

A phytosociological study of the deciduous oak woods of Sardinia (Italy)

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Abstract

We present here the results from a phytosociological and synchronological study of the deciduous oak woods of Sardinia. This vegetation analysis has allowed the individuation of three new associations: *Lonicero implexae-Quercetum virgiliana*, *Ornithogalo pyrenaici-Quercetum ichnusae* and *Glechomo sardoae-Quercetum congestae*. The *Lonicero implexae-Quercetum virgiliana* association includes the woods on calcareous substrata spread throughout Northern Sardinia, which can occasionally be found in southern areas; the first of these are rich in mesophilous species and are attributed to the subassociation *cyclaminetosum repandi*, while the others are referred to *quercetosum virgiliana*. The *Ornithogalo pyrenaici-Quercetum ichnusae* association, more widely distributed in Central-Northern Sardinia, includes the climatophilous deciduous woods that are found on lithological substrata of a non-carbonatic nature, and in particular, on andesites, trachytes and metarenites. The typical aspect is referred to the subassociation *cytisetosum villosi*, while the subassociation *ilicetosum aquifolii* includes the more mesophilous woods on basaltic substrata. The *Glechomo sardoae-Quercetum congestae* association always includes the woods found on the non-carbonatic substrata in the higher altitude areas with an oceanic pluviaseasonal temperate bioclimate. Of this, the subassociation *quercetosum congestae*, on the granite areas, and *oenanthesosum pimpinelloidis*, on those metamorphic and of basalt, are proposed. At the higher hierarchical levels, the association *Lonicero implexae-Quercetum virgiliana* is referred to the endemic Sardinian-Corsican suballiance *Clematido cirrhosae-Quercenion ilicis*, of the alliance *Fraxino orni-Quercion ilicis*, while for the other associations the new suballiance *Paeonio morisii-Quercenion ichnusae*, (holotypus: *Glechoma sardoae-Quercetum congestae* ass. nova) particular to the Sardinian biogeographic subprovince, is proposed, of the alliance *Pino calabricae-Quercion congestae*, the order *Quercetalia pubescenti-petraeae*, and the class *Quercu roboris-Fageteta sylvatica*.

Key words: deciduous oak woods, *Paeonio morisii-Quercenion ichnusae*, phytosociology, *Quercetia ilicis*, *Quercu roboris-Fageteta sylvatica*, Sardinia, synchronology, syntaxonomy.

Riassunto

Studio fitosociologico dei querceti caducifogli della Sardegna (Italia). Vengono presentati i risultati di uno studio fitosociologico e sincronologico riguardante i querceti caducifogli della Sardegna. L'analisi della vegetazione ha permesso di individuare tre nuove associazioni denominate: *Lonicero implexae-Quercetum virgiliana*, *Ornithogalo pyrenaici-Quercetum ichnusae* e *Glechomo sardoae-Quercetum congestae*. L'associazione *Lonicero implexae-Quercetum virgiliana* si riferisce ai boschi dei substrati calcarei diffusi nella Sardegna settentrionale e che risultano sporadici in quella meridionale, i primi, ricchi di specie mesofile, vengono attribuiti alla subassociazione *cyclaminetosum repandi* mentre gli altri alla *quercetosum virgiliana*. L'associazione *Ornithogalo pyrenaici-Quercetum ichnusae*, a più ampia diffusione nella Sardegna centro-settentrionale, si riferisce ai boschi caducifogli climatofili che si rinvengono su substrati litologici di natura non carbonatica, ed in particolare su andesiti, trachiti e metarenarie. L'aspetto tipico viene riferito alla subassociazione *cytisetosum villosi* mentre la subassociazione *ilicetosum aquifolii* si riferisce ai boschi più mesofili su substrati basaltici. L'associazione *Glechomo sardoae-Quercetum congestae* si riferisce sempre a boschi che vegetano su substrati non carbonatici nelle zone più elevate con bioclimate temperato pluvistagionale oceanico. Di questa vengono proposte le subassociazioni *quercetosum congestae*, delle zone granitiche ed *oenanthesosum pimpinelloidis* per quelle metamorfiche e basaltiche.

Ai livelli gerarchici superiori l'associazione *Lonicero implexae-Quercetum virgiliana* viene riferita alla suballeanza, endemica sardo-corsa, *Clematido cirrhosae-Quercenion ilicis* dell'alleanza *Fraxino orni-Quercion ilicis*, mentre per le altre associazioni viene proposta la nuova suballeanza *Paeonio morisii-Quercenion ichnusae*, (holotypus: *Glechoma sardoae-Quercetum congestae* ass. nova) propria della subprovincia biogeografica Sarda, dell'alleanza *Pino calabricae-Quercion congestae*, ordine *Quercetalia pubescenti-petraeae* e classe *Quercu roboris-Fageteta sylvatica*.

Parole chiave: fitosociologia, *Paeonio morisii-Quercenion ichnusae*, *Quercetia ilicis*, querceti caducifogli, *Quercu roboris-Fageteta sylvatica*, Sardegna, sincronologia, sintassonomia.

Introduction

We present here a phytosociological study of the deciduous oak woods present in Sardinia, studies of which have previously progressed slowly mainly due to the uncertainties of the taxonomy of the deciduous oaks of the island, and more in general of

Submediterranean and Mediterranean Italy. In the past, and particularly in the second half of the 1800s, various authors studied the deciduous oaks, and in Sardinia three *taxa* were identified (Bertoloni, 1854; Moris, 1858-59; De Candolle, 1864; Parlatore, 1867; Barbey, 1885; Arcangeli, 1894; Fiori, 1898, 1925; Borzì, 1911): *Quercus pubescens* Willd., *Q. robur* L. (sub *Q. robur*

ssp. *pedunculata* DC.) and *Q. petraea* (Matt.) Liebl. (sub *Q. sessiliflora* Salisb.). Since then, in publishing the results of a critical revision using herbarium samples, Schwarz (1936-1937) recognised for Sardinia the exclusive presence of *Q. virgiliana* (Ten.) Ten. and of *Q. congesta* C. Presl. in J. et C. Presl. These conclusions were also later confirmed by numerous authors (Jalas & Suominen, 1976; Pignatti, 1982; Camarda & Valsecchi, 1983; Greuter *et al.*, 1984-89; Camarda, 1988; Schwarz, 1993), some of which indicated for this island also the presence of *Q. pubescens* Willd. Recently, Mossa *et al.* (1998; 1999) confirmed the presence in Sardinia of *Q. virgiliana* and *Q. congesta*, excluding however the presence of *Q. pubescens*, *Q. robur* and *Q. petraea*; moreover, they noted the presence of *Q. amplifolia* Guss. and *Q. dalechampii* Ten., and they described the new species *Q. ichnusae* Mossa, Bacchetta & Brullo. In contrast, Camarda (2003) attributes all of the Sardinian deciduous oak populations to *Q. pubescens* Willd. s.l.

The phytosociological study of the Sardinian deciduous oak vegetation has stimulated further interest: Camarda, 1977; Arrigoni & Marras, 1990; Arrigoni *et al.*, 1996; Pignatti, 1998; Ubaldi, 2003. In particular, Arrigoni & Marras (1990) referred the coppice woods of chestnut of Central-Eastern Sardinia to the association *Luzulo-Oenanthetum pimpinelloidis* Arrigoni in Arrigoni & Marras 1990 *castanetosum* Arrigoni in Arrigoni & Marras 1990. Later, this association was corrected to *Oenantho pimpinelloidis-Castaneetum sativae* Arrigoni in Arrigoni & Marras 1990 *corr.* Arrigoni in Arrigoni, Di Tommaso, Camarda & Satta 1996 (Arrigoni *et al.*, 1996), within which, besides the subassociation *typicum castaneetosum sativae* Arrigoni in Arrigoni & Marras 1990, the subassociation *quercetosum pubescentis* Arrigoni, Di Tommaso, Camarda & Satta 1996 was also proposed. Following on from this, Ubaldi (2003) used the association *Oenantho pimpinelloidis-Castaneetum sativae* as *typus* of the Sardinian suballiance *Oenantho pimpinelloidis-Quercenion humilis* Ubaldi 2003, which includes the Sardinian deciduous phytocoenoses within the Western European alliance *Quercion humili-petraeae* Br.- Bl. 1932.

Nevertheless, there still exist phytosociological, phytogeographic and nomenclature problems, which we consider in the present study, regarding the wood formations dominated by deciduous oaks, for which a syntaxonomic autonomy has never been recognised. All of the phytocoenoses investigated have generally been described as subassociations of mesophilous woods of

holm oak (Mossa, 1987) or chestnut (Arrigoni *et al.*, 1996); moreover, also the higher units of reference for the Sardinian deciduous communities have been considered in different ways according to different authors (Arrigoni *et al.*, 1996; Pignatti, 1998; Ubaldi, 2003).

Materials and Methods

This vegetation analysis was performed according to the phytosociological method of the Sigmattist school of Zurich-Montpellier (Braun-Blanquet, 1951). Bioclimatic investigation has been conducted following the world bioclimatic classification by Rivas-Martínez *et al.* (1999; 2002), on the basis of the thermo-pluviometric data of the stations present in the study area. Results obtained allowed to determinate bioclimate, bioclimatic variants and phytoclimatic belts for the described coenoses. For the phytosociological nomenclature, reference has been made to the third edition of the International Code of Phytosociological Nomenclature (Weber *et al.*, 2000), while for that taxonomic, the following have been used: “Med-Checklist” (Greuter *et al.*, 1984-89), “*Flora Europaea*” (Tutin *et al.*, 1964-80; 1993), “*Flora d’Italia*” (Pignatti, 1982) and “*Le piante endemiche della Sardegna*” (Arrigoni *et al.*, 1977-1991). Furthermore, for the genus *Quercus* L., the proposals of Mossa *et al.* (1998; 1999) have been followed, and for the genus *Paeonia* L., reference has been made to Cesca *et al.* (2001). For the abbreviations of the authors, the work of Brummit & Powell (1992) has been followed. The biological form, on the basis of the classification of Raunkiaer (1934), has been directly verified in the field, and expressed according to the abbreviations of Pignatti (1982).

Results

The analysis of the relevées taken in the various regions of Sardinia (Fig. 1) has allowed the recognition of three associations, within which six subassociations are recognised. These associations, differentiated from the floristic, structural, synecological and synchronological points of view, are: *Lonicero implexae-Quercetum virgilianae* ass. nova, *Ornithogalo pyrenaici-Quercetum ichnusae* ass. nova and *Glechomo sardoae-Quercetum congestae* ass. nova.

1. *LONICERO IMPLEXAE-QUERCETUM VIRGILIANAE* ass. nova hoc loco (holotypus rel. no. 3, Tab. 1).

1a. *quercetosum virgilianae* subass. nova hoc loco (holotypus rel. no. 3, Tab. 1); Tab. 1, rels. 1-5.

1b. *cyclaminetosum repandi* subass. nova hoc loco (holotypus rel. no. 7, Tab. 1); Tab. 1, rels. 6-8.

To this association are referred the woods found on lithological substrata of a carbonatic nature, and in particular on limestones and Miocene marls, on slope deposits and sometimes on detritus layers, with soils from subalkaline to neutral, deep, at altitudes between 180 and 300 m, on north-facing aspects and with a variable slopes between 5° and 40°. This is an endemic Sardinian association that is spread through the north-western parts of the island and in the region of the Marmilla in the south (Fig. 2). They are micro-

mesowoods dominated by deciduous broad-leaved trees and secondarily by sclerophylls, of heights between 5 and 13 m, with a shrubby layer of medium coverage and a herbaceous layer of mainly scapose or caespitose hemicryptophytes and bulb geophytes. From the bioclimate point of view, they are found in oceanic pluviseasonal Mediterranean macrobioclimate, in thermotypic and ombrotypic conditions between the lower upper subhumid thermomediterranean and the upper lower subhumid mesomediterranean. They have a bioclimate optimum in the upper lower subhumid mesomediterranean belt.

The mesophilous woods found on the Miocene limestones of Anglona, Sassarese and Mejlogu, in ravines or narrow enclosed valleys, at altitudes between 300 and 350 m, on northern exposures, in shallow soils, are referred to the subassociation *cyclaminetosum*

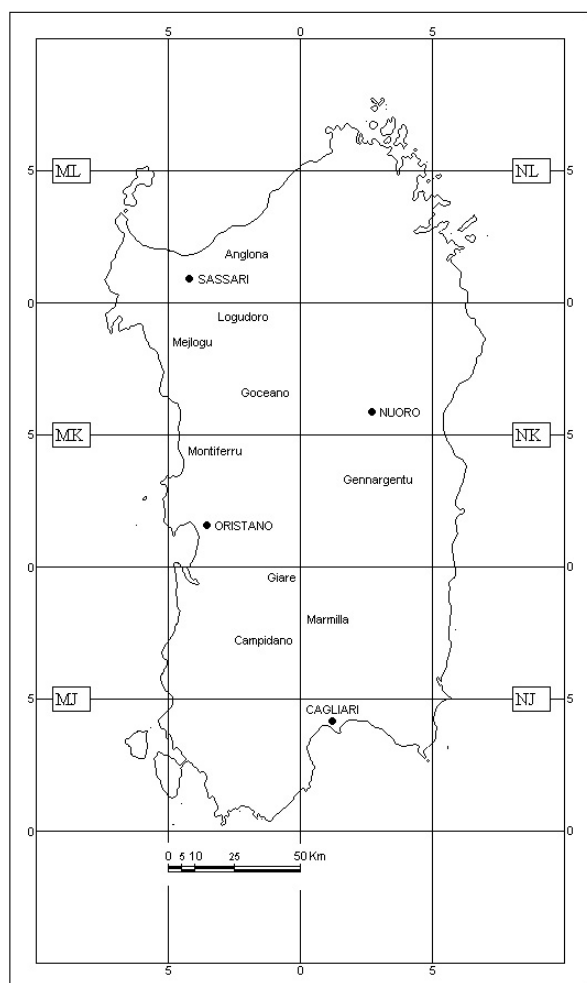


Fig. 1 - Index map of the area under study

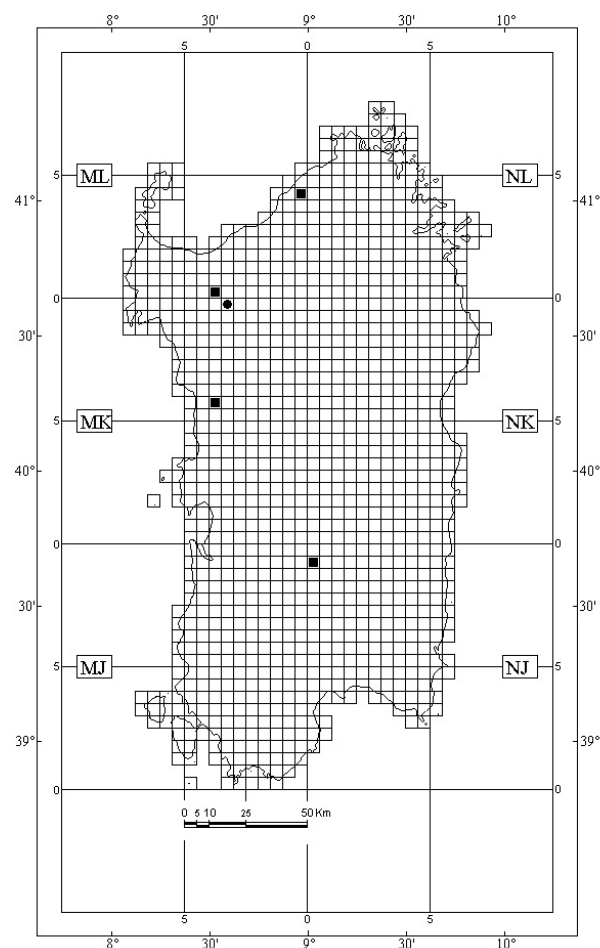


Fig. 2 - Relevés location of *Lonicero implexae-Quercetum virgilianae* (*quercetosum virgilianae* = ■; *cyclaminetosum repandi* = ●)

Tab. 1 - *Lonicera implexae-Quercetum virgiliana* ass. nova (holotypus ril. n. 3)
quercetosum virgiliana subass. nova (holotypus ril. n. 3)
cyclaminetosum repandi subass. nova (holotypus ril. n. 7)

Rel. n.	1	2	3*	4	5	6	7*	8	P
Altitude (m s.l.m.)	300	180	250	185	300	300	300	350	R
Exposure	NNE	ENE	N	W	N	NE	N	NNE	E
Slope (°)	5	5	20	5	40	15	30	5	S.
Substratum (Cal=Calcareous, All=Alluvial)	Cal	All	Cal	All	Cal	Cal	Cal	Cal	
Area (mq)	200	100	120	50	60	100	100	80	
Coverage (%)	90	100	100	90	100	100	90	80	
Average vegetation height (m)	9	10	9	7	5	9	6	13	
Species number	22	13	30	13	23	32	23	23	
Charact. and diff. taxa of the ass.									
P scap	<i>Quercus virgiliana</i> (Ten.) Ten.	4	4	5	5	4	4	4	8
P lian	<i>Rosa sempervirens</i> L.	2	+	2	+	+	1	1	8
P caesp	<i>Pistacia lentiscus</i> L.	.	1	.	1	1	1	+	6
P lian	<i>Lonicera implexa</i> Aiton	.	.	1	+	1	1	+	6
Diff. taxa of the <i>quercetosum virgiliana</i> subass.									
P scap	<i>Olea europaea</i> L. var. <i>sylvestris</i> Brot.	+	.	1	+	.	.	.	3
G bulb	<i>Allium subhirsutum</i> L.	.	+	2	+	.	.	.	3
G rhiz	<i>Arisarum vulgare</i> Targ.-Tozz.	.	.	2	.	2	1	.	3
H caesp	<i>Ampelodesmos mauritanicus</i> (Poiret) Dur. et Asch.	.	3	.	2	.	.	.	2
H caesp	<i>Oryzopsis miliacea</i> (L.) Asch. et Schweinf.	.	.	2	.	+	.	.	2
Diff. taxa of the <i>cyclaminetosum repandi</i> subass.									
G bulb	<i>Cyclamen repandum</i> Sibth. et Sm.	.	.	.	.	.	2	2	2
P lian	<i>Hedera helix</i> L. ssp. <i>helix</i>	.	.	.	.	.	2	1	1
P lian	<i>Clematis vitalba</i> L.	.	.	.	.	.	1	+	1
NP	<i>Euphorbia characias</i> L.	.	.	.	.	.	1	1	1
H ros	<i>Viola alba</i> Besser ssp. <i>dehnhardtii</i> (Ten.) W. Becker	.	.	.	.	.	.	+	1
H scap	<i>Ranunculus bulbosus</i> L. ssp. <i>aleae</i> (Willk.) Rouy et Fouc.	.	.	.	.	.	+	1	1
P caesp	<i>Viburnum tinus</i> L.	.	.	.	.	.	2	+	+
P scap	<i>Quercus ilex</i> L.	.	.	.	.	.	1	+	.
H scap	<i>Calamintha nepeta</i> (L.) Savi ssp. <i>glandulosa</i> (Req.) P. Ball	.	.	.	.	.	.	+	+
Charact. and diff. taxa of the <i>Clematido cirrhosae-Quercenion ilicis</i> all.									
G rad	<i>Tamus communis</i> L.	+	.	2	.	.	+	.	3
NP	<i>Cistus creticus</i> L. ssp. <i>eriocephalus</i> (Viv.) Greuter et Burdet	.	.	.	.	2	.	.	1
P scap	<i>Fraxinus ornus</i> L.	2	.	.	.	.	.	.	1
G rhiz	<i>Arum pictum</i> L. fil. ssp. <i>pictum</i>	+	.	.	.	.	.	.	1
P lian	<i>Clematis cirrhosa</i> L.	.	.	+	.	.	.	.	1
Charact. and diff. taxa of the upper units									
G rhiz	<i>Asparagus acutifolius</i> L.	2	2	2	1	+	1	+	1
P lian	<i>Rubia peregrina</i> L.	1	1	2	1	+	+	1	1
P lian	<i>Smilax aspera</i> L.	2	+	2	.	1	1	1	1
G rhiz	<i>Ruscus aculeatus</i> L.	1	.	1	+	.	+	1	+
NP	<i>Osyris alba</i> L.	.	1	3	2	2	+	+	+
H caesp	<i>Stipa bromioides</i> (L.) Dörfler	.	.	.	.	+	2	1	3
P caesp	<i>Rhamnus alaternus</i> L.	.	+	.	+	.	2	.	3
H caesp	<i>Carex distachya</i> Desf.	2	+	.	.	.	1	.	+
P scap	<i>Phillyrea latifolia</i> L.	+	.	.	.	.	.	.	1
P caesp	<i>Daphne gnidium</i> L.	.	.	.	.	1	.	.	1
P caesp	<i>Anagyris foetida</i> L.	.	.	.	.	.	1	.	1
H ros	<i>Asplenium onopteris</i> L.	.	.	.	.	.	+	.	1
H caesp	<i>Melica arrecta</i> O. Kuntze	.	.	.	.	.	1	.	1
Charact. taxa of the <i>Quercu roboris-Fagetea sylvatica</i> class									
H caesp	<i>Brachypodium sylvaticum</i> (Hudson) Beauv.	+	.	2	.	.	.	1	1
G rhiz	<i>Arum italicum</i> Mill.	.	.	2	.	2	1	.	3
G bulb	<i>Ranunculus ficaria</i> L. ssp. <i>ficaria</i>	.	.	.	.	.	.	1	+
H scap	<i>Prunella vulgaris</i> L.	+	.	.	.	.	.	.	1
H scap	<i>Oenanthe pimpinelloides</i> L.	.	.	1	.	.	.	.	1
H scap	<i>Ranunculus lanuginosus</i> L.	.	.	1	.	.	.	.	1
Other species									
P caesp	<i>Spartium junceum</i> L.	.	.	1	.	1	+	+	.
NP	<i>Rubus</i> gr. <i>ulmifolius</i> Schott	2	.	.	.	.	.	+	+
P caesp	<i>Crataegus monogyna</i> Jacq. ssp. <i>monogyna</i>	2	.	.	.	.	+	.	+
G bulb	<i>Allium triquetrum</i> L.	.	.	1	.	+	2	.	3
P caesp	<i>Prunus spinosa</i> L.	2	.	+	.	.	.	.	3
NP	<i>Cistus salvifolius</i> L.	.	+	.	+	.	.	.	2
H bienn	<i>Smyrniolum rotundifolium</i> Mill.	.	+	1	.	.	.	.	2
H caesp	<i>Dactylis hispanica</i> Roth	.	.	.	.	1	+	.	2
G bulb	<i>Anemone hortensis</i> L.	.	.	.	.	2	+	.	2
H caesp	<i>Brachypodium retusum</i> (Pers.) Beauv.	.	.	.	.	2	.	.	1
T scap	<i>Vicia sativa</i> L.	.	.	.	.	1	.	.	1
Accidental species									
		5	0	8	0	3	1	0	0

repandi. These are micro-mesowoods dominated by deciduous broad-leaved trees and secondarily by lauriphylls and sclerophylls, of heights between 6 and 13 m, with a dense shrubby layer and a reduced herbaceous layer of mainly hemicryptophytes. These formations have a bioclimate optimum in the upper lower subhumid mesomediterranean belt.

With respect to the other Sardinian associations presented here, species of the class *Quercetea ilicis* are differential for this association, such as: *Quercus virgiliana*, *Rosa sempervirens*, *Asparagus acutifolius*, *Rubia peregrina*, *Smilax aspera*, *Ruscus aculeatus*, *Osyris alba*, *Pistacia lentiscus*, *Lonicera implexa* and *Rhamnus alaternus*.

The subassociation *cyclaminetosum repandi* is differentiated from the subassociation *typicum quercetosum virgilianae* by the greater structural complexity, the localisation to narrow valleys, the presence of *Cyclamen repandum*, *Hedera helix* ssp. *helix*, *Clematis vitalba*, *Calamintha nepeta* ssp. *glandulosa*, *Ranunculus bulbosus* ssp. *aleae* and *Stipa bromoides*, and the high frequency of *Euphorbia characias*, *Quercus ilex* and *Viburnum tinus*.

These oak woods represent the head of a subhumid thermo-mesomediterranean, calcicole mesophilous special series of Sardinia. From the chain point of view, contacts are evident with the thermo-mesomediterranean, calcicole climatophilous microwoods of the *Prasio majoris-Quercus ilicis* Σ and with the thermo-mesomediterranean edaphoxerophilous microwoods of the *Oleo sylvestris-Junipero turbinatae* Σ in Southern Sardinia.

The phytocoenosis has many structural, floristic and ecological analogies with the association *Oleo-Quercetum virgilianae* Brullo 1984 of Sicily, from which it can be distinguished by the absence of *Teucrium fruticans* L., *Chamaerops humilis* L., *Ceratonia siliqua* L., *Asparagus albus* L. and *Calicotome infesta* (C. Presl) Guss. (Brullo, 1984; Brullo & Marcenò, 1985).

2. ORNITHOGALO PYRENAICI-QUERCETUM ICHNUSAE ass. nova hoc loco (holotypus rel. no. 13, Tab. 2).

2a. *cytisetosum villosi* subass. nova hoc loco (holotypus rel. no. 13, Tab. 2); Tab. 2, rels. 8-26.

2b. *ilicetosum aquifolii* subass. nova hoc loco (holotypus rel. no. 5, Tab. 2); Tab. 2, rels. 1-7.

To this association are referred the climatophilous deciduous woods found on lithological substrata of a non-carbonatic nature, and in particular on andesites,

trachytes and metarenites in Central-Northern Sardinia (Fig. 3). These are micro-mesowoods dominated by deciduous and semideciduous broad-leaved trees, with variable heights between 6 and 18 m, with a sparse shrubby layer and a herbaceous layer of mainly scapose and caespitose hemicryptophytes and bulb geophytes. They generally grow on slope deposits and detritus layers, sometimes in colluvial places, preferring northern exposures and slight slopes between 5° and 30°. The soils on which they grow are from subacid to neutral, deep, with a limited skeleton, with slow drainage and a medium humus content. From the bioclimatic point of view, they are found in an oceanic, pluvisesonal Mediterranean macrobioclimate, in thermotypic and ombrotypic conditions between the lower lower-subhumid mesomediterranean and lower upper-humid mesomediterranean belt. They have a

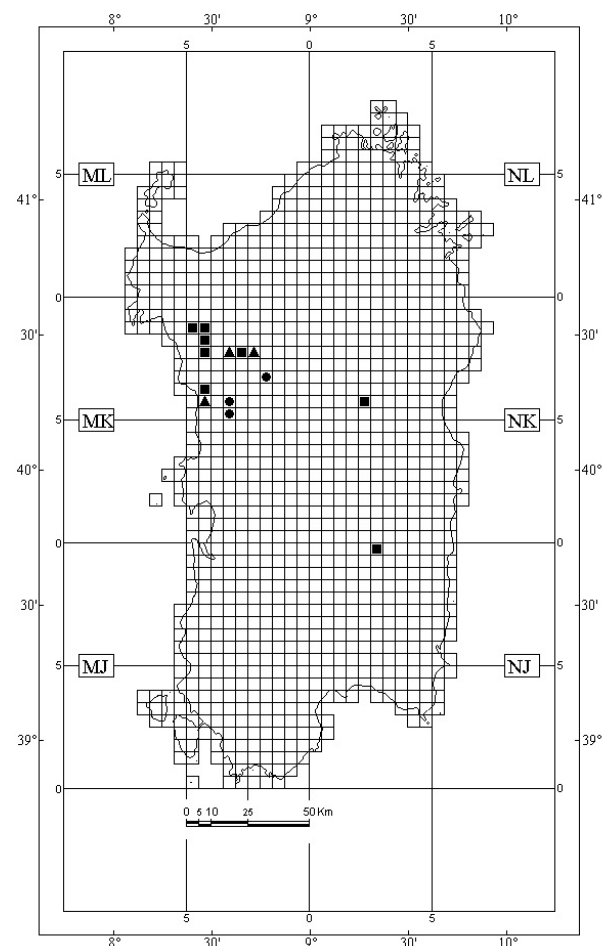


Fig. 3 - Releves location of *Ornithogalo pyrenaici-Quercetum ichnusae* (*cytisetosum villosi* = ■; *ilicetosum aquifolii* = ●; *Fraxinus ornus* variant = ▲)

Tab. 2 - *Ornithogalo pyrenaeici-Quercetum ichnusae* ass. *nova* (*holotypus* ril. n. 13)
cylisetosum villosi subass. *nova* (*holotypus* ril. n. 13)
ilicetosum aquifolii subass. *nova* (*holotypus* ril. n. 5)
Fraxinus ornus variant

	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
Rel. n.	755	750	955	720	740	700	700	450	400	400	560	740	400	650	650	600	750	280	300	650	380	400	490	500	280	200
Altitude (m s.l.m.)	SSW	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE
Exposure	Bas	Bas	Bas	Bas	Bas	Bas	Bas	Tra	Tra	Tra	Ton	Meta	Tra	And	And	Ctra	Ctra	Ctra	Ctra	Ctra	Tra	Tra	Tra	Ctra	Ctra	Ctra
Slope (°)	5	5	5	0	0	0	0	25	5	10	20	30	5	10	0	<5	5	15	5	25	5	5	0	10	20	10
Substratum(And=Andesite,Bas=Basalt,Ctra=trachyte colluvium,Meta=crystal sandstone,Tra=trachyte)	200	400	300	200	200	100	200	150	100	100	200	200	200	50	200	200	80	100	100	200	200	200	60	100	100	100
Area (mq)	100	100	100	100	95	100	100	80	100	90	100	90	95	100	100	100	100	80	100	100	100	100	90	90	100	90
Coverage (%)	16	18	18	15	12	15	8	8	6	8	10	8	12	8	8	8	10	6	6	6	12	10	6	7	7	8
Average vegetation height (m)	20	28	24	27	29	27	32	20	24	31	23	23	24	24	27	19	15	21	26	33	33	26	20	21	31	20
Species number	5	5	4	4	5	3	5	4	4	4	4	4	5	4	4	4	4	4	3	4	4	4	4	4	4	3
Charact. and diff. taxa of the subass., ass., subail.* and ail.**																										
<i>Quercus ichnusae</i> Mossa, Bacchetta et Brullo*																										
<i>Oenanthe pimpinelloides</i> L.*																										
<i>Ornithogalum pyrenaeicum</i> L.*																										
<i>Quercus dalechampii</i> Ten.**																										
<i>Clematis vitalba</i> L.																										
<i>Cyclamen repandum</i> Sibth. et Sm.																										
<i>Ranunculus bulbosus</i> L. ssp. <i>aleae</i> (Willk.) Rouy et Fouc.																										
<i>Ranunculus rotundifolium</i> Mill.																										
<i>Smyrnium olusatrum</i> L.																										
<i>Alex aquifolium</i> L.																										
<i>Teucrium scorodonia</i> L.																										
<i>Sonchula europaea</i> L.																										
<i>Mycelis muralis</i> (L.) Dumort.																										
<i>Poa nemoralis</i> L.																										
<i>Ranunculus ficaria</i> L. ssp. <i>ficaria</i>																										
<i>Maltha sylvestris</i> (L.) Mill.																										
<i>Cephalanthus longifolia</i> (L.) Fritsch																										
<i>Quercus congesta</i> C. Presl in J. et C. Presl**																										
<i>Cytisus villosus</i> Pourret**																										
<i>Rosa sempervirens</i> L.																										
<i>Asplenium onopteris</i> L.																										
<i>Carex divulsa</i> Stokes																										
<i>Allium subirsutum</i> L.																										
<i>Holcus lanatus</i> L.																										
<i>Pulicaria odorata</i> (L.) Rechb.																										
<i>Quercus suber</i> L.																										
<i>Tamus communis</i> L.																										
<i>Asparagus acutifolius</i> L.																										
<i>Galium scabrum</i> L.																										
<i>Melica arrecta</i> O. Kuntze																										
<i>Arbutus unedo</i> L.																										
Diff. species of the variant																										
<i>Fraxinus ornus</i> L.																										
	2 1 + 1																									
	7																									
Charact. taxa of the <i>Quercus roboris-Fageteta sylvaticae</i> class																										
<i>Hedera helix</i> L. ssp. <i>helix</i>																										
<i>Luzula forsteri</i> (Sm.) DC.																										
<i>Viola alba</i> Besser ssp. <i>dehnhardtii</i> (Ten.) W. Becker																										
<i>Brachypodium sylvaticum</i> (Hudson) P. Beauv.																										

bioclimatic optimum in the upper subhumid-upper mesomediterranean belt. They grow between 200 and 955 m of altitude.

The climatophilous woods that are found on basalts in the areas of Montiferru and Monte San Antonio (Central-Western Sardinia), with a shallow incline (5°), on deep soils with little drainage, are referred to the subassociation *ilicetosum aquifolii subass. nova*. These are mesowoods dominated by deciduous broad-leaved trees and lauriphylls, of variable heights between 8 and 18 m, with a sparse shrubby layer and a herbaceous layer of mainly hemicryptophytes, that grow between 700 and 955 m of altitude. This subassociation has a bioclimate optimum in the lower upper-humid mesomediterranean belt.

Finally, the climatophilous woods that are found on the trachytes and andesites of Logudoro-Mejlogu, in colluvial places, with a preferred northern exposure and little or no slope (10° to 20°) are referred to the *Fraxinus ornus* variant. These are microwoods dominated by deciduous broad-leaved trees, of variable heights between 6 and 12 m, with sparse shrubby and herbaceous layers. From the bioclimatic point of view, they have an optimum in the lower lower-subhumid mesomediterranean belt. They grow between 200 and 650 m of altitude.

With respect to the other Sardinian associations presented here, this association is differentiated by: *Quercus ichnusa*, *Q. dalechampii*, *Q. suber* and *Ornithogalum pyrenaicum*. The high frequency taxa are: *Hedera helix* ssp. *helix*, *Luzula forsteri*, *Viola alba* ssp. *dehnhardtii*, *Brachypodium sylvaticum*, *Clematis vitalba*, *Q. ilex*, *Rubia peregrina*, *Carex distachya*, *Rubus* gr. *ulmifolius*, *Crataegus monogyna*, *Pteridium aquilinum*, and *Clinopodium vulgare* ssp. *arundanum*.

With respect to the subassociation typicum *cytisetosum villosi*, the *ilicetosum aquifolii* subassociation is differentiated by the greater structural complexity and by the presence of *Ilex aquifolium*, *Teucrium scorodonia*, *Sanicula europaea*, *Poa nemoralis*, *Q. congesta* and *Malus sylvestris*, and by the high frequency of *Clematis vitalba*, *Ranunculus ficaria* ssp. *ficaria* and *Rosa canina*. The *Fraxinus ornus* variant is differentiated by the lesser structural complexity, the localisation to more thermophilic and continental areas, and by the presence of *Fraxinus ornus*, *Pulicaria odora*, *Galium scabrum* and *Phalaris bulbosa*.

These oak woods represent the head of the subhumid Mesomediterranean, calcifuge climatophilous series of the Sardinian oak. This phytocoenosis has a very high

variability in relation to the past and present use of these woods. Indeed, these are often phytocoenoses used as tree pastures and that are radically modified due to the effects of the repeated fires to which they are subjected.

3. *GLECHOMO SARDOAE-QUERCETUM CONGESTAE* ass. nova hoc loco (holotypus rel. no. 3, Tab. 3).

3.1 *quercetosum congestae subass. nova hoc loco* (holotypus rel. no. 3, Tab. 3); Tab. 3, rels. 1-3.

3.2 *oenanthesum pimpinelloidis subass. nova hoc loco* (holotypus rel. no. 7, Tab. 3); Tab. 3, rels. 4-10.

To this association are referred the climatophilous woods found on lithological substrata of a non-carbonatic nature, and particularly on the basalts, metamorphites and granite of Gennargentu, Barbagie,

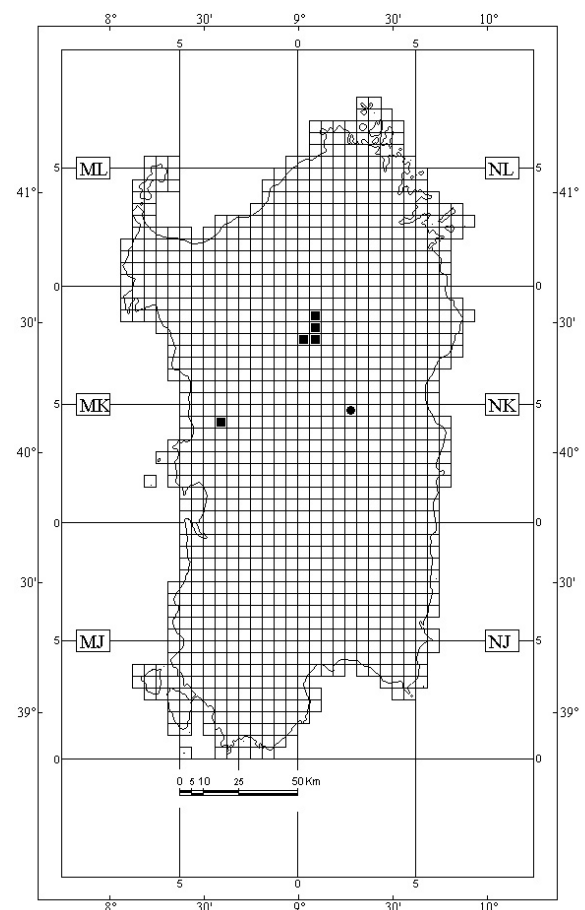


Fig. 4 - Relevés location of *Glechomo sardoae-Quercetum congestae* (*quercetosum congestae* = ■; *oenanthesum pimpinelloidis* = ●)

Tab. 3 - *Glechoma sardoae-Quercetum congestae* ass. nova (holotypus ril. n. 3)
quercetosum congestae subass. nova (holotypus ril. n. 3)
oenanthesum pimpinelloidis subass. nova (holotypus ril. n. 7)

Rel. n.	1	2	3*	4	5	6	7*	8	9	10	
Altitude (m s.l.m.)	855	870	845	1000	750	1000	1000	900	980	800	P
Exposure	NE	E	NNE	SE	.	.	SE	SE	N	NE	R
Slope (°)	30	25	25	15	0	0	10	5	5	5	E
Substratum (Gra=Granite; Met=metamorphyte; Bas=Basalt)	Gra	Gra	Gra	Met	Met	Met	Met	Met	Met	Bas	S.
Area (mq)	200	200	200	100	200	200	100	100	100	200	
Coverage (%)	100	90	90	95	95	100	100	95	90	95	
Average vegetation height (m)	16	14	10	10	18	16	15	10	6	10	
Species number	19	25	24	24	22	33	28	27	19	32	
Charact. and diff. taxa of the subass., ass., suball.* and all.**											
P scap	<i>Quercus congesta</i> C. Presl in J. et C. Presl**	5	4	5	4	5	4	4	4	4	10
G bulb	<i>Cyclamen repandum</i> Sibth. et Sm.	2	1	2	2	2	1	1	1	.	9
H caesp	<i>Luzula forsteri</i> (Sm.) DC.	+	+	+	1	.	+	1	1	.	8
H rept	<i>Glechoma sardoae</i> Beg.*	2	1	2	+	1	+	1	1	.	9
H caesp	<i>Poa nemoralis</i> L.	+	+	+	.	+	1	1	1	1	9
P scap	<i>Quercus dalechampii</i> Ten.	+	1	1	+	.	+	.	.	+	6
P scap	<i>Acer monspessulanum</i> L.	.	+	+	+	2	.	.	.	.	4
H scap	<i>Ranunculus ficaria</i> L. ssp. <i>ficaria</i>	.	.	.	+	.	+	+	1	+	6
H scap	<i>Oenanthe pimpinelloides</i> L.*	.	.	.	1	2	2	1	+	1	6
P scap	<i>Ilex aquifolium</i> L.	.	.	.	1	.	1	2	1	2	6
G rhiz	<i>Paeonia morisii</i> Cesca, Passalacqua et Bernardo*	.	.	.	.	1	.	+	1	.	4
H scap	<i>Mycelis muralis</i> (L.) Dumort.	.	.	.	+	.	+	+	+	.	5
H scap	<i>Viola riviniana</i> Reichb.	.	.	.	.	.	+	.	1	.	3
H rept	<i>Fragaria vesca</i> L.	.	.	.	+	.	+	1	.	.	4
G bulb	<i>Ornithogalum pyrenaicum</i> L.*	.	.	.	.	1	+	1	.	1	4
H caesp	<i>Melica uniflora</i> Retz.	.	.	.	.	+	.	+	+	.	3
P caesp	<i>Cytisus villosus</i> Pourret	.	.	.	.	.	.	.	.	+	1
Charact. taxa of the <i>Quercus roboris-Fagetea sylvaticae</i> class											
H ros	<i>Viola alba</i> Besser ssp. <i>dehnhardtii</i> (Ten.) W. Becker	+	1	+	2	+	+	2	2	2	10
P lian	<i>Hedera helix</i> L. ssp. <i>helix</i>	3	3	2	2	1	1	1	1	3	10
H caesp	<i>Brachypodium sylvaticum</i> (Hudson) P. Beauv.	1	2	1	+	.	+	+	+	1	9
G rhiz	<i>Polystichum setiferum</i> (Forssk.) [T. Moore ex] Woyn.	+	1	+	+	.	.	.	.	.	4
P lian	<i>Clematis vitalba</i> L.	2	1	1	.	1	.	.	.	2	5
H scap	<i>Geum urbanum</i> L.	+	1	+	.	.	.	.	.	+	5
H ros	<i>Sanicula europaea</i> L.	.	.	.	.	.	1	1	.	.	3
P scap	<i>Malus sylvestris</i> (L.) Mill.	.	.	.	.	.	+	.	.	.	2
P scap	<i>Pyrus pyraeaster</i> Burgsd.	.	.	.	.	+	.	.	.	.	1
P scap	<i>Taxus baccata</i> L.	.	.	.	.	.	+	.	.	.	1
G rhiz	<i>Cephalanthera longifolia</i> (L.) Fritsch	.	.	.	.	.	+	.	.	.	1
H scap	<i>Teucrium scorodonia</i> L.	.	.	.	.	.	.	.	.	+	1
P scap	<i>Prunus avium</i> L.	.	.	.	.	.	.	.	.	+	1
Charact. taxa of the <i>Quercetea ilicis</i> class											
H caesp	<i>Carex distachya</i> Desf.	1	+	1	+	.	+	+	1	.	7
P scap	<i>Quercus ilex</i> L.	.	.	.	+	+	+	.	1	.	5
P lian	<i>Rubia peregrina</i> L. ssp. <i>peregrina</i>	.	.	.	.	.	+	+	1	.	4
G rad	<i>Tamus communis</i> L.	+	+	+	.	1	.	.	.	+	5
H ros	<i>Asplenium onopteris</i> L.	.	+	.	.	.	.	+	1	.	4
H scap	<i>Galium scabrum</i> L.	.	.	.	.	.	1	+	+	.	3
G rhiz	<i>Asparagus acutifolius</i> L.	.	.	.	.	+	.	.	.	.	1
G rhiz	<i>Ruscus aculeatus</i> L.	.	.	.	.	.	.	1	.	.	1
Other species											
P caesp	<i>Crataegus monogyna</i> Jacq. ssp. <i>monogyna</i>	+	1	1	2	2	1	1	1	1	10
NP	<i>Rubus gr. ulmifolius</i> Schott	1	1	2	2	2	2	2	2	2	10
NP	<i>Rosa canina</i> L.	1	+	1	1	2	+	+	+	1	10
G rhiz	<i>Pteridium aquilinum</i> (L.) Kuhn	.	+	+	.	.	2	1	1	.	6
P caesp	<i>Prunus spinosa</i> L.	+	1	1	1	1	+	1	.	+	8
H scap	<i>Clinopodium vulgare</i> L. ssp. <i>arundanum</i> (Boiss.) Nyman	.	.	.	.	.	1	+	+	+	5
H bienn	<i>Smyrniolum rotundifolium</i> Mill.	.	+	+	1	.	.	.	.	1	4
H caesp	<i>Dactylis glomerata</i> L.	.	+	+	.	.	.	.	.	.	3
G bulb	<i>Allium subhirsutum</i> L.	.	.	.	+	1	.	.	.	.	2
G bulb	<i>Allium triquetrum</i> L.	.	.	.	.	.	+	+	.	.	2
H scap	<i>Achillea ligustica</i> All.	.	+	+	.	.	.	.	.	.	2
T scap	<i>Milium vermale</i> Bieb.	.	+	+	.	.	.	.	.	.	2
Accidental species											
		1	0	0	1	1	2	0	1	0	4

Montiferru and Goceano (Fig. 4). These are micro-mesowoods dominated by deciduous and semideciduous broad-leaved trees, of variable heights between 6 and 18 m, with a sparse shrubby layer and a herbaceous layer of mainly caespitose hemicryptophytes and geophytes, that generally grow on slope deposits and detritus layers, on slopes of low inclination, between 0° and 30°. The soils upon which they grow are from subacid to neutral, deep, with a limited skeleton, of slow or impeded drainage and of a medium humus content. From the bioclimatic point of view, they are found in oceanic pluvisesonal temperate macrobioclimate, in thermotypic and ombrotypic conditions between the upper upper-subhumid mesotemperate and upper upper-humid supratemperate belts. They have a bioclimate optimum in the lower lower-humid supratemperate belt. They grow between 750 and 1000 m of altitude.

The characteristic and differential species of the association are: *Quercus congesta*, *Q. dalechampii*, *Cyclamen repandum*, *Luzula forsteri*, *Poa nemoralis*, *Acer monspessulanum* and *Glechoma sardoa*. Those of high frequency are: *Hedera helix* ssp. *helix*, *Viola alba* ssp. *dehnhardtii*, *Brachypodium sylvaticum*, *Clematis vitalba*, *Carex distachya*, *Crataegus monogyna* ssp. *monogyna*, *Rubus ulmifolius*, *Rosa canina*, *Pteridium aquilinum* and *Prunus spinosa*.

The differentiating species of the more mesophilous *oenanthesum pimpinelloidis* subassociation, particular to the metamorphic and basalt rocks, are: *Oenanthe pimpinelloides*, *Ilex aquifolium*, *Ranunculus ficaria* ssp. *ficaria*, *Paeonia morisii*, *Mycelis muralis*, *Fragaria vesca*, *Ornithogalum pyrenaicum*, *Viola riviniana* and *Melica uniflora*.

These oak woods represent the head of the meso humid supratemperate, calcifuge climatophilous series of Sardinia. The coenosis of *Q. pubescens* Willd. and *Q. ilex* L. of the Sa Pala Brusiada (Bolotana – NU) locality, described in Camarda (1977), is referred to this association.

Conclusions

At the syntaxonomic level, we propose the inclusion of the association *Lonicero implexae-Quercetum virgiliana* in the endemic Sardinian-Corsican suballiance *Clematido cirrhosae-Quercenion ilicis* (Bacchetta *et al.*, 2004a), of the

alliance *Fraxino orni-Quercion ilicis*, of the class *Quercetea ilicis*.

As far as the associations *Ornithogalo pyrenaici-Quercetum ichnusae* and *Glechomo sardoae-Quercetum congestae* are concerned, their associated entities lead them to be referred to the class *Quercu roboris-Fagetea sylvaticae*, in the order *Quercetalia pubescenti-petraeae*. In this syntaxonomic context, the attribution indicated by Ubaldi (2003) for the oak woods to the alliance *Quercion pubescenti-petraeae* Br.-Bl. 1932 *nom. mut. prop.* Rivas-Martínez, Díaz, Fernández-González, Izco, Loidi, Lousã & Penas 2002 (Ubaldi, 2003 *sub Quercion humili-petraeae* Braun Blanquet 1932) is not considered valid, in that this alliance is particular to the Western European territories and extends in the east as far as the eastern maritime Alps and to Liguria (Barbero *et al.*, 1971). Indeed, the Sardinian-Corsican group provides the western limit of many species that are absent in the territories pertinent to the *Quercion pubescenti-petraeae* alliance: *Ostrya carpinifolia*, *Fraxinus ornus*, *Quercus virgiliana*, *Q. dalechampii*, *Cyclamen repandum*, *C. hederifolium*, and *Clinopodium vulgare* ssp. *arundanum* (= *Satureja vulgaris* ssp. *orientalis*). In contrast, the main floristic links are seen with the South Mediterranean European alliance *Pino calabrica-Quercion congestae* Brullo, Scelsi, Siracusa & Spampinato 1999, of which the characteristic species are: *Quercus congesta*, *Q. dalechampii* and *Cytisus villosus* (Brullo *et al.*, 1999; 2001).

In the Sardinian oak woods, however, endemic species are found, such as: *Quercus ichnusae*, *Paeonia morisii*, *Glechoma sardoa*, and *Digitalis purpurea* var. *gyspergerae*, which are considered characteristic of the new suballiance *Paeonio morisii-Quercenion ichnusae suball. nova hoc loco* (*Holotypus: Glechomo sardoae-Quercetum congestae ass. nova*), which is endemic to the Sardinian biogeographic sub-province (Rivas-Martínez & Penas, 1999). This suballiance includes the phytocoenoses with a deciduous dominance, referred to the following associations: *Ornithogalo pyrenaici-Quercetum ichnusae*, *Glechomo sardoae-Quercetum congestae*, *Oenanthe pimpinelloidis-Castaneetum sativae* Arrigoni in Arrigoni & Marras 1990 *corr.* Arrigoni in Arrigoni, Di Tommaso, Camarda & Satta 1996 (Arrigoni & Marras, 1990) and *Cyclamino repandi-Ostryetum carpinifoliae* Bacchetta, Iriti, Mossa, Pontecorvo & Serra 2003 (Bacchetta *et al.*, 2004b).

Syntaxonomic scheme

QUERCO ROBORIS-FAGETEA SYLVATICAE Br.-Bl. & Vlieger in Vlieger 1937

QUERCETALIA PUBESCENTI-PETRAEAE Klika 1933

Pino calabricae-Quercion congestae Brullo, Scelsi, Siracusa & Spampinato 1999

Paeonio morisii-Quercenion ichnusae suball. nova hoc loco

(Holotypus: *Glechomo sardoae-Quercetum congestae ass. nova*)

Ornithogalo pyrenaici-Quercetum ichnusae ass. nova

cytisetosum villosi subass. nova

ilicetosum aquifolii subass. nova

Glechomo sardoae-Quercetum congestae ass. nova

quercetosum congestae subass. nova

oenanthesum pimpinelloidis subass. nova

Oenanthe pimpinelloidis-Castaneetum sativae Arrigoni in Arrigoni & Marras 1990 corr. Arrigoni in Arrigoni,

Di Tommaso, Camarda & Satta 1996

Cyclamino repandi-Ostryetum carpinifoliae Bacchetta, Iiriti, Mossa, Pontecorvo & Serra 2004

QUERCETEA ILICIS Br.-Bl. ex A. & O. Bolòs 1950

QUERCETALIA ILICIS Br.-Bl. & Molinier 1934

Fraxino orni-Quercion ilicis Biondi, Casavecchia & Gigante 2003

Clematido cirrhosae-Quercenion ilicis Bacchetta, Bagella, Biondi, Farris, Filigheddu & Mossa 2004

Lonicero implexae-Quercetum virgiliana ass. nova

quercetosum virgiliana subass. nova

cyclaminetosum repandi subass. nova

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Locality and date of the relevés

Tab. 1

Rel. 1: Pedrasenta (Suni, NU), 6.X.1997; rel. 2 e 4: Baccu sa Teula (Barumini, CA), 4.X.2001; rel. 3: S. Antonio de li Colti (Trinità d'Agultu, SS), 18.V.1995; rel. 5: Loc. Sa Coa de Su Buscu (Muros, SS), 2.XI.2000; rel. 6: Loc. Elighe Entosu (Florinas, SS), 6.IV.2001; rel. 7 e 8: Loc. Elighe Entosu (Florinas, SS), 1.III.2002.

Tab. 2

Rel. 1 e 2: Monte San Antonio (Macomer, NU), 4.X.2001; rel. 3: Badd'e Salighes (Bolotana, NU), 8.X.2001; rel. 4 e 5: Strada da Sindia a Monte San Antonio (Macomer, NU), 18.V.2001; rel. 6: Monte San Antonio (Macomer, NU), 18.V.2001; rel. 7: Monte San Antonio (Macomer, NU), 15.VI.2001; rel. 8: Funtana Rajada (Villanova Monteleone, SS), 3.I.2001; rel. 9: Monte Mura Donnai (Villanova Monteleone, SS), 18.VI.2001; rel. 10, 13, 21, 22 e 23: Santa Maria (Bosa, NU); rel. 11: Orga (Sarule, NU), 7.X.1997; rel. 12: Sa costa e narbonis (Seui, NU), 7.X.1997; rel. 14-15: Monte Traessu (Giave-Cossoine, SS); rel. 16: Sa Falada de Sos Turcos (Villanova Monteleone, SS), 17.V.2002; rel. 17: Sa Pittada (Bosa, NU), 20.V.2002; rel. 18: Piscinebba (Villanova Monteleone, SS), 23.III.2001; rel. 19: Incrocio s.s. Montresta-Padria-Villanova (Montresta, NU), 18.VI.2001; rel. 20: Monte Traessu (Giave-Cossoine, SS), 27.IX.2001; rel. 24: Monte Majore (Romana, SS), 15.I.2001; rel. 25: Funtana Sa Entale (Bosa, NU), 1.V.2001; rel. 26: Costa Cugurrera (Bosa, NU).

Tab. 3

Rel. 1-3: Govossai (Fonni, NU), 9.X.2001; rel. 4: Nuradorzu

(Anela, SS), 5.VI.2001; rel. 5: Demanio Forestale di Pranu Mannu (Bono, SS), 11.VI.2001; rel. 6: Su Tassu (Bultei, SS), 11.VI.2001; rel. 7 e 8: Nuradorzu (Anela, SS), 11.VI.2001; rel. 9: Seddarderilo-Monte Rasu (Bono, SS); rel. 10: Badde Urbara (Santu Lussurgiu, OR), 15.VI.2001.

Accidental species

Tab. 1

Rel. 1: *Carlina corymbosa* L. (1), *Agrimonia eupatoria* L. (1), *Hypericum perforatum* L. ssp. *perforatum* (+), *Pyrus spinosa* Forssk. (+), *Clinopodium vulgare* L. ssp. *arundanum* (Boiss.) Nyman (+); rel. 3: *Pteridium aquilinum* (L.) Kuhn (1), *Geranium purpureum* L. (1), *Ornithogalum narbonense* L. (1), *Theligonum cynocrambe* L. (1), *Hordeum murinum* L. (+), *Umbilicus rupestris* (Salisb.) Dandy (+), *Leopoldia comosa* (L.) Parl. (+), *Urospermum dalechampii* (L.) Scop. ex F.W. Schmidt (+); rel. 5: *Leontodon tuberosus* L. (2), *Bellis sylvestris* Cyr. (2), *Asphodelus ramosus* L. ssp. *ramosus* (+); rel. 6: *Reichardia picroides* (L.) Roth (+).

Tab. 2

Rel. 2: *Prunella vulgaris* L. (+); rel. 7: *Bellis perennis* L. (1); rel. 9: *Eryngium tricuspdatum* L. (2), *Rumex thyrsoides* Desf. (+); rel. 10: *Dactylis glomerata* L. (1); rel. 12: *Smyrniololus atrum* L. (+); rel. 13: *Robinia pseudoacacia* L. (+); rel. 16: *Achillea ligustica* All. (1); rel. 18: *Cistus salvifolius* L. (1); rel. 19: *Carex flacca* Schreber ssp. *serrulata* (Biv.) Greuter (1); rel. 20: *Selaginella denticulata* (L.) Spring (+); rel. 24: *Cistus monpelienensis* L. (1); rel. 25: *Asphodelus ramosus* L. ssp. *ramosus* var. *ramosus* (+), *Ophrys sphecodes* Mill. ssp. *praecox* Corrias (+), *Orchis papilionacea* L. (+); rel. 26: *Hypericum perforatum* L. ssp. *perforatum* (+), *Orchis provincialis* Balbis ex Lam. et DC. (+).

Tab. 3

Rel. 1: *Sambucus nigra* L. (+); Rel. 4: *Silene alba* (Mill.) Krause (+); rel. 5: *Holcus lanatus* L. (+); rel. 6: *Lathyrus pratensis* L. (+), *Trifolium pratense* L. (+); rel. 8: *Pulicaria odora* (L.) Rchb. (+); rel. 10: *Trifolium pratense* L. (2), *Geranium purpureum* L. (1), *Ranunculus bulbosus* L. ssp. *aleae* (Willk.) Rouy et Fouc. (+), *Carex divulsa* Stokes (+).