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Bryosociological remarks on garrigue environments in Apulia Region (Southern Italy)

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Abstract

A phytosociological study on the bryophyte communities of the xeric environments of Apulia Region was carried out. According to the cluster analysis, the surveyed communities recognized in the context of the garrigue habitats are: *Pleurochaeto squarrosae-Cheilotheletum chloropi*, considered typical of the garrigues, *Rhynchostegietum megapolitani* and *Pleurochaeto squarrosae-Tortuletum ruralis* of the alliance *Homathecio aurei-Pleurochaetion squarrosae*; *Tortello flavovirentis-Trichostometum crispuli* and *Tortelletum papillosissimae* of the psammophytic alliance *Tortellion flavovirentis*; *Weissietum controversae* and *Barbuletum convolutae* of the alliance *Grimaldion fragrantis*.

Key words: Bryophyte vegetation, garrigues, phytosociology, xeric habitats, 92/43/EEC "Habitat" Directive.

Introduction

The study of the bryophyte vegetation of Italy has not been uniformly performed in the Italian regions; in fact, some regions, among which Apulia, have been less or not at all explored (Puglisi & Privitera, 2012). Despite the research carried out in Italy so far, much work is still needed. Because of this lack and in conjunction with a large phytosociological survey on the phanerogamic vegetation of Apulia Region, aimed at a wider knowledge of the territory and comprehensive environmental characterization, a bryosociological investigation on some of the most widespread garrigue communities of this Region was carried out, leading to the identification of many bryophyte communities. Moreover, this study intends to encourage further investigations throughout the Italian Peninsula, considering that the phytosociological approach can be a useful tool for the management of natural resources (e.g., Cano *et al.*, 2017; Piñar-Fuentes *et al.*, 2017; Spampinato *et al.*, 2017; Puglisi *et al.*, 2019). Indeed, currently, the phytosociological data are being increasingly requested for the application of international environmental Conventions and, in particular, the implementation of the 92/43/EEC Habitats Directive and the Management of the Natura 2000 Network in Italy and Europe (e.g., Pavone *et al.*, 2007; Biondi *et al.*, 2012; Gigante *et al.*, 2016, 2018; Zivkovic *et al.*, 2017).

Study area

Apulia Region, located in the south-eastern part of the Italian peninsula, has a surface area of more than 19,000 km² and about 1,000 km of coastline. A peculiarity of this Region is the low average altitude, being represented for 53% of its territory by lowlands and for 45% by hilly areas (Ladisa *et al.*, 2012), with the only exceptions of the Mount Gargano and the Sub-Apennine areas situated in the North-East and North-West of the Region respectively.

Geologically, most of the study area is characterized by Cretaceous limestones and calcarenites, and by alluvial deposits (Pliocene–Pleistocene). Dominant soils are Cambisols, Luvisols and Vertisols (Ladisa *et al.*, 2012). The Region has a semi-arid Mediterranean climate, with hot and dry summers and mild winter season. Average temperatures are about 15–16 °C, with higher values in the Ionian-Salento area and lower ones in the Daunian Sub-Appennine and Gargano. The average annual rainfall values are extremely variable: the rainiest areas are the Gargano area and the Daunian Sub-Appennine, where the average yearly values are higher than 800 mm. Average values less than 500 mm are recorded in the Tavoliere delle Puglie and in the Ionian Salento. In the remaining portion of the area the average annual rainfall is generally between 500 and 700 mm (Cotecchia *et al.*, 2017).

The greatest part of the region (more than 80%) is used for agriculture while natural and semi-natural areas cover about 14% (Zaccarelli et al., 2004). As other arid and semi-arid Mediterranean areas, large part of Apulia Region is affected by land degradation and desertification due to the interaction of a set of natural (bio-physical) and anthropogenic factors having different temporal and spatial variability.

Several areas of Apulia Region have been investigated from the vegetation point of view, some of them falling within protected areas, such as “Alta Murgia” National Natural Park, “Terra delle Gravine” Regional Natural Park, “Gargano” National Park and Salento (e.g., Forte et al., 2005; Biondi & Guerra, 2008; Di Pietro et al., 2009; Di Pietro & Misano, 2010; Perrino et al., 2013; Tomaselli et al., 2011, 2017). The present research was focused on semi-arid environments, on garrigues communities mostly belonging to the phytosociological class *Cisto-Micromerietea* Oberdorfer 1954. In particular, we surveyed the bryophyte vegetation in the ambit of phanerogamic communities dominated by *Thymra capitata* (*Helianthemo jonii-Thymetum capitati* Biondi & Guerra 2008), *Salvia rosmarinus* (syn.: *Rosmarinus officinalis*), a facies of the *Helianthemo jonii-Thymetum capitati* Biondi & Guerra 2008), *Satureja montana* (*Asyneumo limonifolii-Saturejetum montanae* Biondi & Guerra 2008), *S. cuneifolia* (*Sedo ochroleuci-Saturejetum cuneifoliae* Di Pietro & Misano 2010), *Erica forskalii* (*Saturejo-Ericetum manipuliflorae* Brullo, Minissale, Signorello & Spampinato 1986), alliance belonging to the alliance *Cisto-Ericion* Horvatić 1958, and by *Genista michelii* and *Satureja cuneifolia* (*Chamaecytiso spinescentis-Genistetum michelii* De Faveri ex Nimis ex Biondi 1997) of the alliance *Cytiso spinescentis-Satureion montanae* Pirone & Tammaro 1997 (Biondi, 1997; Pirone & Tammaro, 1997; Biondi & Guerra, 2008; Di Pietro et al., 2009; Di Pietro &

Misano, 2010). Also the coastal communities dominated by *Helichrysum italicum* subsp. *pseudolitoreum* and belonging to the association *Agropyro-Helichrysetum italicum* Bartolo, Brullo & Signorello 1989 (*Helichrysetalia italicum* Biondi et Géhu in Géhu et Biondi 1994; *Crithmo maritimi-Staticetea* Br.-Bl. in Br.-Bl. et al. 1952; Tomaselli & Terzi, 2019) were examined.

Material and methods

The bryovegetational study, which follows the phytosociological method of Braun-Blanquet (1964), is based exclusively on inedited data. The field work has been carried out in spring and late spring of the years 2016 and 2018.

The phytosociological relevés have been carried out in standard 5x5 dm² areas. For each plot, basic geographic and ecological details of the sampling areas have been recorded, besides total cover of the bryovegetation and specific cover. Additionally, the number of total species per relevé has been reported. The cover of each taxon has been estimated according to the following values: + (<1%), 1 (1-10%), 2 (10.1-25%), 3 (25.1-50%), 4 (50.1-75%), 5 (75.1-100%), as reported by many bryosociologists (e.g., Cano et al., 1999; Lo Giudice & Galesi, 2001; Marstaller, 2010; Puglisi et al., 2013, 2016; Alataş & Uyar, 2017).

A multivariate analysis (Linkage method: Flexible Beta, Distance measure: Euclidean) has been applied, using the PC-ORD 6 software. For multivariate analysis purposes, the cover values have been transformed according to the method proposed by Van Der Maarel (1979).

The syntaxonomic arrangement and nomenclature follow Puglisi & Privitera (2012); the nomenclature of the *taxa* follows Ros et al. (2013). As for phanerophytes, nomenclature follows the recent check-list of the Italian Flora (Bartolucci et al., 2018).

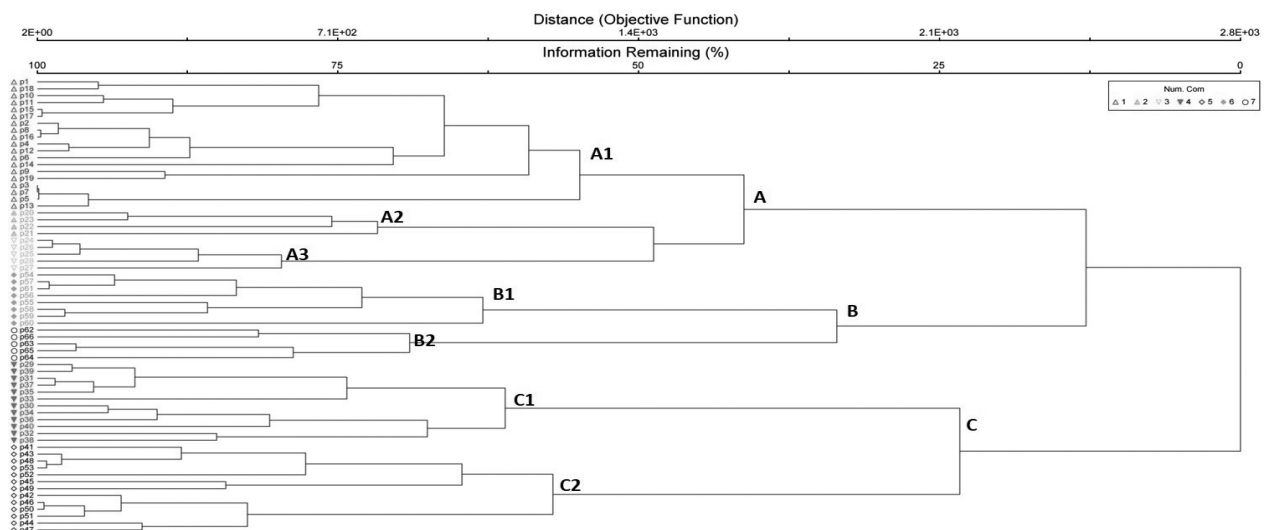


Fig. 1 - Cluster analysis derived from the multivariate analysis of the phytosociological relevés.

Results and discussion

The results of the cluster analysis show three main, well separated, vegetation groups (A, B, C; Fig. 1), each of them characterized by specific indicator species. The first one includes three clusters (A1, A2, A3), the second two clusters (B1, B2) and the third two clusters too (C1, C2). On the ground of their floristic and ecological features, the detected clusters of relevés have been referred to three phytosociological alliances included in the order *Barbuletalia unguiculatae* of the class *Psoretea decipientis*. In particular, clusters A1, A2, A3 (28 relevés) assemble the bryophyte communities belonging to the alliance *Homalothecio aurei-Pleurochaetion squarrosae*. Clusters B1 and B2 (13 relevés) correspond to 2 communities of the alliance *Tortellion flavovirentis*. Finally, clusters C1 and C2 (25 relevés), the most separated ones, correspond to bryocoenoses of the alliance *Grimaldion fragrantis*.

Cluster A1 corresponds to the association *Pleurochaeto squarrosae-Cheilotheletum chloropi*, linked to the other two associations of the same alliance, *Rhynchostegietum megapolitani* (A2) and *Pleurochaeto squarrosae-Tortuletum ruralis* (A3), most closely joined together. These clusters are related to clusters B1 and B2, corresponding to the associations *Tortelletum papillosissimae* and *Tortello-flavovirentis-Trichostometum crispuli*, respectively. As regards the floristic set, the clusters of group A are characterized by the presence of *Tortella squarrosa*, characteristic of the alliance *Homalothecio aurei-Pleurochaetion squarrosae* almost constantly present in all three associations. Moreover, clusters A2 and A3 are more closely joined by the occurrence of some pleurocarpous mosses. The clusters of group B are characterized by the occurrence

of *Tortella flavovirens* var. *flavovirens*, a halotolerant psammophyte widespread in coastal areas, where it preferably colonizes sandy soil in the dune system. The clusters of group C are dominated by small acrocarpous mosses, such as *Weissia controversa*, *Barbula convoluta*, *Didymodon* spp., typically occurring on particularly disturbed sites, and for this reason, they constitute the most isolated and separated group.

PLEUROCHAETO SQUARROSAE-CHEILOTHELETUM CHLOROPI Privitera & Puglisi 1996

(Tab. 1) - Cluster A1

This is the most widespread bryophyte association in the surveyed garrigues of Apulia Region. It was mainly found in contact with garrigues characterized by *Thymra capitata* and *Helianthemum jonium*, by *Satureja cuneifolia* and *Petrosedum ochroleucum*, and by *Phagnalon rupestre*. It occurs in various sites within the "Terre delle Gravine" Park, but also in some sites of the Gargano National Park (Vallone di Pulsano, FG) and of the Salento peninsula (Ostuni, BR). The association has been found also in the context of *Satureja montana*-dominated communities at Santeramo (BA).

Pleurochaeto squarrosae-Cheilotheletum chloropi was found on loose soil in more or less shady sites, behaving as a terricolous, meso-xerophytic, photo-sciophytic community. The vegetation cover ranges from 40% to 100%, with a species number of 3-5, exceptionally 6 (Rel. 1). The community is composed almost exclusively by acrocarpous mosses showing a "turf" life form and "colonist" life strategy. This association is floristically characterized by *Cheilothela chloropus*, an oceanic Mediterranean species occurring sometimes with a very high cover value. This species is almost constantly accompanied by *Tortella squarrosa*, char-

Tab. 1 - *Pleurochaeto squarrosae-Cheilotheletum chloropi* Privitera & Puglisi 1996.

| Relevé number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Presences | |
|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----------|----|
| Altitude (m a.s.l.) | 190 | 190 | 195 | 185 | 197 | 284 | 280 | 270 | 470 | 475 | 181 | 172 | 465 | 460 | 454 | 345 | 340 | 330 | 174 | | |
| Cover (%) | 80 | 65 | 80 | 95 | 75 | 100 | 80 | 70 | 65 | 40 | 40 | 65 | 75 | 45 | 95 | 80 | 45 | 90 | 75 | | |
| Number of species | 6 | 4 | 4 | 3 | 3 | 5 | 3 | 4 | 5 | 5 | 3 | 5 | 4 | 4 | 3 | 5 | 3 | 5 | 3 | | |
| Char. association | | | | | | | | | | | | | | | | | | | | | |
| <i>Cheilothela chloropus</i> | 4 | 3 | 3 | 5 | 3 | 4 | 3 | 4 | 3 | 2 | 3 | 3 | 3 | 2 | 5 | 4 | 3 | 5 | 3 | V | |
| Char. alliance (<i>Homalothecio aurei-Pleurochaetion squarrosae</i>) | | | | | | | | | | | | | | | | | | | | | |
| <i>Tortella squarrosa</i> | + | 2 | 3 | 2 | 3 | 3 | 3 | 1 | . | 1 | . | 2 | 2 | 1 | 2 | 2 | 1 | + | . | V | |
| <i>Scorpiurium circinatum</i> | 1 | . | . | . | . | . | . | . | 1 | 1 | 1 | + | . | . | . | . | . | 1 | 2 | II | |
| Char. order and class (<i>Barbuletalia unguiculatae</i> , <i>Psoretea decipientis</i>) | | | | | | | | | | | | | | | | | | | | | |
| <i>Bryum dichotomum</i> | . | + | 2 | . | 1 | . | 2 | . | 1 | . | . | . | 2 | . | . | . | . | . | . | 2 | II |
| <i>Didymodon vinealis</i> | . | . | . | 1 | . | . | . | . | + | 2 | 1 | . | 1 | . | 2 | . | + | . | . | II | |
| <i>Trichostomum crispulum</i> | 1 | 1 | . | . | . | . | + | . | 1 | . | . | . | . | . | . | . | 1 | . | 1 | II | |
| <i>Trichostomum brachydontium</i> | . | . | . | . | . | . | . | . | . | 1 | + | . | . | . | 1 | . | 1 | . | . | II | |
| <i>Didymodon fallax</i> | . | . | . | . | . | 1 | . | . | . | . | . | . | 1 | . | . | . | . | . | . | . | I |
| Other species | | | | | | | | | | | | | | | | | | | | | |
| <i>Ptychostomum imbricatum</i> | . | . | . | . | . | 1 | . | . | + | . | . | 1 | . | . | . | . | . | . | . | . | I |
| <i>Bryum argenteum</i> | 1 | . | + | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I |
| <i>Tortella flavovirens</i> var. <i>flavovirens</i> | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | + | . | I |
| <i>Tortella nitida</i> | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | I |
| <i>Tortella inclinata</i> | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | I |

acteristic of the alliance *Homalothecio aurei-Pleurochaetion squarrosae*; a group of characteristics of order and class are associated too. The alliance *Homalothecio aurei-Pleurochaetion squarrosae*, where the association is included, has been described by Ros & Guerra (1987) for the Iberian Peninsula and referred by the Authors to the order *Barbuletalia unguiculatae* of the class *Barbuletea unguiculatae* (synonym of the class *Psoretea decipientis*). It was afterwards moved by Marstaller (2006) to the class *Pleurochaeto squarrosae-Abietinelletea abietinae* Marstaller 2002 and finally by Mucina et al. (2016) to the class *Hylocomi-etea splendidis* Marstaller 1992. The last Authors consider it as a synonym of the alliance *Rhytidion rugosi* Štefureac 1941 which includes “Communities of large weft-forming pleurocarpous bryophytes on calcareous soils on dry, exposed rocks in grasslands and open forest” (Mucina et al., 2016). Taking into consideration the ecology, the floristic composition and the settlement habitat, as also supported by the cluster analysis, we comply with the original frame of the alliance *Homalothecio aurei-Pleurochaetion squarrosae* in the order *Barbuletalia unguiculatae*, belonging to the class *Psoretea decipientis*, where the alliances *Tortellion flavovirentis* and *Grimaldion fragrantis* are included too.

Pleurochaeto squarrosae-Cheilotheletum chloropi is a bryocommunity with Mediterranean character. To date, it is known only for Sicily (Privitera & Puglisi, 1996; Lo Giudice & Galesi, 2001); therefore, it is here reported for the first time from the Italian Peninsula.

RHYNCHOSTEGIETUM MEGAPOLITANI Puglisi 1995 (Tab. 2) - Cluster A2

This association was found at the edge of a holm oak forest in the area of Torre Guaceto (BR), in contact with garrigues with *Erica manipuliflora*, *Satureja cu-*

Tab. 2 - *Rhynchostegietum megapolitani* Puglisi 1995.

| Relevé number | 1 | 2 | 3 | 4 | Presences |
|--|----|----|----|----|-----------|
| Altitude (m a.s.l.) | 5 | 5 | 5 | 5 | |
| Cover (%) | 95 | 85 | 65 | 75 | |
| Number of species | 5 | 4 | 5 | 5 | |
| Char. association | | | | | |
| <i>Rhynchostegium megapolitanum</i> | 4 | 3 | 3 | 4 | 4 |
| Char. alliance (<i>Homalothecio aurei-Pleurochaetion squarrosae</i>) | | | | | |
| <i>Tortella squarrosa</i> | 2 | 3 | . | 1 | 3 |
| <i>Scleropodium touretii</i> | 2 | . | 1 | + | 3 |
| <i>Scorpiurium circinatum</i> | . | 1 | 2 | . | 3 |
| Char. order and class (<i>Barbuletalia unguiculatae</i> , <i>Psoretea decipientis</i>) | | | | | |
| <i>Didymodon fallax</i> | . | 2 | + | 1 | 3 |
| <i>Trichostomum crispulum</i> | 1 | . | + | . | 2 |
| Other species | | | | | |
| <i>Rhynchostegiella tenella</i> | 1 | . | . | + | 2 |

neifolia and *Thymbra capitata*, protected by the phanerogamic vegetation. From the synecological point of view, *Rhynchostegietum megapolitani* is a terricolous, xerophytic or meso-xerophytic, markedly sciophytic association. The most represented species is *Rhynchostegium megapolitanum*, an oceanic Mediterranean species characterizing floristically the community. It is associated to some characteristic taxa of higher units, such as *Scleropodium touretii*, *Scorpiurium circinatum* and *Tortella squarrosa* (sometimes sub-dominant). The occurrence of pleurocarpous mosses, numerically well represented in the community (*Rhynchostegium megapolitanum*, *Scleropodium touretii*, *Scorpiurium circinatum* and *Rhynchostegiella tenella*) reflects a more marked sciophily compared to *Pleurochaeto squarrosae-Cheilotheletum chloropi*. The cover, quite high, varies from 75% to 95% and the species number is 4-5. The association is referred to the alliance *Homalothecio aurei-Pleurochaetion squarrosae* of the order *Barbuletalia unguiculatae* and class *Psoretea decipientis*. *Rhynchostegietum megapolitani*, with a Mediterranean character, has been reported from Southern Italy and Sicily (Puglisi & Privitera, 2012; Puglisi et al., 2012).

PLEUROCHAETO SQUARROSAE-TORTULETUM RURALIS Brullo, Lo Giudice & Privitera 1991 (Tab. 3) - Cluster A3

Pleurochaeto-Tortuletum ruralis is a terricolous, photophytic, highly xerophytic association, found over scarcely developed, very dry and sunny soils in the ambit of *Satureja montana*-dominated garrigues at Gravina di Laterza (Terre delle Gravine Park, TA) and of communities characterized by *Thymbra capitata* and *Helianthemum jonium* at Mt. S. Angelo (Gargano, FG). The average cover is 60% with a minimum of 45% (Rel. 5); the species number ranges from 3 to 5. From a structural point of view, the conspicuous brown-whitish tufts of *Syntrichia ruralis* prevail,

Tab. 3 - *Pleurochaeto squarrosae-Tortuletum ruralis* Brullo, Lo Giudice & Privitera 1991.

| Relevé number | 1 | 2 | 3 | 4 | 5 | Presences |
|--|-----|-----|-----|-----|-----|-----------|
| Altitude (m a.s.l.) | 330 | 335 | 335 | 580 | 580 | |
| Cover (%) | 75 | 50 | 60 | 70 | 45 | |
| Number of species | 3 | 4 | 3 | 5 | 4 | |
| Char. association | | | | | | |
| <i>Syntrichia ruralis</i> var. <i>ruralis</i> | 4 | 3 | 3 | 4 | 2 | V |
| Char. alliance, order and class (<i>Homalothecio aurei Pleurochaetion squarrosae</i> , <i>Barbuletalia unguiculatae</i> , | | | | | | |
| <i>Tortella squarrosa</i> | 2 | 1 | 2 | . | 2 | I |
| <i>Didymodon vinealis</i> | . | + | 1 | 1 | . | II |
| <i>Cheilotheletum chloropus</i> | . | . | . | + | 1 | II |
| Other species | | | | | | |
| <i>Syntrichia intermedia</i> | . | 1 | . | 1 | . | II |
| <i>Bryum argenteum</i> | . | . | . | 1 | 1 | II |
| <i>Tortella flavovirens</i> var. <i>flavovirens</i> | + | . | . | . | . | I |

a xerophytic species characterizing the association floristically as well. In addition, *Tortella squarrosa* and *Cheilothela chloropus*, characteristic taxa of the alliance *Homalothecio aurei-Pleurochaetion squarrosae*, and *Didymodon vinealis*, characteristic of the order *Barbuletalia unguiculatae*, were found. The association is known from Greece, Turkey, southern Italy, Sicily and Sardinia (Brullo *et al.*, 1991; Puglisi & Privitera, 2012; Puglisi *et al.*, 2012).

TORTELLETUM PAPILLOSISSIMAE Puglisi 2010 (Tab. 4) - Cluster B1

This community was found on loose soils in dry and more or less exposed places facing the sea, in the ambit of garrigues with dominance of *Thymbra capitata*. It grows on coastal dunes in various localities of the Salento peninsula, also in contact with garrigues with *Halimium halimifolium* and *Erica multiflora* (*Erico multiflorae-Halimietum halimifolii*), typical of sandy soils, at Bosco Isola di Lesina (FG). From the synecological point of view, it behaves as a thermo-xerophytic, photo-sciophytic, psammophytic, halotolerant community. The vegetation cover ranges from 60% to 90% (average cover 75%), with a species number of 3-6. Characteristic of the association is *Tortella flavovirens* var. *papillosissima*, known only from Spain, Balearic Islands, Malta, Italy (Campania region) and Sicily (Linosa islet and Lipari Island) (Privitera & Puglisi, 2006, Privitera *et al.*, 2008; Puglisi, 2010). *Tortella flavovirens* var. *papillosissima* is almost constantly accompanied by *T. flavovirens* var. *flavovirens* and by *Trichostomum brachydontium*, both characteristic of *Tortellion flavovirentis*, a psammophytic and halotolerant alliance with a Mediterranean-Atlantic distribution. A set of characteristic taxa of the order *Barbuletalia unguiculatae* and class *Psoretea decipientis*, to which *Tortelletum papillosissimae* belongs, is associated too; among these, *Bryum dichotomum* is the most abundant. To date, this association is known for Sicily and Campania Regions (Puglisi, 2010; Puglisi *et al.*, 2012).

TORTELLO FLAVOVIRENTIS-TRICHOSTOMETUM CRISPULI Brullo, Lo Giudice & Privitera 1991 (Tab. 5) - Cluster B2

This association occurs on calcarenites covered by the garrigue characterized by *Satureja cuneifolia* and *Petrosedum ochroleucum* (*Sedo ochroleuci-Saturejetum cuneifoliae* Di Pietro & Misano 2010) and by *Thymbra capitata* (*Helianthemum jonii-Thymetum capitati* Biondi & Guerra 2008), found in various localities of the "Terra delle Gravine" Regional Park and of the Salento peninsula. It is a terricolous, xerophytic, sciophytic community. The cover is high, ranging from 70% to 100%, exceptionally 60% (Rel. 5); the species number is 3-6. The association is floristically

Tab. 4 - *Tortelletum papillosissimae* Puglisi 2010.

| Relevé number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Presences |
|--|----|----|----|----|----|----|----|----|-----------|
| Altitude (m a.s.l.) | 2 | 2 | 2 | 20 | 20 | 2 | 60 | 58 | |
| Cover (%) | 60 | 80 | 85 | 60 | 90 | 70 | 90 | 65 | |
| Number of species | 4 | 3 | 5 | 5 | 5 | 6 | 3 | 6 | |
| Char. association | | | | | | | | | |
| <i>Tortella flavovirens</i> var. <i>papillosissima</i> | 3 | 4 | 4 | 3 | 4 | 3 | 4 | 3 | V |
| Char. alliance (<i>Tortellion flavovirentis</i>) | | | | | | | | | |
| <i>Tortella flavovirens</i> var. <i>flavovirens</i> | 1 | . | 1 | 2 | + | 1 | 2 | 1 | V |
| <i>Trichostomum brachydontium</i> | . | 1 | 2 | 1 | 3 | 2 | . | 2 | IV |
| Char. order and class (<i>Barbuletalia unguiculatae</i> , <i>Psoretea decipientis</i>) | | | | | | | | | |
| <i>Bryum dichotomum</i> | 2 | . | . | 1 | 1 | 1 | . | 1 | IV |
| <i>Didymodon fallax</i> | 1 | . | 1 | + | . | . | . | + | III |
| <i>Ptychostomum capillare</i> | . | 2 | . | . | 1 | + | . | . | II |
| <i>Didymodon acutus</i> | . | . | 1 | . | . | . | . | . | I |
| Other species | | | | | | | | | |
| <i>Pottiopsis caespitosa</i> | . | . | . | . | . | . | 2 | + | II |
| <i>Tortella inclinata</i> | . | . | . | . | . | 1 | . | . | I |

Tab. 5 - *Tortello flavovirentis-Trichostometum crispuli* Brullo, Lo Giudice & Privitera 1991

| Relevé number | 1 | 2 | 3 | 4 | 5 | Presences |
|--|-----|----|-----|-----|-----|-----------|
| Altitude (m a.s.l.) | 54 | 55 | 320 | 330 | 190 | |
| Cover (%) | 100 | 70 | 85 | 70 | 60 | |
| Number of species | 4 | 4 | 4 | 3 | 6 | |
| Char. association | | | | | | |
| <i>Trichostomum crispulum</i> (D) | 5 | 3 | 4 | 4 | 3 | V |
| Char. alliance (<i>Tortellion flavovirentis</i>) | | | | | | |
| <i>Tortella flavovirens</i> var. <i>flavovirens</i> | 1 | 2 | 2 | 1 | 1 | V |
| Char. order and class (<i>Barbuletalia unguiculatae</i> , <i>Psoretea decipientis</i>) | | | | | | |
| <i>Bryum dichotomum</i> | 2 | . | . | . | 1 | II |
| <i>Didymodon luridus</i> | . | . | 2 | . | 1 | II |
| <i>Ptychostomum capillare</i> | . | 2 | . | 1 | . | II |
| <i>Didymodon vinealis</i> | . | 1 | 1 | . | . | II |
| Other species | | | | | | |
| <i>Didymodon cordatus</i> | 1 | . | . | . | . | I |
| <i>Tortella nitida</i> | . | . | . | . | 1 | I |
| <i>Bryum argenteum</i> | . | . | . | . | 1 | I |

characterized by *Trichostomum crispulum*, always accompanied by *Tortella flavovirens* var. *flavovirens*, characteristic of alliance, and more sporadically *Bryum dichotomum*, *Didymodon vinealis*, *D. luridus* and *Ptychostomum capillare*, characteristics of higher units. *Tortello flavovirentis-Trichostometum crispuli* is included in the alliance *Tortellion flavovirentis* of the order *Barbuletalia unguiculatae* and class *Psoretea decipientis*. In Italy, it is known from Sicily, Sardinia and Central-Southern Italy (Brullo *et al.*, 1991; Privitera & Puglisi, 2009; Puglisi *et al.*, 2012).

WEISSIETUM CONTROVERSAE Marstaller 1988 (Tab. 6) - Cluster C1

It is a terricolous, photo-sciophytic association, found in many sites: in various localities of the "Terre delle Gravine" Park, in contact with *Thymbra capitata-Helianthemum jonium* or *Satureja montana*-dominated

communities, at Monopoli (BA) in correspondence of *Thymra capitata*, and in the coastal areas next to island La Chianca (Gargano, FG) with the halotolerant garrigues of the association *Agropyro-Helichrysetum italicum*. The vegetation cover varies from 65% to 100%, with a mean value of 80%; the species number ranges from 3 to 6. *Weissia controversa* is the characteristic species of the association, accompanied by several *Didymodon* species and *Trichostomum brachydontium*, characteristic of higher units. This association is included in the alliance *Grimaldion fragrantis* of the order *Barbuletalia unguiculatae* and class *Psoretea decipiens*. Described for the Thuringian region (Marstaller, 1988), in Italy it has been reported only for Sicily (Privitera & Puglisi, 1996; Privitera et al., 2006);

therefore, it is here recorded for the first time from the Italian Peninsula.

BARBULETUM CONVOLUTAE Hadac & Šmarda 1944 (Tab. 7) - Cluster C2

Barbuletum convolutae is a widespread community in the investigated area, with a distribution ranging from Gargano to the Salento peninsula, where it was observed in several localities on shady and slightly humid soils along the trampled pathways, in various types of garrigue dominated by *Thymra capitata*, *Satureja montana*, *S. cuneifolia* or *Phagnalon rupestre*. This association, as well as almost all associations here discussed, consists only of acrocarpous species with caespitose habit. In syncological terms, *Barbuletum*

Tab. 6 - *Weissietum controversae* Marstaller 1988.

| Relevé number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Presences | |
|---|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|-----|-----------|--|
| Altitude (m a.s.l.) | 190 | 180 | 185 | 330 | 330 | 290 | 290 | 2 | 2 | 5 | 7 | 5 | | |
| Cover (%) | 90 | 80 | 65 | 90 | 80 | 65 | 95 | 70 | 65 | 90 | 70 | 100 | | |
| Number of species | 3 | 3 | 4 | 5 | 3 | 4 | 4 | 4 | 6 | 4 | 4 | 4 | | |
| Char. association | | | | | | | | | | | | | | |
| Weissia controversa | 5 | 4 | 3 | 4 | 4 | 3 | 5 | 4 | 3 | 4 | 4 | 5 | V | |
| Char. alliance, order and class (<i>Grimaldion fragrantis</i> , <i>Barbuletalia unguiculatae</i> , <i>Psoretea decipiens</i>) | | | | | | | | | | | | | | |
| Didymodon vinealis | 1 | . | 2 | 1 | . | + | 2 | . | 2 | . | 1 | . | III | |
| Didymodon fallax | . | . | 1 | . | 2 | 1 | . | . | + | . | 1 | 1 | III | |
| Didymodon acutus | . | 2 | . | 1 | . | 2 | . | 1 | . | 1 | . | 2 | III | |
| Didymodon luridus | . | . | . | 2 | . | . | . | . | 1 | 2 | + | . | II | |
| Trichostomum brachydontium | . | . | . | . | . | . | + | 1 | . | . | . | . | I | |
| Other species | | | | | | | | | | | | | | |
| Ptychostomum imbricatum | . | . | 1 | 1 | . | . | 1 | . | 1 | . | . | 2 | III | |
| Weissia condensa | . | 1 | . | . | . | . | . | . | . | 2 | . | . | I | |
| Tortella nitida | + | . | . | . | . | . | . | 1 | . | . | . | . | I | |
| Tortella squarrosa | . | . | . | . | 1 | . | . | . | . | . | . | . | I | |
| Tortella flavovirens var. flavovirens | . | . | . | . | . | . | . | . | + | . | . | . | I | |

Tab. 7 - *Barbuletum convolutae* Hadac & Šmarda 1944.

| Relevé number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | Presences | |
|---|-----|-----|-----|-----|-----|-----|----|----|-----|-----|-----|-----|-----|-----------|--|
| Altitude (m a.s.l.) | 270 | 285 | 280 | 470 | 180 | 181 | 50 | 56 | 443 | 440 | 450 | 220 | 230 | | |
| Cover (%) | 90 | 90 | 55 | 80 | 70 | 65 | 95 | 70 | 90 | 85 | 70 | 70 | 90 | | |
| Number of species | 5 | 3 | 4 | 5 | 6 | 3 | 6 | 3 | 6 | 3 | 4 | 6 | 3 | | |
| Char. association | | | | | | | | | | | | | | | |
| Barbula convoluta | 4 | 5 | 3 | 4 | 3 | 4 | 5 | 3 | 4 | 5 | 4 | 3 | 5 | V | |
| Didymodon acutus | 2 | . | 1 | . | 2 | . | . | 2 | 1 | . | . | 2 | 1 | II | |
| Char. alliance, order and class (<i>Grimaldion fragrantis</i> , <i>Barbuletalia unguiculatae</i> , <i>Psoretea decipiens</i>) | | | | | | | | | | | | | | | |
| Didymodon vinealis | + | . | 1 | 2 | . | 1 | 1 | 2 | . | 1 | 1 | . | 1 | I | |
| Bryum dichotomum | . | 1 | . | . | 1 | . | . | . | 2 | . | + | 1 | . | II | |
| Weissia controversa | . | 1 | . | 1 | . | . | + | . | 1 | + | . | . | . | II | |
| Didymodon fallax | 2 | . | 1 | . | . | . | 1 | . | . | . | . | 1 | . | II | |
| Aloina ambigua | . | . | . | . | 1 | + | . | . | . | . | . | . | . | I | |
| Other species | | | | | | | | | | | | | | | |
| Ptychostomum imbricatum | 1 | . | . | + | 1 | . | 1 | . | 1 | . | . | . | . | II | |
| Tortella flavovirens var. flavovirens | . | . | . | . | . | . | 1 | . | 1 | . | . | . | . | I | |
| Tortella squarrosa | . | . | . | . | 1 | . | . | . | . | . | . | . | . | I | |
| Didymodon sicculus | . | . | . | 1 | . | . | . | . | . | . | . | . | . | I | |
| Weissia condensa | . | . | . | . | . | . | . | . | . | . | 1 | 1 | . | I | |
| Barbula convoluta var. sardoa | . | . | . | . | . | . | . | . | . | . | . | 1 | . | I | |

convolutae is a terricolous, meso-xerophytic, photosciophytic community, not strictly linked to garrigue formations but typical of trodden paths. It grows on soils with medium nutrient content subjected to a strong human impact. Characteristic *taxa* of the association are *Barbula convoluta* and *Didymodon acutus*, the latter sporadically present. To these species, a contingent of characteristics of higher units, such as *Didymodon fallax*, *D. vinealis*, *Aloina ambigua*, *Weissia controversa*, *Bryum dichotomum*, is added. The mean cover is 78%, ranging from 55% to 95%; the number of species in each relevé varies from 3 to 6. *Barbuletum convolutae* is referred to the alliance *Grimaldion fragrantis* of the order *Barbuletalia unguiculatae* and class *Psoretea decipientis*. Rather diffused in C-Europe (Bardat & Hauguel, 2002; Marstaller, 2006), in the Mediterranean region it has been signalled from Spain (Gil, 1997), central and southern Italy and Sicily (Puglisi & Privitera, 2012; Puglisi *et al.*, 2012).

Conclusions

The garrigue environments investigated in various localities of Apulia Region, due to their climatic and edaphic features, favour the settlement of thermo-xerophytic bryophyte communities, some of which typically Mediterranean. The floristic and vegetational bryophyte component does not reveal a high degree of diversity, due to a moderate variety of environments and substrates. However, 7 bryocommunities have been identified, mostly linked to different microclimatic conditions and located at different distances from the sea.

In the phytosociological relevés the liverworts are absent and, within the mosses, a strong dominance of the acrocarpous component is present (87.1%) with a very high percentage of *Pottiaceae* (71.0%), showing an overall dry or very dry environment. The dominant biotype is the turf (87.1%), corresponding to the biotype of all the acrocarpous *taxa* found, and the colonist is the prevailing life strategy (80.6%), as emphasized in other studies on the bryophyte flora of Mediterranean territories (Privitera *et al.*, 2010, 2015). The cluster analysis reveals the presence of three main groups identified with the three reported alliances, belonging to the class *Psoretea decipientis*. Among the *Homathecio aurei-Pleurochaetion squarrosae* detected bryocommunities, the most widespread association is *Pleurochaeto squarrosae-Cheilotheletum chloropi*, considered typical of the garrigues. *Rhynchostegietum megapolitani*, from the same alliance, was found only at Torre Guaceto while in the most exposed areas on shallow soil, it was possible to recognize *Pleurochaeto*

squarrosae-Tortuletum ruralis, with a more xerophytic character. Within the second main group (*Tortellion flavovirentis* with a psammophytic feature distinctive of the alliance), *Tortelletum papillosissimae*, typically found near the coast, shows a more halotolerant character than *Tortello flavovirentis-Trichostometum crispuli*. Finally, the last main group (*Grimaldion fragrantis*) includes the associations *Weissietum controversae* and *Barbuletum convolutae*, both xerophytic and from man-disturbed habitats, the latter typical of trodden paths.

In conclusion, the investigated bryophyte vegetation of the garrigues of southern Apulia is represented by well-characterized and floristically well-defined bryocoenoses. It shows a Mediterranean character, particularly detected by the communities of the alliances *Homathecio aurei-Pleurochaetion squarrosae* and *Tortellion flavovirentis*. Anyway, this vegetation cannot be considered exclusive of the garrigues, although very well adapted to the mesoclimatic, microclimatic and edaphic features of these habitats, as well as to the proximity to the sea. Among these communities, it is possible to select the most typical one, that is *Pleurochaeto squarrosae-Cheilotheletum chloropi*, the most widespread association in the different types of garrigues of the investigated areas. Equally interesting are the other Mediterranean associations (*Tortello flavovirentis-Trichostometum crispuli*, *Tortelletum papillosissimae*, *Rhynchostegietum megapolitani* and *Pleurochaeto squarrosae-Tortuletum ruralis*) which suffer the anthropic disturbance to which they are subject especially along the coast. All these communities deserve to be considered in conservation projects by way of proper management and action plans aimed to safeguard the coastal areas.

Some of the plant communities cited in this paper fall within Annex I habitats of EEC interest, according to the 92/43/EEC "Habitat" Directive, always in the context of coastal communities. In particular, *Halimium halimifolium*-dominated garrigues typical of sandy coastal environments of the northern part of the Gargano peninsula and *Thymbra capitata*-dominated communities growing on coastal dunes in various sites of the Salento peninsula, can be included in the habitat 2260 - *Cisto-Lavanduletalia* dune sclerophyllous scrubs. Based on the present study, the association *Tortelletum papillosissimae* turned out to be specifically linked to this habitat type. Similarly, the coastal *Helichrysum italicum* subsp. *pseudolitoreum* communities, typical of coastal rocky sites of the Gargano, fall within the habitat 5320 - Low formations of *Euphorbia* close to cliffs and host the association *Weissietum controversae*.

Syntaxonomic scheme

PSORETEA DECIPIENTIS Mattick ex Follmann 1974

BARBULETALIA UNGUICULATAE von Hübschmann 1960

Homalothecio aurei-Pleurochaetion squarrosae (Ros & Guerra 1987) Marstaller 1993

Pleurochaeto squarrosae-Cheilotheletum chloropodis Privitera & Puglisi 1996

Rhynchostegietum megapolitani Puglisi 1995

Pleurochaeto squarrosae-Tortuletum ruralis Brullo, Lo Giudice & Privitera 1991

Tortellion flavovirentis Guerra ex Guerra & Puche 1984

Tortelletum papillosissimae Puglisi 2010

Tortello flavovirentis-Trichostometum crispuli Brullo, Lo Giudice & Privitera 1991

Grimaldion fragrantis Šmarda & Hadàc 1944

Barbuletum convolutae Hadàc & Šmarda 1944

Weissietum controversae Marstaller 1988

References

- Alataş M. & Uyar G., 2017. A new bryophyte community and three new records for the epiphytic bryophyte vegetation of Turkey. *Turk. J. Bot.* 41: 308-323.
- Bardat J. & Hauguel J.-C., 2002. Synopsis bryosociologique pour la France. *Cryptogamie, Bryol.* 23: 279-343.
- Bartolucci F., Peruzzi L., Galasso G., Albano A., Alessandrini A., Ardenghi N.M.G., et al., 2018. An updated checklist of the vascular flora native to Italy. *Plant Biosyst.* 152(2): 179-303.
- Biondi E., 1997. Syntaxonomy of the Mediterranean chamaephytic and nanophanerophytic vegetation in Italy. *Coll. Phytosoc.* 27: 123-145.
- Biondi E., Burrascano S., Casavecchia S., Copiz R., Del Vico E., Galdenzi D., et al. 2012. Diagnosis and syntaxonomic interpretation of Annex I Habitats (Dir. 92/43/EEC) in Italy at the alliance level. *Plant Sociology* 49(1): 5-37.
- Biondi E. & Guerra V., 2008. Vegetazione e paesaggio vegetale delle gravine dell'arco jonico. *Fitosociologia* 45(1) suppl.1: 57-125.
- Braun-Blanquet J., 1964. *Pflanzensoziologie - Grundzüge der Vegetationskunde*, 3. Springer, Berlin, 865 pp.
- Brullo S., Lo Giudice R. & Privitera M., 1991. Phytogeographical considerations on the psammophilous mosses from Mediterranean area. *Botanika Chronika* 10, special vol.: 873-887, 1991. Patras.
- Cano E., Musarella C.M., Cano-Ortiz A., Piñar J.C., Pinto Gomes C.J., Rodríguez Torres A. & Spampinato G., 2017. A phytosociological review of siliceous sedges in C-W Spain and their state of conservation based on diversity indices. *Plant Sociology* 54(2), Suppl. 1: 5-14.
- Cano M.J., Ros R.M., Guerra J. & Garcia-Zamora P., 1999. A new bryophytic community from the mountains of southern Spain and Morocco, *Tortulo subulatae-Sybtrichietum ruralis*. *Cryptogamie, Bryol.*, 20: 197-202.
- Cotecchia V., Simeone V. & Gabriele S., 2017. Caratteri climatici della Regione Puglia. In: *Memorie descrittive della Carta Geologica d'Italia*, vol. 92: 338-368. ISPRA.
- Di Pietro R. & Misano G., 2010. Shrubland and garrique vegetation in the « Gravine » gorges (Apulia region, south-eastern Italy). *Acta Bot. Gallica*, 157(2): 195-229.
- Di Pietro R., Sciandrello S., Wagensommer R., Di Bionto P., Garziano G., Medagli P. & Tomaselli V., 2009. Preliminary results of floristic and vegetational surveys in three coastal humid areas in Puglia region (southern Italy). *Lazaroa* 30: 99-107.
- Forte L., Perrino E.V. & Terzi M., 2005. Le praterie a *Stipa austroitalica* Martinovsky ssp. *austroitalica* dell'Alta Murgia (Puglia) e della Murgia Materana (Basilicata). *Fitosociologia* 42(2): 83-103.
- Gigante D., Acosta A.T.R., Agrillo E., Armiraglio S., Assini S., Attorre F., et al. 2018. Habitat conservation in Italy: the state of the art in the light of the first European Red List of Terrestrial and Freshwater Habitats. *Rend. Fis. Acc. Lincei* 29(2): 251-265.
- Gigante D., Attorre F., Venanzoni R., Acosta A.T.R., Agrillo E., Aleffi M., et al. (2016) A methodological protocol for Annex I Habitats monitoring: the contribution of Vegetation science. *Plant Sociology* 53(2): 77-87.
- Gil J.A., 1997. Flora y vegetación briofíticas de las Sierras de Cazorla y Segura (NE de Jaen, España). *Monogr. Fl. Veg. Béticas* 10: 1-73.
- Ladisa G., Todorovic M. & Trisorio Liuzzi G., 2012. A GIS-based approach for desertification risk assessment in Apulia region, SE Italy. *Physics and Chemistry of the Earth* 49: 103-113.
- Lo Giudice R. & Galesi R., 2001. Synecologie, syntaxonomie and syndinamism of terrestrial bryophyte communities of southern Sicily. *Nova Hedwigia* 72 (3-4): 503-530.

- Marstaller R., 1988. Bryosoziologische Studien im Naturschutzgebiet Heinrichstein bei Ebersdorf (Kreis Lobenstein, Bezirk Gera). 40 Beitrag zur Moosvegetation Thüringens. Ber. Bayer. Bot. Ges. 59: 27-50.
- Marstaller R., 2006. Syntaxonomischer Konspekt der Moosgesellschaften Europas und angrenzender Gebiete. *Haussknechtia* 13: 1-192.
- Marstaller R., 2010. Die Moosvegetation des Herrscherbergs und des Bocks bei Nebra (Burgenlandkreis, Sachsen-Anhalt). *Mitt. Florist. Kart. Sachsen-Anhalt (Halle)* 15: 75-100.
- Mucina L., Bültmann H., Dierßen K., Theurillat J.P., Raus T., Čarni A., *et al.* 2016. Vegetation of Europe: Hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities *Appl. Veg. Sci.* 19 (Suppl. 1): 3-264.
- Pavone P., Spampinato G., Tomaselli V., Minissale P., Costa R., Sciandrello S. & Ronsisvalle F., 2007. Cartografia degli habitat della Direttiva CEE 92/43 nei biotopi della Provincia di Siracusa (Sicilia orientale). *Fitosociologia* 44(2), Suppl. 1: 183-193.
- Perrino E.V., Tomaselli V., Costa R. & Pavone P., 2013. Conservation status of habitats (Directive 92/43 EEC) of coastal and low hill belts in a Mediterranean biodiversity hot spot (Gargano - Italy). *Plant Biosystems* 147(4): 1006-1028.
- Piñar Fuentes J.C., Cano-Ortiz A., Musarella C.M., Pinto Gomes C.J., Spampinato G. & Cano E. 2017. Rupicolous habitats of interest for conservation in the central-southern Iberian Peninsula. *Plant Sociology* 54(2) Suppl.1: 29-42.
- Pirone G. & Tammaro F., 1997. The hilly calciophilous garigues in Abruzzo (Central Apennines, Italy). *Fitosociologia* 32: 73-90.
- Privitera M. & Puglisi M., 1996. La vegetazione briofitica dell'Etna (Sicilia, Italia). *Braun-Blanquetia* 19: 1-59.
- Privitera M. & Puglisi M., 2006. On the occurrence of some interesting mosses from Linosa (Pelagian archipelago, Sicily). *Fl. Medit.* 16: 5-9.
- Privitera M. & Puglisi M., 2009. Outlines of the bryophyte vegetation of the Circeo National Park (central Italy). *Cryptogamie, Bryol.* 30(1): 91-107.
- Privitera M., Campisi P., Carratello A., Cogoni A., Flore F., Gueli L., Lo Giudice R., Provenzano F., Petraglia A., Sguazzin F. & Zimbone A., 2008. La flora briofitica dell'Isola di Lipari (Arcipelago delle Eolie, Sicilia). *Inf. Bot. Ital.* 40(1): 3-13.
- Privitera M., Puglisi M. & Ferro G., 2006. Outlines of the bryophyte vegetation of Vulcano (Aeolian Islands, Sicily). *Fitosociologia* 43(1): 85-95
- Privitera M., Zimbone A., Beone G.M., Cenci R.M. & Puglisi M., 2010. Mosses and soil to evaluate the air quality in Sicily: A study on the Integral Natural Reserve "Grotta Monello" (Syracuse, SE Sicily). *Italian Botanist* 42(1): 171-176.
- Privitera M., Galesi R., Arato L. & Puglisi M., 2015. Bryophyte diversity in Augusta-Priolo territory (South-Eastern Sicily). *Fl. Medit.* 25 (special issue): 115-126.
- Puglisi M., 2010. Contribution to the bryophyte vegetation of the Pelagian Archipelago: the Island of Linosa (Sicily Channel, Italy). *Nova Hedwigia Beihefte* 138: 257-282.
- Puglisi M. & Privitera M., 2012. A synopsis of the Italian bryophyte vegetation. *Cryptogamie, Bryol.* 33(4): 357-382.
- Puglisi M., Costa R. & Privitera M., 2012. Bryophyte coastal vegetation of the Cilento and Vallo di Diano National Park (S Italy) as a tool for ecosystem assessment. *Plant Biosyst.* 146, Suppl. 1: 309-323.
- Puglisi M., Kürschner H. & Privitera M., 2013. Saxicolous bryophyte communities of mountain areas of Greece – phytosociology, ecology, life forms and life strategies. *Nova Hedwigia* 97(1-2): 159-178.
- Puglisi M., Kürschner H. & Privitera M., 2016. The mountain and high-mountain bryophyte vegetation of the Pollino National Park (Southern Italy): Syntaxonomy and ecology. *Nova Hedwigia* 103 (3-4): 385-413.
- Puglisi M., Campisi P., Dia M.G., Privitera M. & Spampinato G., 2019. Bryophytes as ecological indicators in the beech woods of Sicily. *Nova Hedwigia* 108(3): 339-363.
- Ros R. M. & Guerra J., 1987. Vegetación briofítica terrícola de la Region de Murcia (sureste de Espana). *Phytocoenologia* 15(4): 505-567.
- Ros R.M., Mazimpaka V., Abou-Salama U., Aleffi M., Blockeel T.L., Brugués M., *et al.*, 2013. Mosses of the Mediterranean, an annotated checklist. *Cryptogamie, Bryol.* 34: 99-283.
- Spampinato G., Crisarà R., Cannavò S. & Musarella C.M. 2017. Phytotoponyms of southern Calabria: A tool for the analysis of the landscape and its transformations. *Atti Soc. Tosc. Sc. Nat. Mem. Serie B* 124: 61-72.
- Tomaselli V., Di Pietro R. & Sciandrello S., 2011. Plant communities structure and composition in three coastal wetlands in southern Apulia (Italy). *Biologia* 66(6): 1027-1043.
- Tomaselli V., Adamo M., Veronico G., Sciandrello S., Tarantino C., Dimopoulos P., Medagli P., Nagendra H. & Blonda P., 2017. Definition and application of expert knowledge on vegetation pattern, phenology and seasonality for habitat mapping, as exemplified in a Mediterranean coastal site. *Plant Biosystems* 151(5): 887-899.
- Tomaselli V. & Terzi M., 2019. Rocky coastal vegetation of the class Crithmo-Staticetea in the south-east of Italy. *Acta Botanica Croatica* 78(1): 46-56.
- Van der Maarel E., 1979. Transformation of cover-

abundance values in phytosociology and its effects on community similarity. *Vegetatio* 39: 97-114.

Zaccarelli N., Zurlini G., Riitters K., Petrosillo I. & Dadamo M., 2004. Profili di propagazione multiscale dell'ecological change in relazione alle attività antropiche. 14th Meeting of the Italian Society of Ecology, 4-6 October 2004, Siena.

Zivkovic L., Biondi E., Pesaresi S., Lasen C., Spampinato G. & Angelini P., 2017. The third report on the conservation status of habitats (Directive 92/43/EEC) in Italy: processes, methodologies, results and comments. *Plant Sociology* 54(2): 51-64.

Appendix: Localities and dates of the relevés

Tab. 1 - Rels. 1-3: *Helianthemo jonii-Thymetum capitati*, Gravina di Fantiano, Grottaglie (TA), 24/5/2016; rels. 4-5: *Salvia rosmarinus* comm., Gravina di Riggio, Grottaglie (TA), 24/5/2016; rels. 6-8: *Helianthemo jonii-Thymetum capitati*, Cave di Tufo, Laterza (TA), 22/5/2018; rels. 9-10: *Sedo ochroleuci-Saturejetum cuneifoliae*, Vallone di Pulsano (FG), 29 /5/2018; rel. 11: *Phagnalon rupestre* comm., Gravina del Triglio, Statte (TA), 10/5/2018; rel. 12: *Sedo ochroleuci-Saturejetum cuneifoliae*, San Biagio, Ostuni (BR), 24/5/2016; rel. 13-15: *Asyneumo limonifolii-Saturejetum montanae*, Lamalunga, Santeramo, 22/5/2018; rels. 16-18: *Sedo ochroleuci-Saturejetum cuneifoliae*, Gravina di Laterza (TA), 22/5/2018; rel. 19: *Sedo ochroleuci-Saturejetum cuneifoliae*, San Biagio, Ostuni (BR), 25/5/2016.

Tab. 2 - Rels. 1-4: *Saturejo-Ericetum manipuliflorae*, at the edge of a holm-oak wood, Torre Guaceto (BR), 16/5/2018.

Tab. 3 - Rels. 1-3: *Asyneumo limonifolii-Saturejetum*

montanae, Gravina di Laterza (TA), 11/5/2018; rels. 4-5: *Helianthemo jonii-Thymetum capitati*, M. S. Angelo, 26/5/2016.

Tab. 4 - Rels. 1-2: *Thymbra capitata* comm. on coastal dunes, Torre Guaceto (BR), 21.04.2016; rel. 3: *Erico multiflorae-Halimietum halimifolii*, Bosco Isola di Lesina (FG), 17/4/2018; rels. 4-5: *Helianthemo jonii-Thymetum capitati*, Otranto (LE); rel. 6: *Thymbra capitata* comm. on coastal dunes, Torre Guaceto (BR), 21.04.2016; rels. 7-8: *Helianthemo jonii-Thymetum capitati*, Minervino di Lecce (LE), 3/5/2018.

Tab. 5 - Rels. 1-2: *Sedo ochroleuci-Saturejetum cuneifoliae*, Cerfignano (LE), 23/5/2018; rels. 3-4: *Sedo ochroleuci-Saturejetum cuneifoliae*, Laterza (TA), 22/5/2018; rel. 5: *Helianthemo jonii-Thymetum capitati*, Grottaglie (TA), 24/5/2016.

Tab. 6 - Rels. 1-3: *Helianthemo jonii-Thymetum capitati*, Gravina di Riggio, Grottaglie (TA), 24/5/2016; rels. 4-7: *Satureja montana* comm., Gravina di Laterza (TA), 27/4/2016; rels. 8-9: *Helichrysum italicum* subsp. *pseudolitoreum* comm., Isola la Chianca, Peschici (FG), 31/5/2016; rels. 10-12: *Helianthemo jonii-Thymetum capitati*, Monopoli (BA), 16/5/2018.

Tab. 7 - Rels. 1-3: *Helianthemo jonii-Thymetum capitati*, Cave di Tufo, Laterza (TA), 22/5/2018; rel. 4: *Sedo ochroleuci-Saturejetum cuneifoliae*, Vallone di Pulsano, 29 /5/2018; rels. 5-6: *Phagnalon rupestre* comm., Cava del Triglio, Statte (TA), 10/5/2018; rels. 7-8: *Helianthemo jonii-Thymetum capitati*, Alimini, Otranto (LE), 03/5/2018; rels. 9-11: *Satureja montana* comm., Lamalunga, Santeramo (BA), 22/5/2018; rels. 12-13: *Sedo ochroleuci-Saturejetum cuneifoliae*, Masseria Lamastuoia, Laterza (TA), 10/5/2018.