lives in the submediterranean bioclimatic variant, mesotemperate humid to hyper-humid. A new association namely *Genisto falcatae-Quercetum broteroanae* ass. nova with two subassociations were also identified. Based on the vegetation distribution, new biogeographic limits are proposed. Thus, it was intended to identify the southern limits of the European Atlantic Province (Atlantic Orolusitania Subrovince) based on the vegetation cover, namely the distinction between the Estrela Sierran District and a new Biogeographical District, the Alvo-Gardunhense.

Keywords

Biogeography, geobotany, native forest, relict vegetation, vegetation cover dynamics

Introduction

Despite the Temperate macrobioclimate's presence on all continents, it's more expressive in Eurasia and in North America (Rivas-Martínez et al. 2011). In the Iberian Peninsula, the Atlantic European Province has its southern limit in mainland Portugal, corresponding to the transition from the temperate macrobioclimate to the Mediterranean macrobioclimate. The distinction between Temperate and Mediterranean macrobioclimates is identified by the lack of aridity during at least two consecutive months in the summer as well as the higher mediterranean aridity during least two consecutive months (Rivas-Martínez et al. 2017a). In general, the European Atlantic Province is characterized by the dominance of a Temperate macrobioclimate, where most of the natural potential forests of *Quercus robur* L. and *Fagus sylvatica* L. develop (Rivas-Martínez et al. 2017b).

In the southernmost part of Portugal, the European Atlantic Province is delimited by the Estrela Sierran District, which is characterized by the submediterranean variant. This variant, although inserted in the temperate macrobioclimate, is defined by the existence of at least one month during the summer's quarter with an average precipitation in millimeters that is 2.8 tenths lower than the average temperature in degrees Celsius (Rivas-Martínez et al. 2017a).

Due to the terrain's elevation, the submediterranean variant extends to the central part of Portuguese mainland, through the Serra da Estrela, Açor and Lousã mountain ranges, constituting a block to the humid Atlantic winds that favor the precipitations of the relief (Pisani et al. 2019; Santos et al. 2017). Thus, the increase in humidity favors the occurrence of *Quercus robur* subsp. *broteroana* O. Schwartz, whose natural potential vegetation has been represented by the *Viburno tini-Querco broteroanae sigmetum* (Costa et al. 2015; Raposo et al. 2021). Although there are several works on the mountains' flora of central Portugal (Costa et al. 2012; Santos-Silva 1985; Silveira 2007; van der Knaap and van Leeuwen 1995), information on the plant communities that can be used as bioindicators of the temperate macrobioclimate is still lacking.

On the other hand, there is some difficulty in defining the boundaries for the Estrela Sierran District, considering the frequent erosion of the schist substrates at the lowest levels, due to strong slopes, promoting soil thiness and even the occurrence of outcrops. In these substrates, typical temperate plant communities (more demanding in terms of moisture) find it difficulty in settling, taking refuge in deep soils and north facing slopes exposed to the north quadrant (Connor et al. 2012). Although the Estrelense District was defined by *Holco mollis-Quercetum pyrenaicae*, *Teucrium salviastri-Quercetum rotundifoliae*, *Frangulo alni-Prunetum lusitanicae* and *Viburno tini-Quercetum broteroanae* (Costa et al. 2015; Rivas-Martínez et al. 2017b), there is a clear separation at 900/1000 meters of altitude between the series of potential vegetation. The temperature's reduction, signaled by the rise in altitude to the supertemperate, has resulted in the *Quercus broteroana* with *Prunus lusitanica* L. is disappearance and its alteration to *Quercus pyrenaica* Willd. groves. In terms of vegetation cover and landscape, this clear separation led us to study this territory's vegetation landscape in greater depth, as plant bioindicators can be a very useful tool in distinguishing and characterizing the environment, regarding thermicity, shoulder climate, edaphology and even the biogeographic limits of a given territory (Cano-Ortiz et al. 2022; Rivas-Martínez 2005).

Thus, since the main ecological characteristic of plants and plant communities is fidelity, based on plant bioindicators (Burger 2006; Parmar et al. 2016), we seek to improve the southern boundary of the European Atlantic Province. To achieve this objective, we tried to identify existing plant communities (with special attention to relics) and characterize them from a chorological, bioclimatic and edaphic point of view in order to select plant bioindicators to identify the submediterranean bioclimatic variant. Second, based on the distribution of identified taxa and syntaxa, we seek to identify the cartography that expresses the southern limit of the new biogeography for the European Atlantic Province.

Materials and methods

The studied territory is part of the mountains of the center of mainland Portugal, whose maximum elevation is located at 1,993 meters of altitude, including the Lousã-Açor-Estrela mountain range. It is a territory dominated by the Mediterranean pluviseasonal oceanic bioclimate and temperate oceanic, meso to supra, humid to ultrahyperhumid, semi-hyperoceanic to euoceanic (Rivas-Martínez et al. 2017). At the substrate level, siliceous rocks dominate, composed of greywacke, schist and granite at higher levels (Rodríguez Fernández et al. 2015). At the hydrographic level, Serra da Estrela gives rise to the two largest rivers that have their source in Portugal, the Mondego and the Zezere river. In Serra da Estrela, the river Alva is the most representative within the study area and flows into the Mondego. The Serra do Açor has its highest elevation in Pico da Ceboça, at 1,418 m a.s.l. and gives rise to the Ceira river, which flows into the Mondego. Serra da Lousã has its maximum elevation in Trevim, at about 1,205 m a.s.l. These three mountains are part of the Montejunto-Estrela mountain range and have a southwest-northeast orientation, crossing the national territory diagonally (Crispim 2008).

Taxonomic and syntaxonomic nomenclature follows up the work of Costa et al. (2012), complemented with Rivas-Martínez et al. (2002) and Rivas-Martínez (2011). Coutinho (1939), Franco (1971, 1984), Franco and Rocha-Afonso (1994) and Castroviejo et al. (1986) are used for plant identification. Plants with a subspecific epithet appear for the first time in the document in full and accompanied by the respective classifier. In the rest of the document they are abbreviated and presented only with the name of the genus and the subspecific epithet. For the syntaxa comparison tables, the caracteristic plants at the level of the association and higher units were used. In the relevé table, the plants' scientific name was abbreviated to the subspecific epiptet. The biogeographical and bioclimatic framework follows up the work of Rivas-Martínez et al. (2017a, 2017b). This work is conducted according to the the phytosociological method proposed by Braun-Blanquet (1979), Géhu and Rivas-Martínez (1981), Rivas-Martínez (2005) and updated by Biondi (2011). The International Code of Phytosociological Nomenclature (4th Editions) was used for the description of new plant communities (Theurillat et al. 2021).

For the numerical analysis, we collected 18 field relevés, which were compared with another 106 relevés from the literature review (Table 1). Due to the relict character of some communities, it was not possible to carry out more phytosociological relevés. For each community, from a

Table 1. Origin of the used relevés.

Communities	Original relevés	Bibliographic relevés	Authors
Quercus robur L. s.l.	7	.	
	.	5	Braun-Blanquet et al. 1956
	.	11	Honrado et al. 2002
	.	4	Monteiro-Henriques 2010
	.	4	Pinto da Silva et al. 1950
	.	8	Rivas-Martínez et al. 2002
Corylus avellana L.	3	.	
	.	14	Amigo et al. 1994
	.	8	Nicolau and Sánchez-Mata 2015
	.	11	Rivas-Martínez et al. 2002
Cytisus striatus (Hill) Rothm.	5	.	
	.	4	Díaz and Prieto 1994
	.	6	Pinto-Gomes et al. 2012
Sambucus nigra L.	3	.	
	.	4	Bolòs 1978
	.	9	Silva et al. 2012
Total	18	88	

floristic and biogeographic point of view, the closest associations existing in the Iberian Peninsula were used. For the hierarchical analysis, the characteristic plants at the association level were used. One hundred twenty-four relevés were submitted to hierarchial cluster analysis using Ward´s method with Euclidean distance to measure dissimilarity, using the software RStudio (Rodríguez-Guitián et al. 2007). The transformation of the cover-abundance values followed up Van der Maarel (1979).

Results and discussion

The fieldwork allowed a more detailed recognition of the Montemuro and Estrela Sierras Sector southern zone floristic identity (Atlantic Orolusitania Subprovince, European Atlantic Province). With the relevés and floristic analyzes four new plant communities and two subassociation of climatophilous oak forests of *Genisto falcatae-Quercetum broteroanae* were identified. These plant communities are typical of climatophilous and tempori-hygrophilous positions and have their own geographic identity, which contributes to the definition of biogeographical boundaries. Most of the identified associations belong to ecological positions of deep soils, taking into account the dynamics of the climatophilous oak forest series.

Analysis and description of plant communities

CYTISETUM GRANDIFLORO-STRIATI ass. nova *hoc loco*

Synecology and Synstructure: Siliceous community dominated by *Cytisus striatus* (Hill) Rothm. that colonizes clearings and forest edges on deep soils (*Holotypus* associationis *hoc loco*: Table 2, relevé 5). After a fire, vigorous regeneration is frequent, forming very dense brooms. It occurs in territories influenced by a submediterranean bioclimate, with a mesotemperate thermotype, a humid to hyper-humid shoulder type and a semi-hyperoceanic continentality. In its composition, the presence of *Cytisus grandiflorus* (Brot.) DC., *Genista falcata* Brot. and *Adenocarpus complicatus* (L.) J. Gay stands out. It is distinguished from the *Lavandulo viridis-Cytisetum striati*, which develops in the southwest of the Iberian Peninsula under a sub-humid thermomediterranean bioclimate, due to the absence of *Lavandula viridis* L´Hér. The most similar community is *Ulici latebracteati-Cytisetum striati* from northwest Portugal, which develops under a humid to hyper-humid thermotemperate bioclimate, but is distinguished by the absence of *Ulex europaeus* subsp. *latebracteatus* (Mariz) Rothm. (Figure 1). In order to highlight the floristic differences between the *Cytisus striatus* associations, the characteristic plants are presented in Table 3.

Synchorology: The soil's strong erosion has reduced the potential area for this gyestal occurrence; however, the new Alvo-Gardunhense District here defined is its ecological *optimum*. This association is well represented in Serra do Açor, as well as in the União de Freguesias de Vide e Cabeça.

Syndynamics and catenal contacts: This broom constitutes a replacement stage and integrates the edge of the climatophilous series of oak-alvarinho of *Viburno tini-Querco broteroanae sigmetum*. It frequently comes into contact with the Portuguese-laurel of *Frangulo alni-Prunetum lusitanicae* and with the heliophilous communities of the *Calluno-Ulicetea* class´s degraded soils.

SCROPHULARIO GRANDIFLORAE-SAMBUCETUM NIGRAE ass. nova *hoc loco*

Synecology and Synstructure: Siliceous community dominated by *Sambucus nigra* that develops along water courses and surface runoff of nitrophilous water, on deep soils with high organic matter. It occurs in territories influenced by a submediterranean bioclimate, with a meso

Table 2. Relevés of *Cytisetum grandifloro-striati* ass. nova *hoc loco* (*Cytisetea scopario-striati, Cytisetalia scopario-striati, Ulici europaei-Cytision striati*).

Nº of relevé	1	2	3	4	5*	Presence
Altitude (m)	560	450	770	690	680	
Area (m²)	60	50	60	70	80	
Cover (%)	75	80	90	85	95	
Slope (%)	10	8	15	10	15	
Average height (m)	2.5	2	2	2	2.5	
Exposition	SE	NO	SO	E	N	
Nº of taxa	16	17	18	20	29	
Characteristics						
Cytisus striatus (Hill) Rothm	4	5	5	4	4	V
Cytisus grandiflorus (Brot.) DC.	2	+	.	1	2	IV
Pteridium aquilinum (L.) Kuntz	1	.	+	2	1	IV
Genista falcata Brot.	+	.	+	2	1	IV
Adenocarpus complicatus (L.) J. Gay	+	1	.	.	.	II
Orobanche rapum-genistae Thuill.	.	.	.	.	+	I
Companions						
Calluna vulgaris (L.) Hull.	+	1	+	1	2	V
Halimium alyssoides (Lam.) C. Koch	1	1	1	.	+	IV
Cistus psilosepalus Sweet	+	.	1	1	+	IV
Pterospartum lasianthum (Spach) Willk.	1	.	+	+	1	IV
Erica aragonensis (Willk) Cout.	1	+	+	.	+	IV
Agrostis curtisii Kerguélen	+	1	.	+	+	IV
Campanula lusitanica L.	.	+	1	+	+	IV
Arbutus unedo L.	.	+	1	+	+	IV
Erica arborea L.	.	1	.	+	+	III
Agrostis castellana Boiss. & Reut.	.	1	+	.	+	III
Digitalis purpurea L.	.	+	.	1	+	III
Genista triacanthos Brot.	.	.	1	+	+	III
Quercus broteroana O. Schwartz	+	.	+	.	+	III
Lithodora prostrata (Loisel) Griseb.	+	+	.	+	.	III
Erica cinerea L.	+	.	+	+	.	III
Rubus ulmifolius Schott	.	+	+	.	+	III
Arenaria montana L.	.	+	.	+	+	III
Lavandula luisieri (Rozeira) Rivas Mart.	.	.	+	+	+	III
Cistus populifolius L.	+	.	.	+	.	II
Viburnum tinus L.	+	.	.	.	+	II
Holcus lanatus L.	.	+	.	.	+	II
Castanea sativa Mill.	.	.	+	.	+	II
Linaria triorniphophora (L.) Willd.	.	.	+	.	+	II
Ruscus aculeatus L.	.	.	.	+	+	II

Table 3. Summary table of associations dominated by *Cytisus striatus*. A) C*ytisetum grandifloro-striati* ass. nova; B) *Lavandulo viridis-Cytisetum striati*; C) *Ulici latebracteati-Cytisetum striati*.

	A	B	C
Cytisus striatus (Hill) Rothm	V	V	V
Cytisus grandiflorus (Brot.) DC.	IV	.	.
*Pteridium aquilinum (*L.) Kuntz	IV	II	IV
Genista falcata Brot.	IV	.	.
Adenocarpus complicatus (L.) J. Gay	II	.	.
Orobanche rapum-genistae Thuill.	I	.	.
Lavandula viridis L'Hér.	.	V	.
Erica arborea L.	.	III	III
Ulex latebracteatus (Mariz) Rothm.	.	.	IV
Cytisus multiflorus (L'Hér.) Sweet	.	.	II
Cytisus scoparius (L.) Link	.	.	II
Adenocarpus lainzii Castrov.	.	.	I

to supratemperate thermotype, a humid to hyper-humid shoulder type and a semi-hyperoceanic continentality. In its composition, the presence of several elements of the *Galio-Urticetea* class, namely *Urtica dioica* L., *Scrophularia grandiflora* DC. and *Alliaria petiolata* (M. Bieb.) Cavara & Grande (*Holotypus associationis hoc loco*: Table 4, relevé 3). It is distinguished from *Clematido vitalbae-Sambucetum nigrae* by the absence of taxa such as *Cornus sanguinea* L., *Rubus caesius* L., *Euonymus europaeus* L. and *Hedera helix* L., as well as being distributed throughout the northeast of the Iberian Peninsula, at a chorological level (Bolòs 1978). More recently, *Rubo vigoi-Sambucetum nigrae* was described for the Serra de Sintra and Portalegre, growing on slightly nitrified siliceous substrates and in a humid thermomediterranean bioclimate (Silva et al. 2012).

However, several taxa distinguish these associations, especially the presence of elements with a more temperate hue such as *Scrophularia grandiflora*, *Hypericum androsaemum* L., *Prunus lusitanica*, *Ilex aquifolium* L., *Quercus broteroana*, *Primula acaulis* L. and *Salix salviifolia* Brot. (Figure 2). In order to highlight the floristic differences between the *Sambucus nigra* L. associations, the characteristic plants are shown in Table 5.

Synchorology: This syntaxon has a reduced distribution area due to anthropic action over the last decades, which is why only three phytosociological relevés could be carried out. This syntaxon occurs in the mountains of central Portugal, corresponding in biogeographic terms to the Montemuro and Estrela Sierras Sector, having its ecological optimum in Mata da Margaraça-Serra do Açor.

Syndynamics and catenal contacts: The *Sambucus nigra* community occurs in conditions very similar to the position of *Ulmus glabra* Huds., and may represent the first stage of this forest's replacement that is currently very altered. In the study area, it was observed in the most hygrophilous variants of the edges of the new potential oak groves of *Quercus broteroana* here proposed (*Genisto falcatae-Querco broteroanae*), also integrating the boundary of the ammias of *Scrophulario scorodonae-Alno glutinosae sigmetum*.

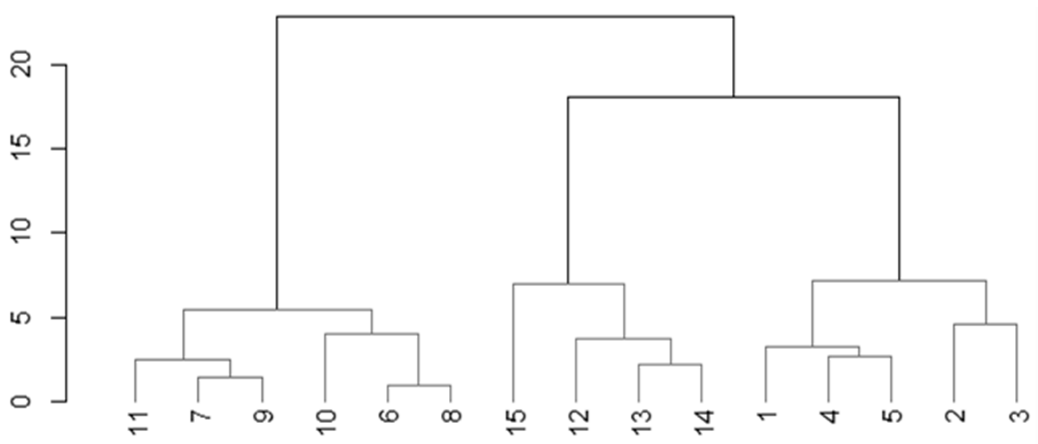

Figure 1. Dendrogram of *Cytisus striatus* communities. Rels 1–5: *Cytisetum grandifloro-striati* ass. nova; rels 6–11: L*avandulo viridis-Cytisetum striati* Pinto-Gomes, Cano-Ortiz, Quinto-Canas, Vila-Viçosa & Martínez-Lombardo 2012; rels 12–15: *Ulici latebracteati-Cytisetum striati* Rivas-Martínez ex J.C. Costa, Izco, Lousã, Aguiar & Capelo in J.C. Costa, Capelo, Lousã, Antunes, Aguiar, Izco & Ladero 2000.

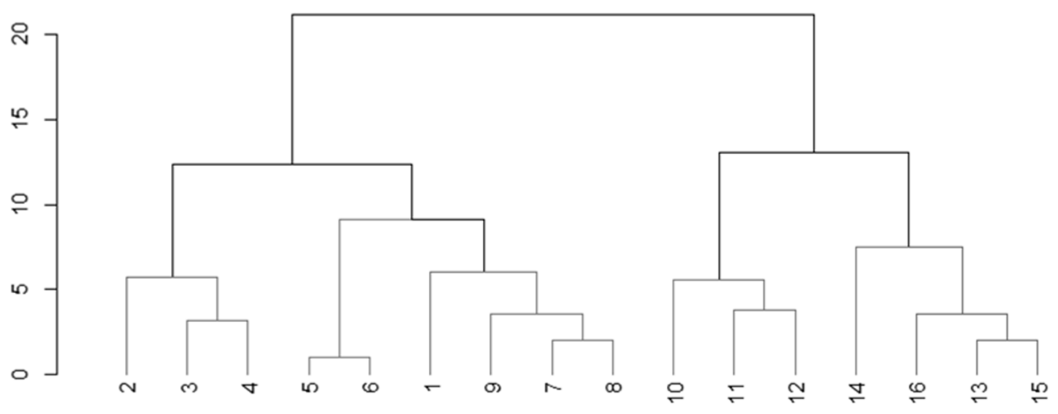

Figure 2. Dendrogram of *Sambucus nigra* communities. Rels 1–9: *Clematido vitalbae-Sambucetum nigrae* O. Bolòs 1978; rels 10–12: *Scrophulario grandiflorae-Sambucetum nigrae* ass. nova; rels 13–16: *Rubo vigoi-Sambucetum nigrae* V. Silva & Pinto-Cruz 2012.

Table 4. Relevés of *Scrophulario grandiflorae-Sambucetum nigrae* ass. nova *hoc loco*.

Nº of relevé	1	2	3*	Presence
Altitude (m)	510	560	670	
Area (m²)	80	80	100	
Slope (%)	15	20	30	
Cover (%)	90	90	85	
Exposition	N	NE	N	
Average height (m)	2.5	3	2.5	
Nº of taxa	15	17	19	
Characteristics				
Sambucus nigra L.	4	5	5	V
Rubus ulmifolius Schott	2	1	1	V
Urtica dioica L.	1	+	2	V
Scrophularia grandiflora DC.	+	1	+	V
Alliaria petiolata (M. Bieb.) Cavara & Grande	.	+	2	IV
Tamus communis L.	.	+	1	IV
Lonicera hispanica (Boiss.& Reut.) Nyman	.	+	+	IV
Crataegus monogyna Jacq.	+	.	.	II
Companions				
Chelidonium majus L.	1	2	1	V
Polystichum setiferum (Forssk.) Woynar	+	2	1	V
Digitalis purpurea L.	1	+	+	V
Hypericum androsaemum L.	1	+	1	V
Geranium purpureum Vill.	+	+	+	V
Quercus broteroana O. Schwartz	+	+	+	V
Ulmus minor Mill.	.	+	2	IV
Primula acaulis (L.) L.	.	+	1	IV
Pteridium aquilinum (L.) Kuntz	+	+	.	IV
Salix salviifolia Brot.	+	+	.	IV
Arum neglecti Mill.	+	.	+	IV
Ruscus aculeatus L.	.	+	+	IV
Prunus lusitanica L.	.	.	1	II

Table 5. Summary table of associations dominated by *Sambucus nigra*. A) *Scrophulario grandiflorae-Sambucetum nigrae* ass. nova; B) *Rubo vigoi-Sambucetum nigrae*; C) *Clematido vitalbae-Sambucetum nigrae*.

	A	B	C
Sambucus nigra L.	V	V	V
Rubus ulmifolius Schott	V	V	V
Scrophularia grandiflora DC.	V	.	.
Urtica dioica L.	V	.	.
Tamus communis L.	IV	.	.
Alliaria petiolata (M. Bieb.) Cavara & Grande	IV	.	.
Lonicera hispanica (Boiss.& Reut.) Nyman	IV	III	.
Crataegus monogyna Jacq.	II	III	.
Rubus vigoi Roselló, Peris & Stübing	.	V	.
Clematis vitalba L.	.	.	V
Cornus sanguinea L.	.	.	II
Rubus caesius L.	.	.	II
Solanum dulcamara L.	.	.	I
Euonymus europaeus L.	.	.	I
Rosa canina L.	.	.	I
Bryonia dioica Jacq.	.	.	I

PRUNO LUSITANICAE-CORYLETUM AVELLANAE ass. nova *hoc loco*

Synecology and Synstructure: In the mountains of central Portugal, a community of *Corylus avellana* was identified accompanied by a set of plants distinct from the only association previously mentioned for Portugal (Costa et al. 2012). *Omphaloto nitidae-Coryletum avellanae* was described for embedded and shady valleys, on deep limestone soils with high humidity (cambisols). Its floristic composition is rich, with approximately an average of about 34 species per relevés, accompanied by several trees and hygrophilous taxa. It occurs between 600 and 900 m a.s.l., in territoies with high precipitation (> 1,400 mm per year), and may occasionally descend to areas of humid shoulder type (Amigo et al. 1994). Although the floristic composition of *Omphaloto nitidae-Coryletum avellanae* is similar to the communities found in Serra da Estrela and Açor, it is worth mentioning the enrichment of mediterranean elements in the new association, such as *Fraxinus angustifolia* Vahl, *Viburnum tinus* and *Arbutus unedo*. Although Honrado (2003) proposed the subassociation *lauretosum nobilis* for the Peneda-Gerês and Monteiro-Henriques (2010) mountains for the Paiva river basin, the substrate and the floristic composition allowed us to separate the relevés carried out in the mountains of central Portugal. In this new association, taxa such as *Acer pseudoplatanus* L., *Fraxinus excelsior* L., *Daphne laureola* L., *Carex sylvatica* Huds., *Hedera helix* L., *Oxalis acetosella* L. and *Helleborus viridis* subsp. *occidentalis* (Reut.) Schiffn. are absent (Figure 3; Table 6). The presence of *Hedera hi-*

Table 6. Summary table of associations dominated by *Corylus avellana*. A) *Linario triorniphophylae-Coryletum avellanae*; B) *Laserpitio eliasii-Coryletum avellanae*; C) *Chamaeiris foetidissimo-Coryletum avellanae*; D) *Omphalodo nitidae-Coryletum avellanae*; E) *Pruno lusitanicae-Coryletum avellanae* ass. nova.

	A	B	C	D	E		A	B	C	D	E
Corylus avellana L.	V	V	V	V	V	*Ribes alpinum* L.	.	III	.	.	.
Sorbus aucuparia L.	V	.	.	II	.	*Chamaeiris foetidissimus* L.	.	.	V	.	.
Quercus petraea (Matt.), Liebl.	V	.	.	II	.	*Fraxinus angustifolia* Vahl	.	.	V	.	.
Stellaria holostea L.	V	V	.	.	.	*Narcissus portensis* Pugsley	.	.	V	.	.
Linaria triornithophora (L.) Willd.	V	.	.	.	.	*Ranunculus ficaria* L.	.	.	IV	.	.
Vaccinium myrtillus L.	IV	.	.	.	.	*Vitis sylvestris* (C.C. Gmel.) Hegi	.	.	III	.	.
Melampyrum pratense L.	IV	III	.	.	.	*Carex pendula* Huds.	.	.	III	.	.
Sorbus aira (L.) Crantz	IV	III	.	.	.	*Salix atrocinerea* Brot.	.	.	III	II	.
Teucrium scorodonia L.	IV	.	.	.	.	*Fraxinus excelsior* L.	.	.	.	V	.
Crepis lampsanoides (Gouan) Tausch	IV	V	.	.	.	*Ulmus glabra* Huds.	.	.	.	IV	.
Poa nemoralis L.	IV	III	.	.	.	*Ilex aquifolium* L.	.	.	.	IV	V
Dryopteris filix-mas (L.) Schott	IV	III	.	.	.	*Castanea sativa* Mill.	.	.	.	IV	.
Hepatica nobilis Schreb.	.	V	.	.	.	*Fagus sylvatica* L.	.	.	.	IV	.
Crataegus monogyna Jacq.	.	V	.	.	.	*Acer pseudoplatanus* L.	.	.	.	III	.
Mercurialis perennis L.	.	V	.	.	.	*Quercus broteroana* O. Schwartz	.	.	.	IV	IV
Melica uniflora Retz	.	V	.	.	.	*Prunus avium* L.	.	.	.	III	.
Laserpitium eliasii Sennen & Pau	.	V	.	.	.	*Acer campestre* L.	.	.	.	II	.
Milium effusum L.	.	V	.	.	.	*Tilia platyphyllos* Scop.	.	.	.	II	.
Primula columnae (Ten.) Maire & Petitm.	.	V	.	.	.	*Tilia cordata* Mill.	.	.	.	II	.
Sanicula europaea L.	.	V	.	.	II	*Salix caprea* L.	.	.	.	I	.
Helleborus occidentalis (Reut.) Schiffn.	.	V	.	.	.	*Crataegus laevigata* (DC.) Baranec	.	.	.	I	.
Rosa canina L.	.	V	.	.	.	*Quercus pyrenaica* Willd.	.	.	.	I	.
Viola reichenbachiana Jord. ex Boreau	.	V	.	.	.	*Hedera hibernica* Bean	.	.	.	.	V
Polystichum aculeatum (L.) Roth	.	V	.	.	.						
Ranunculus nemorosus DC.	.	IV	.	.	.	*Blechnum spicant* L.	.	.	.	.	IV
Daphne laureola L.	.	IV	.	.	.	*Viola riviniana* Rchb.	.	.	.	.	IV
Lilium martagon L.	.	IV	.	.	II	*Primula acaulis* (L.) L.	.	.	.	.	IV
Amelanchier ovalis Medik.	.	III	.	.	.	*Holcus mollis* L.	.	.	.	.	II
Pimpinella major (L.) Huds.	.	III	.	.	.	*Aquilegia vulgaris* L.	.	.	.	.	II
Viburnum lantana L.	.	III	.	.	.	*Luzula forsteri* (Sm.) DC.	.	.	.	.	II

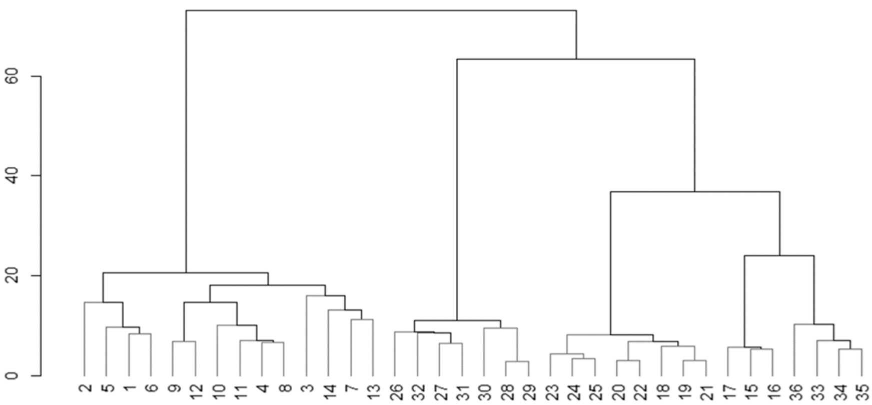

Figure 3. Dendrogram of *Corylus avellana* communities. Rels 1–14: *Omphaloto nitidae-Coryletum avellanae* Amigo, G. Azcárate & Romero 1994; rels 15–17: *Pruno lusitanicae-Coryletum avellanae* ass. nova; rel. 18–25: *Chamaeiris foetidissimo-Coryletum avellanae* Nicolau & Sánchez-Mata 2015; rels 26–32: *Laserpitio eliasii-Coryletum avellanae* Puente, M.J. López, Penas & F. Salegui 2002; rels 33–36: *Linario triorniphophylae-Coryletum avellanae* R. Alonso, Puente, Penas & F. Salegui 2002.

bernica Bean, *Quercus broteroana, Viburnum tinus, Lonicera periclymenum* subsp. *hispanica, Prunus lusitanica, Ulmus glabra, Arbutus unedo* and *Fraxinus angustifolia* helped this new association's identification. *Pruno lusitanicae-Coryletum avellanae* ass. nova *hoc loco* is a siliceous association that occupies a tempori-hygrophilous position and develops in limit with a meso to supratemperate humid to hyper-humid semi-hyperoceanic (*Holotypus associationis hoc loco*: Table 7, relevé 3).

Both ecologically and floristically, this new association is very close to the azereiro communities of *Frangulo alni-Prunetum lusitanicae*, similarly to what happens in the north of the Iberian Peninsula (Bolòs 1956; Lara et al. 2007; Raposo et al. 2021). However, their biotopes are distinguished by greater need for water, need for shade and greater cold resistance of hazel trees. On the other hand, these communities must be considered relicts, once they are hardly recoverable after being destroyed. The few known spontaneous hazel nuclei are found in limit that are physiographically protected from fires, such as embedded valleys or rocky slopes.

Synchorology: The new association develops in the Montemuro and Estrela Sierras Sector, with its main population centres in the Municipality of Seia (Portugal). These hazel trees correspond to the southern limit of associations dominated by *Corylus avellana* for mainland Portugal.

Syndynamics and catenal contacts: In dynamic terms, this syntaxon represents the first stage of replacement or forest edge of the oak-alvarinho communities of *Genisto falcatae-Querco broteroanae sigmetum* and of riparian galleries of white borrazeira riparian galleries of *Salico salviifoliae minorisigmetum*. The tree cover's destruction promotes the appearance of a thicket of the association *Lonicero hispanicae-Rubetum ulmifoliae*. Catenally, it comes into contact with the temporary-hygrophilous Portuguese-laurel of the association *Frangulo alni-Prunetum lusitanicae* and with the alders of *Galio broteriani-Alno glutinosae sigmetum*.

Table 7. Relevés of *Pruno lusitanicae-Coryletum avellanae* ass. nova *hoc loco*.

Nº of relevé	1	2	3*	Presence
Altitude (m)	720	820	630	
Area (m²)	80	70	70	
Exposition	N	NE	N	
Slope (%)	30	40	15	
Average height (m)	7	7	7	
Cover (%)	85	80	95	
Nº of taxa	17	18	31	
Characteristics				
Corylus avellana L.	3	4	4	V
Ilex aquifolium L.	2	1	1	V
Viola riviniana Rchb.	+	.	+	IV
Primula acaulis (L.) L.	.	+	+	IV
Lilium martagon L.	.	.	+	II
Aquilegia vulgaris L.	.	.	+	II
Sanicula europaea L.	.	.	+	II
Diferentials				
Hedera hibernica Bean	3	1	2	V
Quercus broteroana O. Schwartz	1	.	1	IV
Blechnum spicant L.	.	+	1	IV
Holcus mollis L.	.	+	.	II
Luzula forsteri (Sm.) DC.	.	.	+	II
Companions				
Rubus ulmifolius Schott	1	+	1	V
Polystichum setiferum (Forssk.) Woynar	+	+	1	V
Viburnum tinus L.	+	+	+	V
Castanea sativa Mill.	1	.	1	IV
Sambucus nigra L.	1	.	+	IV
Lonicera hispanica (Boiss.& Reut.) Nyman	+	.	1	IV
Prunus lusitanica L.	.	1	+	IV
Arbutus unedo L.	.	1	+	IV
Ulmus glabra Huds.	.	+	1	IV
Fraxinus angustifolia Vahl	+	+	.	IV
Hypericum androsemum L.	+	.	+	IV
Pteridium aquilinum (L.) Kuntz	+	.	+	IV
Ruscus aculeatus L.	.	+	+	IV
Asplenium onopetris L.	.	+	+	IV
Brachypodium sylvaticum (Huds.) P. Beauv.	.	+	+	IV
Quercus pyrenaica Willd.	.	1	.	II

GENISTO FALCATAE-QUERCETUM BROTEROANAE ass. nova *hoc loco*

Synecology and Synstructure: Oak groves of *Quercus broteroana* from central Portugal were initially described as a subassociation of *Rusco aculeati-Quercetum roboris*, belonging to *viburnetosum tini* (Braun-Blanquet et al. 1956). However, the geographical and floristic differences allowed this subassociation to be raised to the *Viburno tini-Quercetum broteroanae* (Costa et al. 2012). It has been described as a thermotemperate (submediterranean) humid hyperoceanic syntaxon, occurring up to 500 m altitude (Rivas-Martínez et al. 2002). However, the oak groves that occur in the upper accounts have an original floristic composition, enriched with plants such as *Genista falcata, Quercus pyrenaica, Eryngium juresianum* (Laínz) Laínz, *Prunus lusitanica* and *Veronica micrantha* Hoffmann. & Link. Thus, based on 11 phytosociological relevés, we propose *Genisto falcatae-Quercetum broteroanae* ass. nova *hoc loco* (*Holotypus associationis hoc loco*: Table 8, relevé 3) for mesotemperate territories, occasionally reaching the supratemperate (submediterranean) humid to hyperhumid, semihyperoceanic, occurring from 500 to 800 meters in altitude, more thermal slopes at an altitude of 1,000 meters, on acid substrates formed by greywacke, schist or granite. In view of the anthropic action, the best oak groves are found on north facing slopes. As a southern series of *Quercus broteroana*, influenced by the submediterranean subtype, the presence of elements of *Quercetea ilicis* is frequent.

Of all the associations of *Quercus robur*, the one that most closely resembles it is the *Viburno tini-Quercetum broteroanae* by the absence of thermal elements, such as *Smilax aspera* and *Asparagus aphyllus* L., and the presence of *Prunus lusitanica* in climatophilous position, *Genista falcata* and *Quercus pyrenaica* (Table 9). Though having some plants in common, the remaining associations, have their own taxa that allow them to be distinguished at the floristic level (Figure 4).

For Serra da Gardunha we point out the subassociation *asphodeletosum bento-rainhae* (*Holotypus associationis hoc loco*: Table 8, relevé 11), marked by the presence of *Asphodelus bento-rainhae* P. Silva and also by the strong presence of *Quercus pyrenaica*. This subassociation marks the southeast limit of this series distribution area of potentially climatophilous vegetation. As this is an ecological limit, the oak groves in this territory have low ecological resilience, being found only on the north facing slopes. A good part of Serra da Gardunha has been transformed into *Castanea sativa* forests, so the oak groves are generally poorly preserved.

Synchorology: Both subassociations have their ecological optimum in the new Alvo-Gardunhense District (Montemuro and Estrela Sierras Sector Montemuro-Estrelense, Atlantic Orolusitania Subprovince, European Atlantic Province). The *typus* association occurs in Serra da Estrela, Açor and Lousã, while *asphodeletosum bento-rainhae* occurs from the northern slope of Serra da Gardunha to Sertã. The *Genisto falcatae-Quercetum broteroanae* ass. nova distribution area corresponds to the southern limit of the Atlantic European Province.

Syndynamics and catenal contacts: The forests of *Genisto falcatae-Quercetum broteroanae* represent the climatic stage (Figure 5). The first replacement stage is formed by the azereira of *Frangulo alni-Prunetum lusitani-*

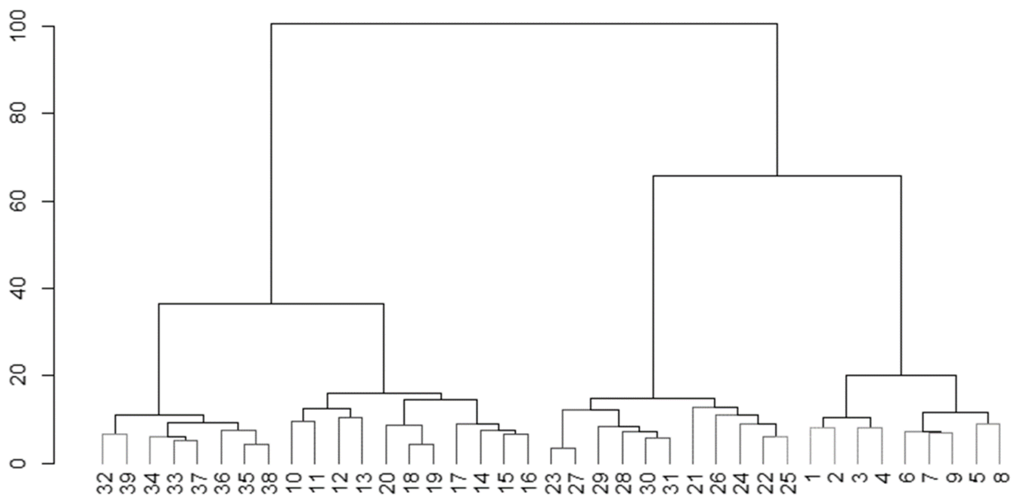

Figure 4. Dendrogram of *Quercus robur* s.l. communities. Rels 1–4: *Vaccinio myrtilli-Quercetum roboris* P. Silva, Rozeira & Fontes 1950 corr. Br.-Bl., P. Silva & Rozeira 1955; rels 5–9: *Rusco aculeati-Quercetum roboris* Br.-Bl., P. Silva & Rozeira 1955 *em*. Amigo, Izco, J. Guitián & Romero 1998; rels 10–20: *Genisto falcatae-Quercetum broteroanae* ass. nova; rels 21–31: *Hyperico androsaemi-Quercetum roboris* Honrado, Rocha, P. Alves & B. Caldas in Honrado, P. Alves, Nepomuceno & B. Caldas 2022; rels 32–39: *Viburno tini-Quercetum broteroanae* (Br.- Bl., P. Silva & Rozeira 1955) J.C. Costa, Capelo, Honrado, Aguiar & Lousã 2002.

Table 8. Relevé of subassociations of *Genisto falcatae-Quercetum broteroanae* subass. *typicum* (rels 1–8); *Genisto falcatae-Quercetum broteroanae* subass. *asphodeletosum bento-rainhae* (rels 9–11).

N.º relevé	1	2	3*	4	5	6	7	8	9	10	11+	Presence
Altitude (m)	500	700	480	760	760	690	580	475	620	690	570	
Slope (%)	25	30	15	50	25	12	30	40	15	20	10	
Exposure	N	W	N	S	W	NW	N	W	N	NE	NW	
Coverage (%)	95	100	100	100	95	85	100	100	90	100	100	
N.º of taxa	18	21	23	24	26	28	33	34	17	21	29	
Characteristics												
Quercus broteroana O. Schwartz	4	5	3	5	4	3	4	4	4	4	5	V
Teucrium scorodonia L.	.	2	+	2	.	+	+	1	1	1	1	V
Hedera hibernica Bean	1	3	1	2	+	.	2	2	+	.	3	V
Genista falcata Brot.	.	.	+	.	1	.	+	2	+	+	+	V
Quercus pyrenaica Willd.	.	.	+	1	.	1	.	1	2	3	2	IV
Viola riviniana Rchb.	.	.	1	.	.	+	+	+	+	+	.	IV
Luzula forsteri (Sm.) DC.	.	.	+	.	1	1	+	1	.	.	.	III
Ilex aquifolium L.	.	.	+	.	.	+	2	.	.	.	+	III
Prunus lusitanica L.	.	.	1	.	.	+	2	.	.	.	.	II
Omphalodes nitida (Willd.) Hoffmanns. & Link	+	+	.	.	.	.	.	+	.	.	.	II
Blechnum spicant L.	.	.	+	.	.	+	+	.	.	.	.	II
Holcus mollis L.	.	2	.	3	.	.	.	.	.	.	.	I
Stellaria holostea L.	.	1	.	1	.	.	.	.	.	.	.	I
Crepis lampsanoides (Gouan) Tausch	.	.	.	+	.	.	.	1	.	.	.	I
Primula acaulis (L.) L.	.	.	+	.	+	.	.	.	.	.	.	I
Eryngium juresianum (Laínz) Laínz	.	.	+	.	.	.	+	.	.	.	.	I
Arenaria montana L.	.	.	+	.	.	.	.	+	.	.	.	I
Polygonatum odoratum (Miller) Druce	.	.	.	.	.	.	.	.	.	+	+	I
Physospermum cornubiense (L.) DC.	.	.	.	.	.	.	.	.	.	.	1	I
Euphorbia amygdaloides L.	+	.	.	.	.	.	.	.	.	.	.	I
Lilium martagon L.	.	.	.	.	.	.	+	.	.	.	.	I
Veronica micrantha Hoffmann. & Link	.	.	.	.	.	.	+	.	.	.	.	I
Prunus avium L.	.	.	.	.	.	.	.	+	.	.	.	I
Cephalanthera longifolia (L.) Fritsch	.	.	.	.	.	.	.	+	.	.	.	I
Characteristics *asphodeletosum*												
Asphodelus bento-rainhae P. Silva	.	.	.	.	.	.	.	.	+	+	+	II
Companions												
Pteridium aquilinum (L.) Kuntz	1	2	+	2	1	1	+	2	+	2	1	V
Castanea sativa Mill.	+	.	2	2	1	1	1	2	2	1	2	V
Lonicera hispanica (Boiss.& Reut.) Nyman	1	3	+	.	1	1	1	+	.	.	2	V
Ruscus aculeatus L.	+	4	.	.	+	1	1	1	.	+	1	V
Arbutus unedo L.	.	.	1	.	1	+	+	.	2	2	1	IV
Erica arborea L.	+	.	+	.	+	1	.	1	.	+	+	IV
Cytisus striatus (Hill) Rothm.	.	.	.	+	+	+	+	+	.	+	.	IV
Rubus ulmifolius Schott	1	.	.	+	+	1	.	.	.	.	+	III
Crataegus monogyna Jacq.	2	.	+	.	.	+	.	.	+	.	+	III
Calluna vulgaris (L.) Hull.	.	.	.	.	+	1	+	.	.	+	+	III
Frangula alnus Mill.	+	+	+	+	.	+	+	.	.	.	.	III
Tamus communis L.	+	+	.	.	.	.	.	+	+	+	.	III
Rubia peregrina L.	.	.	.	.	.	+	+	.	.	1	1	III
Viburnum tinus L.	.	.	1	.	+	+	1	.	.	.	.	III
Digitalis purpurea L.	+	+	.	+	.	.	.	+	.	.	.	III
Lithodora lusitanica (Samp.) Holub.	.	.	.	.	.	.	.	.	1	1	+	III
Asplenium onopteris L.	+	+	.	.	.	.	.	1	.	.	.	III
Agrostis stolonifera L.	+	.	.	1	.	.	.	+	.	.	.	III
Cytisus grandiflorus (Brot.) DC.	.	1	.	.	.	.	.	.	+	.	+	II
Asplenium onopeteris L.	.	.	1	.	.	+	+	.	.	.	.	II
Holcus lanatus L.	.	.	.	.	+	1	+	.	.	.	.	II
Agrostis curtisii Kerguélen	.	.	.	.	+	.	.	.	.	1	+	II
Laurus nobilis L.	+	.	.	.	.	+	+	.	.	.	.	II
Polystichum setiferum (Forssk.) Woynar	.	.	+	.	+	+	.	.	.	.	.	II
Fragaria vesca L.	.	.	+	.	+	+	.	.	.	.	.	II
Linaria triornitpphylla (L.) Willd.	.	.	.	.	+	.	+	.	.	.	+	II
Pterospartum lasianthum (Spach) Willk	.	.	.	.	+	+	.	.	.	.	+	II
Clinopodium arundanum (Boiss.) Nyman	.	.	.	1	.	.	.	1	.	.	.	I
Rubus sp.	.	2	.	+	.	.	.	.	.	.	.	I
Pinus pinaster Aiton	.	.	.	.	.	.	.	.	.	1	+	I
Cytisus multiflorus (L'Hér.) Sweet	.	+	.	+	.	.	.	.	.	.	.	I
Ceratocapnos claviculata (L.) Lidén	.	+	.	+	.	.	.	.	.	.	.	I
Polypodium interjectum Shivas	.	+	.	.	.	.	.	+	.	.	.	I
Dactylis hispanica Roth	.	.	.	+	.	.	.	+	.	.	.	I
Jasione montana L.	.	.	.	+	.	.	.	+	.	.	.	I
Silene nutans L.	.	.	.	+	.	.	.	.	.	+	.	I
Hypericum androsaemum L.	.	.	.	.	.	+	+	.	.	.	.	I
Quercus suber L.	.	.	.	.	.	.	.	.	.	+	+	I

Table 9. Summary table of associations dominated by *Quercus robur* s.l. in mainland Portugal. A) V*accinio myrtilli-Quercetum roboris*; B) *Rusco aculeati-Quercetum roboris*; C) *Genisto falcatae-Quercetum broteroanae* ass. nova; D) *Hyperico androsaemi-Quercetum roboris*; E) V*iburno tini-Quercetum broteroanae*.

	A	B	C	D	E		A	B	C	D	E
Quercus robur s.l.	V	V	V	V	V	*Veronica montana* L.	.	.	.	+	.
Vaccinium myrtillus L.	V	.	.	.	.	*Smilax aspera* L.	.	.	.	.	IV
Rubus lusitanicus R.P.Murray	V	.	.	.	.	*Luzula baetica* P. Monts.	.	.	.	.	IV
Galium rotundifolium L.	V	.	.	.	.	*Vinca difformis* Pourr.	.	.	.	.	IV
Laserpitium thalictrifolium Samp.	IV	.	.	.	.	*Asparagus aphyllus* L.	.	.	.	.	III
Melittis melissophyllum L.	IV	.	.	.	.	*Phillyrea latifolia* L.	.	.	.	.	III
Prunella grandiflora (L.) Scholler	IV	.	.	.	.	**Other plants**					
Picris longifolia (Boiss. & Reuter) P.D. Sell	II	.	.	.	.	*Teucrium scorodonia* L.	V	V	V	.	V
Aquilegia dichroa Freyn	.	I	.	.	.	*Lonicera periclymenum* L.	V	V	+	.	V
Scilla verna Huds.	.	I	.	.	.	*Polygonatum odoratum* (Miller) Druce	V	II	I	.	.
Veronica chamaedrys L.	.	I	.	.	.	*Hypericum pulchrum* L.	V	III	.	.	.
Hieracium sabaudum L.	.	I	.	.	.	*Lilium martagon* L.	V	.	+	.	.
Melampyrum pratense L.	.	I	.	.	.	*Ilex aquifolium* L.	IV	II	II	.	IV
Lonicera hispanica (Boiss.& Reut.) Nyman	.	.	IV	.	.	*Quercus pyrenaica* Willd.	IV	II	IV	.	.
Luzula forsteri (Sm.) DC.	.	.	IV	.	.	*Physospermum cornubiense* (L.) DC.	IV	II	+	.	.
Primula acaulis L.	.	.	II	.	.	*Pyrus cordata* Desv.	IV	II	.	.	.
Blechnum spicant L.	.	.	II	.	.	*Anemone trifolia* L.	IV	I	.	.	.
Asphodelus bento-rainhae P. Silva	.	.	II	.	.	*Eryngium juresianum* (Laínz) Laínz	IV	.	II	.	.
Prunus lusitanica L.	.	.	II	.	.	*Viola riviniana* Rchb.	III	V	III	.	IV
Crataegus monogyna Jacq.	.	.	II	.	.	*Satureja vulgaris* (L.) Halácsy	III	III	.	.	.
Veronica micrantha Hoffmann. & Link	.	.	I	.	.	*Crepis lampsanoides* (Gouan) Tausch	III	II	I	.	.
Prunus avium L.	.	.	+	.	.	*Arenaria montana* L.	III	II	I	.	.
Cephalanthera longifolia (L.) Fritsch	.	.	+	.	.	*Euphorbia amygdaloides* L.	II	II	+	.	.
Polystichum setiferum (Forssk.) Woynar	.	.	.	V	.	*Omphalodes nitida* Hoffmanns. & Link	II	I	II	.	.
Acer pseudoplatanus L.	.	.	.	V	.	*Euphorbia dulcis* L.	II	I	.	.	.
Hedera canariensis Willd.	.	.	.	V	.	*Castanea sativa* Willd.	.	III	V	.	.
Fraxinus angustifolia L.	.	.	.	IV	.	*Holcus mollis* L.	.	II	I	.	IV
Salix atrocinerea Brot.	.	.	.	III	.	*Genista falcata* Brot.	.	II	IV	.	.
Osmunda regalis L.	.	.	.	III	.	*Stellaria holostea* L.	.	II	I	.	.
Woodwardia radicans (L.) Sm.	.	.	.	III	.	*Hedera hibernica* Bean	.	.	V	.	V
Alnus glutinosa (L.) Gaertn.	.	.	.	II	.	*Ruscus aculeatus* L.	.	.	III	IV	V
Helleborus foetidus L.	.	.	.	II	.	*Arbutus unedo* L.	.	.	III	.	V
Lysimachia nemorum L.	.	.	.	II	.	*Tamus communis* L.	.	.	II	.	IV
Phyllitis scolopendrium (L.) Newman	.	.	.	I	.	*Laurus nobilis* L.	.	.	I	V	.
Sanicula europaea L.	.	.	.	I	.	*Asplenium onopteris* L.	.	.	I	IV	.
Anthriscus sylvestris (L.) Hoffm.	.	.	.	+	.	*Viburnum tinus* L.	.	.	I	.	V
Carex remota L.	.	.	.	+	.	*Rubia peregrina* L.	.	.	+	.	V
Mercurialis perennis L.	.	.	.	+	.	*Corylus avellana* L.	.	.	+	IV	.
Thalictrum speciosissimum L.	.	.	.	+	.	*Hypericum androsaemum* L.	.	.	+	III	.

cae or by the avenal of *Pruno lusitanicae-Coryletum avellanae* ass. nova, which differs from the azereira grove due to the greater water requirement, need for shade and greater resistance to cold of *Corylus avellana*, although in this territory both associations have a relict character. However, *Pruno lusitanicae-Arbutetum unedonis* is more common and grows in less humid areas. On the edges of the forest and as a second replacement stage, a gyestal of *Cytisetum grandifloro-striati* ass. nova. Still on the forest edges, there is sometimes a herbaceous community of *Omphalodo nitidae-Linarietum triornithophorae*. In addition, on deep soils there are the perennial meadows of *Avenella flexuosa* (L.) Parl., which are currently quite altered, preventing the proper relevés performance. In clearings, slopes and roadsides there is a meadow dominated by *Brachypodium phoenicoides* (L.) Roem. & Schult., maintained through shrub vegetation grazing or cutting. With soil erosion, the heath and gorse of *Erico umbellatae-Pterospartetum tridentati* appear and with the decapitation of the soil, the association *Pterosparto lasianthi-Ericetum cinereae* appears. The last replacement stage is formed by a therophytic meadow of *Galio parisiensis-Logfietum minimae*. In catenal terms, they come into contact at lower levels with oak groves of *Viburno tini-Quercetum broteroanae* and at higher levels with the oak woods of *Holco mollis-Quercetum pyrenaicae*. At the valley´s bottom, it comes into contact with the edapho-hygrophilous series of the alder of *Scrophulario scorodoniae-Alno glutinosae sigmetum* and with the ash trees of *Omphalodo nitidae-Fraxino angustifolae sigmetum*.

COMMUNITY OF *BRACHYPODIUM PHOENICOIDES*

Synecology and Synstructure: Lively meadow dominated by *Brachypodium phoenicoides* that develops in mesotemperate humid to hyper-humid semi-hyperoceanic to euoceanic on siliceous substrates derived from schists, quartzites, granites and sandstones. Therefore, it clearly differs from *Galio concatenati-Brachypodietum phoenicoidis* Pinto-Gomes & P. Ferreira 2005 and *Phlomido lychnitidis-Brachypodietum phoenicoidis* Br.-Bl., P. Silva & Rozeira 1955 because it grows on calcareous substrates, where plants such as *Galium concatenatum* Coss., *Centaurea occasus* Fern.Casas, *Salvia sclareoides* Brot., *Teucrium chamaedrys* L. and *Phlomis lychnitis* L. are absent.

This new community occurs mainly on recently abandoned paths, sparsely grazed areas or scrub clearings. Although it occurs on acidic substrates, it differs from *Hyacinthoido transtaganae-Brachypodietum phoenicoidis*, which occurs in sandy substrates in a tempori-hygrophilous position in the lower Tagus and Sado basins, consisting of plants such as *Festuca ampla* subsp. *simplex* (Pérez Lara) Devesa, *Hyacinthoides vicentina* subsp. *transtagana* Franco & Rocha Afonso, *Avenula sulcata* subsp. *gaditana* Romero Zarco, *Serratula monardii* Dufour and *Lepidophorum rapandum* (L.) DC. (Raposo et al. 2016) and of *Festuco amplae-Brachypodietum phoenicoides* that occurs in a temporary-hygrophilous position in the Luso-Extremadurense Sector, presenting as main characteristic plants *Festuca ampla, Scirpoides holoschoenus* and *Crepis capillaris* (Ribeiro et al. 2013).

Therefore, this silicic community is accompanied by plants such as *Dactylis glomerata* subsp. *lusitanica* (Stebbins & Zohary) Rivas-Mart. & Izco, *Ranunculus bupleuroides* Brot., *Narcissus triandrus* subsp. *pallidulus* (Graells) Rivas Goday ex Fern. Casas, *Arenaria montana* L. and *Hypericum linariifolium* Vahl. However, deeper studies are needed to interpret the syntaxonomic position of this plant community.

Synchorology: This community occurs in the Lousã, Açor and Estrela mountains, corresponding in biogeographic terms to the Sierran Montemuro-Estrelense Sector.

Syndynamics and catenal contacts: This lively lawn is part of the stage of replacement of the oak-alvarinho forests of *Genisto falcatae-Querco broteroanae sigmetum*. In catenal terms, it is in contact with the *Cytisetea scopario-striati* scrub and the *Calluno-Ulicetea* scrub.

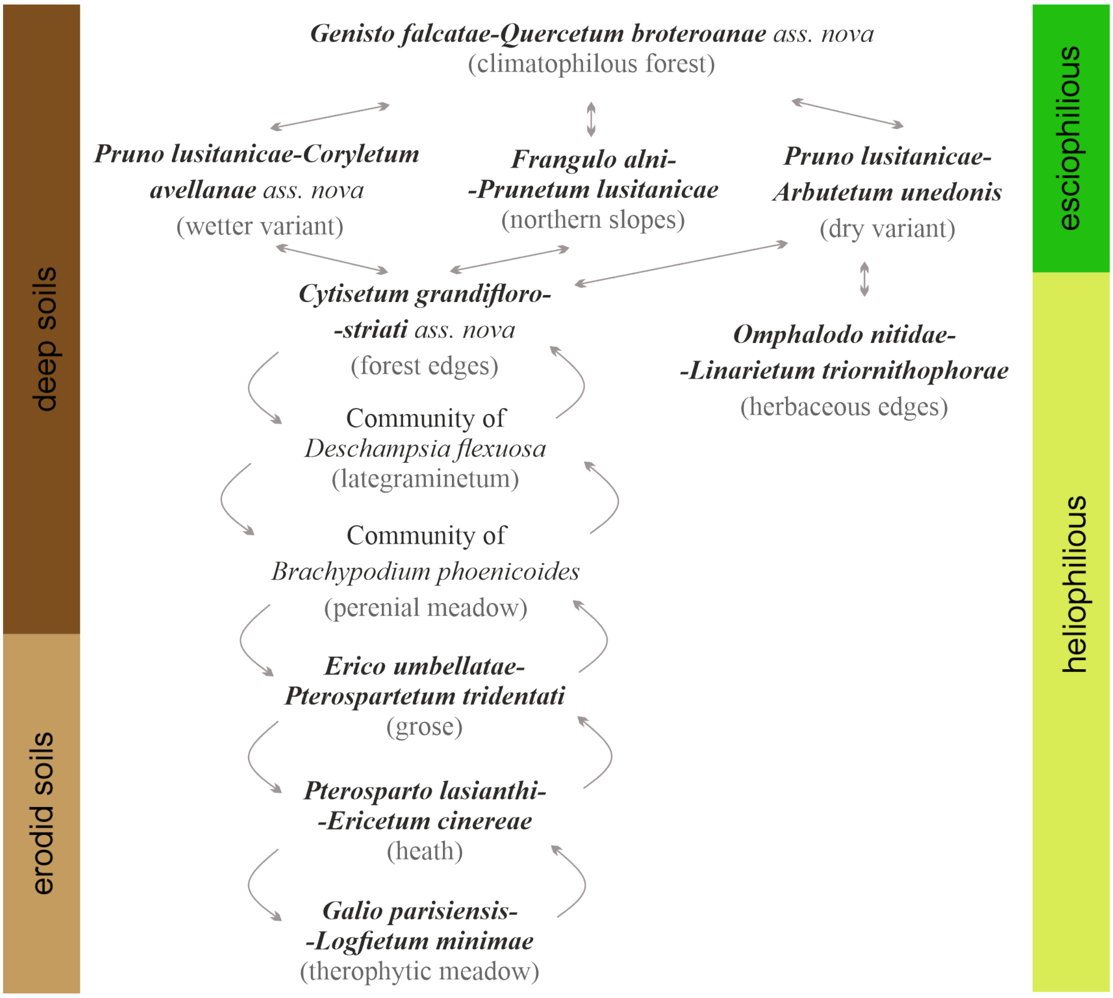

Figure 5. Dynamics of *Genisto falcatae-Quercetum broteroanae* ass. nova.

COMMUNITY OF *ULMUS GLABRA*

Synecology and Synstructure: Mesophilous and tempori-hygrophilous communities that develop on deep soils and cool slopes, with a preference for sheltered areas. Due to this specie´s reduction, derived from the elm graphiosis (*Ophiostoma ulmi* and *Ophiostoma novo-ulmi*) pest in recent decades, there are few representative areas of this species, which is why there are no dense or well-preserved forests (Monteiro-Henriques et al., 2010). Possibly, the elm trees in the study area correspond to *Fraxino angustifoliae-Ulmetum glabrae*. Frequent plants: *Ulmus glabra, Quercus broteroana, Prunus lusitanica, Sambucus nigra, Rubus ulmifolius, Frangula alnus, Corylus avellana, Crataegus monogyna, Hedera hibernica, Lonicera hispanica, Polystichum setiferum, Blechnum spicant, Hypericum androsaemum, Ilex aquifolium, Tamus communis, Urtica dioica, Chelidonium majus, Luzula henriquesii* and *Primula acaulis*.

Synchorology: In the study area, one of the best places to observe this species is Mata da Margaraça, but it has also been observed along streams, namely in Vale de Loriga, Lapa dos Dinheiro (Seia), Cascata da Forja (Vide) and near Donas (North slope of Serra da Gardunha). Thus, we think that the presence of *Ulmus glabra* can help define the Alvo-Gardunhense District boundaries.

Syndynamics and catenal contacts: The communities of *Ulmus glabra* are in contact catenally with the climatophilous oaks of *Genisto falcatae-Quercetum broteroanae* and with the edaphohygrophilous amylias of *Scrophulario scorodoniae-Alnetum glutinosae*. As the main replacement step, we identified a community of *Sambucus nigra* from *Scrophulario grandiflorae-Sambucetum nigrae* ass. nova.

COMMUNITY OF *BETULA CELTIBERICA*

Synecology and Synstructure: Although not very representative, some forest fragments of *Betula celtiberica* were identified in the study area. From an ecological point of view, the *Betula* forests form secondary communities that descend at 450 meters. Although their presence is residual, they are of great interest due to the coexistence with characteristic plants of *Quercetea ilicis*, namely, *Viburnum tinus, Ruscus aculeatus*, *Erica arborea*, *Rubia peregrina* and *Phillyrea angustifolia* L., which could represent a new syntaxon. This occurs in the semihyperoceanic to euoceanic hyperhumid mesotemperate level. Due to the low expression it was not possible to carry out phytosociological relevés. Frequent plants: *Betula celtiberica, Quercus broteroana, Prunus lusitanica, Ilex aquifolium, Viburnum tinus, Frangula alnus, Dryopteris affinis, Viola riviniana, Pteridium aquilinum, Hedera hibernica, Rubus ulmifolius, Castanea sativa, Rubia peregrina, Ulex minor*, *Brachypodium sylvaticum, Teucrium scorodonia, Polystichum setiferum, Avenella flexuosa, Genista falcata, Crataegus monogyna*, *Daphne gnidium* and *Prunus avium*.

They differ from the Geresian association of *Carici reuterianae-Betuletum celtibericae* by the presence of a set of lauroid elements, as well as taxa belonging to *Quercetea ilicis*. *Carici reuterianae-Betuletum celtibericae* has a hygrophilous character and occurs in upper mesotemperate and supratemperate thermotypes, affiliated with *Osmundo regalis-Alnion glutinosae*, where taxa as *Athyrium filix-femina* (L.) Roth, *Salix atrocinerea, Oenanthe crocata* L., *Osmunda regalis* L. occur with a high degree of coverage (Honrado et al. 2003).

This birchwood is geographically close to the association *Saxifrago spathularidis-Betuletum celtibericae*, however, they are differentiated through the thermotype, normally occurring above 1,000 meters, in the above supra to orotemperate thermotypes of the Estrela and Oresano-Sanabriense territories, as well as by the absence taxa of lauroid, *Quercetea ilicis* and *Saxifraga spathularis* (L.) Link, *Taxus baccata* L., *Sorbus aucuparia* L., *Festuca elegans* Boiss. and *Cytisus oromediterraneus* Rivas-Mart., T.E. Díaz, Fern., Prieto, Loidi & Penas.

Synchorology: These relict communities occur in the low altitudes of the Estrela and Açor mountains, corresponding to the southern limit of the *Betula celtiberica*'s natural distribution area in mainland Portugal. In biogeographic terms, they help to define the Alvo-Gardunhense District.

Syndynamics and catenal contacts: *Betula* communities occupy a secondary position in the potential forests of *Genisto falcatae-Querco broteroanae sigmetum*. In catenal terms, it contacts the amyal of *Scrophulario scorodoniae-Alno glutinosae sigmetum*.

Biogeographic proposal for the study area

The improvement knowledge of the syntaxa's range has made it possible to identify a new territorial domain with its own identity and to distinguish it from surrounding biogeographic territories. Within the Montemuro and Estrela Sierras Sector, depending on the orientation of the slopes, the vegetation change occurs, on average, between 900 and 1,000 m a.s.l. This altitude is close to the work by Costa et al. (1998), when he refers to the Montemuro and Estrela Sierras Sector's altitudinal limit. The altitudinal limit of the Alvo-Gardunhense District can reach a minimum level of 400 m a.s.l., especially on coasts exposed to the north quadrant. Other works published on the biogeography of Serra da Estrela also followed the series of natural potential vegetation (Rivas-Martínez et al. 2017). However, the new Alvo-Gardunhense District now corresponds to the southernmost part of the former Estrela Sierran District (Rivas-Martínez et al. 2017). Below this altitude the natural potential vegetation is formed by the humid to hyper-humid meso to supratempered alvarinho oak series of *Genisto falcatae-Querco broteroanae sigmetum*, which is represented by the Alvo-Gardunhense District (Figure 6). Thus, it is a District influenced by the submediterranean variant, mesotemperate humid to hyper-humid.

At elevations above 1,000 meters, the natural potential vegetation is represented by the series of black oak from *Holco mollis-Querco pyrenaicae sigmetum*, corresponding to the Estrelense District. This District is influenced by the submediterranean variant, supra to orotemperate hyper-humid to ultra-hyper-humid. In order to differentiate and consequente definition of the adjacent sectors' biogeographic boundaries, the potential climatophilous vegetation corresponding to each territory is presented in Table 10.

Based on the ecological fidelity of plants and plant communities, it was possible to improve the Atlantic European Province´s southern limits definition in mainland Portugal, which now corresponds to the Alvo-Gardunhense District. The potential climatophilous forests that best define this District are *Genisto falcatae-Quercetum broteroanae* subass. *typicum* and subass. *asphodeletosum bento-rainhae*. These territories, mostly mesotemperate, are thus separated from the Estrelense District characterized by the supra and orotemperate thermotypes, where *Quercus broteroana* communities are absent. However, it is necessary to conduct more studies in order to understand the real distribution of the *Viburno tini-Quercetum broteroanae*, since the thermotempered territories are outside the European Atlantic Province and belong to the Portuguese Divisive Sector.

In order to help characterize this new Biogeographic District, the main stages of replacement of the series of

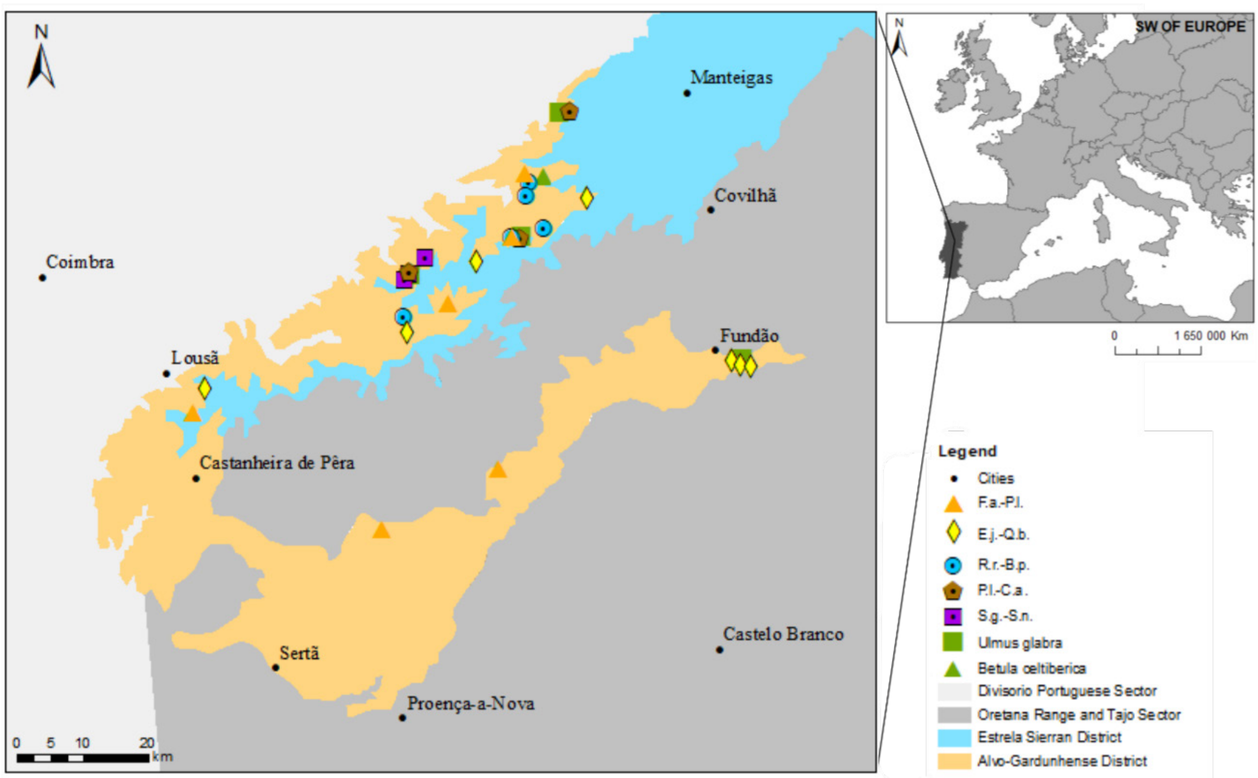

Figure 6. Proposal for the limits of the new Biogeographic District: Alvo-Gardunhense (Montemuro and Estrela Sierras Sector, Atlantic Orolusitania Subprovince, Atlantic European Province). F.a.-P.l., *Frangulo alni-Prunetum lusitanicae*; G.f.-Q.b., *Genisto falcatae-Quercetum broteroanae*; P.l.-C.a., *Pruno lusitanicae-Coryletum avellanae*; S.g.-S.n., *Scrophulario grandiflorae-Sambucetum nigrae* ass. nova.

Table 10. Main series of potential vegetation that allow to distinguish the different biogeographical sectors.

Biogeographical units	Divisorio Portuguese Sector	Montemuro and Estrela Sierras Sector	Oretana Range and Tajo Sector
Edafoxerophilous	*Lonicero implexae-Querco rotundifoliae S.* *Asparago aphylli-Querco suberis S.*	*Teucrio salviastri-Querco rotundifoliae S.* *Teucrio salviastri-Querco suberis S.* *Holco mollis-Querco pyrenaicae S.*	*Pyro bourgaeanae-Querco rotundifoliae S.*
Climatophilous	*Arisaro simorrhini-Querco broteroi S.* *Arisaro simorrhini-Querco pyrenaicae S.* *Viburno tini-Querco broteroanae S.*	*Genisto falcatae-Querco broteroanae S.*	*Smilaco asperae-Querco suberis S. Arisaro simorrhini-Querco pyrenaicae S.*
Edafohygrophilous	*Ficario ranunculoidis-Fraxino angustifoliae S.*	*Salico salviifoliae S.* *Scrophulario scorodoniae-Alno glutinosae S.*	*Salico salviifoliae S.* *Scrophulario scorodoniae-Alno glutinosae S.*

potential climatophilous vegetation were identified, some of which were new to the scientific community. Although other syntaxa may help this biogeographic territory´s definition, the humanization of the landscape and climate change may contribute to its limits's redution, due to the tendency of future lower precipitation. Therefore, *Genisto falcatae-Quercetum broteroanae* ass. nova must be considered a relict vegetation series that needs urgent special conservation measures.

Syntaxonomical scheme

CYTISETEA SCOPARIO-STRIATI Rivas-Martínez 1974
CYTISETALIA SCOPARIO-STRIATI Rivas-Martínez 1974
Ulici europaei-Cytision striati Rivas-Martínez, Báscones, Díaz, Fernandez-González & Loidi 1991
Cytisetum grandifloro-striati ass. nova

RHAMNO CATHARTICAE-PRUNETEA SPINOSAE Rivas Goday & Borja ex Tüxen 1962
PRUNETALIA SPINOSAE Tüxen 1952
Pruno spinosae-Rubion ulmifolii O. Bolòs 1954
Rosenion carioti-pouzinii Arnáiz ex Loidi 1989
Scrophulario grandiflorae-Sambucetum nigrae ass. nova

QUERCO-FAGETEA SYLVATICAE Br.-Bl. & Vlieger in Vlieger in Ned. Kruidk 1937
BETULO PENDULAE-POPULETALIA TREMULAE Rivas-Martínez & Costa 2002
Betulion fontqueri-celtibericae Rivas-Martínez & Costa 2002
Betulenion fontqueri-celtibericae Rivas-Martínez & Costa 2011
Pruno lusitanicae-Coryletum avellanae ass. nova
QUERCETALIA ROBORIS Tüxen 1931
Quercion pyrenaicae Rivas-Goday ex Rivas-Martínez 1964
Quercenion robori-pyrenaicae (Br.-Bl., P. Silva & Rozeira 1955) Rivas-Martínez 1975
Genisto falcatae-Quercetum broteroanae ass. nova

Other syntaxa quoted in the text

Arisaro simorrhini-Quercetum broteroi Br.-Bl., P. Silva & Rozeira 1955 corr. Rivas-Martínez 1975; *Arisaro simorrhini-Quercetum pyrenaicae* Pinto-Gomes, P. Ferreira, Aguiar, Lousã, J.C. Costa, Ladero & Rivas-Martínez in Pinto-Gomes, P. Ferreira & Meireles 2007 corr. Pinto-Gomes & J.C. Costa 2012; *Asparago aphylli-Quercetum suberis* J.C. Costa, Capelo, Lousã & Espírito Santo 1996; *Calluno vulgaris-Ulicetea minoris* Br.-Bl. & Tüxen ex Klika & Hadač 1944; *Carici reuterianae-Betuletum celtibericae* (Honrado, P. Alves, Aguiar, Ortiz & B. Caldas 2003) Honrado 2004; *Chamaeiris foetidissimo-Coryletum avellanae* Nicolau & Sánchez-Mata 2015; *Clematido vitalbae-Sambucetum* nigrae O. Bolòs 1978; *Erico umbellatae-Pterospartetum tridentati* (Br.-Bl., P. Silva & Rozeira 1965) J.C. Costa, Honrado, Monteiro-Henriques & Aguiar 2008; *Festuco amplae-Brachypodietum phoenicoidis* S. Ribeiro, Ladero & Espírito-Santo 2013; *Ficario ranunculoidis-Fraxinetum angustifoliae* Rivas-Martínez & Costa in Rivas-Martínez, Costa, Castroviejo & E. Valdés 1980; *Frangulo alni-Prunetum lusitanicae* C. Lopes, J.C. Costa, Lousã & Capelo in J.C. Costa, C. Lopes, Capelo & Lousã 2000; *Fraxino angustifoliae-Ulmetum glabrae* Monteiro-Henriques, J.C. Costa & A. Bellu 2011; *Galio concatenati-Brachypodietum phoenicoidis* Pinto-Gomes & P. Ferreira 2005; *Galio parisiensis-Logfietum minimae* Izco & Ortiz 1985; *Holco mollis-Quercetum pyrenaicae* Br.-Bl., P. Silva & Rozeira 1955; *Hyacinthoido transtaganae-Brachypodietum phoenicoidis* Raposo, Mendes, Cano-Ortíz & Pinto-Gomes 2016; *Hyperico androsaemi-Quercetum roboris* Honrado, Rocha, P. Alves & B. Caldas in Honrado, P. Alves, Nepomuceno & B. Caldas 2002; *Laserpitio eliasii-Coryletum avellanae* Puente, M.J. López, Penas & F. Salegui 2002; *Lavandulo viridis-Cytisetum striati* Pinto-Gomes, Cano-Ortiz, Quinto-Canas, Vila-Viçosa & Martínez-Lombardo 2012; *Linario triornithophorae-Coryletum avellanae* R. Alonso, Puente, Penas & F. Salegui 2002; *Lonicero hispanicae-Rubetum ulmifolii* Rivas-Martínez, Costa, Castroviejo & Valdés 1980; *Lonicero implexae-Quercetum rotundifoliae* Lousã, Espírito Santo & J.C. Costa 1994; *Omphalodo nitidae-Coryletum avellanae* Amigo, G. Azcárate & Romero 1994; *Omphalodo nitidae-Fraxinetum angustifoliae* Monteiro-Henriques, J.C. Costa, A. Bellu, Aguiar & Portela Pereira 2012; *Omphalodo nitidae-Linarietum triornithophorae* Rivas-Martínez in Rivas-Martínez, T.E. Díaz, F. Prieto, Loidi & Penas 1984; *Osmundo regalis-Alnion glutinosae* (Br.-Bl., P. Silva & Rozeira 1956) Dierschke & Rivas-Martínez in Rivas-Martínez 1975; *Phlomido lychnitidis-Brachypodietum phoenicoidis* Br.-Bl., P. Silva & Rozeira 1955; *Pruno lusitanicae-Arbutetum unedonis* (Aguiar & Capelo 1995) J.C. Costa, Capelo & Lousã in J.C. Costa, C. Lopes, Capelo & Lousã 2000; *Pterosparto lasianthi-Ericetum cinereae* Rothmaler 1954 corr. Rivas-Martínez, T.E. Díaz, Fernández González, Izco, Loidi, Lousã & Penas 2002; *Pyro bourgaeanae-Quercetum rotundifoliae* Rivas-Martínez 1987; *Quercetea ilicis* Br.-Bl. ex A. & O. Bolòs 1950; *Rubo vigoi-Sambucetum nigrae* V. Silva & Pinto-Cruz in V. Silva, Portela-Pereira, J.C. Costa, Arsénio, Monteiro-Henriques, Neto & Pinto-Cruz 2012; *Rusco aculeati-Quercetum roboris* Br.-Bl., P. Silva & Rozeira 1955 in Amigo, Izco, J. Guitián & Romero 1998; *Saxifrago spathularidis-Betuletum celtibericae* Rivas-Martínez 1981; *Scrophulario scorodoniae-Alnetum glutinosae* Br.-Bl., P. Silva & Rozeira 1955; *Smilaco asperae-Quercetum suberis* Pinto-Gomes, Ladero, P. Gonçalves, S. Mendes & M.C. Lopes 2004; *Teucrio salviastri-Quercetum rotundifoliae* Pinto-Gomes, Ladero, Cano, Meireles, Aguiar & P. Ferreira 2010; *Teucrio salviastri-Quercetum suberis* C. Meireles, P. Ferreira, Passos, Vila-Viçosa & Pinto-Gomes in Pinto-Gomes, P. Ferreira & Meireles 2007; *Ulici latebracteati-Cytisetum striati* Rivas-Martínez ex J.C. Costa, Izco, Lousã, Aguiar & Capelo in J.C. Costa, Capelo, Lousã, Antunes, Aguiar, Izco & Ladero 2000; *Vaccinio myrtil-*

li-Quercetum roboris P. Silva, Rozeira & Fontes 1950 corr. Br.-Bl., P. Silva & Rozeira 1955; *Viburno tini-Quercetum broteroanae* (Br.- Bl., P. Silva & Rozeira 1955) J.C. Costa, Capelo, Honrado, Aguiar & Lousã 2002 corr. J.C. Costa & Monteiro-Henriques 2012.

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Appendixes

Appendix I – Sporadic species

Table 2 - + *Quercus suber* in rel. 4; + *Prunella vulgaris*, *Ilex aquifolium* and *Prunus lusitanica* in rel. 5.

Table 4 - + *Salix atrocinerea* in rel. 1; + *Ilex aquifolium* and *Chrysosplenium oppositifolium* in rel. 3.

Table 6 - + F*rangula alnus, Rosa pouzinii* and *Pyrus cordata* in rel 1; + *Osmunda regalis* in rel. 2; + *Laurus nobilis, Luzula henriquesii, Chelidonium majus, Fragaria vesca, Urtica dioica* and *Omphalodes nitida* in rel. 3.

Table 8 - + *Rosa* sp. in rel 1; + B*ryonia dioica, Chelidonium majus* and *Fumaria officinalis* in rel. 2; 2 *Andryala integrifolia*, + *Silene latifolia* and *Lamium maculatum* in rel. 4; + *Agrimonia eupatoria, Anogramma leptophylla, Erica cinerea, Phillyrea angustifolia* and *Halimium alyssoides* in rel. 5; 1 *Ulmus glabra*, + *Scrophularia grandiflora, Polypodium cambricum*, *Corylus avellana* and *Luzula henriquesi* in rel. 7; 1 A*sphodelus ovoides, Anthoxanthum odoratum*, + *Fraxinus angustifolia, Dactylis lusitanica, Brachypodium sylvaticum, Galium helodes, Origanum virens and Peucedanum officinale* in rel. 8; + A*cacia dealbata, Fraxinus angustifolia* and *Scrophularia scorodonia* in rel. 9; + *Geranium robertianum, Vincetoxicum nigrum* and *Daphne gnidium* in rel. 11.

Appendix II – Relevès localities

Table 2 - Rel. 1: Casas Figueira (Vide, Seia); rel. 2: Cebeça (Seia); rel. 3: Ceiroco (Pampilhosa da Serra); rel. 4: Balocas (Vide, Seia); rel. 5: Mata da Margaraça (Arganil).

Table 4 - Rel. 1: Casarias (Serra do Açor); rel. 2: Enxudro (Arganil); rel. 3: Mata da Margaraça (Arganil).

Table 6 - Rel. 1: Ribeira da Caniçada (Lapa dos Dinheiros, Seia); rel. 2: Cascata da Forja (Vide, Seia); rel. 3: Mata da Margaraça (Serra do Açor).

Table 8 - Rel. 1: Mosteiro (Viseu); rel. 2: Picão (Viseu); rel. 3: Cabeça (Seia); rel. 4: Mata do Bugalhão (Castro Daire); rel. 5: São Romão (Seia); rel. 6: Cerdeira (Lousã); rel. 7: Mata da Margaraça (Arganil); rel. 8: Mata do Bugalhão (Castro Daire); rel. 9: Alcaide (Fundão); rel. 10: Sra. do Souto (Fundão); rel. 11: Donas (Fundão).