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Mediterranean *Taxus baccata* woodlands in Sardinia: a characterization of the EU priority habitat 9580

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with 2 figures, 6 tables and 1 appendix

Abstract: The results of a field investigation on the structure and species composition of *Taxus baccata* L. forests in Sardinia (Italy) is given. The species, that occupies a wide range of altitudes from 50 to 1550 m a.s.l., but prefers to live from 800 to 1200 m a.s.l., was found to be the dominating tree in mesophylous forests, here described as new associations: 1) Cyclamino repandi-Taxetum baccatae ass. nova, at the top of Sardinian mountains, with 4 subassociations corresponding to local variation of geological substratum; 2) Polysticho setiferi-Taxetum baccatae ass. nova, at intermediate altitudes, near streams, in northern slopes of central Sardinian mountains. Moreover, in contact with mountain oak forests, the new sub-associations Saniculo europaeae-Quercetum ilicis taxetosum baccatae subass. nova and Glechomo sardoae-Quercetum congestae taxetosum baccatae subass. nova have been described. The multivariate analysis of plant assemblages showed a significant separation among the four different communities. Contrary to previous studies, our findings support the evidence for the presence of pure or yew-dominated woods in Sardinia. In particular, the Cyclamino repandi-Taxetum baccatae, has a relic character and a great biogeographic importance. The scattered distribution of the two habitats suitable for the yew in Sardinia can be considered the main current ecological trait that plays a fundamental role in the process of population isolation. To preserve the existing Mediterranean yew woods, we recommend not only measures directed to the species conservation, but also actions that should accomplish the phytocoenotic diversity highlighted by this investigation.

Keywords: Conservation, Habitats Directive, Refugia, Syntaxonomy, Yew woods.

Introduction

Since 1992 the Habitats Directive (HD) was adopted by the Council of the European Communities and member countries to maintain or restore a favourable conservation status of habitat types and species that are considered important for the conservation of the biodiversity within the European Union (European Commission 1992). This implies that all the habitat types listed in the Annexe I of the HD, should be well known and characterized under the structural and functional aspects. Unfortunately, for many European habitats information on distribution, species composition, and conservation status are lacking (Lengyel et al. 2008a, 2008b). Efforts to characterize and classify plant communities on the basis of the Interpretation Manual of European Union Habitats (European Commission 2007), taking into account species composition, have been undertaken only for few habitat types, in particular those related to human-induced grazing activities (e. g. Galán de Mera et al. 2000, Díaz et al. 2001, Kahmen et al. 2002, Muller 2002, Ejrnaes et al. 2004, Peco et al. 2005, Stewart & Pullin 2008, Farris et al. 2010b).

A typical European habitat that needs to be better characterized is that of Mediterranean yew woods. Mediterranean yew stands are recognised as a priority habitat for biodiversity conservation and they are designated as habitat code 9580* by the HD (European Commission 1992). The Interpretation Manual of European Union Habitats (European Commission 2007) identifies as Mediterranean *Taxus baccata* woods those forests dominated by *Taxus baccata*, often with *Ilex aquifolium*, of very local occurrence. The Manual indicates two possible origins: senescent phase of a beech wood or beech-fir wood, made up of clusters of *Taxus* after the fall of the tall species, surrounded by layered stands of beech-yew; or residual *Taxus* stands with disappearance of the tall species, both above and in the proximity of *Taxus*. Among the habitat sub-types, the Sardinian yew woods are included with the code 42.A73: *Taxus baccata* and *Ilex aquifolium* woods of the Marghine mountain and the Mount Limbara system. Corsican yew woods are also included as a sub-type with the code 42.A72 and yew woods from Portugal are also mentioned. Any mention is present about yew woods from the Mediterranean areas of the remnant European countries. Characteristic plants listed by the Manual are: *Buxus sempervirens, Ilex aquifolium, Mercurialis perennis, Sorbus aria, Taxus baccata.* Any reference is given. Even Thomas & Polwart (2003), in their interesting and complete monograph on the English yew, reported that outside of Britain, the yew appears to form single-species stands only in the oceanic climates of the Crimea and Caucasus mountains. They mention

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very local woodlands from Sardinia and Corsica referring directly to the Interpretation Manual of European Union Habitats (2007), stating that these woods are thought to represent a senescent phase of the original beech or beech-fir wood. It's noteworthy that beech and fir are both absent from the Sardinian flora (Conti et al. 2005, 2007).

Given the importance of Sardinian yew stands in the context of the European law and the lack of information on Sardinian yew woods, we therefore consider extremely urgent to improve the knowledge on the structure and species composition of this habitat as a management instrument for its better conservation.

In this paper we present the results of the geobotanical analyses, aiming at better defining 1) the present distribution of the habitat in Sardinia and 2) the phytosociological interpretation of the Sardinian yew stands.

Materials and methods

Study species and area

Yew (*Taxus baccata* L.) is a dioecius, long-lived (> 1000 years), slow-growing, non-resinous, evergreen gymnosperm, up to 20(-28) m, reaching sexual maturity at c. 70 years (Thomas & Polwart 2003). Female structures (Stützel & Röwekamp 1999) produce ovoid seeds, with a tough seed coat and partially surrounded by a fleshy red aril that falls with the seed at maturity. Seeds are dispersed by birds and mammals (Thomas & Polwart 2003) and seedlings emerge in the second spring after seedfall (Melzak & Watts 1982).

Yew is a relic tree showing severe decline all over its range in Europe (Hulme 1996, Svenning & Magård 1999, García et al. 2000). In the Mediterranean area, probably as a result of both regression after the last Ice Age (Bennett et al. 1991, García et al. 2000) and human disturbance over recent centuries (Svenning & Magård 1999, O'Connell & Molloy 2001), yew distribution is limited to mountain areas: it consists of a reduced number of small populations located mainly on shady northern slopes (García et al. 2000, Thomas & Polwart 2003).

Although some populations have been seen expanding in central-northern European areas where conditions are suitable (Seidling 1999, Iszkuło & Boratyński 2005) or under active management (Svenning & Magård 1999), natural regeneration of yew is limited by both seed-predators and herbivores and scarcity of microsites for recruitment (Hulme 1996, García et al. 2000, García & Obeso 2003). Several works have shown positive spatial association between yew and shrubs: this suggested that regeneration might depend on facilitative effects (Hulme 1996, García et al. 2000, García & Obeso 2003, Farris & Filigheddu 2008).

In Sardinia, *Taxus baccata* was reported for ca. 50 distinct localities, mostly distributed in central-northern part of the island, except four located in the south-western one. Even if the altitudinal range of yew in Sardinia extends from 50 m a.s.l. to 1,550 m

Table 1. Temperature and precipitation values, bioclimatic index, and classification of three stations of the study area (T = average annual temperature; M = average of the maximum temperatures of the coldest month; m = average of the minimum temperatures of the coldest month; P = mean annual rainfall; It = thermicity index; Tp = positive annual temperature; Ic = continentality index; Io = ombrothermic index; Ios2 = bimonthly summer ombrothermic index; Ios3 = three-monthly summer ombrothermic index; Ios4 = four-monthly summer ombrothermic index; MPO = Mediterranean Pluviseasonal Oceanic; TO = Temperate Oceanic). Data were gathered from Farris et al. (2007) for Campeda and Vallicciola, and from Bacchetta et al. (2009) for Genna Silana.

Station	**Campeda**	**Genna Silana**	**Vallicciola**
Coordinates	40°19'34"N-8°47'08"E	40°09'34"N-9°30'34"E	40°51'04"N-9°09'05"E
Altitude (m a.s.l.)	651	1010	1040
Years of observation	1965–1986	1955–2005	1965–1987
T (°C)	12.6	11.6	10.3
M (°C)	9.4	7.0	6.3
m (°C)	1.9	1.5	0.4
P (mm)	850	1119	1271
It	239	204	170
Tp	1518	1397	1235
Ic	15.8	16.8	15.9
Io	5.6	8.0	10.3
Ios2	0.6	0.8	1.3
Ios3	1.0	1.0	1.6
Ios4	1.6	1.8	2.7
Bioclimate	MPO	MPO	TO
Thermotype	Upper mesomediterranean	Lower supramediterranean	Lower supratemperate (submediterranean)
Ombrotype	Upper subhumid	Lower humid	Upper humid
Continentality	Euoceanic	Euoceanic	Euoceanic

a.s.l., more than 50% of the known sites grow at altitude ranging from 600 to 1,000 m a.s.l. (Bacchetta & Farris 2007), therefore mainly included in the transition altitude between the upper mesomediterranean-lower supramediterranean and the upper mesotemperate-lower supratemperate (submediterranean variant) phytoclimatic belts, usually with subhumid or humid ombrotypes (sensu Rivas-Martínez et al. 2002, Rivas-Martínez 2011). As an example we provide in the Table 1 the bioclimatic data of three stations located near yew sites. For a detailed description of the Sardinian bioclimate see Bacchetta et al. (2009).

Data collection

Field investigation was conducted by carrying out 45 phytosociological releveés, following the Zürich-Montpellier method (Braun-Blanquet 1965, Tüxen 1979, Géhu & Rivas-Martínez 1981, Rivas-Martínez 2005). Releveés came from four different plant assemblages: i) top of the mountains (CY); ii) valleys and gorges (PO); iii) holm oak (*Quercus ilex*) woods (SA); iv) deciduous oaks woods (GL).

Location of the surveyed yew populations was assessed by bibliographic data (Bacchetta & Farris 2007) and field excursions carried out by the authors in the last 15 years. Before carrying out further analysis, each point was marked by the use of a GPS instrument and information on altitude, slope, aspect, substratum and bioclimate, was collected and reported on a database.

The names of the plant species follow Conti et al. (2005, 2007), whereas the syntaxonomy follows Weber et al. (2000).

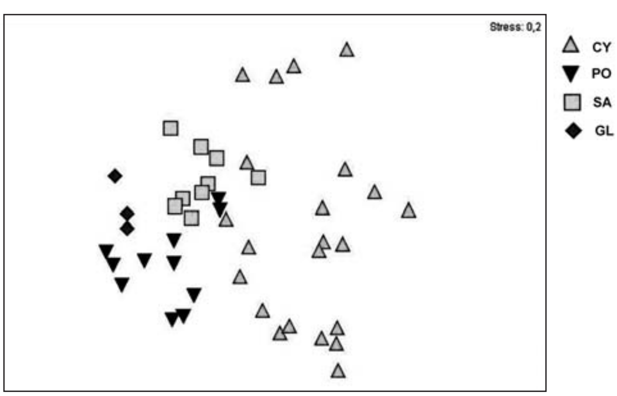

Fig. 1. Two-dimensional non-metric multidimensional scaling ordination (NMDS) of phytosociological surveys comparing plant species assemblages among four assemblages (▲ = CY: top of mountains; ▼ = PO: valleys and gorges; ■ = SA: holm oak woods; ♦ = GL: deciduous oaks woods).

Data analysis

The phytosociological data relating to cover underwent multivariate analysis using the PRIMER software (Plymouth Marine Laboratory, UK; Clarke & Warwick 1994). First, a matrix of 45 releveés x 110 taxa was elaborated, in which the cover values were converted following the quantitative scale proposed by Van der Maarel (1979). Secondly, the Bray-Curtis similarity matrix was used to generate a two-dimensional unconstrained ordination plot with Non-metric Multidimensional Scaling (NMDS) technique (Clarke 1993). An analysis of similarity test (ANOSIM; Clarke 1993) was performed to examine the differences among the plant communities from the four assemblages. Finally, the similarity percentages procedure (SIMPER; Clarke 1993) was employed to identify the major plant species contributing to the differences among communities.

Results

Multivariate analysis

The NMDS showed a clear-cut separation among the four different communities (Fig. 1). The ANOSIM test highlighted strong differences among the different assemblages ($R = 0.284$; $P < 0.001$). The SIMPER procedure identified certain plant species as major contributors to the dissimilarities observed between different assemblages (Table 2): more than 30% of the dissimilarity among the different plant assemblages was given by 4–7 taxa. Similarity within assemblages ranges from 37.7% in CY to 56.9% in GL; dissimilarity between assemblages varies from 61.7% between SA and GL to 77.6% between CY and GL.

Vegetation

The four phytocoenoses show structural and ecological autonomy from each other and can be therefore considered as different syntaxa (Fig. 2). The first includes those yew stands growing at the top of Sardinian mountains, divided into 4 subgroups depending on different substrata or biogeographic assessment of the territories; the second represents yew communities growing at intermediate altitudes, near streams or springs, often in valleys or gorges; the third and fourth group are holm-oak and deciduous oaks woods with yew, respectively. On the whole, 2 new associations and 6 new subassociations were found, which are described below.

Cyclamino repandi-Taxetum baccatae ass. nova hoc loco (typus rel. no. 1 Table 3)

taxetosum baccatae subass. nova typica hoc loco (typus rel. no. 1 Table 3)

rhamnetosum alpinae subass. nova hoc loco (typus rel. no. 8 Table 3)

phillyreetosum latifoliae subass. nova hoc loco (typus rel. no. 17 Table 3)
amelanchieretosum ovalis subass. nova hoc loco (typus rel. no. 22 Table 3)
The plant communities referred to this association are those growing mainly at the top of the mountains. The average altitude is indeed high (1,036 m a.s.l.). This association is characterized by the presence of many species of the Querco-Fagetea class, whereas elements of the Quercetea ilicis class are scarce. Furthermore many endemic and orophilous taxa are present and mark the mountain character of this association. Differential species of this association are the central-Mediterranean *Cyclamen repandum* ssp. *repandum* and the two endemics *Ribes multiflorum* ssp. *sandalioticum* and *Stachys corsica*.

Four subassociations can be distinguished on the basis of the geographic separation and substratum differences. The typical subassociation taxetosum baccatae is exclusive of the Gennargentu massif, where it develops on siliceous substrates at an average altitude of 1,212 m a.s.l. Differential species of this subassociation with respect to the other three, are *Luzula forsteri* and *Ranunculus ficaria* ssp. *ficaria*. The rhamnetosum alpinae subassociation is found only on the Mesozoic limestone of eastern Sardinia, where it is present at an average altitude of 1,075 m a.s.l. A large number of plants differentiates this subassociation; among the others, orophilous as *Rhamnus alpina* ssp. *alpina* and endemics as *Arenaria bertolonii, Hypochaeris robertia, Poa balbisii* and *Galium corsicum*. The third subassociation phillyreetosum latifoliae, is that growing at the lowest altitude and the southernmost latitude. It develops indeed on granitic substrata of the Sulcis-Iglesiente, at an average altitude of 748 m a.s.l. As a consequence, differential species are thermophilous ones, as *Phillyrea latifolia, Arbutus unedo, Ruscus aculeatus* and *Clematis cirrhosa*. Finally, the last subassociation amelanchieretosum ovalis, was found at the top of the Mount Limbara, growing on granite at an average altitude of 1,287 m a.s.l. Exclusive species of this subassociation are *Solidago virgaurea*, *Dryopteris oreades* and *Amelanchier ovalis*.

The plant communities herein described grow in the supratemperate, submediterranean, humid phytoclimatic belt, with the exception of the subassociation phillyreetosum latifoliae, that is growing at the transition zone between the Mediterranean and the Temperate bioclimate. The taxetosum baccatae subassociation establishes dynamic and topographic contacts with the communities related to the series of the Juniperetum nanae and the Glechomo sardoae-Quercetum congestae on the Gennargentu massif; the rhamnetosum alpinae subassociation mainly with the communities related to the Aceri monspessulani-Quercetum ilicis series and rarely with patchy communities of the Juniperetum nanae at the Supramonte and the Tonneri of Seui; the phillyreetosum latifoliae subassociation, shows contacts with the mesomediterranean Galio scabri-Quercetum ilicis and Pistacio-Juniperetum oxycedri series; finally the amelanchieretosum ovalis subassociation on Mount Limbara takes topographic contact with the communities of the Saniculo europaeae-Quercetum ilicis series. Growing mainly at the top of mountains, at rocky places with poorly developed soil, these communities have contacts also with chasmophytic communities of the Potentilletalia caulescentis order.

Polysticho setiferi-Taxetum baccatae ass. nova hoc loco (typus rel. no. 29 Table 4)
This association includes the mesophylous yew and holly stands, growing at medium altitude, that were found on volcanic and metamorphic substrates of the Montiferru, Marghine and Goceano mountains, at an average altitude of 1,004 m a.s.l. These woods are the

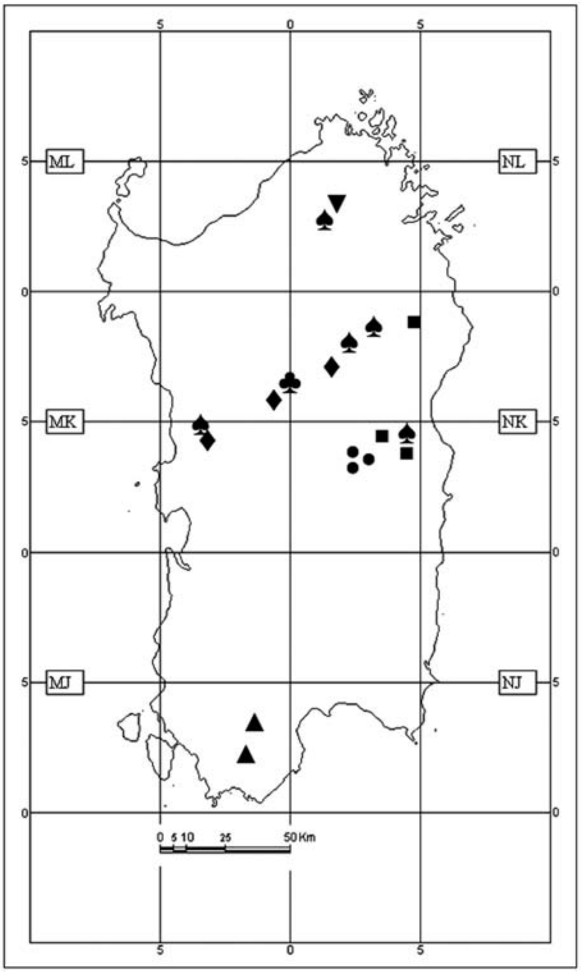

Fig. 2. Geographic distribution of the yew woods in Sardinia: ● = Cyclamino repandi-Taxetum baccatae taxetosum baccatae; ■ = Cyclamino repandi-Taxetum baccatae rhamnetosum alpinae; ▲ = Cyclamino repandi-Taxetum baccatae phillyreetosum latifoliae; ▼ = Cyclamino repandi-Taxetum baccatae amelanchieretosum ovalis; ♦ = Polysticho setiferi-Taxetum baccatae; ♠ Saniculo europaeae-Quercetum ilicis taxetosum baccatae; ♣ = Glechomo sardoae-Quercetum congestae taxetosum baccatae.

Table 2. Major plant species contributing (%) to dissimilarity between assemblages (CY: top of mountains; PO: valleys and gorges; SA: holm oak woods; GL: deciduous oaks woods) according to SIMPER analysis. Cut off for low contributions: 30.00%. Av.Abund = Average abundance; Av.Diss = Average dissimilarity; Contrib% = Contribution %.

Groups CY and PO
Average dissimilarity = 70.48%

Taxa	Av.Abund CY	Av.Abund PO	Av.Diss	Contrib%
Ilex aquifolium	0.73	6.00	7.64	10.84
Taxus baccata	8.09	6.00	4.44	6.29
Cyclamen repandum ssp. repandum	2.50	4.27	3.97	5.63
Polystichum setiferum	0.27	2.00	2.56	3.64
Quercus ilex	2.55	0.73	2.55	3.61

Groups CY and SA
Average dissimilarity = 69.70%

Taxa	Av.Abund CY	Av.Abund SA	Av.Diss	Contrib%
Taxus baccata	8.09	2.44	5.90	8.47
Quercus ilex	2.55	7.89	5.19	7.45
Ilex aquifolium	0.73	3.33	2.35	3.37
Rubus gr. *ulmifolius*	1.50	3.22	2.29	3.29
Cyclamen repandum ssp. *repandum*	2.50	2.44	2.04	2.93
Erica arborea	1.32	1.00	1.89	2.70
Polystichum setiferum	0.27	2.22	1.83	2.63

Groups PO and SA
Average dissimilarity = 65.01%

Taxa	Av.Abund PO	Av.Abund SA	Av.Diss	Contrib%
Quercus ilex	0.73	7.89	7.03	10.81
Taxus baccata	6.00	2.44	6.72	10.33
Ilex aquifolium	6.00	3.33	5.74	8.83
Cyclamen repandum ssp. *repandum*	4.27	2.44	4.28	6.58

Groups CY and GL
Average dissimilarity = 77.56%

Taxa	Av.Abund CY	Av.Abund GL	Av.Diss	Contrib%
Taxus baccata	8.09	2.00	6.73	8.68
Quercus congesta	0.27	8.33	6.03	7.78
Acer monspessulanum ssp. *monspessulanum*	0.59	4.33	2.76	3.56
Quercus ilex	2.55	0.33	2.70	3.48
Ilex aquifolium	0.73	4.33	2.60	3.35
Brachypodium sylvaticum	0.18	3.33	2.47	3.18

Groups PO and GL
Average dissimilarity = 64.12%

Taxa	Av.Abund PO	Av.Abund GL	Av.Diss	Contrib%
Taxus baccata	6.00	2.00	7.54	11.77
Ilex aquifolium	6.00	4.33	5.20	8.10
Quercus congesta	1.55	8.33	3.99	6.22
Cyclamen repandum ssp. *repandum*	4.27	3.33	3.84	5.99

Groups SA and GL
Average dissimilarity = 61.72%

Taxa	Av.Abund SA	Av.Abund GL	Av.Diss	Contrib%
Quercus ilex	7.89	0.33	7.51	12.17
Quercus congesta	1.22	8.33	5.38	8.71
Acer monspessulanum ssp. *monspessulanum*	1.33	4.33	2.69	4.36
Brachypodium sylvaticum	0.89	3.33	2.11	3.41
Asplenium onopteris	2.11	0.00	1.95	3.16

Table 3. Cyclamino repandi-Taxetum baccatae (typus rel. no. 1). taxetosum baccatae (typus rel. no. 1). rhamnetosum alpinae (typus rel. no. 8). phillyreetosum latifoliae (typus rel. no. 17). amelanchieretosum ovalis (typus rel. no. 22). Nd = not determined; Met = metamorphic; Lim = limestone; Gra = granite; Pres = presence.

Rel. no.	1*	2	3	4	5	6	7	8*	9	10	11	12	13	14	15	16	17*	18	19	20	21	22*	
Coverage (%)	90	90	100	100	90	80	80	80	80	90	90	90	100	80	90	100	90	80	nd	60	nd	60	
Area (m^2)	100	50	50	100	100	100	100	50	50	50	50	50	50	80	50	50	50	50	25	25	25	40	
Aspect	N	NE	N	N	NNE	NE	NNW	N	NE	NW	WNW	N	E	E	N	ENE	N	NNE	NW	NW	NW	NE	
Slope (%)	30	10	40	50	20	40	30	60	50	45	10	30	25	40	10	20	10	10	5	5	5	5	
Altitude (m asl)	1250	1200	1180	1220	945	780	950	1250	1180	1230	1190	860	840	850	520	750	820	600	1313	1313	1313	1245	
Substratum	Met	Met	Met	Met	Lim	Lim	Lim	Lim	Lim	Lim	Lim	Gra	Gra	Gra	Gra	Gra	Gra	Gra	Gra	Gra	Gra	Gra	
Rocks percentage (%)	30	nd	nd	60	nd	70	40	90	90	80	50	60	nd	40	nd	nd	nd	nd	70	70	70	70	
Stone percentage (%)	40	40	30	10	80	nd	30	10	10	10	20	20	70	40	90	80	80	90	10	10	10	10	
Average vegetation height (m)	8	6	8	10	10	12	6	5	7	8	8	8	10	10	5	10	8	7	nd	nd	nd	nd	
No. of taxa	19	18	17	17	17	19	24	27	22	24	22	13	14	15	19	17	16	17	9	12	9	14	Pres.
Charact. and diff. taxa of the ass.																							
Taxus baccata	5	5	5	5	5	4	4	4	4	5	4	3	5	3	4	5	5	3	3	3	3	3	22
Cyclamen repandum ssp. *repandum*	2	2	.	+	2	2	+	1	1	+	+	1	1	.	2	2	2	.	.	.	.	.	15
Ribes multiflorum ssp. *sandalioticum*	.	.	.	.	.	.	.	+	+	1	+	.	.	.	.	.	.	.	+	+	1	1	8
Stachys corsica	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	+	+	.	.	.	.	6
Diff. taxa of the *taxetosum baccatae* subass.																							
Luzula forsteri	1	2	1	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	5
Ranunculus ficaria ssp. *ficaria*	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
Diff. taxa of the *rhamnetosum alpinae* subass.																							
Rhamnus alpina ssp. *alpina*	.	.	.	.	+	.	+	1	+	1	+	.	.	.	.	.	.	.	.	.	.	.	6
Epipactis helleborine	.	.	.	.	+	1	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	6
Acer monspessulanum ssp.*monspessulanum*	.	.	.	.	.	+	1	1	.	1	+	.	.	.	.	.	.	.	.	.	.	.	5
Sorbus aria ssp. *aria*	.	.	.	.	1	.	1	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	4
Arenaria bertolonii	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	4
Hypochaeris robertica	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	4
Poa balbisii	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	3
Galium corsicum	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	3
Diff. taxa of the *phillyreetosum latifoliae* subass.																							
Phillyrea latifolia	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	1	+	+	.	.	.	.	6
Arbutus unedo	.	.	.	.	.	.	.	.	.	.	.	2	1	2	2	.	1	.	.	.	.	.	5
Ruscus aculeatus	.	.	.	.	.	.	.	.	.	.	.	2	+	1	.	.	.	+	.	.	.	.	4
Clematis cirrhosa	.	.	.	.	.	.	.	.	.	.	.	+	.	.	2	+	+	.	.	.	.	.	4
Diff. taxa of the *amelanchieretosum ovalis* subass.																							
Solidago virgaurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2	1	4
Dryopteris oreades	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	+	4
Amelanchier ovalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	2	4
Charact. and diff. taxa of the upper units																							
Hedera helix ssp. *helix*	+	2	1	+	1	+	1	2	1	2	3	1	+	1	+	1	1	+	.	.	.	.	18
Viola reichenbachiana	2	+	.	.	+	+	.	+	+	1	+	+	+	.	.	.	1	.	.	.	.	.	11
Dryopteris filix-mas	1	1	+	.	1	+	.	1	1	1	+	.	.	.	.	.	.	.	.	.	.	.	9

Table 3 (continued)

Rel. no.	1*	2	3	4	5	6	7	8*	9	10	11	12	13	14	15	16	17*	18	19	20	21	22*	Pres.
Tamus communis	.	.	.	.	.	+	+	.	.	+	.	.	1	1	.	+	.	+	.	.	.	.	7
Glechoma sardoa	+	2	.	.	.	+	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	6
Ilex aquifolium	+	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	1	6
Viola alba ssp. *dehnhardtii*	1	.	+	+	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
Lactuca muralis	+	.	.	.	+	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	5
Paeonia corsica	.	.	.	.	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	3
Brachypodium sylvaticum	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	2
Polystichum setiferum	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	2
Quercus congesta	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Osmunda regalis	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	2
Quercus dalechampii	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Helleborus lividus ssp. *corsicus*	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Fraxinus ornus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1
Charact. and diff. taxa of the *Quercetea ilicis* class																							
Quercus ilex	.	+	1	+	1	+	1	.	+	+	1	2	.	2	+	+	.	+	2	2	2	1	18
Asplenium onopteris	+	+	+	+	.	.	.	.	.	.	.	1	+	+	1	+	1	1	.	.	.	.	11
Erica arborea	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	+	.	1	2	2	1	2	8
Rubia peregrina ssp. *peregrina*	+	+	1	1	.	.	.	.	.	.	.	.	1	.	+	.	+	.	.	.	.	.	7
Carex distachya	1	1	.	.	.	.	.	.	.	.	.	.	1	.	+	.	+	1	.	.	.	.	6
Galium scabrum	.	.	+	+	.	.	.	.	.	.	.	.	.	+	.	+	1	.	.	.	.	.	5
Smilax aspera	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	+	.	.	.	.	3
Erica scoparia	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Selaginella denticulata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1
Other species																							
Crataegus monogyna	1	+	2	1	.	1	1	+	+	+	1	.	.	.	.	.	.	.	.	+	+	+	13
Rosa gr *canina*	1	+	.	+	.	.	+	+	+	1	1	+	+	+	.	.	.	.	.	.	.	.	11
Rubus gr *ulmifolius*	.	1	1	1	+	+	.	.	.	.	1	.	.	2	.	1	2	.	.	+	.	+	11
Asplenium trichomanes ssp. *quadrivalens*	.	.	.	.	.	.	+	+	.	+	.	+	.	.	1	+	1	1	.	.	.	.	8
Arenaria balearica	.	.	.	.	+	.	.	+	1	1	.	.	.	.	.	+	1	1	.	.	.	.	7
Geranium lucidum	.	.	.	.	+	1	1	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	6
Bellium bellidioides	.	.	.	.	.	.	+	+	.	+	.	.	.	+	.	.	.	1	.	.	.	.	5
Cymbalaria aequitriloba	+	.	.	.	.	.	+	.	.	+	.	.	.	.	.	+	1	.	.	.	.	.	5
Sambucus nigra	.	.	.	.	+	+	+	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	5
Digitalis purpurea	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	4
Sporadic species	1	1	1	1	1	1	4	5	2	1	3	0	0	1	4	2	0	3	1	0	0	3	

Place and date of the relevées

Cyclamino repandi-Taxetum baccatae (CY)

1 – sine die 9.1996 – Madonna della Neve – DESULO (NU); 2 – sine die 9.1996 – Mercudargiu – DESULO (NU); 3, 4 – sine die 9.1996 – Tascusì – DESULO (NU); 5 – 27.6.1998 – Fennau – URZULEI (OG); 6 – 27.6.1998 – Pischina Urtaddala – URZULEI (OG); 7 – 28.6.1998 – Punta Turuddò – LULA (NU); 8, 9, 10, 11 – 28.6.1998 – Monte Novo San Giovanni – ORGOSOLO (NU); 12, 14 – sine die – Senna Manna – UTA (CA); 13, 16, 17 – sine die – Monte Lattias – UTA (CA); 15, 18 – sine die – Canale di Longuvresu – PULA (CA); 19, 20 – 30.6.2004 – P.ta Balistreri – TEMPIO PAUSANIA (OT); 21 – 28.7.2003 – P.ta Balistreri – TEMPIO PAUSANIA (OT); 22 – 30.6.2004 – P.ta Giogantinu – TEMPIO PAUSANIA (OT).

Sporadic species

Cyclamino repandi-Taxetum baccatae (CY)

Rel. 1: Pteridium aquilinum +; rel. 2: Pteridium aquilinum +; rel. 3: Thymus herba-barona; rel. 4: Thymus herba-barona; rel. 5: Ceterach officinarum +; rel. 6: Scrophularia trifoliata +; rel. 7: Sedum dasyphyllum +, Asperula pumila +, Saxifraga pedemontana ssp. cervicornis +, Sesleria insularis ssp. barbaricina +; rel. 8: Sanguisorba minor +, Scrophularia trifoliata +, Ceterach officinarum +, Saxifraga pedemontana ssp. cervicornis +, Sesleria insularis ssp. barbaricina +; rel. 9: Sanguisorba minor +, Sedum dasyphyllum +; rel. 10: Sedum dasyphyllum +; rel. 11: Sanguisorba minor +, Scrophularia trifoliata +, Asperula pumila +; rel. 14: Allium triquetrum +; rel. 15: Allium triquetrum 1, Polypodium cambricum 1, Umbilicus rupestris +, Leucojum autumnale +; rel. 16: Allium triquetrum +, Geranium lanuginosum +; rel. 18: Geranium lanuginosum +, Polypodium cambricum +, Umbilicus rupestris +; rel. 19: Hieracium mattirolianum +; rel. 22: Pteridium aquilinum +, Hieracium mattirolianum +, Fragaria vesca +.

natural potential vegetation of an edapho-hygrophylous series that develops on moist soils in mountain valleys near streams and springs, in areas included in the upper mesotemperate-lower supratemperate, submediterranean, subhumid-humid phytoclimatic belt. Closest associations to Polistycho setiferi-Taxetum baccatae are the Sicilian Ilici-Taxetum baccatae and the Corsican Asperulo-Taxetum baccatae, from which the Sardinian association differs because of the lowest presence of species belonging to the Fagetalia sylvaticae order and the sporadic presence of some endemic taxa such as *Hypericum hircinum* ssp. *hircinum*, *Paeonia corsica* and *Rubus arrigonii.*

Dynamic contacts were detected between these yew stands and shrub communities dominated by *Rubus* gr. *ulmifolius, Prunus spinosa, Rosa* gr. *canina, Crataegus monogyna, Clematis vitalba* and *Acer monspessulanum* ssp. *monspessulanum*, of the association Crataego monogynae-Aceretum monspessulani (Farris et al. 2007). Facilitative effects of holly and spiny shrubs on the performance of *Taxus baccata* recruits were highlighted in the sites of occurrence of this association (Farris & Filigheddu 2008).

Topographic contacts exist between this association and those related to holm-oak (Galio scabri-Quercetum ilicis and Saniculo europaeae-Quercetum ilicis) and deciduous oaks (Loncomelo pyrenaici-Quercetum ichnusae corr. and Glechomo sardoae-Quercetum congestae) series (Bacchetta et al. 2004a, 2004b, 2009).

Saniculo europaeae-Quercetum ilicis Bacch., Bagella, Biondi, Farris, Filigheddu & Mossa 2004 (Table 6)

taxetosum baccatae subass. nova hoc loco (typus rel. no. 38, Table 5)

This subassociation is characteristic of the contact areas between yew stands and meso-supratemperate, submediterranean woods dominated by *Quercus ilex*, referred to the association Saniculo europaeae-Quercetum ilicis (Bacchetta et al. 2004a). This community develops usually in humid places, near streams, where the yew is present with some hygrophylous and mesophylous taxa, as *Carex microcarpa, Osmunda regalis* and *Blechnum spicant*. It grows at an average altitude of 945 m a.s.l. and seems to be indifferent to the substratum.

As a consequence of the proposal to establish this new subassociation, the typical subassociation quercetosum ilicis is established too, corresponding to the type relevée of the association (rel. no. 8 of Table 4 by Bacchetta et al. 2004a).

Dynamic contacts are present between yew stands and hygrophylous shrub communities of the Caricion microcarpae alliance, dominated by *Rubus* gr. *ulmifolius, Erica terminalis, Carex microcarpa* and *Hypericum hircinum* ssp. *hircinum*. Topographic contacts are established mainly with the holm-oak woods of the Saniculo europaeae-Quercetum ilicis subass. quercetosum ilicis.

Glechomo sardoae-Quercetum congestae Bacch., Biondi, Farris, Filigheddu & Mossa 2004 (Table 6)

taxetosum baccatae subass. nova hoc loco (typus rel. no. 45, Table 6)

This subassociation is characteristic of the contact areas between yew stands and meso-supratemperate, submediterranean, humid woods dominated by *Quercus congesta*, referred to the association Glechomo sardoae-Quercetum congestae (Bacchetta et al. 2004b). This subassociation develops usually in northern slopes, at an average altitude of 997 m a.s.l. It was found only in the Marghine mountain, on volcanic substrates, but it is supposed to be present also in other sites of the island.

Dynamic contacts were detected between these yew stands and shrub communities dominated by *Rubus* gr. *ulmifolius, Prunus spinosa, Rosa* gr. *canina, Crataegus monogyna, Clematis vitalba* and *Acer monspessulanum* ssp. *monspessulanum*, of the association Crataego monogynae-Aceretum monspessulani (Farris et al. 2007). Topographic contacts are established mainly with the typical deciduous oak woods of the Glechomo sardoae-Quercetum congestae subass. quercetosum congestae.

Syntaxonomy

The floristic composition of the studied plant communities allowed us, in accordance to previous studies (Bacchetta et al. 2004b, 2009), to exclude for Sardinia the presence of associations referred to the Fagetalia sylvaticae order. We consider the associations Cyclamino repandi-Taxetum baccatae and Polysticho setiferi-Taxetum baccatae and the subassociation Glechomo sardoae-Quercetum congestae taxetosum baccatae, to be referred to the Quercetalia pubescenti-petraeae order of the Querco-Fagetea class. In particular, we include these 3 syntaxa into the Sardinian-Corsican suballiance Paeonio corsicae-Quercenion ichnusae of the Pino calabricae-Quercion congestae alliance.

The yew stands included within sclerophyllous woods, notably the Saniculo europaeae-Quercetum ilicis taxetosum baccatae, are included in the Clematido cirrhosae-Quercenion ilicis Sardinian-Corsican suballiance of the Fraxino orni-Quercion ilicis central Mediterranean alliance, order Quercetalia ilicis and class Quercetea ilicis, as follows:

QUERCETEA ILICIS Br.-Bl. ex A. & O. Bolòs 1950
Quercetalia ilicis Br.-Bl. ex Molinier 1934 em. Rivas-Martínez 1975
Fraxino orni-Quercion ilicis Biondi, Casavecchia & Gigante 2003
Clematido cirrhosae-Quercenion ilicis Bacch., Bagella, Biondi, Farris, Filigheddu & Mossa 2004
Saniculo europaeae-Quercetum ilicis *Bacch., Bagella, Biondi, Farris, Filigheddu & Mossa 2004*
quercetosum ilicis subass. nova
taxetosum baccatae subass. nova
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 corsicae-Quercenion ichnusae Bacch., Biondi, Farris, Filigheddu & Mossa 2004
Cyclamino repandi-Taxetum baccatae ass. nova
taxetosum baccatae subass. nova
rhamnetosum alpinae subass. nova
phillyreetosum latifoliae subass. nova
amelanchieretosum ovalis subass. nova
Polysticho setiferi-Taxetum baccatae ass. nova
Glechomo sardoae-Quercetum congestae Bacch., Biondi, Farris, Filigheddu & Mossa 2004
taxetosum baccatae subass. nova

Discussion

Biogeography

Taxus baccata communities are present in almost all the mountains of Sardinia, and not only in the Limbara and Marghine mountains, as stated by the Interpretation Manual of European Union Habitats (European Commission 2007). The yew shows its highest occurrence in the central-northern part of the island. Despite its preference for intermediate altitudes (600–1,000 m a.s.l.), it can be found from 50 to 1,550 m a.s.l. (Bacchetta & Farris 2007), showing ecological adaptability to different altitudes. The yew seems to be more exigent for water requirements, than for temperature (which is related to altitude), because in Sardinia it grows often near streams or springs. Only communities referred to the association Cyclamino repandi-Taxetum baccatae, typical of the top of Sardinian mountains, can be found far from water sources. Any preference to substrata has been highlighted by this research. All these ecological requirements are consistent with previous studies on yew peripheral populations in the southern limit of distribution (García et al. 2000, Thomas & Polwart 2003).

The floristic composition of the Sardinian yew stands is original and presents several peculiarities. The four assemblages studied can be considered as different syntaxa based on the multivariate analysis (Fig. 1), because they show dissimilarities ranging from 61.7% to 77.6%. Two new associations are herein described and correspond to yew communities growing at two phytoclimatic belts: the first which is supra-orotemperate in the submediterranean variant (Cyclamino repandi-Taxetum baccatae), and the second which is meso-supratemperate in the submediterranean variant (Polysticho setiferi-Taxetum baccatae). Other two communities have been herein described as new subassociations, corresponding to the contact between yew and oak woods (Saniculo europaeae-Quercetum ilicis taxetosum baccatae and Glechomo sardoae-Quercetum congestae taxetosum baccatae, respectively). It is noteworthy that the lower dissimilarity highlighted by the multivariate analysis was that between the two oak dominated communities (SA and GL): this means that oak forests are more similar each other even if one is an evergreen wood and the other a deciduous one. High dissimilarity (> 70%) was detected between the two yew dominated communities: in particular the orophylous yew forest (CY) was that having the higher divergence from the other three communities under study.

Contrary to previous studies (Thomas & Polwart 2003), our findings support the evidence for the presence of pure or yew-dominated woods in Sardinia: this is the case for Cyclamino repandi-Taxetum baccatae and Polysticho setiferi-Taxetum baccatae. In our opinion, these two communities can be considered as the potential natural vegetation (sensu Farris et al. 2010a) of special edaphophilous series developed on poor soils in oceanic climatic areas of Sardinian mountains. This finding has a relevant phytogeographical importance, because the most part, if not all, of the yew stands in the Tyrrhenian area are patches included in old-growth beech forests (Piovesan et al. 2009, Scarnati et al. 2009). To our knowledge, in the western Mediterranean there are forest communities dominated by the yew to which the Sardinian Polysticho setiferi-Taxetum baccatae is related for the ecological features (e.g. altitude, exposition, slope, water supply): this is the case of the Spanish Saniculo eu-

Table 4. Polysticho setiferi-Taxetum baccatae (typus rel. no. 29). Vol = volcanic; Bas = basalt; Met = metamorphic; Pres = presence.

Rel. no.	23	24	25	26	27	28	29*	30	31	32	33	
Coverage (%)	100	100	100	100	100	100	100	100	100	100	100	
Area (m^2)	50	50	200	200	200	300	200	100	100	400	100	
Aspect	NW	NW	N	N	N	SE	N	N	N	N	N	
Slope (%)	15	15	<5	<5	<5	8	<5	20	20	15	25	
Altitude (m asl)	900	900	980	980	980	1080	1035	1050	1050	1043	1050	
Substratum	Vol	Vol	Bas	Bas	Bas	Bas	Vol	Met	Met	Met	Met	
Rock percentage (%)	10	10	<5	<5	<5	10	<5	5	10	0	5	
Stone percentage (%)	20	20	10	5	8	0	5	15	10	5	8	
Average vegetation height (m)	8	8	10	10	10	10	6	10	8	10	12	
No. of taxa	16	18	11	13	8	10	20	16	10	8	9	Pres.
Charact. and diff. taxa of the ass.												
Taxus baccata	2	2	1	2	1	1	3	4	5	5	5	11
Ilex aquifolium	3	4	4	3	4	3	3	2	1	1	1	11
Polystichum setiferum	1	1	+	+	+	r	1	+	r	+	r	11
Sanicula europaea	.	+	.	+	.	.	2	1	r	+	2	7
Charact. and diff. taxa of the upper units												
Hedera helix ssp. *helix*	1	1	.	+	.	+	+	+	+	r	+	9
Quercus congesta	.	.	+	1	1	1	+	1	r	.	.	7
Lactuca muralis	.	.	.	.	.	.	+	+	+	+	+	5
Acer monspessulanum ssp. *monspessulanum*	.	.	.	+	+	1	+	.	.	.	.	4
Luzula forsteri	+	.	+	+	.	.	1	.	.	.	.	4
Melica uniflora	.	.	+	+	.	.	1	+	.	.	.	4
Cephalanthera longifolia	.	.	+	+	.	r	.	.	.	.	.	3
Viola alba ssp. *dehnhardtii*	.	+	+	+	.	.	.	.	.	.	.	3
Osmunda regalis	1	1	.	.	.	.	.	.	.	.	.	2
Viola reichenbachiana	.	.	.	.	.	.	.	.	+	.	+	2
Brachypodium sylvaticum	.	.	.	.	.	.	+	.	.	.	.	1
Castanea sativa	.	.	.	.	.	+	.	.	.	.	.	1
Fagus sylvatica	.	.	.	.	.	.	.	r	.	.	.	1
Oenanthe pimpinelloides	.	.	+	.	.	.	.	.	.	.	.	1
Paeonia corsica	+	.	.	.	.	.	.	.	.	.	.	1
Sorbus torminalis	.	.	.	.	.	.	r	.	.	.	.	1
Tamus communis	.	.	.	.	.	.	.	.	.	+	.	1
Charact. and diff. taxa of the *Quercetea ilicis* class												
Cyclamen repandum ssp. *repandum*	2	1	2	2	2	2	2	2	1	1	1	11
Rubia peregrina ssp. *peregrina*	+	.	.	.	.	.	r	r	.	.	.	3
Quercus ilex	1	1	.	.	.	.	+	.	.	.	.	3
Asplenium onopteris	1	1	.	.	.	.	r	.	.	.	.	3
Rosa sempervirens	+	.	.	.	.	.	.	.	.	.	.	1
Galium scabrum	.	+	.	.	.	.	.	.	.	.	.	1
Ruscus aculeatus	.	.	.	+	.	.	.	.	.	.	.	1
Other species												
Rubus gr *ulmifolius*	1	1	.	.	.	.	+	+	.	.	+	5
Crataegus monogyna	.	+	+	.	+	.	.	+	.	.	.	4
Pteridium aquilinum	.	.	.	.	+	r	1	.	.	.	.	3
Sporadic species	3	5	0	0	0	0	2	3	1	0	0	

Place and date of the relevées

Polysticho setiferi-Taxetum baccatae (PO)

23, 24 – 6.6.2002 – Rio S'Abba Lughida – SANTULUSSURGIU (OR); 25, 26, 27 – 23.5.2003 – Badde Salighes – BOLOTANA (NU); 28 – 15.6.2004 – Badde Salighes – BOLOTANA (NU); 29 – 13.5.2003 – Sa Serra – BOLOTANA (NU); 30, 31, 33 – 04.7.2003 – Sos Niberos – BONO (SS); 32 – 15.6.2004 – Sos Nibberos – BONO (SS).

Sporadic species

Polysticho setiferi-Taxetum baccatae (PO)

Rel. 23: Asplenium adiantum-nigrum +, Hypericum hircinum ssp. hircinum 1, Melica arrecta +; rel. 24: Asplenium adiantum-nigrum +, Hypericum hircinum ssp. hircinum 1, Melica arrecta +, Allium triquetrum +, Asplenium bil-lotii +; rel. 29: Dactylorhiza insularis +, Sambucus nigra r; rel. 30: Rubus arrigonii 1, Fragaria vesca r, Rosa canina r; rel. 31: Rubus arrigonii r.

Table 5. Saniculo europaeae-Quercetum ilicis Bacch., Bagella, Biondi, Farris, Filigheddu & Mossa 2004. subass. taxetosum baccatae (typus rel. no. 38). Nd = not determined; Vol = volcanic; Met = metamorphic; Lim = limestone; Gra = granite; Pres = presence.

Rel. no.	34	35	36	37	38*	39	40	41	42	
Coverage (%)	100	95	100	100	100	100	100	40	80	
Area (m^2)	400	200	50	200	400	200	400	400	400	
Aspect	N-NE	SW	NW	NW	NE	WNW	nd	0	NW	
Slope (%)	nd	30	15	10	20	15	nd	0	40	
Altitude (m asl)	980	880	850	880	800	915	1000	1096	1100	
Substratum	Met	Vol	Vol	Vol	Gra	Gra	Lim	Gra	Lim	
Rock percentage (%)	nd	25	nd	25	15	25	5	70	20	
Stone percentage (%)	nd	5	20	5	20	2	1	20	50	
Average vegetation height (m)	12	10	8	10	8	7	8	3	10	
No. of taxa	26	23	22	23	23	14	21	11	18	Pres.
Charact. and diff. taxa of the ass.										
Quercus ilex	4	5	3	3	3	5	5	3	4	9
Crataegus monogyna	1	1	1	1	+	+	+	+	+	9
Polystichum setiferum	+	+	1	2	1	r	+	.	+	8
Ilex aquifolium	2	2	2	2	2	.	+	1	.	7
Luzula forsteri	+	+	.	1	1	+	+	.	+	7
Viola alba ssp. *dehnhardtii*	+	.	+	.	+	.	+	+	+	6
Sanicula europaea	1	.	+	1	2	.	+	.	.	5
Brachypodium sylvaticum	+	1	.	1	.	.	.	.	.	3
Diff. taxa of the *taxetosum baccatae* subass.										
Taxus baccata	+	+	1	1	1	+	+	1	+	9
Hypericum hircinum ssp. *hircinum*	+	.	+	.	1	.	.	.	.	3
Carex microcarpa	+	.	.	.	1	.	+	.	.	3
Osmunda regalis	.	.	+	+	1	.	.	.	.	3
Blechnum spicant	.	.	+	.	+	.	.	.	.	2
Charact. and diff. taxa of the upper units										
Asplenium onopteris	+	1	1	1	+	+	+	+	.	8
Cyclamen repandum ssp. *repandum*	2	2	+	1	2	+	.	.	.	6
Rubia peregrina ssp. *peregrina*	1	+	.	.	+	+	+	.	1	6
Erica arborea	.	.	+	.	1	r	1	.	.	4
Galium scabrum	+	.	1	1	.	.	+	.	.	4
Ruscus aculeatus	+	1	.	2	.	.	.	.	.	3
Arbutus unedo	.	.	.	.	1	1	.	.	.	2
Digitalis purpurea	.	.	.	+	.	.	+	.	.	2
Juniperus oxycedrus ssp. *oxycedrus*	.	.	.	.	.	.	r	.	1	2
Carex distachya	.	.	.	.	.	.	.	.	+	1
Erica terminalis	.	.	.	.	1	.	.	.	.	1
Smilax aspera	.	+	.	.	.	.	.	.	.	1
Charact. and diff. taxa of the *Querco-Fagetea* class										
Hedera helix ssp. *helix*	1	1	1	1	1	+	1	+	+	9
Acer monspessulanum ssp. *monspessulanum*	.	+	.	+	.	.	.	2	1	4
Quercus congesta	1	+	1	1	.	.	.	.	.	4
Lactuca muralis	r	.	.	+	1	.	.	.	.	3
Cephalanthera longifolia	.	+	.	.	.	r	.	.	.	2
Tamus communis	+	1	.	.	.	.	.	.	.	2
Cephalanthera damasonium	.	r	.	.	.	.	.	.	.	1
Fragaria vesca	.	.	+	.	.	.	.	.	.	1
Fraxinus ornus	.	.	.	.	.	r	.	.	.	1
Melica uniflora	1	.	.	.	.	.	.	.	.	1
Prunus avium	.	+	.	.	.	.	.	.	.	1
Viola odorata	.	.	.	.	1	.	.	.	.	1
Other species										
Rubus gr *ulmifolius*	2	1	1	+	+	r	2	2	1	9
Pteridium aquilinum	2	+	.	1	1	.	1	.	.	5
Sporadic species	3	2	4	3	0	0	3	2	6	

Place and date of the relevées

Saniculo europaeae-Quercetum ilicis subass. taxetosum baccatae (SA)

34 – 27.7.2004 – Loc. Su Tassu – BULTEI (SS); 35 – 15.6.2004 – La Madonnina – SANTULUSSURGIU (OR); 36 – 6.6.2002 – La Madonnina – SANTULUSSURGIU (OR); 37 – 8.5.2003 – La Madonnina – SANTULUSSURGIU (OR); 38 – 9.5.2003 – Fontana Abba Lughida, Monte Lerno – PATTADA (SS); 39 – 30.6.2004 – S'Ampulla – BERCHIDDA (OT); 40, 42 – 12.8.2004 – Funtana Bona – ORGOSOLO (NU); 41 – 19.8.2004 – Parte sommitale, Monte Lerno – PATTADA (SS).

Sporadic species

Saniculo europaeae-Quercetum ilicis subass. taxetosum baccatae (SA)

Rel. 34: Sambucus nigra +, Rosa canina +, Salix atrocinerea +; rel. 35: Allium triquetrum r, Teucrium scorodonia +; rel. 36: Sambucus nigra +, Allium triquetrum +, Asplenium billotii +, Melica arrecta +; rel. 37: Teucrium scorodonia +, Clematis vitalba 1, Pyrus communis r; rel. 40: Sambucus nigra +, Rosa canina 1, Salix atrocinerea +; rel. 41: Prunus spinosa +, Pyrus spinosa +; rel. 42: Ceterach officinarum r, Galium schmidii 1, Melica minuta +, Saxifraga pedemontana ssp. cervicornis r, Stachys corsica +, Teucrium flavum ssp. glaucum +.

ropaeae-Taxetum baccatae, the Sicilian Ilici-Taxetum baccatae and the Corsican Asperulo-Taxetum baccatae.

The Cyclamino repandi-Taxetum baccatae is probably a more relic community, as supported by the higher separation from the other communities revealed by the multivariate analysis: on the top of the mountains, it survived as the top most tree community of Sardinia. It is a supra-orotemperate (submediterranean variant) wood, able to cover wide areas at the top of the main Sardinian mountains, as it is evident on the Mounts Limbara, Albo, Corrasi, Gennargentu, and Tonneri. At these sites, yew is not conditioned by the presence of running water, and is spread as the dominant tree with many old individuals, but also saplings that are growing mainly in shrubby patches (Farris & Filigheddu 2008). It is noteworthy that in many other parts of Europe and the Mediterranean Basin, including the adjacent island of Corsica, the top of the mountains, when suitable for forest vegetation, is colonized by more competitive species than yew, as *Fagus*, *Betula* and many conifers (e.g. *Abies, Larix, Picea*). Species belonging to all these genera are not present in Sardinia and probably never reached this island, leaving space to the yew to establish and persist at the top of Sardinian mountains, where oaks are not able to grow. We hypothesize that the potential vegetation dominated by the yew at the top of the Sardinian mountains has been fragmented in historical times by human activities (clearing, burning and shepherding), as confirmed by previous studies (Desole 1948, 1966). Palaeo-ecological considerations coming also from the rest of the Mediterranean area (e.g. Gamisans 1970, 1977, Pignatti 1979, Biondi 1982, Di Benedetto et al. 1983, Brullo et al. 1995), strongly support the relic character and the great biogeographic importance of the Sardinian yew stands, in particular the Cyclamino repandi-Taxetum baccatae.

Habitat conservation

Beyond the phytogeographic significance of the Sardinian yew stands, they have also a high conservation value, as recognized by the European Commission (1992): within the Annexe I of the HD, they are designated as priority habitat (code 9580*). The presence of this habitat is also reported by the Italian Interpretation Manual of the 92/43/EEC Directive habitats (Biondi et al. 2009). However, our investigation shows that Sardinian yew woods are related to more habitat types than 9580* only; in fact they establish dynamic and topographic contacts with other habitats as the "Endemic oro-Mediterranean heaths with gorse" (4090), "*Salix alba* and *Populus alba* galleries" (92A0), "*Quercus ilex* and *Quercus rotundifolia* forests" (9340) and "Forests of *Ilex aquifolium*" (9380). The conservation of the yew stands is therefore a key-issue of the Mediterranean forest conservation as a whole.

Sardinian yew populations are old and sometimes senescent: Farris & Filigheddu (2008) reported an average age of 250 years calculated on a sample of 147 individuals in 6 populations. Yew is a persisting tree but its renewal, recruitment and establishment are difficult, in particular because of the lacking of microsites (Hulme 1996, García et al. 2000, García & Obeso 2003) and the overgrazing pressure due to domestic livestock (Mysterud & Østbye 2004, Perrin et al. 2006, Farris & Filigheddu 2008).

Tree species composition and richness in Europe is shaped and strongly influenced by both historical and environmental conditions, in particular climate (Svenning & Skov 2005); these two factors seem to be responsible also of the fragmentation and isolation of the European yew populations (Thomas & Polwart 2003). In Mediterranean mountains many yew populations are characterized by unique gene pools: high levels of divergence have been highlighted, particularly on islands, even at small spatial scales, which have been attributed to the combined effects of climatic changes, current ecological conditions, and anthropogenic factors, that have originated a long history of population isolation (González-Martínez et al. 2010). Yew is a temperate-oceanic species, suspected to undergo a serious decline in Europe by 2100, ranging from −15% to −33%, as a consequence of the climatic change (Normand et al. 2007), that has been indicated as a major threat in particular for the populations located at the rear edge of temperate and boreo-alpine species distribution (Hampe & Petit 2005). Furthermore, many of the species linked to yew stands are mountain-temperate plants, that are hypothesized to decline because of climate changes in southern European mountains (Stanisci et al. 2005, Erschbamer et al. 2009, Mendoza et al. 2009), and in particular in the Mediterranean, that is considered a hot-spot of global climatic change (Giorgi 2006, Bravo et al. 2008).

We found yew and associated species distributed in two types of climatic islands: one that can be considered an altitudinal one (top of mountains) and the second that can be considered a geomorphological one (valleys and gorges). These two distinct situations correspond to two different types of Mediterranean refugia (sensu Medail & Diadema 2009), as previously detected by Fenu et al. (2010) for the Supramontes region (CE Sardinia), that are considered areas of special value for the long-term persistence of biodiversity. The scattered distribution of these two habitats for the yew can be considered, to our opinion, the main current ecological condition that plays a pivotal role in the process of population isolation highlighted by González-Martínez et al. (2010).

To preserve the existing Mediterranean yew woods, measures to protect the senescent stands and to enhance seed dispersal and juveniles survival (species conservation) will not be enough if not linked to conservation actions that should accomplish the ecological and phytocoenotic diversity highlighted by this investigation (habitat conservation).

Table 6. Glechomo sardoae-Quercetum congestae Bacch., Biondi, Farris, Filigheddu & Mossa 2004. subass. taxetosum baccatae (typus rel. no. 49). Nd = not determined; Bas = basalt; Pres = presence.

Rel. no.	43	44	45*	
Coverage (%)	100	90	100	
Area (m^2)	200	200	200	
Aspect	N	NW	NE	
Slope (%)	2	5	3	
Altitude (m asl)	955	1000	1035	
Substratum	Bas	Bas	Bas	
Rock percentage (%)	4	2	5	
Stone percentage (%)	2	2	2	
Average vegetation height (m)	nd	nd	8	
No. of taxa	19	20	25	Pres.
Charact. and diff. taxa of the ass.				
Quercus congesta	5	3	5	3
Acer monspessulanum ssp. *monspessulanum*	2	1	2	3
Luzula forsteri	+	+	2	3
Cyclamen repandum ssp. *repandum*	.	2	2	2
Poa nemoralis	+	.	1	2
Glechoma sardoa	+	.	+	2
Diff. taxa of the *taxetosum baccatae* subass.				
Taxus baccata	+	+	+	3
Charact. and diff. taxa of the upper units				
Brachypodium sylvaticum	2	1	+	3
Hedera helix ssp. *helix*	1	1	1	3
Ilex aquifolium	1	2	2	3
Oenanthe pimpinelloides	.	+	2	2
Sanicula europaea	.	2	1	2
Viola alba ssp. *dehnhardtii*	1	.	+	2
Ranunculus ficaria ssp. *ficaria*	.	.	2	1
Melica uniflora	.	.	1	1
Fragaria vesca	.	.	1	1
Castanea sativa	+	.	.	1
Geum urbanum	+	.	.	1
Lactuca muralis	.	.	+	1
Loncomelos pyrenaicus	.	.	+	1
Ranunculus lanuginosus	.	+	.	1
Sorbus torminalis	.	+	.	1
Viola reichenbachiana	.	+	.	1
Other species				
Crataegus monogyna	1	+	+	3
Pteridium aquilinum	1	1	1	3
Rubia peregrina ssp. *peregrina*	+	+	r	3
Rubus gr. *ulmifolius*	2	1	1	3
Carex divulsa	.	+	r	2
Sporadic species	3	2	2	

Place and date of the relevées

Glechomo sardoae-Quercetum congestae subass. taxetosum baccatae (GL)

43–16.5.2003 – Badde Salighes – BOLOTANA (NU); 44–23.5.2003 – Badde Salighes – BOLOTANA (NU); 45–13.5.2003 – Sa Serra – BOLOTANA (NU).

Sporadic species

Glechomo sardoae-Quercetum congestae subass. taxetosum baccatae (GL)

Rel. 43: Rosa canina 2, Smyrnium rotundifolium +, Teucrium scorodonia +; rel. 44: Clematis vitalba +; Colchicum alpinum ssp. parvulum 1; rel. 45: Quercus ilex r, Ranunculus neapolitanus r.

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Appendix 1 – List of other syntaxa cited in text but not included in the syntaxonomic scheme

Aceri monspessulani-Quercetum ilicis Arrigoni, Di Tommaso & Mele 1985
Asperulo-Taxetum baccatae Gamisans 1970
Caricion microcarpae Gamisans 1975
Crataego monogynae-Aceretum monspessulani Farris, Secchi & Filigheddu 2007
Fagetalia sylvaticae Pawłowski in Pawłowski, Sokołowski & Wallisch 1928
Galio scabri-Quercetum ilicis Gamisans (1977) 1986
Ilici-Taxetum baccatae Brullo, Minissale & Spampinato 1996
Juniperetum nanae Litar. & Malcuit 1926
Loncomelo pyrenaici-Quercetum ichnusae Bacch., Biondi, Farris, Filigheddu & Mossa 2004 corr.
Pistacio-Juniperetum oxycedri Camarda, Lucchese, E. Pignatti & S. Pignatti 1995
Potentilletalia caulescentis Br.-Bl. in Br.-Bl. & Jenny 1926
Saniculo europaeae-Taxetum baccatae O. de Bolòs 1967