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A new association of *Satureja montana* L. subsp. *montana* dominated garrigues in Puglia (SE Italy)

Valeria Tomaselli[1], Giuseppe Silletti[2], Luigi Forte[1,3]

1 *Department of Biology, University of Bari, Via Orabona 4, 70125 Bari, Italy*
2 *via Gioia 80, 70029, Santeramo in Colle (Bari), Italy*
3 *Museo Orto Botanico, University of Bari, Via Orabona 4, 70125 Bari, Italy*

Corresponding author: Valeria Tomaselli (valeria.tomaselli@uniba.it)

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Abstract

In this paper a survey on the garrigue vegetation dominated by *Satureja montana* subsp. *montana* occurring in the Alta Murgia National Park is presented. These communities were compared with those of the Ionian Arc ravines. Syntaxonomic, structural, chorological and ecological analyses were performed in order to achieve a proper classification of this vegetation. A new association is here described, the *Rhamno saxatilis-Saturejetum montanae*, with two new subassociations, *typicum* and *fumanetosum procumbentis*. It is a garrigue vegetation dominated by *Satureja montana* subsp. *montana* occurring in the Murgian area, in sites characterized by rocky and stony soils and by a Mediterranean Pluviseasonal oceanic weak semicontinental phytoclimate, with thermotype upper meso-Mediterranean and ombrotype lower subhumid, and is here framed in the *Cytiso spinescentis-Saturejion montanae* alliance (order *Cisto cretici-Ericetalia manipuliflorae*, class *Cisto cretici-Micromerietea julianae*). The results contribute to add a further piece to the knowledge of the natural plant landscape of the territory of the Alta Murgia National Park.

Keywords

chamaephytic vegetation, *Cisto cretici-Ericion manipuliflorae*, *Cytiso spinescentis-Saturejion montanae*, phytosociology, syntaxonomy

Introduction

Satureja montana subsp. *montana*, commonly known as winter or mountain savory, is a suffruticose chamaephyte, native to N-Mediterranean, with distribution area ranging from Iberian to Balkan peninsula (Tutin et al. 1972). As regards the Italian distribution, *S. montana* occurs throughout the territory with the exception of some northern regions and Sicily (Bartolucci et al. 2018), thriving mainly in dry, discontinuous rocky basophilous grasslands of *Festuco-Brometea* (*Cytiso spinescentis-Bromion erecti*; Biondi et al. 1995; Biondi et al. 2005; Di Pietro 2011), in montane and sub-montane xeric chamaephytic grasslands and garrigues (Allegrezza et al. 1997; Pirone and Tammaro 1997; Allegrezza et al. 2003; Pirone et al. 2014), as well as in stream-bed garrigues (Scoppola and Angiolini 1997; Angiolini et al. 2005) of *Cisto-Micromerietea julianae*, in central-southern Apennine areas ranging from Temperate to sub-Mediterranean bioclimates. Chamaephytic grasslands and garrigues have been referred to both the two alliances *Cytiso spinescentis-Saturejion montanae* and *Artemisio albae-Saturejion montanae* (*Cisto-Micromerietea julianae* class; Biondi et al. 2014). *S. montana* is quite common also in chasmophytic vegetation, especially in the Adriatic area (Trinajstić 1980; Di Pietro and Wagensommer 2008; Terzi et al. 2018).

As regards the Puglia region, garrigue vegetation characterizes large parts of the territory, especially in coastal areas but also in hilly, sub-mountain and mountain belts; numerous contributions have been provided to the knowledge and the phytosociological characterization of this vegetation (De Faveri and Nimis 1982; Géhu et al. 1984; Brullo et al. 1986; Taffetani and Biondi 1989; Biondi 2000; Brullo et al. 1997; Biondi and Guerra 2008; Di

Pietro and Misano 2010; Forte et al. 2011). In particular, *S. montana* dominated garrigues have been described by Biondi and Guerra (2008) as the *Asyneumo limonifolii-Saturejetum montanae*, association occurring in some sectors of the ravines of the Ionian Arc (Taranto), at altitudes ranging between 280 and 340 m a.s.l., in Mediterranean (Pluviseasonal Oceanic) bioclimate, upper meso-Mediterranean bioclimatic belt.

Recently, during phytosociological investigations on the vegetation of the Alta Murgia National Park, some garrigue communities dominated by *S. montana* and *Rhamnus saxatilis* have been identified and analysed. This vegetation is set in the upper Murgian landscape, tipically characterized by sub-Mediterranean xeric grasslands, dominated by *Stipa austroitalica* ssp. *austroitalica*, and widely interspersed with rocky outcrops (Forte et al. 2005). Aim of this paper is the phytosociological characterization of these communities, with a comparison with the *S. montana* garrigues of the Ionian Arc, in order to provide a further element to the description of the upper Murgian landscape.

Study area

Alta Murgia lies in the north-western part of Murge hill, an oblong plateau in the centre of Puglia Region, stretching out NW-SE towards the nearby Basilicata Region. It is included in the Natura 2000 network as SCI/SPA IT9120007 (125.000 ha); part of this area (about 68.000 ha) falls within the Alta Murgia National Park (Fig. 1).

Altitude of this area ranges between 300 and 679 m a.s.l. The geological substrate is made up of a thick layer of Jurassic-Cretaceous carbonate sedimentary rocks, covered in alternate tracts by thin and discontinuous Plio-Pleistocene deposits. The site shows a typical karst landscape, slightly corrugated with dolinas, poljes and dry karst valleys (locally called "lame") (Cotecchia 2014). According to the Rivas-Martínez classification (2011), the Alta Murgia macrobioclimate is Mediterranean, with a pluviseasonal-oceanic bioclimate and continental character (IC > 17). The ombrotypes range from dry to sub-humid and the thermotype is meso-Mediterranean (Forte et. al. 2005).

The vegetation of the upper part of Alta Murgia consists mainly of widespread submediterranean xeric grasslands physiognomically characterized by *Stipa austroitalica* (Forte et al. 2005) and, depending on the level of soil nutrient, of grasslands with dominant *Ferula communis*, *Asphodelus ramosus*, *Charybdis pancration* (Tarantino et al. 2021). Scattered shrubs or trees determine physiognomic types of shrub-steppe or steppe-woodland (Bianco 1962). Where rocky outcrops emerge abundantly, grasslands alternate with *S. montana* communities, object of the present contribution. These garrigues form a mosaic with the bryophytic vegetation of *Pleurochaeto squarrosae-Cheilotheletum chloropi* Privitera and Puglisi 1996 and of *Barbuletum convolutae* Hadàc and Šmarda 1944 (Puglisi et al. 2019) and are in contact with the *Stipa austroitalica* subsp. *austroitalica* grasslands (the *Acino suaveolentis-Stipetum austroitalicae* Forte and Terzi in Forte, Perrino and Terzi 2005) that dominate the natural landscape of this part of Puglia. In correspondence of cliffs and vertical rocks, *Aurinia saxatilis* subsp. *megalocarpa* and *Athamanta sicula* chasmophytic communities occur (*Iberido carnosae-Athamantetum siculi* Terzi and D'Amico 2008).

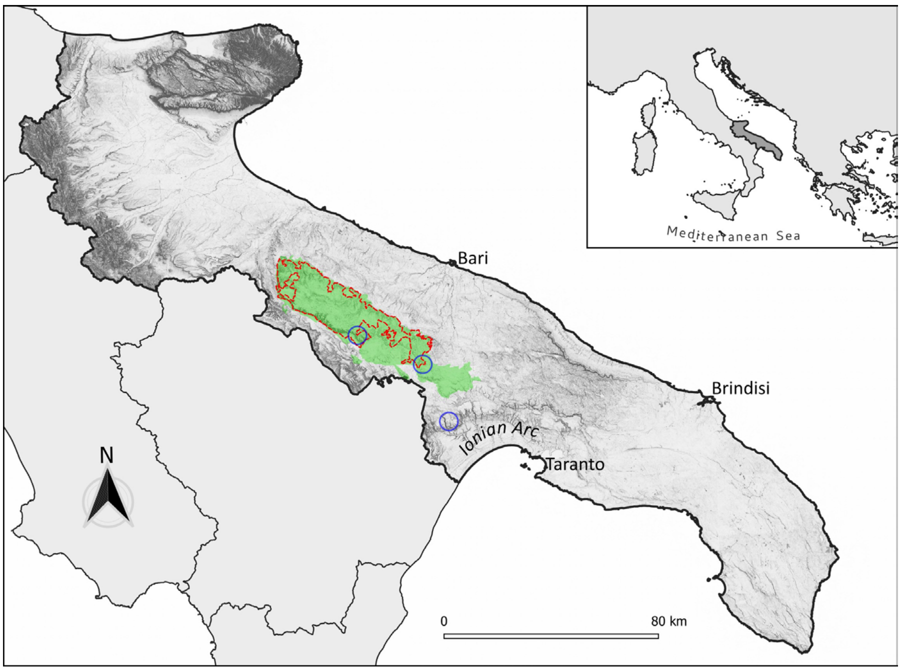

Figure 1. Study area. SCI/SPA "Murgia Alta" IT9120007 in green and "Alta Murgia" National Park with red boundaries. The blue circles indicate the location of the sample sites.

Material and methods

For the phytoclimatic characterization of the study sites, bioclimatic indices according to Rivas-Martínez et al. (2011), and rainfall data in raster data format (resolution 900 m - period 1960–1990), retrieved from the "Bioclimates of Italy" database (Pesaresi et al. 2017), were used. We used this database rather than the most recent WorldClim version 2.1 (climate data for 1970–2000; Fick and Hijmans 2017) because, comparing the rainfall data obtained from the local meteorological stations (https://protezionecivile.puglia.it/) with those extracted from the WorldClim 2.1 database, a considerable level of inaccuracy of the rainfall data in WordClim emerged at the regional scale (as already noticed by Pesaresi et al. (2017) for the previous WorldClim version 1.4 (Hijmans et al. 2005)). Temperature data, corresponding to the same time period (1960–1990), were instead extracted from the WorldClim version 1.4 (Hijmans et al. 2005), because the average monthly values of maximum and minimum temperature, required for the calculation of the Potential Evapotranspiration (ETP) according to Hargreaves and Samani (1982; 1985), are not available in the "Bioclimates of Italy" database.

On the basis of these data and by means of the Worldwide Bioclimatic Classification System (WBCS; Rivas-Martínez et al. 2011) and of the Bioclimatic Intensity (IB) method (Montero de Burgos and González Rebollar 1974), the phytoclimatic characterization of the study sites (i.e., the sites where the phytosociological relevès were performed) was achieved. The IB indices were calculated with specific worksheet (Forte 2002). The equation proposed by Hargreaves and Samani (1982, 1985) to compute the Potential Evapotranspiration was used for the hydrological balances required for the calculation of the IB indices; a soil water storage value of 65 mm was used, as the power of the soil in the garrigue stations is about 30 cm and the AWC of the soils of the Alta Murgia is 2.1 mm/cm (Terzi et al. 2001).

The vegetation survey was carried out on the *S. montana* garrigue vegetation, occurring in Alta Murgia, in an area between the municipalities of Gravina in Puglia, Altamura and Santeramo in Colle (BA), at altitudes between 430 and 560 m a.s.l. Twenty relevès were performed using the phytosociological method proposed by Braun-Blanquet (1964), and by random sampling in homogeneous vegetation areas; plot size was determined as minimum area (Braun-Blanquet 1964; Dietvorst et al. 1982; Michalcová et al. 2011). In order to achieve a more complete framework of these communities for the Apulia region, a comparative analysis with those occurring in Ionian Arc (TA) was planned, adding seven relevès to the data-set, of which four from literature (Biondi and Guerra 2008) and three from new survey (with these last performed as described above). Cover data were transformed according to van der Maarel (1979) and sporadic species (i.e. occurring in only 1 relevé in the matrix) were excluded from statistical processing. Thus, to evaluate the aggregation of relevès in defined plant communities, hierarchical clustering was performed on the final matrix of 27 relevès, by using flexible beta linkage, with the Bray-Curtis coefficient. Beta was set at -0.25 (McCune and Grace 2002).

On the defined plant communities, biological and chorological spectra were calculated, weighted by both frequency and cover index (Pirola 1970). Life forms and Chorotypes (Pignatti et al. 2017–2019) were assigned to each species, as well as Ellenberg indicator values (Pignatti et al. 2005; Guarino et al. 2012) that were used for the implementation of the ecograms, according to Pignatti et al. (1996). In order to point out the role of the species with Balkan gravitation or with eastern Mediterranean distribution in the analyzed vegetation, these species have been identified and labeled as SE-European-Pontic-Illyrian and E-Mediterranean, respectively.

The significance of the differences between the percentage values in the groups of observations, for each biological type and each chorotype, was evaluated with the χ^2 test. The Mann-Whitney U-test for two independent samples was used to evaluate the statistical significance between the different average values taken by the various ecological indices in the different ecograms. This test was performed by using the SPSS II.5 software package (SPSS Inc., Chicago 1989–2002).

The results of all these analyses were compared with the diagnoses of the alliances, orders and classes in Mucina et al. (2016) and Biondi et al. (2014), in order to identify the most suitable syntaxonomic frame for the surveyed communities, in terms of structural, bioclimatic, phytogeographical, ecological and floristic features. Syntaxonomic framing of the investigated communities, at the level of higher rank syntaxa (alliances, orders, and classes) is in accordance with the Vegetation Prodrome of Italy (Biondi et al. 2014). Syntaxonomic nomenclature of alliances, orders, and classes follows Biondi et al. (2014), except for the class *Festuco hystricis-Ononidetea striatae* that is in accordance with Mucina et al. (2016). For the identification of characteristic and differential species of alliances *Cytiso spinescentis-Saturejion montanae*, *Cisto cretici-Ericion manipuliflorae* and higher rank syntaxa we referred to Pirone et al (2014) and Biondi et al (2014), and also to Biondi and Guerra (2008) and Di Pietro and Misano (2010), as these latter two researches carried out in areas partially matching the study area of the present survey. Plant species nomenclature follows Bartolucci et al. (2018). The syntaxa names comply with the International Code of Phytosociological Nomenclature (ICPN) (Theurillat et al. 2020)

Results

The dendrogram resulting from the cluster analysis (Fig. 2) separates in A (*S. montana* communities of Ionian Arc, the *Asyneumo limonifolii-Saturejetum montanae* association) and B (Alta Murgia communities). B, in turn, clearly separates in two sub-clusters, B1 and B2.

Table 1 reports the performed relevès: cluster A correspond to rels 1–8, cluster B1 to 9–21 and B2 to 22–28.

A significant contingent of species of the *Cytiso spinescentis-Saturejion montanae* is well represented in the group B, while it is missing in A, except for *S. montana* (considered by Biondi & Guerra (2008) as characteristic of the *Asyneumo limonifolii-Saturejetum montanae*). On the other hand, the *Cisto cretici-Ericion manipuliflorae* floristic contingent is far richer in group A, with more thermophilous species (e.g., *Thymbra capitata*, *Fumana scoparia*, *Phagnalon rupestre* subsp. *illyricum*). Moreover, the second group of Alta Murgia relevès is characterized by the presence (and significant frequency) of a numerous amount of species of the *Hippocrepido glaucae-Stipion austroitalicae* (*Scorzoneretalia villosae*). Finally, in the Alta Murgia group two subgroups may be identified (rels 9–21 and 22–28), corresponding to the two sub-clusters of the dendrogram (B1 and B2 respectively) and with the second characterized by the presence, also with significant cover values, of *Fumana procumbens*. These two sub-groups are differentiated also in terms of soil surface aspect, with sub-group B2 showing a pronounced stoniness (50 to 80%) respect to the sub-group B1 (Tab. 1).

According to the Rivas-Martínez classification (2011), all the sites of the performed relevès (groups A, B1 and B2) turned out to share the same phytoclimate, that is Mediterranean Pluviseasonal oceanic, weak semicontinental with thermotype upper meso-Mediterranean and ombrotype lower subhumid. On the other hand, comparing the annual trend of the Bioclimatic Intensities (IB) of Montero de Burgos and González Rebollar (Table 2), some significant traits arose between the sites of the three groups A, B1 and B2, that can be well differentiated. In general, for all three groups emerges a phytoclimatic annual trend characterized by two periods of vegetative activity, with the autumn more intense than the spring (Fig. 3), as already known for the vegetation types on low-power soils of this geographical area (Forte et al. 2005). These periods of activity alternate with two periods of pause, one in winter and the other in summer (dryness). The sites of the relevès belonging to group A differ mainly in a shorter and less intense winter break (January and February only) and for a more intense dryness (greater than 0.1 ubc/month). In those of group B, on the other hand, the vegetative activity due to winter cold is interrupted for three months (December included), with IBF always greater than 0.75 ubc/month. Sub-group B2, then, differs from that B1 for a slightly greater summer dryness and a less intense winter stasis. These results highlight a more thermo-xeric phytoclimate for the *S. montana* garrigues of the Ionian Arc, compared to those of the Alta Murgia, justifying the floristic and vegetational differences found between the two areas, also represented by the respective biological and chorological spectra, and ecograms. In fact, even if the biological spectra weighted by frequency indicate no statistically significant differences in the biological composition (Fig. 4a), those ones weighted by cover index show highly significant differences ($p < 0.001$; Fig. 4b) between the biological structures of the two different plant communities, mainly due to the different role of chamaephytes, hemicryptophytes and nanophanerophytes. In the *Asyneumo limonifolii-Saturejetum montanae* (A) chamaephytes are clearly dominating on the other biological types, while the communities of Alta Murgia (B), even being chamaephytic garrigues (Ch = 59.5%, see Fig. 4b) and physiognomically marked by the presence of Rhamnus saxatilis (NP), are also characterized by an important component of hemicryptophytes that participate in the vegetation structure, even beyond the 20%.

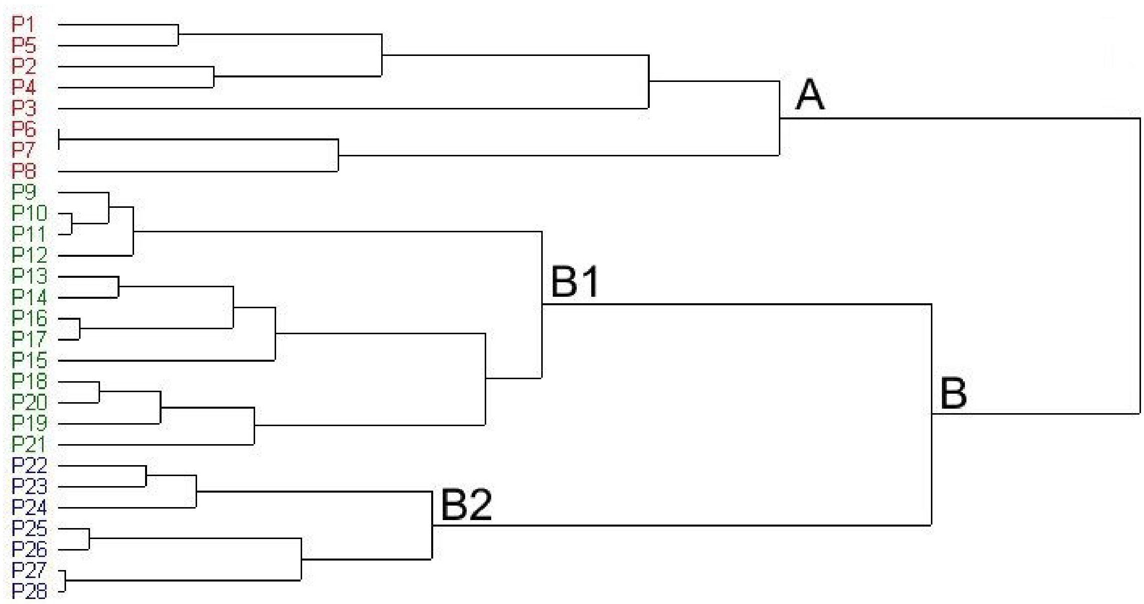

Figure 2. Dendrogram resulting from the cluster analysis. In red, group A; green, group B1; blue, group B2.

Table 1. *Asyneumo limonifolii-Saturejetum montanae* Biondi and Guerra 2008 (rels 1-8); *Rhamno saxatilis-Saturejetum montanae* ass. nova (rels 9-28), *typicum* (rels 9-21), *fumanetosum procumbentis* subass. nova (rels 22-28).

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Area (m^2)	10	15	10	50	40	30	60	80	30	20	20	30	50	80	70	70	80	30	25	50	50	50	40	40	70	50	50	60
Vegetation cover (%)	75	80	70	70	70	60	65	70	60	60	50	60	60	70	75	80	75	80	70	65	70	80	70	80	70	75	65	60
Elevation (m s.l.m.)	340	330	300	435	445	348	345	365	560	562	550	560	475	495	550	510	500	480	500	495	510	515	485	485	485	430	470	470
Aspect	SSE	S	SW	NNO	-	O	O	-	O	ONO	O	NO	OSO	O	SO	E	O	SO	S	SO	SO	S	S	S	E	NE	SO	NE
Slope (°)	5	20	90	20	-	15	25	-	40	45	50	45	25	40	25	20	25	15	25	30	25	-	-	-	10	10	10	10
Soil surface aspect, rocky outcrops (%)	/	/	/	/	/	30	20	25	25	30	20	25	30	30	25	20	25	20	25	30	25	5	5	5	10	20	5	5
Soil surface aspect, stoniness (%)	/	/	/	/	/	5	10	10	5	5	10	10	5	5	10	10	5	5	5	10	5	50	60	50	70	50	80	80
vegetation height (cm)	/	/	/	/	/	20	20	25	30	25	25	25	25	30	30	25	25	30	30	25	30	40	30	40	30	35	25	25
Diff ass																												
Asyneuma limonifolium subsp. *limonifolium*	1	1	.	+	1	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
Ruta graveolens	.	.	.	.	.	.	.	.	.	+	.	1	1	2	1	+	1	+	+	.	1	.	.	.	.	.	+	+
Euphorbia nicaeensis subsp. *japygica*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	1	1	1	+	+	+	1
Allium apulum	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	2	2	1	1	+	+	+	.	.	.	.
Sabulina attica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	1	1	+	.	.	+	.	+	+
Centaurea brulla	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	+	.	.	.	.	.
Diff subass																												
Fumana procumbens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	1	2	3	2	3
Odontites luteus subsp. *luteus*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	+	+	+	+
Cisto cretici-Ericion manipuliflorae																												
Cistus creticus subsp. *eriocephalus*	.	.	.	.	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thymbra capitata	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cytiso spinescentis-Saturejon montanae																												
Satureja montana subsp. *montana*	4	4	4	4	5	3	4	4	3	4	3	4	4	4	4	4	3	4	4	4	4	4	3	4	4	4	3	3
Rhamnus saxatilis	.	.	.	.	.	.	.	.	2	2	3	2	4	3	3	2	3	2	3	3	3	.	1	2	+	+	+	1
Euphorbia spinosa	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	+	.	.	2	.	1	+	.	.	.	.
Ononis pusilla L. *pusilla*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	+
Silene otites	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Cisto-Micromerietea, Cisto-Ericetalia																												
Teucrium capitatum subsp. *capitatum*	+	.	.	1	1	1	1	+	+	+	+	1	1	+	2	1	1	+	+	+	1	1	1	1	1	+	+	+
Petrosedum ochroleucum subsp. *mediterraneum*	+	1	.	.	1	1	+	+	1	+	1	+	1	+	1	+	2	+	1	+	1	+	.	.	+	+	.	+
Micromeria graeca subsp. *graeca*	+	.	.	.	+	1	1	.	2	1	1	1	1	1	1	+	2	2	2	2	1	.	+	.	.	.	.	.
Fumana thymifolia	1	.	.	.	+	2	1	1	.	.	.	.	.	.	.	1	.	.	.	2	.	2	1	2	2	1	2	2
Helianthemum jonium	.	.	1	.	.	1	1	+	.	.	.	.	.	.	.	2	.	.	.	1	.	1	2	+	+	1	+	+
Phagnalon rupestre subsp. *illyricum*	1	2	.	2	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fumana ericifolia	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Fumana scoparia	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hippocrepido glaucae-Stipion austroitalicae, Scorzonero-Chrysopogonetalia, Festuco Brometea																												
Stipa austroitalica subsp. *austroitalica*	+	.	.	+	+	1	1	+	+	1	1	1	+	2	2	2	+	2	2	2	2	1	1	2	2	1	2	2
Convolvulus cantabrica	.	.	.	.	+	+	+	.	1	+	.	+	+	+	+	1	1	+	1	+	+	+	.	+	+	.	+	+
Koeleria subcaudata	.	.	.	.	.	.	.	.	1	+	+	1	2	1	2	1	.	1	+	1	1	1	1	1	1	+	1	+
Scorzonera villosa subsp. *columnae*	+	.	.	.	.	1	+	.	2	1	1	2	+	1	+	1	.	1	.	.	1	1	1	1	+	1	+	.

Table 1. Continuation.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Area (m²)	10	15	10	50	40	30	60	80	30	20	20	30	50	80	70	70	80	30	25	50	50	50	40	40	70	50	50	60
Vegetation cover (%)	75	80	70	70	70	60	65	70	60	60	50	60	60	70	75	80	75	80	70	65	70	80	70	80	70	75	65	60
Elevation (m s.l.m.)	340	330	300	435	445	348	345	365	560	562	550	560	475	495	550	510	500	480	500	495	510	515	485	485	485	430	470	470
Aspect	SSE	S	SW	NNO	-	O	O	-	O	ONO	O	NO	OSO	O	SO	E	O	SO	S	SO	SO	S	S	S	E	NE	SO	NE
Slope (°)	5	20	90	20	-	15	25	-	40	45	50	45	25	40	25	20	25	15	25	30	25	-	-	-	10	10	10	10
Soil surface aspect, rocky outcrops (%)	/	/	/	/	/	30	20	25	25	30	20	25	30	30	25	20	25	20	25	30	25	5	5	5	10	20	5	5
Soil surface aspect, stoniness (%)	/	/	/	/	/	5	10	10	5	5	10	10	5	5	10	10	5	5	5	10	5	50	60	50	70	50	80	80
vegetation height (cm)	/	/	/	/	/	20	20	25	30	25	25	25	25	30	30	25	25	30	30	25	30	40	30	40	30	35	25	25
Anthyllis vulneraria subsp. *rubriflora*	.	.	.	.	.	.	.	1	+	+	.	+	+	1	+	1	.	.	1	1	.	2	2	1	1	1	1	1
Festuca circummediterranea	.	.	.	.	.	.	.	.	2	1	1	1	2	1	1	3	2	1	1	1	+	+	.	.	+	+	.	.
Petrorhagia saxifraga subsp. *gasparrinii*	.	.	.	+	+	.	.	+	+	1	1	+	.	.	1	+	1	1	.	.	.	+	+	+	+	.	.	.
Leontodon crispus	.	.	.	.	.	.	.	1	1	+	+	+	.	.	.	.	.	.	.	.	.	2	1	1	+	+	1	1
Dianthus tarentinus	.	.	.	.	.	.	.	.	1	+	1	1	.	+	.	.	1	1	1	1	+	.	.	.	.	.	.	.
Teucrium chamaedrys subsp. *chamaedrys*	.	.	.	.	.	.	.	.	.	+	.	+	2	.	.	+	+	+	+	+	+	.	.	.	.	.	+	.
Clinopodium suaveolens	.	.	.	.	.	.	.	.	+	.	.	+	2	+	1	2	+	+	+	.	.	.	.	.	+	.	.	.
Euphorbia myrsinites subsp. *myrsinites*	.	.	.	.	.	.	.	.	1	+	+	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Hippocrepis glauca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	1	+	1	1	+
Eryngium amethystinum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	.	+
Linum tommasinii	.	.	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Bromopsis erecta subsp. *erecta*	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	+	.	.	.	1	.	.
Thesium humifusum	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.
Iris pseudopumila	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+
Other species																												
Thymus spinulosus	.	.	.	+	.	1	.	.	+	+	.	+	2	1	1	1	1	.	.	.	1	1	2	+	1	+	.	+
Asperula aristata subsp. *aristata*	.	1	.	+	.	.	.	.	+	.	+	+	+	+	2	1	2	1	1	1	2	.	+	1	+	+	.	+
Stachys romana	+	+	.	+	.	+	.	.	+	+	.	+	.	.	.	.	+	+	+	+	.	+	+	.	+	+	.	.
Reichardia picroides	.	.	.	.	.	.	+	+	1	+	+	.	.	1	.	1	+	1	+	1	1	.	+	.	.	.	.	.
Linum strictum	+	.	.	.	+	+	+	.	.	+	.	+	.	.	+	+	1	.	.	.	1	.	.	.	+	1	+	.
Thapsia asclepium	+	.	.	+	.	+	+	.	+	1	1	.	+	+	+	.	.	.	.	.	2	.	+	.	.	+	.	.
Allium sphaerocephalon	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	+	+	1	2	+	.	.	.	+	+	+	+
Crupina crupinastrum	.	.	.	.	.	+	+	.	.	+	+	1	.	+	.	+	.	.	+	+	.	+	+	.	.	.	+	.
Helianthemum salicifolium	.	.	.	.	.	1	1	.	+	+	.	+	.	.	.	.	1	1	+	1	+	.	.	.	.	+	.	.
Hypochaeris achyrophorus	.	.	.	.	.	1	1	+	.	.	.	.	.	+	+	1	+	+	+	.	+	1	.	.	.	.	.	.
Stachys germanica subsp. *salviifolia*	.	.	.	.	.	.	.	.	+	.	+	+	1	.	+	.	+	+	1	.	.	.	.	.	.	.	.	.
Linum trigynum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	1	.	.	.	.	+	1	+	+
Bellardia trixago	.	.	.	.	+	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	+	+	.	+	+	.	.
Trifolium scabrum	.	.	.	.	.	+	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	+	+	.	+	+	.	.
Asphodelus ramosus subsp. *ramosum*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	+	1	+	+	.	.	+
Osyris alba	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1	.	+	.	.	.	1	1
Carex flacca subsp. *erythrostachys*	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	1	.	.	.	.
Onobrychis aequidentata	.	.	.	.	.	+	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
Asparagus acutifolius	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	+	.	.	+	.	.	.	.	.

Table 1. Continuation.

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Area (m^2)	10	15	10	50	40	30	60	80	30	20	20	30	50	80	70	70	80	30	25	50	50	50	40	40	70	50	50	60
Vegetation cover (%)	75	80	70	70	70	60	65	70	60	60	50	60	60	70	75	80	75	80	70	65	70	80	70	80	70	75	65	60
Elevation (m s.l.m.)	340	330	300	435	445	348	345	365	560	562	550	560	475	495	550	510	500	480	500	495	510	515	485	485	485	430	470	470
Aspect	SSE	S	SW	NNO	-	O	O	-	O	ONO	O	NO	OSO	O	SO	E	O	SO	S	SO	SO	S	S	S	E	NE	SO	NE
Slope (°)	5	20	90	20	-	15	25	-	40	45	50	45	25	40	25	20	25	15	25	30	25	-	-	-	10	10	10	10
Soil surface aspect, rocky outcrops (%)	/	/	/	/	/	30	20	25	25	30	20	25	30	30	25	20	25	20	25	30	25	5	5	5	10	20	5	5
Soil surface aspect, stoniness (%)	/	/	/	/	/	5	10	10	5	5	10	10	5	5	10	10	5	5	5	10	5	50	60	50	70	50	80	80
vegetation height (cm)	/	/	/	/	/	20	20	25	30	25	25	25	25	30	30	25	25	30	30	25	30	40	30	40	30	35	25	25
Centaurium pulchellum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	+	+
Hippocrepis ciliata	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+
Onobrychis caput-galli	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.
Ononis reclinata	.	.	.	.	.	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Aurinia saxatilis subsp. *megalocarpa*	.	.	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eryngium campestre	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	+	+	.	.
Ornithogalum gussonei	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+
Charybdis pancration	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.
Hippocrepis comosa subsp. *comosa*	.	.	.	+	.	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Brachypodium distachyon	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	.	.	.	.	.
Briza maxima	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.
Bupleurum baldense	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	.
Centaurium erythraea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.
Convolvulus altheoides	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Galium corrudifolium	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	+	.	.	.	.	.	.
Urospermum dalechampii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	.	.
Melica ciliata	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	.	.	.	.	.	.	.
Ajuga chamaepitys	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carlina corymbosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
Dactylis glomerata subsp. *hispanica*	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Linum usitatissimum subsp. *angustifolium*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
Ononis ornithopodioides	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plantago bellardii subsp. *bellardii*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.
Silene conica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.
Centaurium erythraea	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Olea europaea	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Convolvulus elegantissimus	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Sixalix atropurpurea	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Stachys major	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

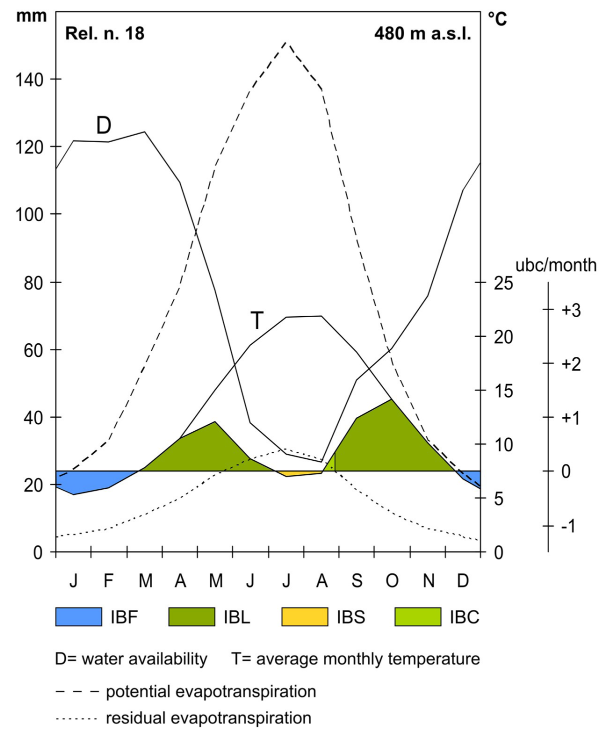

Figure 3. Bioclimatic diagram according to Montero de Burgos and González Rebollar. (IBF = Cold bioclimatic intensity; IBL = Free Bioclimatic Intensity; IBS = Dry Bioclimatic Intensity; IBC = Conditional Bioclimatic Intensity).

Statistically significant ($p < 0.05$; Fig. 5a) and highly significant ($p < 0.001$; Fig. 5b) differences are pointed out in the chorological spectra, weighted by frequency and by cover index. In both the communities, Mediterranean species clearly dominate, in terms of both presence (see Fig. 5a) and dominance (see Fig. 5b), and the presence of Endemic species is quite considerable. Nevertheless, the statistically significant difference in the chorological composition is due to the higher presence of E-Mediterranean species in the *Asyneumo limonifolii-Saturejetum montanae* (A) and of a Balkan chorological element (that is, SE-European-Pontic-Illyrian) in the Alta Murgia garrigues (B) (Fig. 5a). These last species, along with the Endemic element, contribute to a large extent (13,0% and 14,4%, respectively; see Fig. 5b) in outlining the structure of the Alta Murgia garrigues. In other words, in the *Asyneumo limonifolii-Saturejetum montanae* there is a sharp dominance of the Mediterranean elements, in the Alta Murgia garrigues this dominance is mitigated by the Balkan and the Endemic elements (Fig. 5b).

The application of the Ellenberg's indicator values (Eiv) shows very similar profiles in both the two groups of relevès A and B (Fig. 6a, 6b). The two ecograms outline, for both the garrigues, an ecological profile typical of heliophilous, moderately thermophilous, xerophilous, neutro-basiphilous and basically oligotrophic communities. However, the statistical analyses highlighted some differences (some of them highly significant, $p < 0.001$; Tab. 3) between different indicators, which indicate that

Table 2. Values of the Bioclimatic Intensities (IB) according to Montero de Burgos and González Rebollar, for the sites representative of the three main groups of the dendrogram, A, B1 and B2 (that is, the sites where the holotypes of the three corresponding syntaxa were performed). IBL = Free Bioclimatic Intensity; IBS = Dry Bioclimatic Intensity; IBC = Conditional Bioclimatic Intensity; IBF = Cold bioclimatic intensity.

Group A (rel. n. 6)													
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**Year**
IBL (ubc/mese)	0,00	0,00	0,27	0,82	0,72	0,00	0,00	0,00	0,60	1,51	0,72	0,06	4,70
IBS (ubc/mese)	0,00	0,00	0,00	0,00	0,00	0,00	0,16	0,00	0,00	0,00	0,00	0,00	0,16
IBC (ubc/mese)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,06	0,14	0,00	0,00	0,00	0,20
IBF (ubc/mese)	0,23	0,10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,33

Group B1 (rel. n. 18)													
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**Year**
IBL (ubc/mese)	0,00	0,00	0,05	0,61	0,91	0,23	0,00	0,00	0,91	1,32	0,52	0,00	4,54
IBS (ubc/mese)	0,00	0,00	0,00	0,00	0,00	0,00	0,03	0,02	0,00	0,00	0,00	0,00	0,05
IBC (ubc/mese)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,06	0,00	0,00	0,00	0,06
IBF (ubc/mese)	0,43	0,31	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,15	0,89

Group B2 (rel. n. 28)													
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**Year**
IBL (ubc/mese)	0,00	0,00	0,11	0,66	0,82	0,14	0,00	0,10	0,91	1,33	0,55	0,00	4,62
IBS (ubc/mese)	0,00	0,00	0,00	0,00	0,00	0,00	0,08	0,00	0,00	0,00	0,00	0,00	0,08
IBC (ubc/mese)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,09
IBF (ubc/mese)	0,39	0,27	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,10	0,76

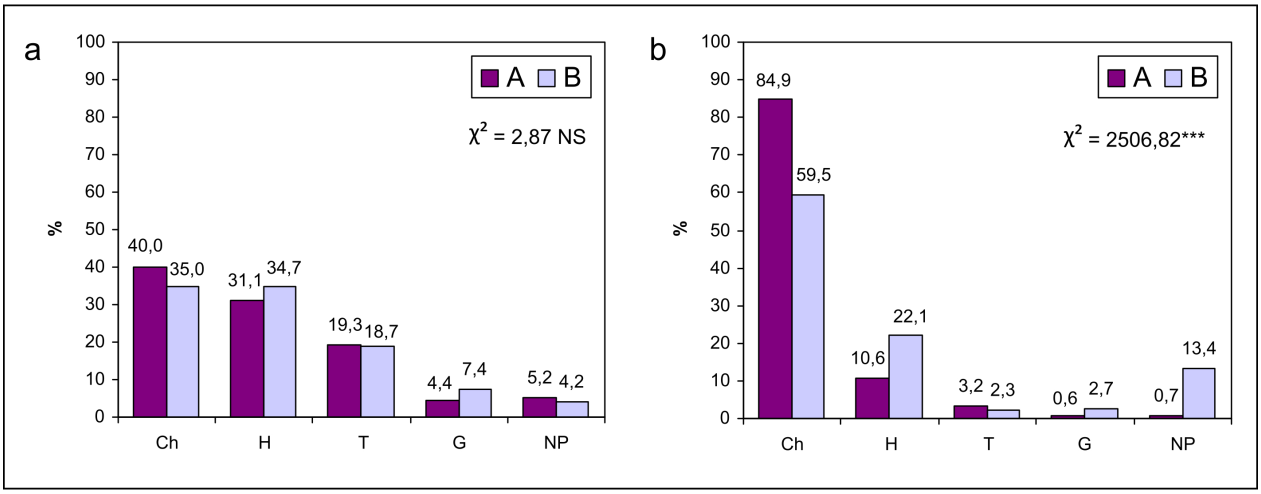

Figure 4. Biological spectra weighted by frequency (a) and cover index (b) of the *Satureja montana* garrigues in Ionian Arc (A) and in Alta Murgia (B). *** = p<0,001; NS = Not significant.

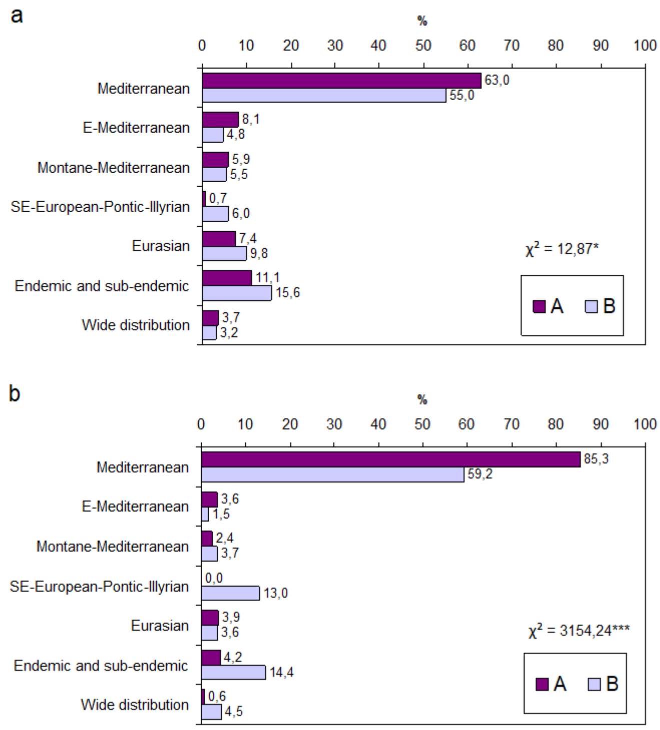

Figure 5. Chorological spectra weighted by frequency (a) and cover index (b) of the *Satureja montana* garrigues in Ionian Arc (A) and in Alta Murgia (B). * = p<0,05; *** = p<0,001.

the Alta Murgia garrigues are quite less thermophilous and xerophilous and have higher sub-continental and oligotrophic features respect to the Ionian Arc garrigues, as already shown in the phytoclimatic and chorological characterization of these plant communities.

Discussion

For ecology and floristic composition, the analyzed communities can be framed in the *Cytiso spinescentis-Saturejion montanae* alliance, described by Pirone and Tammaro (1997) for the garrigues of the Central and Southern Apennines, growing on calcareous substrata in correspondence of the hilly to submountain belts with meso-Mediterranean to mountain bioclimate.

Mucina et al. (2016) report the *Cytiso spinescentis-Saturejion montanae* and the *Artemisio albae-Saturejion montanae* Allegrezza et al. 1997 as syntaxonomic synonym ("submediterranean montane dry calciphilous grasslands rich in dwarf shrubs of the Central Apennines"), with the first having priority due to the previous publication date, and we agree with this interpretation, because the two alliance are largely overlapping in terms of ecology (bioclimate, soil) and distribution, and in part also in terms of floristic composition (Pirone and Tammaro 1997; Allegrezza et al. 1997). Nevertheless, in the same contribution, Mucina et al (2016) classify the *Cytiso spinescentis-Saturejion montanae* within the *Erysimo-Jurineetalia bocconei* Brullo 1984 (as "submediterranean xeric calcicolous grasslands on skeletal soils of the Apennine Peninsula and in the oromediterranean belt of Sicily") and, in turn, in the *Festuco hystricis-Ononidetea striatae* Rivas-Mart. et al. 2002 (as "submediterranean submontane-montane and oromediterranean dry grasslands and related dwarf scrub on calcareous substrates of the Iberian Peninsula, the Western Alps and the Apennines"). However, this classification appears to have no valid evidences from both phytogeographic and floristic point of view. In fact, Brullo (1984) described the *Erysimo-Jurineetalia* order for the cushion-like vegetation growing in the mountain and high-mountain belts of northern Sicily and ascribed this order to the *Cerastio-Carlinetea nebrodensis* class (= *Ru-*

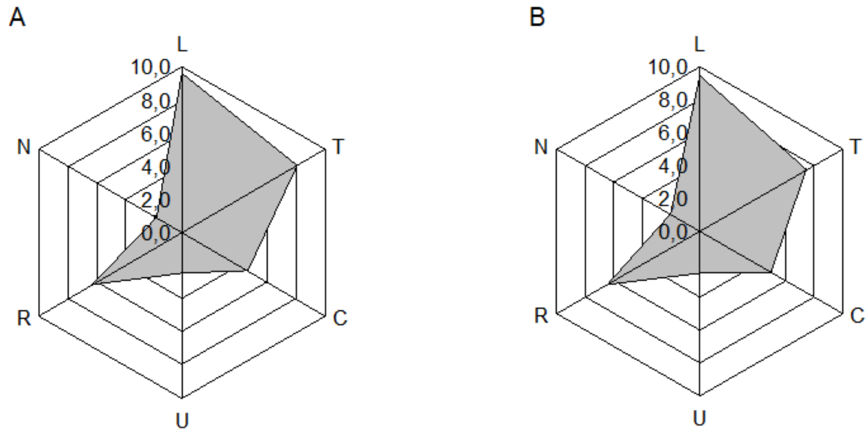

Figure 6. Ecograms of the *Satureja montana* garrigues in Ionian Arc (A) and in Alta Murgia (B).

Table 3. Ellenberg's indicator values for the two groups of Satureja montana garrigues (L = light, T = temperature, C = continentality, U = humidity, N = nutrients; * = p<0,05; *** = p<0,001; NS = Not significant) .

	L	T	C	U	R	N
Ionic Arc community (A)	9.64	8.03	4.58	2.41	6.24	1.74
Murgia Alta community (B)	9.45	7.47	5.02	2.53	6.50	2.10
Mann–Whitney U test	38987.5 NS	30388.0***	29388.0***	36626.0*	24204.5 NS	32621.5***

mici-Astragaletea siculi Pignatti et Nimis in Pignatti et al. 1980), initially described for the cushion-like vegetation of Sicily and then expanded to the Aspromonte and Sila massifs in Calabria (Brullo et al. 2004). Both order and class are characterized by a large contingent of narrow endemic species, exclusive of Sicilia and Calabria massifs, indicative of the complex paleogeographical vicissitudes that have affected these areas. Mucina et al. (2016) take the *Erysimo-Jurineetalia* out from the *Rumici-Astragaletea siculi* and place this order within the *Festuco hystricis-Ononidetea striatae*, class conceived by its Authors (Rivas-Martínez et al 1991) for grouping dry grasslands and dwarf scrub of the sub-Mediterranean zone of the Eurosiberian region and of the supra- and oro- Mediterranean zone of the Mediterranean region, with a well-defined south-western European distribution and including, among the characteristic species, a rich amount of SW Europe and W Mediterranean species (some of them with a southern French-Iberian to north African-mesatlantic distribution; Rivas-Martínez et al 1991). So, apart from these floristic and phytogeographical features of the *Festuco-Ononidetea*, which would lead to exclude the possibility of including the *Erysimo-Jurineetalia*, there are other considerations to be focused on. In fact, as discussed by Guarino and Pasta (2017): "…the opportunity to include the Sicilian basiphilous oro-Mediterranean vegetation into an Iberian class and to keep the Calabrian-Sicilian silicicolous oro-Mediterranean vegetation into an autonomous class is unacceptable from the biogeographic and phylogenetic viewpoint. …Instead, none of the character species of *Festuco hystricis-Ononidetea striatae* occurs on the Sicilian and Calabrian high mountains".

Likewise, there doesn't seem to be opportunity of including neither the *Cytiso spinescentis-Saturejion montanae*, nor the *Artemisio albae-Saturejion montanae*, alliances described for the chamaephytic grasslands of mesotemperate and lower supratemperate thermotypes of the central-southern Apennines (Pirone and Tammaro 1997; Allegrezza et al. 1997; Biondi 2014), in an order (*Erysimo-Jurineetalia*) that has strong autonomy and a precise floristic, phytogeographic and paleogeographic connotation. Moreover, neither the *Festuco hystricis-Ononidetea striatae*, for its phytogeographical significance as discussed above, nor the *Rumici-Astragaletea siculi*, a narrowly ranging class, clearly outlined by a group of orophytes and endemic species at a local level (Brullo et al 2005), may be considered as higher rank syntaxa of reference.

For these reasons, we prefer to comply with the syntaxonomical interpretation provided by Biondi et al. (2014), that include the *Cytiso spinescentis-Saturejion montanae* within the *Cisto cretici-Ericetalia manipuliflorae* (*Cisto cretici-Micromerietea julianae*).

Various associations have been described in central and southern Apennines areas for classifying *Satureja montana* dominated vegetation. Scoppola and Angiolini (1997) described the *Santolino etruscae-Saturejetum montanae* vegetation of stream-bed garrigues in the Antiapennine range of Tuscany and Latium (Temperate macroclimate; Scoppola and Angiolini (1997)), and framed it in the *Artemisio albae-Saturejion montanae*; as character and differential species *Santolina etrusca* (endemic to Tuscany, Latium, and Umbria), *Helichrysum italicum*, *Trigonella wojciechowskii*, *Seseli tortuosum* subsp *tortuosum* (sub-nitrophilous species frequent in stream-bed environments), were detected. Pirone et al. (2014) described, for the central-southern Apennines, the *Saturejo montanae-Centaureetum scannensis* (character species: *Centaurea scannensis*, strictly endemic to Abruzzo) and the *Saturejo montanae-Ephedretum nebrodensis* (character and differential species: *Globularia meridionalis* and *Centaurea ambigua*, both endemic to central-southern Apennines, and *Ephedra major*), both growing in sites with carbonate outcrops, steep inclinations, on lithosols or poorly evolved soils, in areas with Temperate macroclimate with bioclimatic belt from the upper Mesotemperate to the upper Supratemperate; the Authors framed these associations in the *Cytiso spinescentis-Saturejion montanae*. Allegrezza et al. (1997) described, for the central Apennines, the *Cephalario leucanthae-Saturejetum montanae* (char. and diff.: *Artemisia alba*, *Fumana procumbens*, *Helichrysum italicum*, *Cephalaria leucantha*, *Thymus longicaulis*); the *Cistus eriocephalus* subsp. *eriocephalus* variant of the association was then typified as *Saturejo montanae-Cistetum eriocephali* (char. and diff.: *Cistus creticus* subsp. *eriocephalus*, *Astragalus monspessulanus*, *Ruta graveolens*, *Argyrolobium zanonii*; Allegrezza et al. 2003). These are vegetation of semi-rocky habitats, consisting of small chamaephytes, which sometimes interpenetrate with hemicryptophytes from neighboring grasslands of the *Cytiso spinescenti-Bromion erecti*; framed by the Authors in the *Artemisio albae-Saturejion montanae*, both fall within Temperate macroclimate, bioclimatic belt from Meso-temperate to the upper Supratemperate.

On the basis of the foregoing, all these association fall in the *Cytiso spinescentis-Saturejion montanae* and well differentiates from the communities here described, for bioclimatic frame, ecology, but mostly for floristic and chorological features. In particular, *Santolino etruscae-Saturejetum montanae*, *Saturejo montanae-Centaureetum* and *Saturejo montanae-Ephedretum nebrodensis* are characterized, among others, by endemic or strictly endemic species. The Murgian communities here described are well differentiated by some endemic taxa such as *Euphorbia nicaeensis* subsp. *japygica* (endemic to Puglia and Basilicata, doubtful in Campania; typically growing in arid grassland and garrigues; Fenu et al. 2016; Bartolucci et al. 2018), *Allium apulum* (endemic to Puglia, widely distributed in coastal areas and occasionally in inland areas, mainly in stony grasslands and in Mediterranean garrigues; Brullo et al. 2006; Wagensommer et al 2018), *Centaurea brulla* (endemic to Puglia and Basilicata, typically growing in rocky and stony environments; Di Pietro and Wagensommer 2008).

For the Alta Murgia communities analyzed in this contribution, a new association is described, with two subassociations, described below.

RHAMNO SAXATILIS-SATUREJETUM MONTANAE ass. nova

(*holotypus*: rel. n. 18, Table 1), *typicum* (Table 1, rels n. 9–21; holotypus: rel. n. 18); *fumanetosum procumbentis* subass. nova (Table 1, rels n. 22–28; *holotypus*: rel. n. 28)

Physiognomy and structure - *Satureja montana* garrigues, with *Rhamnus saxatilis* as co-dominant in the subass. *typicum*; in the subass. *fumanetosum procumbentis*, *Fumana procumbens* and *F. thymifolia* have major cover values.

Diagnostic species - *Satureja montana* subsp. *montana* and *Rhamnus saxatilis*, the two species dominating the vegetation in the subass. typicum, are both diagnostic of the *Cytiso spinescentis-Saturejion montanae*. As diagnostic of association (and subass. *typicum*), have been selected: *Euphorbia nicaeensis* subsp. *japygica*, *Allium apulum*, *Centaurea brulla*, *Ruta graveolens* (this species also occurs in the *Stipa austroitalica* subsp. *austroitalica* grasslands of the Alta Murgia (Forte et al 2001), but limited to those aspects with higher rocky outcrops; in these garrigues *R. graveoles* occurs with even higher frequence and cover values), and *Sabulina attica* (Eurasiatic chamaephyte, in Italy growing in dry grasslands, garrigues and stony environments in southern regions). As diagnostic of subass. fumanetosum procumbentis, *Fumana procumbens* and *Odontites luteus* where selected.

Syntaxonomy - On the basis of the considerations made previously, the new association *Rhamno saxatilis-Saturejetum montanae* ass. nova is framed in the *Cytiso spinescentis-Saturejion montanae* alliance (order *Cisto cretici-Ericetalia manipuliflorae*, class *Cisto cretici-Micromerietea julianae*).

Syndynamics - This vegetation belongs to the series of the oak forests of the *Stipo bromoidis-Quercetum dalechampii* Biondi et al. 2004, included in the order *Carpinion orientalis* Horvat 1958, and in the class *Quercetalia pubescenti-petraeae* Klika 1933 (Biondi et al. 2004; Forte et al. 2005).

Synecology - These garrigues grow at altitudes between 400 and 600 m a.s.l., thriving on immature soils developed on calcareous substrates, with relative stoniness but extensive rocky outcrops in the subass. *typicum*, and with a much higher stoniness in the subass. *fumanetosum procumbentis*. The bioclimate is Mediterranean Pluviseasonal oceanic, weak semicontinental with thermotype upper meso-Mediterranean and ombrotype lower subhumid. The phytoclimatic trend throughout the year is characterized by two periods favorable for the vegetative activity (spring and autumn, with autumn characterized by a higher intensity), alternating with periods of winter pause and summer dryness, with IBF greater than 0.75 ubc/month and IBS less than 0.1 ubc/month. The subass. *fumanetosum procumbentis* occurs in site characterized by a slightly higher drought in summer and by a less intense period of winter pause.

Conclusions

In this paper the results of syntaxonomic, structural, chorological and ecological analyses on the *Satureja montana* garrigue vegetation of the upper Murgia were illustrated and discussed; these analyses clearly showed the autonomy and the peculiarity of the studied vegetation, that was formalized in the new association *Rhamno saxatilis-Saturejetum montanae* ass. nova. Two subassociations, *typicum* and *fumanetosum procumbentis*, have been identified. This new association has been framed in the *Cytiso spinescentis-Saturejion montanae* alliance (order *Cisto cretici-Ericetalia manipuliflorae*, class *Cisto cretici-Micromerietea julianae*), following the interpretation of Biondi et al. (2014). The present work contributes to add a further piece to the knowledge of the natural plant landscape of the territory of the Alta Murgia National Park.

Syntaxonomic scheme

CISTO CRETICI- MICROMERIETEA JULIANAE Oberdorfer ex Horvatić 1958
CISTO CRETICI-ERICETALIA MANIPULIFLORAE Horvatić 1958
Cytiso spinescentis-Saturejion montanae Pirone and Tammaro 1997
Rhamno saxatilis-Saturejetum montanae ass. nova
typicum
fumanetosum procumbentis subass. nova
Cisto cretici-Ericion manipuliflorae Horvatic 1958
Asyneumo limonifolii-Saturejetum montanae Biondi and Guerra 2008

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Appendixes

Appendix I – Date and site of the phytosociological relevés

Table 1 - Rels. 1-5: Biondi and Guerra 2008, tab. 20 rels. 1-5; rel. 6: 27/04/2016, Gravina di Laterza (TA), 16.811185E, 40.607818N; rel. 7: 27/04/2016, Gravina di Laterza (TA), 16.812067E, 40.607245N; Rel. 8: 27/04/2016, Gravina di Laterza (TA), 16.825114E, 40.607598N; rel. 9: 15/06/2016, Pulicchio, Gravina in Puglia (BA), 16.423962E, 40.9033584N; rel. 10: 15/06/2016, Pulicchio, Gravina in Puglia (BA), 16.423902E, 40.903359N; rel. 11: 15/06/2016, Pulicchio, Gravina in Puglia (BA), 16.423966E, 40.901881N; rel. 12: 15/06/2016, Pulicchio, Gravina in Puglia (BA), 16.424222E, 40.901634N; rel. 13: 29/06/2016, Serramezzana, Altamura (BA), 16.449026E, 40.874058N; rel. 14: 29/06/2016, Serramezzana, Altamura (BA), 16.449675E, 40.874402N; rel. 15: 29/06/2016, Serramezzana, Altamura (BA), 16.450498E, 40.875697N; rel. 16: 29/06/2016, Serramezzana, Altamura (BA), 16.449579E, 40.877619N; rel. 17: 29/06/2016, Serramezzana, Altamura (BA), 16.448554E, 40.877974N; rel. 18: 25/05/2017, Parisi Vecchia, Altamura (BA), 16.460415E, 40.885229N; rel. 19: 25/05/2017, Parisi Vecchia, Altamura (BA), 16.458845E, 40.888861N; rel. 20: 25/05/2017, Parisi Vecchia, Altamura (BA), 16.454801E, 40.891722N; rel. 21: 25/05/2017, Parisi Vecchia, Altamura (BA), 16.441982E, 40.879191N; rel. 22: 15/05/2018, Santeramo (BA), 16.755937E, 40.773581N; rel. 23: 15/05/2018, Santeramo (BA), 16.707268E, 40.822864N; rel. 24: 15/05/2018, Santeramo (BA), 16.706923E, 40.822338N; rel. 25: 22/05/2018, Lamalunga, Santeramo (BA), 16.709575E, 40.814822N; rel. 26: 22/05/2018, Lamalunga, Santeramo (BA), 16.704625E, 40.807626N; rel. 27: 22/05/2018, Lamalunga, Santeramo (BA), 16.710086E, 40.784385N; rel. 28: 22/05/2018, Lamalunga, Santeramo (BA), 16.710706E, 40.784538N.

Appendix II – Sporadic species

Table 1 - Rel. 1: *Brachypodium distachyon* (+), P*hillyrea latifolia* (+), *Teucrium chamaedrys* L. subsp. *chamaedrys* (+); rel. 2: *Achnatherum bromoides* (1), *Hyparrhenia hirta* subsp. *hirta* (1), *Petrosedum rupestre* (+); rel. 5: *Linum corymbulosum* (+); rel. 6: *Helictotricon convolutum* (1); rel. 7: *Jurinea mollis* subsp. *mollis*; rel. 8: *Juniperus oxycedrus* (+), *Asparagus acutifolius* (+); Rel. 11: *Centaurea deusta* (+); rel. 12: *Alkanna tinctoria* subsp. *tinctoria* (+), *Olea europaea* (+); Rel. 20: *Thesium humile* (+); rel. 22: *Asphodeline liburnica* (+); *Trifolium campestre* (+), *Triticum vagans* (+); rel. 23: *Silene vulgaris* subsp. *tenoreana* (+); rel. 25: *Onobrychis alba* subsp. *alba* (2), *Xeranthemum inapertum* (+); rel. 26: *Poterium sanguisorba* (+).