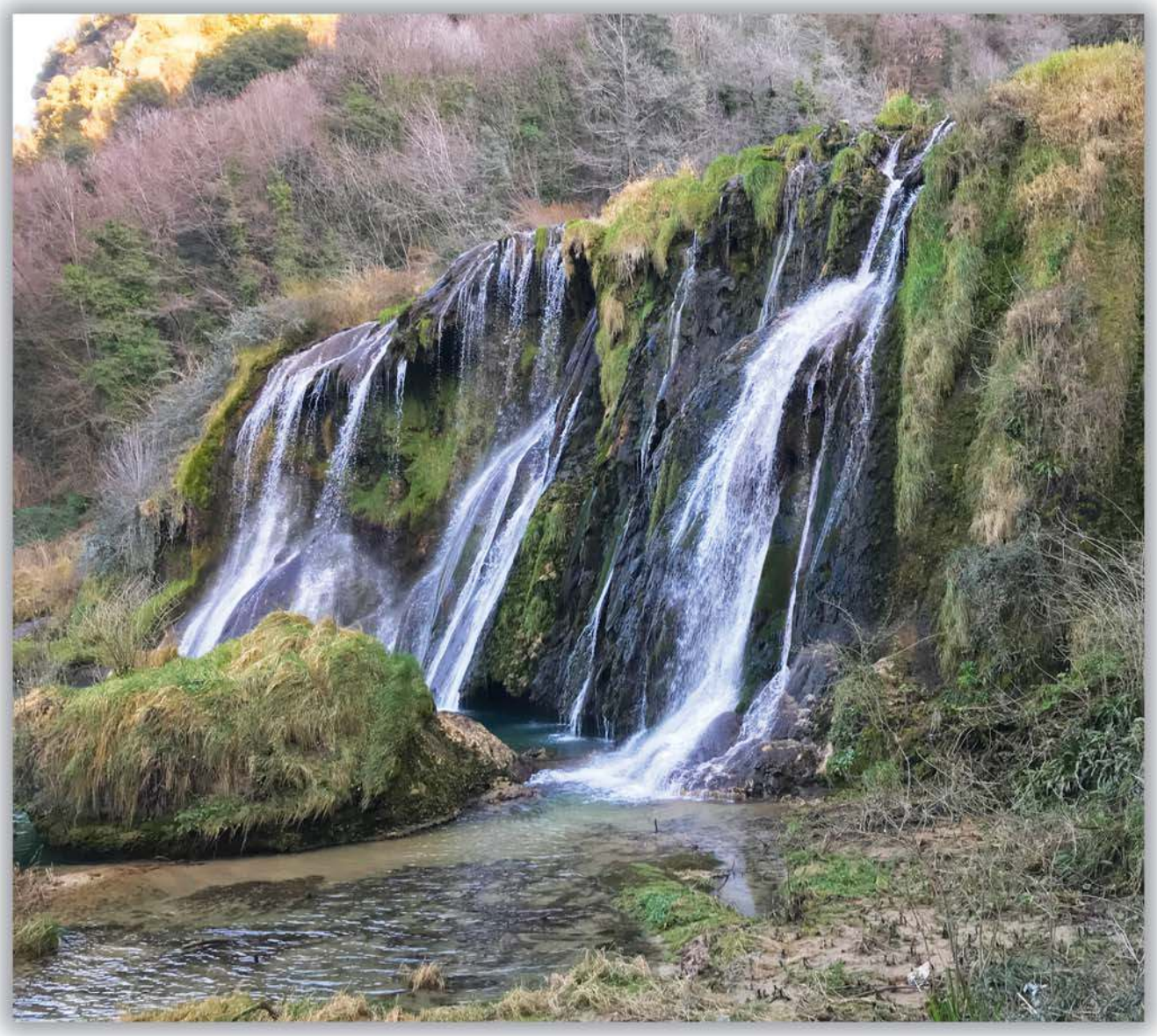
PLANT SOCIOLOGY

formerly FITOSOCIOLOGIA

Volume 55 (1) - June 2018

RIVISTA SEMESTRALE - POSTE ITALIANE S.P.A. - SPED. ABB. POST. - D.L. 353/2003 - (CONV. IN L. 27/02/2004 N. 46) ART. 1, COMMA 2, DCB ANCONA TASSA RISCOSSA-TAXE PERÇUE-CMPP AN
EDITO DALLA SOCIETA' ITALIANA DI SCIENZA DELLA VEGETAZIONE ONLUS - PAVIA - DIRETTORE RESPONSABILE PROF. E. BIONDI - VOLUME 1 - I° SEMESTRE 2018



Journal of the Italian Society for Vegetation Science

Plant Sociology, Vol. 55, No. 1, June 2018, pp. 31-44
DOI 10.7338/pls2018551/03

PLANT SOCIOLOGY
©Italian Society for Vegetation Science

Bryophytic vegetation of fragile and threatened ecosystems: the case of the Mediterranean temporary ponds in inland Central Italy

S. Poponessi[1], M. Aleffi[2], F. Maneli[1], R. Venanzoni[1], D. Gigante[1]
[1]*Department of Chemistry, Biology and Biotechnology, University of Perugia, Italy.*
[2]*School of Biosciences and Veterinary Medicine, Plant Diversity & Ecosystems Management Unit, Bryology Laboratory & Herbarium, University of Camerino, Italy.*

Abstract
The first overview of the bryophytic vegetation of the Mediterranean temporary ponds in Umbria region is reported. Phytosociological relevés were carried out in a scattered system of ephemeral pools, where seasonal fluctuation in the water level is the main driving factor. By applying Braun-Blanquet's approach to sample the bryo-communities and multivariate analysis tools to analyse data, the identification of some bryophyte communities was possible, one of which is here described as new association. It is *Entosthodono fascicularidis-Archidietum alternifolii* ass. nova, referable to the class *Psoretea decipientis*. The other bryo-communities have been framed into the classes *Cladonio digitatae-Lepidozietea reptantis*, *Ceratodonto purpurei-Polytrichetea piliferii* and *Psoretea decipientis* again.

Key words: biodiversity, conservation, habitat 3170*, moss vegetation, phytosociology.

Introduction

The temporary ponds are "usually small (<10 ha in area) and shallow wetlands which are characterized by an alternation of flooded and dry phases, and whose hydrology is largely autonomous. They occupy depressions, often endorheic, which are flooded for a sufficiently long period to allow the development of hydromorphic soils and wetland-dependent aquatic or amphibious vegetation and fauna communities" (Ramsar Convention, 1971; Ramsar Convention Bureau, 2002). Another important component is that the flooded period typically alternates with dry phases, a condition that prevents the development of species and communities from the permanently wet habitats.

These peculiar habitats are characterized by specific environmental and hydroecological conditions, where a basic role is played by the length of the flooded period together with the waterdepth, the pond size and its slope. Different ecological conditions give rise to different types of temporarily wet habitats, from waterlogged soils and flat ponds, which get totally dry in early spring, to basin-shaped ponds, whose bottom keeps wet till the start of summer (Gigante *et al*., 2007, 2013b; Ernandes & Marchiori, 2013). Deil (2005) proposed several ecological models, distinguishing waterlogged, amphibic, shallow and deep submerged aquatic conditions on the ground of the amplitude of water-level fluctuations in relation to soil surface. In large and deep ponds, water can persist till full summer and different types of habitats, from temporarily to permanently flooded, can often be found in contact with each other, depending on the length of the wet period.

The ephemeral wetland habitats have a very wide distribution all over the world, although they are always rather localized and represented by very restricted areas of occurrence (Deil, 2005).

Similar ephemeral wetlands are widespread in most of the world's Mediterranean-climate regions: the west coasts of North and South America, the Mediterranean Basin, South Africa, and Southern Australia (Barbour *et al*., 2005). Their distributional range, according to Deil (2005), includes the Mediterranean Basin and the sub-humid areas on both sides of the Tropic of Cancer. In the subtropical regions, the wet season is mostly spring and the pools desiccate in early summer (seasonal pool habitat).

Temporary ponds are present in Mediterranean and Submediterranean Italy, however, their actual distribution is restricted and very localized, due to their peculiar ecology as well as to human impact and environmental changes and climate change (Gigante *et al*., 2007, 2013b; Bagella *et al*., 2010; Bagella & Caria, 2012, 2013; Poponessi *et al*., 2014).

The Mediterranean temporary wet habitats are fragile environments, being closely dependent on water fluctuations and frequently localized in small surface areas. Even though recently there is an increasing awareness of the importance of these types of environments, not always appropriate safeguard measures are being taken (Grillas, 2004a).

The Mediterranean temporary ponds represent a very important biotope for bryophytes. One of the features

Corresponding author: Silvia Poponessi. *Department of Chemistry, Biology and Biotechnology, University of Perugia, Italy; e-mail: silvia.poponessi@hotmail.it*

that allows them to succeed in these environments is the ability to tolerate long periods of dehydration without suffering any physiological damage. Bryophytes also have the ability to protect the soil from excessive dehydration and erosion, thus promoting the establishment of vascular species, particularly amphibious species of the *Isoëto-Nanojuncetea* class. Indeed, the vegetation of European ephemeral wetlands has been assigned to the class *Isoëto-Nanojuncetea* Br.-Bl. et Tüxen ex Westhoff, Dijk et Passchier 1946 (Pietsch, 1973; Philippi, 1977; Brullo & Minissale, 1998; Deil *et al*., 1999; Deil, 2005), often neglecting the prominent role of the bryophytic *taxa*. In fact, in many botanical studies the cryptogams are skipped, although this taxonomic group is very important just because it contributes considerably to the total biomass of the ephemeral wetland vegetation by even modifying the vascular germination conditions (Deil, 2005).

The plant species present in the temporary ponds depend to a large extent on the type of substrate beneath the pond, on the water depth and the duration of flooding. In general they are all conditioned by a short life cycle and are able to produce seeds and spores (in the case of bryophytes) in the short favourable season (Ruiz, 2008). The ecological factors that mostly influence the affirmation and diversity of the bryophytic populations in temporary wetlands are temperature, oligotrophy and the water regime (Cogoni *et al*., 2009).

In Italy, the first studies on the bryophytic vegetation have been carried out by several researchers in different time periods (e.g. Giacomini, 1939; Hèbrard, 1978; Cortini Pedrotti, 1982; Cortini Pedrotti, 1985; Privitera, 1989, 1990; Lo Giudice, 1991; Aleffi, 1992a; Aiello *et al*., 1997; Puglisi *et al*., 1991; Puglisi, 1995; Puglisi *et al*., 2006) with reference to scattered areas in Sicily, Abruzzo and Calabria. A strong improvent to the knowledge of the phytocoenotic aspects of bryophytes has been given by a huge syntaxonomic overview for the whole of Italy (Puglisi & Privitera, 2012) and further developments have been added by the recent European Vegetation Checklist (Mucina *et al*., 2016) that takes into account also the bryophytic *syntaxa*.

In Umbria Region, the bryophytic component of these habitats has been studied only with reference to the flora (Aleffi, 1992b; Cortini, 1985; Ellis *et al*., 2015; Ellis *et al*., 2016; Poponessi *et al*., 2016; Ellis *et al*., 2017) while an overview of the bryophytic communities is still missing, to date. This is the first contribution focusing on bryophytic assemblages in this type of ecosystems.

Aims of the present study are: i) to improve the knowledge about the bryo-vegetation of the Mediterranean temporary ponds in central Italy and ii) to point out the species with a prominent role in colonizing the different micro-environments.

Study area

The study was carried out in the lowlands west of Lake Trasimeno in Umbria (inland central Italy) at Piana di Ferretto (N: 43°9.957', S: 11°59.667'), a flat area near Castiglione del Lago, which is very particular in terms of its ecology (Fig. 1). The area belongs to the Mediterranean Bioclimate with transitional traits to the sub-Mediterranean variant of the temperate bioclimate (Gigante & Venanzoni, 2007; Pesaresi *et al*., 2014). The substratum is represented by sandy-clayey Plio-Pleistocenic sediments which generate oligotrophic soils. The dominant soils are represented by leached decarbonated sandy-argillaceous types (Giovagnotti *et al*., 2003).

The investigations focused on a system of Mediterranean temporary ponds categorized as a priority habitat under the EU Directive 92/43/EEC and listed in Annex I with the code 3170*. The site has been selected as a SAC (Special Area of Conservation) belonging to Natura 2000 (IT5210020). These pond systems are exclusively powered by rainwater, distributed in an area of more than two hectares, where crops, pig farms and oak forests are alternated (Gigante *et al*., 2007). Data on the bryological vegetation are here provided for the first time, specifically regarding the Mediterranean temporary pond systems of this area.

Materials and methods

The bryophytic vegetation surveys were carried out in the spring period of the years 2015 and 2016. The sampling sites were scattered in the system of temporary ponds of the study area, taking into account the different micro-habitats characterized by different eco-hydrological conditions. The ponds locations were known and already investigated with reference to their vascular component (Gigante *et al*., 2007, 2013b). As concerns the sampling methodology, the

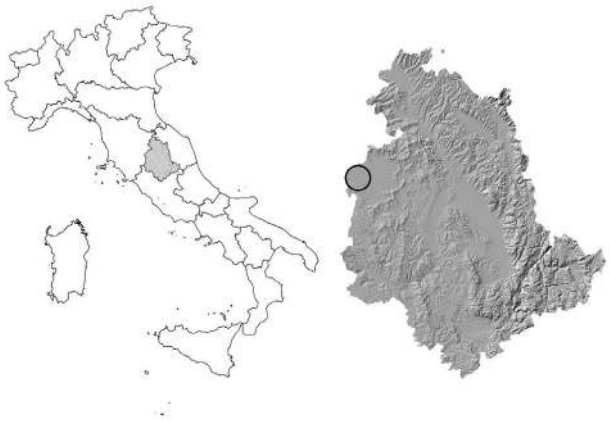


Fig. 1 - The study area, located in the western sector of Umbria Region.

phytosociological approach of Braun-Blanquet (1979) was adopted, based on the collection of complete lists of species and estimates of the related cover values, by way of a 9-values alpha-numerical scale (Westhoff & Van Der Maarel, 1978), adopting the subdivision of the value "2" into three distinct ranges: "2m", "2a" and "2b" (Barkman *et al*., 1964). A total amount of 59 phytosociological relevés were carried out in standard 10x10 cm^2 areas. The relevés took into account only the bryophytic component. The occurrence of vascular species, generally represented only by the first leaves due to the phenological shift compared to the bryophytes, has been annotated and reported as total number. For each plot, basic geographic and ecological details of the sampling areas have been recorded: geographic coordinates, slope, exposure, total cover of the vegetation, total cover of the bryophytes. Additionally, the number of total species per relevé has been calculated and reported. The relevés have been stored in the vegetation plot database VegItaly (Gigante *et al*., 2012; Landucci *et al*., 2012; Venanzoni *et al*., 2012).

After a first critical review of the 59 carried out relevés, seven of them have been removed since they referred to extremely species-poor communities, in some cases monospecific, and not appropriate to be used for a phytosociological characterization. For this reason they have not been included in the multivariate analyses and they are only briefly commented in the results. For the statystical analyses, 52 relevés have been used to produce a "21 rows (species) x 52 columns (relevés)" matrix, after a transformation of the cover values according to Westhoff & Van Der Maarel (1978). The differences among relevés have been measured by applying the complete link algorithm (Orloci, 1978) and the Euclidean distance as dissimilarity measure. The analyses have been performed by using the SynTax 5.02 package (Podani, 1995). Groups of similar relevés have been identified based on the dendrogram clusters and interpreted on the ground of a cross-check of their floristic composition with the available literature. They have been referred to bryo-phytosociological units at the association level. When no correspondence to already described *syntaxa* was possible, new associations or sub-associations have been proposed, complying with the rules of the International Code of Phytosociological Nomenclature (Weber *et al*., 2000). For the syntaxonomic framing of the bryo-communities, we followed the standards proposed by Puglisi & Privitera (2012) and the most recent updates provided by Mucina *et al*. (2016). The cited nomenclature of vascular *syntaxa* follows Biondi & Blasi (2013) and Biondi *et al*. (2014). The statistical significance of the differences between variables (number and cover of bryopytic vs. vascular species) in the identified groups of relevés was analyzed by applying nonparametric statistical methods (Mann-Whitney U-Test) by using the software *Analyst Soft StatPlus*, mac v2009.

For each detected bryo-community, a description is hereafter reported which includes also notes on the co-occurrence of vascular *taxa*. For the Bryophytes the used nomenclature follows Ros *et al*. (2007) for Marchantiophyta and Ros *et al*. (2013) for Bryophyta. For the critical genera we used Aleffi & Schumacker (1995) and Hodgetts (2015). For the vascular species, nomenclature is updated according to the most recent reviews (Conti *et al*., 2005) and matches with the database AnArchive (Lucarini *et al*., 2015).

Results

The results of the multivariate analyses are shown in Fig. 2. The dendrogram highlights eight clusters that have been attributed to seven bryo-communities. The phytosociological relevés, grouped based on their similarity as indicated by the dendrogram, have been organized in tables showing the single observed bryo-communities. Data have been analyzed by way of a huge comparison with bibliographic data, in order to interpret and define the phytocoenotic arrangement of the observed communities. The identified bryo-communities are here described with reference to their ecological, taxononomic and syntaxonomic features, grouped according to the phytosociological class. Additionally, a comparison of number and cover values of bryophytic vs. vascular *taxa* for each bryo-community is reported in Figs. 3 and 4.

Description of the bryo-communities

Vegetation of the class Psoretea decipientis *Mattick ex Follmann 1974*

ENTOSTHODONO FASCICULARIDIS-ARCHIDIETUM ALTERNIFOLIUM ass. nova

(*Holotypus*: rel. n. 2, Tab.1; Cluster I)

This community is the most widespread and abundant in the temporary pools of Ferretto. It was found on waterlogged soil, on very changeable slopes (around 18±7° on average). It is characterized by the abundant presence of *Archidium alternifolium* and *Entosthodon fascicularis*, both acrocarpous mosses which give the community its typical physiognomy. These two species are typical of the Mediterranean temporary ponds. Some thalloid and small leafy liverworts are associated to this community, such as *Riccia sorocarpa*, *R. subbifurca*, *Fossombronia pusilla*. The cover is high, ranging between 60-90% (87% on average), and the number of bryophytic species varies from 3 to 5. *Archidium alternifolium* was often observed colonizing the bottom of the pond, after the disappearance of surface water, lasting also during the dry period and still detectable in August. Sometimes, the bottom of the ponds is first colonized by species of *Algae* (uni-

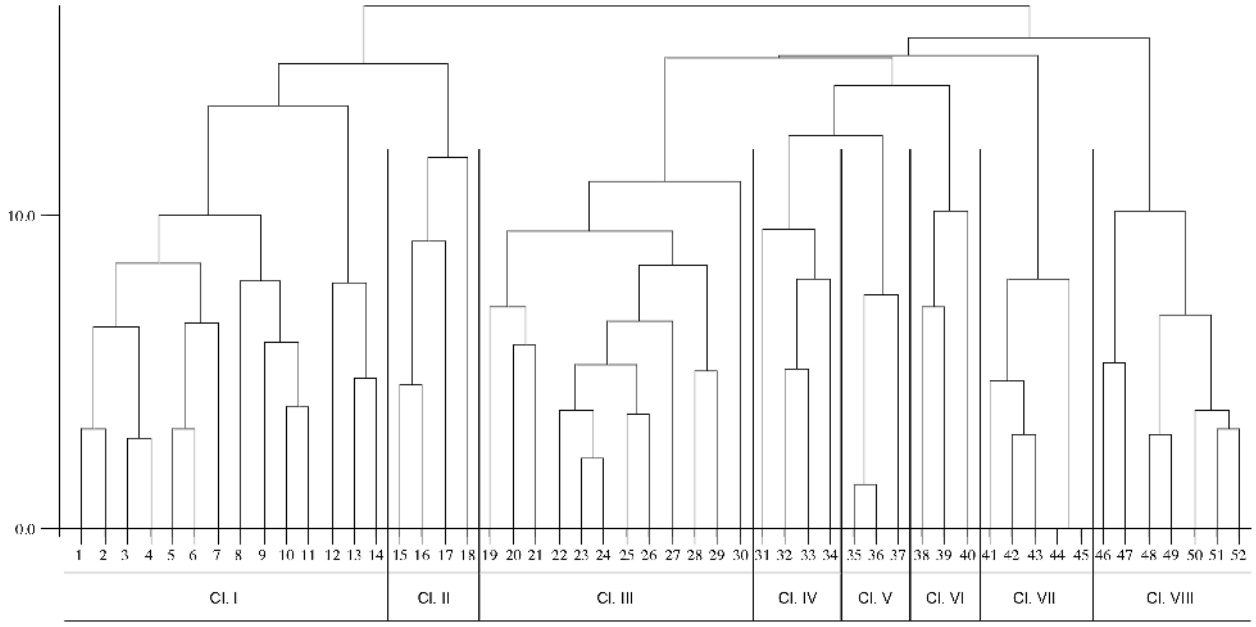


Fig. 2 - Dendrogram derived from the multivariate analysis of the phytosociological relevés (Complete Link, Euclidean Distance).

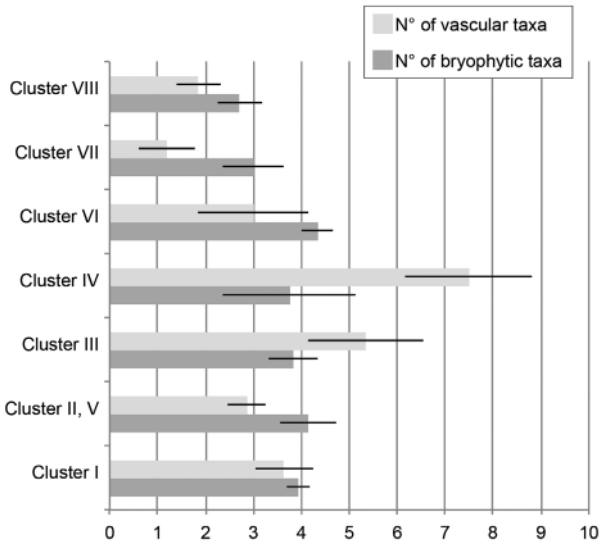


Fig. 3 - Number of bryophytic and vascular *taxa* per relevé in the surveyed bryo-communities (average values ± SE); no statistically significant difference was detected.

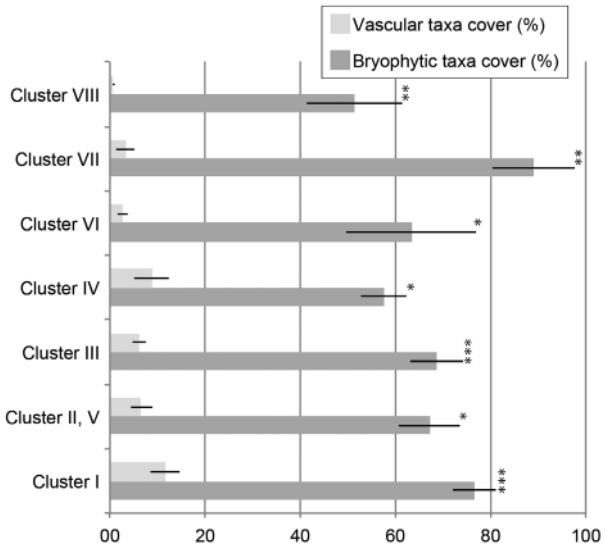


Fig. 4 - Cover values (%) of bryophytic and vascular *taxa* per relevé in the surveyed bryo-communities (average values ± SE; the statistically significant differences are pointed out: "*"= p<0.05; "**"= p< 0.01; "***"= p<0.001; p values refer to Mann-Whitney U Test).

dentified), showing a fast, ephemeral phenology and completely disappearing when the top sediment gets dry. Soon after, *Archidium alternifolium* colonizes the microhabitat and can persists, coexisting with the annual vascular phytocoenoses which colonize the same micro-environment in late spring.

Archidium alternifolium and *Entosthodon fascicularis* are indicated as characteristic species of the new association. Both are typical elements of the dwarf moss communities that colonize temporary pools (Grillas, 2004a). From an ecological point of view, both the dominant species prefer acid-subneutrophilic and temporarily flooded soils (Dierßen, 2001). On the whole, this ephemeral community behaves as terricolous and sub-acidophilic. The vascular presence is rather irrelevant, both in number and cover values (Figs. 3 and 4), mostly due to young individual fronds of *Isöetes histrix* L. and initial leaves of *Solenopsis laurentia* (L.) C. Presl.

Archidium alternifolium is considered a typical species of the class *Campylopodetea vaporarii* Brullo *et al*. 2004 (Mucina *et al*., 2016; Puglisi & Privitera, 2012),

Tab. 1 - Cluster I - *Entosthodono fascicularidis-Archidietum alternifolium* ass. nova.

Relevé number	1	2*	3	4	5	6	7	8	9	10	11	12	13	14	
N° vascular species	4	3	11	4	4	4	2	3	2	3	4	2	3	2	
N° bryophytic species	4	4	3	3	5	5	4	5	4	3	5	4	4	1	
Slope (°)	30	0	0	0	1	0	60	0	25	0	45	20	70	0	
Exposure (°)	130	-	-	-	310	-	100	-	290	-	228	110	220	-	
Total cover (%)	98	98	50	75	75	90	70	95	98	85	95	95	80	90	
Cover Bryophytes (%)	90	90	45	45	75	80	57	85	95	80	90	90	70	90	
Cover Vascular (%)	10	10	5	30	2	10	10	10	3	5	5	5	15	3	Presence
Diagnostic species of the association															
Archidium alternifolium	4	4	3	3	4	4	3	4	4	3	2b	2a	+	.	13
Enthostodon fascicularis	2a	2b	+	+	.	.	.	2a	2m	1	1	4	4	5	11
Diagnostic species of higher units															
Fossombronia pusilla	1	2m	.	.	1	1	1	2a	3	3	4	.	1	.	10
Riccia sorocarpa var. sorocarpa	.	.	+	.	1	1	.	.	.	.	.	.	.	.	3
Fossombronia caespitiformis subsp. multispira	.	.	.	.	.	.	+	.	2m	.	.	.	.	.	2
Riccia subbifurca	.	.	.	+	.	.	.	.	.	.	.	.	.	.	1
Other species															
Ptychostomum pseudotriquetrum	+	.	.	.	.	1	2a	.	.	.	+	2a	.	.	5
Pseudoscleropodium purum	.	+	.	.	.	.	.	2m	.	.	1	.	1	.	4
Tortella squarrosa	.	.	.	.	+	1	.	.	.	.	.	.	.	.	2
Fissidens curvatus	.	.	.	.	+	.	.	.	.	.	.	.	.	.	1
Imbribryum alpinum	.	.	.	.	.	.	.	2a	.	.	.	.	.	.	1
Calliergonella cuspidata	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1

while *Entosthodon fascicularis* is considered typical of the class *Psoretea decipientis* Mattick ex Follmann 1974 (Mucina *et al*., 2016). Indeed, also Puglisi & Privitera (2012) included an association dominated by *Entosthodon fascicularis* in the alliance *Phascion cuspidati* Waldheim ex v. Krusenstjerna 1945 of the class *Psoretea*. Based on a comparable combination of species, recently Puglisi *et al*. (2015a) described a *Pleuridio acuminati-Archidietum alternifolii* Puglisi & Privitera in Puglisi *et al*. 2015 but they included it in the alliance *Dicranellion heteromallae* Philippi 1963 of the class *Cladonio digitatae-Lepidozietea reptantis* Ježek & Vondrácek 1962. However, for the observed community, based on the floristic combination and on the syntaxonomical role of the dominant species, we think that the arrangement in the class *Psoretea decipientis* Mattick ex Follmann 1974 (syn.: *Barbuletea unguiculatae* Mohan 1978) is more suitable. This is also confirmed by the relevant presence of *Fossombronia pusilla*, also a typical *taxon* of the class *Psoretea decipientis* (Mucina *et al*., 2016).

Based on the available literature, there is no bryocommunity already described suitable for the attribution of the observed community. For this reason, a new association called *Entosthodono fascicularidis-Archidietum alternifoliium* is here proposed. For their abundant presence and frequency, *Archidium alternifolium*, *Entosthodon fascicularis* and *Fossombronia pusilla* are proposed as diagnostic species of the association. Compared to the recently described *Pleuridio acuminati-Archidietum alternifolii* Puglisi & Privitera 2015 in Puglisi *et al*. 2015, the here described community is more hygrophilous; the dominant species show a slightly nitrophilic attitude (Dierßen, 2001). The new association is referred to the order *Barbuletalia unguiculatae* von Hübschmann 1960 and the alliance *Phascion cuspidati* Waldheim 1944.

Archidium alternifolium is a rare species in Italy and is considered threatened in several European Countries (Puglisi *et al*., 2015a; Hodgetts, 2015).

RICCIO SOROCARPAE-FUNARIETUM FASCICULARIS Lecointe 1978 *FOSSOMBRONIETOSUM* Lecointe 1978 (Tab. 2; Clusters II and V)

The association was described by Lecointe (1978) as a rather pioneer, open community developed on partially bare, wet loamy soils, with a remarkable component of annual bryophytes. It has a NW-European distribution, generally in areas with (sub-)oceanic climates (Gueli & Lo Giudice, 2007). The subassociation *fossombronietosum* was described for Normandy (France), with reference to wetter micro-habitats and is considered more hygrophylous than the *typicum* (Lecointe, 1978). It was reported from Sicily by Puglisi *et al*. (2015a).

Characteristic *taxa* of the *Riccio sorocarpae-Funarietum fascicularis typicum* are *Riccia sorocarpa* var. *sorocarpa* and *Entosthodon fascicularis*, while the subassociation *fossombronietosum* is characterized by both *Fossombronia pusilla* and *F. caespitiformis* subsp. *multispira* (Puglisi *et al*., 2015a). It should be noted that Lecointe (1978, p. 295 and Tab. III) in the original typification of the subassociation indicated as differential species *Fossombronia* cf. *pusilla*, and explained this uncertainty with a note where he declared that the observed individuals were sterile and thus not

Tab. 2 - Clusters II, V - *Riccio sorocarpae-Funarietum fascicularis* Lecointe 1978 *fossombronietosum* Lecointe 1978.

Relevé number	15	16	17	18	35	36	37	
N° vascular species	2	1	3	3	4	3	4	
N° bryophytic species	2	3	7	5	4	4	4	
Slope (°)	0	3	60	50	0	0	0	
Exposure (°)	-	120	90	20	-	-	-	
Total cover (%)	85	60	85	90	60	65	70	
Cover Bryophytes (%)	85	50	85	85	55	60	60	
Cover Vascular (%)	1	5	4	6	5	5	10	Presence
Character species of the association								
Enthostodon fascicularis	.	1	2a	2a	.	.	.	3
Riccia sorocarpa var. sorocarpa	.	.	.	.	2b	2b	3	3
Differential species of the subassociation								
Fossombronia pusilla	5	3	3	2a	.	.	.	4
Fossombronia caespitiformis subsp. multispira	.	.	2b	.	2a	2b	2a	4
Other species								
Pseudoscleropodium purum	+	.	1	2a	.	.	.	3
Archidium alternifolium	.	+	1	.	.	.	1	3
Ptychostomum pseudotriquetrum	.	.	1	2a	.	.	.	2
Tortula subulata	.	.	.	.	2b	2a	.	2
Imbribryum alpinum	.	.	.	.	1	1	.	2
Ephemerum serratum	.	.	+	.	.	.	.	1
Calliergonella cuspidata	.	.	.	4	.	.	.	1
Campylopus pilifer	.	.	.	.	.	.	1	1

identifiable at the species level.

In the study area we recognize in this bryo-community two very different aspects, both dominated by mesophytic and subneutrophytic *taxa*, colonizing damp and shady soils, rich in clay, on rather changeable slopes (around 16±10° on average). Their remarkable difference is also pointed out by the dendrogram (Fig. 2) that splits these relevés into 2 very diverse groups. One type (Tab. 2, rels. 35-37) is dominated by *Fossombronia caespitiformis* subsp. *multispira* together with *Riccia sorocarpa*, localized on waterlogged clayey-sandy soils in the clearings of the heathlands. The bryophytic component is represented by *Tortula subulata*, *Imbribryum alpinum*, *Archidium alternifolium* and *Campylopus pilifer*. The cover is high, ranging between 60-70% (65% on average), and the number of bryophytic species per relevé always 4. The second type (Tab. 2, rels.15-18) is dominated by *Fossombronia pusilla*, accompanied by *Entosthodon fascicularis*, *Archidium alternifolium*, *Ptychostomum pseudotriquetrum* and *Pseudoscleropodium purum* and colonizes waterlogged clayey soils along the borders of small ponds. The cover is generally high (80% on average), and the average number of bryophytic species per relevé is 4. Also in this case the vascular presence is very low, both in number and cover values, basically due only to sporadic fronds of *Isöetes histrix* (Figs. 3 and 4). *Fossombronia caespitiformis* subsp. *multispira* is present in only one relevé of the second type. The dominant species of the association (*Entosthodon fascicularis*) is present only in the first type. We can interpret these facies of the subassociation as extremely impoverished aspects, compared to the original description of the subassociation (Lecointe, 1978). Also reports from the Sicilian territory show rather species-poor communities, where the supposed dominant *taxon Entosthodon fascicularis*, is often present with low cover values (Gueli *et al*., 2007). The *syntaxon* is included in the alliance *Phascion cuspidati*.

This is the first report of this bryophytic vegetation type for the territory of Umbria Region. In Italy, the association is known from Sicily (Lo Giudice, 1995; Privitera & Puglisi, 1996). The subassociation *typicum* was reported in Italy only from Sicily (Puglisi & Privitera, 2012); the subassociation *fossombronietosum* was reported for the first time by Puglisi *et al*. (2015a), on moist volcanic soil, also in Sicily. According to Puglisi *et al*. (2015a), this bryo-community appears to be tolerant to human disturbance, behaving as mesophytic and euhemerobic.

RICCIETUM GOUGETIANAE Marstaller 1993 (Tab. 5; Cluster VI)

Riccia gougetiana is a diagnostic species for the alliance *Mannion androgynae,* which refers to Mediterranean spring vegetation rich in thalloid liverworts, with a subneutrophytic ecology (Puglisi & Privitera, 2012). This species shows the life form "solitary thalloid" and a typical "shuttle" life strategy, as reported by Puglisi *et al*. (2015a, 2016).

This community, described by Marstaller (1993) for South Hungary, is here signalled for the first time for the bryophyte vegetation of Umbria Region. Formerly, it was reported for Sicily, Latium and Sardinia (Puglisi *et al*., 2015a). According to Puglisi *et al*. (2015a) this bryo-community is often associated to the presence of *Isoëtes histrix*.

It is an ephemeral, meso-hygrophytic and thermophytic community, where the prevalent liverworts are represented by species of the *Riccia* genus (*R. gougetiana*, *R. subbifurca*). This genus is distinctive for the Mediterranean region and is especially typical of the Mediterranean temporary ponds (Grillas, 2004b). In the study area this community was observed on subacid sandy/clayey soils, on flat substrata (slope 0°). The total cover is rather changeable, ranging between 45-95% (66% on average), and the number of bryophytic species varies from 4 to 5. The vascular presence is low and heterogeneous, with irrelevant cover (Figs. 3 and 4).

RICCIETUM CANALICULATAE Puglisi & Privitera in Puglisi, Minissale, Sciandrello & Privitera 2015 (Tab. 7; Cluster VIII)

Riccietum canaliculatae, recently described based on recordings from Latium and Sardinia, is one of the most typical bryophyte community of the Mediterranean ponds (Puglisi *et al*., 2015a).

The present report is the first in the territory of Umbria region. It has been observed along the borders of

large, flat ponds (average slope 3±3°) where it colonizes areas with changeable water levels, showing a high degree of tolerance for the temporary emerged conditions. The clayey soil maintains always a certain degree of humidity even after the end of the flooded period.

From an ecological point of view, it can be considered as a terricolous, meso-thermophytic, hygro-hydrophytic, ephemeral community (Puglisi *et al*., 2015a). The stands sampled in Ferretto represent an impoverished aspect, probably due to the transitional climatic conditions between Mediterranean and Temperate climate. For this reason, the number of bryophytic species is always low (ranging from 1 to 5) and many typical *taxa* indicated by Puglisi *et al*. (2015a) have not been observed. Among the most frequent species we can mention *Archidium alternifolium*, *Ephemerum crassinervium*, *Ptychostomum pseudotriquetrum*, *Entosthodon fascicularis* and *Calliergonella cuspidata* (Tab. 7). The total cover is very changeable, ranging from 25 to 85% (50% on average). The role of the vascular *taxa* is quantitatively irrelevant (Figs. 3 and 4); the most frequently observed species are *Isöetes histrix*, *Alisma plantago-aquatica* L. and *Gratiola officinalis* L.

Tab. 3 - Cluster III - *Gongylanthetum ericetorum* Puglisi, Costa & Privitera 2012.

Relevé number	19	20	21	22	23	24	25	26	27	28	29	30	
N° vascular species	8	9	5	1	2	1	4	4	12	6	11	13	
N° bryophytic species	6	3	6	3	3	2	3	2	7	5	4	2	
Slope (°)	0	0	1	2	-	0	0	0	0	1	1	1	
Exposure (°)	-	-	10	0	0	-	-	-	-	10	10	10	
Total cover (%)	50	72	70	80	95	95	95	55	75	65	60	95	
Cover Bryophytes (%)	40	70	70	70	75	95	95	55	70	65	55	90	Presence
Cover Vascular (%)	10	2	2	10	15	1	1	1	5	1	5	5	
Character species of the association													
Gongylanthus ericetorum	2b	3	1	4	4	5	5	4	4	2b	2a	3	12
Other species													
Archidium alternifolium	2b	+	1	.	1	+	1	.	.	+	.	.	7
Riccia sorocarpa var. sorocarpa	.	.	+	.	.	.	.	.	+	3	1	.	4
Fossombronia pusilla	+	2b	1	.	.	.	.	.	.	.	.	.	3
Fossombronia caespitiformis subsp. multispira	+	.	.	1	.	.	.	.	+	.	.	.	3
Imbribryum alpinum	.	.	.	.	1	.	.	.	1	+	.	.	3
Cephaloziella rubella	.	.	+	.	.	.	.	.	.	.	.	4	2
Enthostodon fascicularis	1	.	.	.	.	.	.	.	.	.	.	.	1
Riccia subbifurca	+	.	.	.	.	.	.	.	.	.	.	.	1
Dichranodonthium asperulum	.	.	3	.	.	.	.	.	.	.	.	.	1
Hypnum jutlandicum	.	.	.	1	.	.	.	.	.	.	.	.	1
Pseudoscleropodium purum	.	.	.	.	.	.	+	.	.	.	.	.	1
Campylopus introflexus	.	.	.	.	.	.	.	+	.	.	.	.	1
Polytrichum juniperinum	.	.	.	.	.	.	.	.	1	.	.	.	1
Hypnum cupressiforme	.	.	.	.	.	.	.	.	1	.	.	.	1
Pleuridium acuminatum	.	.	.	.	.	.	.	.	+	.	.	.	1
Riccia crozalsii	.	.	.	.	.	.	.	.	.	2a	.	.	1
Campylopus brevipilus	.	.	.	.	.	.	.	.	.	.	3	.	1
Fossombronia sp.	.	.	.	.	.	.	.	.	.	.	1	.	1

Vegetation of the class **Cladonio digitatae-Lepidozietea reptantis *Jezek et Vondrácek 1962***

GONGYLANTHETUM ERICETORUM Puglisi, Costa & Privitera 2012 (Tab. 3; Cluster III)

The vegetation dominated by *Gongylanthus ericetorum* was observed on waterlogged shady soils in the forest clearings, on flat locations (slope 0°), often in contact with *Calluna vulgaris* providing shady sheltered sites. It was sampled in May and June, showing a slightly delayed phenology compared to the other bryo-communities. *Gongylanthus ericetorum* is constantly present with abundant cover values (between 50-95%, 78% on average). The number of bryophytic species varies from 2 to 7 (Tab. 3). The vascular presence is remarkable in number but quantitatively irrelevant (Figs. 3 and 4); the most frequently observed species are, besides *Isoëtes histrix*, *Hypochaeris glabra* L. and *Serapias lingua* L.

A bryo-community dominated by *G. ericetorum* was first observed in Vulcano island (Puglisi *et al*., 2006) and later described in Cilento as *Gongylanthetum ericetorum* Puglisi, Costa & Privitera, 2012 (Puglisi *et al*., 2012). The comparison with the phytosociological tables reported in those studies, points out that the surveyed community is rather species-poor (Tab. 3). In both Cilento and Vulcano (Puglisi *et al*., 2006, 2012), *Pleuridium acuminatum* is frequently present and sometimes abundant, while in the study area this taxon was never observed in co-occurence with *Gongylanthus ericetorum*.

To date, this association has been reported in Italy only for Sicily and Campania, where it was observed in different environments compared to Ferretto area: in Vulcano it was located on humid shady soils (Puglisi *et al*., 2006) while in Cilento and Vallo di Diano National Park it was noticed on shady soil covering rocky slopes of cliffs, in damp hollows on coastal heaths and on roadside banks near the sea (Puglisi *et al*., 2012). Ecologically, *Gongylanthetum ericetorum* behaves as a meso-hygrophytic association, colonizing acid or sub-neutrophytic soils. At a higher hyerarchical level, the association is included in the alliance *Dicranellion heteromallae*.

Vegetation of the class **Ceratodonto purpurei-Polytrichetea piliferi *Mohan 1978***

IMBRIBRYUM ALPINUM-DOMINATED BRYO-COMMUNITY (Tab. 4; Cluster IV)

Imbribryum alpinum often acts as pioneer in unshaded areas, both on acidic to slightly base-rich rocks and on open, wet sandy soils (Jansen & Menezes De Sequeira, 1999; BBS, 2010).

The species has been recently reported for the area of Ferretto (Poponessi *et al*., 2016). The surveyed bryo-community dominated by *Imbribryum alpinum* has been observed on sandy-clayey waterlogged soils in the drying phase, in open areas and clearings in the *Calluna vulgaris*-dominated heathlands (*Danthonio-Callunetum* Pedrotti 1982). The cover values are medium-high, ranging from 55 to 95% (70% on average), and the number of bryophytic species varies from 1 to 7. The presence of the vascular component is quantitatively irrelevant, however this bryo-community is the

Tab. 4 - Cluster IV - *Imbribryum alpinum*-dominated bryo-community.

Relevé number	31	32	33	34	
N° vascular species	3	1	2	0	
N° bryophytic species	5	1	2	7	
Slope (°)	1	0	0	0	
Exposure (°)	300	-	-	-	
Total cover (%)	95	55	70	60	
Cover Bryophytes (%)	65	55	65	60	Presence
Cover Vascular (%)	25	1	5	2	
Character species					
Imbribryum alpinum	2a	3	4	3	4
Diagnostic species of higher units					
Polytrichum juniperinum	2a	.	.	.	1
Other species					
Fossombronia caespitiformis subsp. multispira	3	.	2a	.	2
Gongylanthus ericetorum	1	.	.	2a	2
Archidium alternifolium	+	.	.	+	2
Riccardia chamaedryfolia	.	.	.	2a	1
Pleuridium acuminatum	.	.	.	+	1
Cephaloziella rubella	.	.	.	+	1
Phaeoceros laevis	.	.	.	+	1

Tab. 5 - Cluster VI - *Riccietum gougetianae* Marstaller 1993.

Relevé number	38	39	40	
N° vascular species	3	1	5	
N° bryophytic species	4	4	5	
Slope (°)	0	0	0	
Exposure (°)	-	-	-	
Total cover (%)	57	45	95	
Cover Bryophytes (%)	55	44	90	Presence
Cover Vascular (%)	2	1	5	
Character species of the association				
Riccia gougetiana	2b	2a	5	3
Diagnostic species of higher units				
Fossombronia caespitiformis subsp. multispira	2b	2b	.	2
Riccia subbifurca	2b	.	.	1
Other species				
Tortula subulata	+	2a	.	2
Archidium alternifolium	.	+	1	2
Imbribryum alpinum	.	.	+	1
Hypnum cupressiforme var. cupressiforme	.	.	+	1
Tortella tortuosa var. tortuosa	.	.	+	1

one with the highest observed number of vascular *taxa* (7±1 on average).

In Portugal *Imbribryum alpinum* is the dominant *taxon* of the thero-bryophytic association *Holco gayani-Bryetum alpini* Jansen in Jansen & Menezes De Sequeira 1999, belonging to the class *Isoëto-Nanojuncetea*. It is a vegetation type rich in vascular annual species, with a very different ecology compared to the bryo-communities observed in the study area, since it colonizes rocky granitic outcrops in the Oro- and Supra-Mediterranean Bioclimatic Belts (Jansen & Menezes De Sequeira, 1999). In Italy, Privitera (1990) described the subassociation *bryetosum alpini* of the association *Scapanio compactae-Polytrichetum juniperini* Privitera 1990, of the alliance *Dicranellion heteromallae* (Philippi 1956) Philippi 1963, reported for Madonie and Peloritani Mountains(Privitera & Puglisi, 2004). However, in the study area *Scapania compacta* is absent and *Imbribryum alpinum* was found together with *Polytrichum juniperinum* only in one location, showing a closer relation with *Gongylanthus ericetorum*, *Fossombronia caespitiformis* subsp. *multispira* and *Archidium alternifolium* (Tab. 4).

Puglisi *et al*. (2015a) report *Imbribryum alpinum* as a companion species in the association *Riccietum canaliculatae*, but in our study area the two species grow in very different locations, being *Riccietum canaliculatae* linked to clayey, wetter soils often in shady locations. Mucina *et al*. (2016) indicate the species *Imbribryum alpinum* as a diagnostic *taxon* for the class *Ceratodonto purpurei-Polytrichetea piliferi* Mohan 1978. On the ground of the little information available considering the small amount of performed relevés, we treat this community only at the level of order and refer it to *Polytrichetalia piliferi* von Hübschmann 1975.

CAMPYLOPUS INTROFLEXUS - DOMINATED BRYO-COMMUNITY (Tab. 6; Cluster VII)

Campylopus introflexus is an alien, native to the southern emisphere (Lambdon, 2008) and currently diffused in the southern part of South America and in Africa and parts of Australia as well as along the Pacific, Atlantic, and Indian Ocean where it is considered native (Klinck, 2009). In 1956 it arrived to Italy and recently was detected also in Umbria, Latium up to Sicily (Puglisi *et al*., 2015b; Poponessi *et al*., 2016; Ellis *et al*., 2017). It is included among the 100 worst aliens in the world (www.europe-aliens.org) since it can harm other species, occupying their space or preventing their growth (Hahn 2006). Its ecological tolerance is wide and the growth sites vary from region to region. In Umbria it prefers a predominantly acidic soil where it reproduces mostly vegetatively, more rarely with sporophytic production. It is currently still a rare taxon in Italy, but it has been observed in the fragile context of the Priority Habitat 3170* (Puglisi *et al*., 2015a; Poponessi *et al*., 2016).

The *Campylopus introflexus*-dominated vegetation

Tab. 6 - Cluster VII - *Campylopus introflexus*-dominated bryocommunity .

Relevé number	41	42	43	44	45	
N° vascular species	0	2	0	1	3	
N° bryophytic species	4	5	2	2	2	
Slope (°)	0	0	85	0	0	
Exposure (°)	-	-	32	-	-	
Total cover (%)	100	65	100	100	100	
Cover Bryophytes (%)	100	60	100	100	90	Presence
Cover Vascular (%)	0	5	0	1	10	
Character species						
Campylopus introflexus	4	3	5	4	4	5
Diagnostic species of higher units						
Campylopus atrovirens	3	.	.	.	.	1
Other species						
Polytrichum juniperinum	+	.	.	3	3	3
Pseudoscleropodium purum	.	1	+	.	.	2
Hypnum cupressiforme var. cupressiforme	+	.	.	.	.	1
Ptychostomum capillare	.	2b	.	.	.	1
Atrichum undulatum	.	1	.	.	.	1
Archidium alternifolium	.	+	.	.	.	1

Tab. 7 - Cluster VIII - *Riccietum canaliculatae* Puglisi & Privitera in Puglisi, Minissale, Sciandrello & Privitera 2015.

Relevé number	46	47	48	49	50	51	52	
N° vascular species	0	1	1	3	3	3	2	
N° bryophytic species	3	5	3	2	1	3	2	
Slope (°)	3	20	0	0	0	0	0	
Exposure (°)	120	110	-	-	-	-	-	
Total cover (%)	85	70	65	30	35	35	25	
Cover Bryophytes (%)	85	70	65	30	35	35	25	Presence
Cover Vascular (%)	0	0.1	0.1	0.1	0.1	0.1	0.1	
Character species of the association								
Riccia canaliculata	5	4	3	2a	3	2b	2b	7
Diagnostic species of higher units								
Ephemerum crassinervium subsp. sessile	2a	2a	.	.	.	.	.	2
Entosthodon fascicularis	.	1	.	.	.	.	.	1
Other species								
Archidium alternifolium	+	2a	+	.	.	+	1	5
Calliergonella cuspidata	.	.	2b	2a	.	.	.	2
Ptychostomum pseudotriquetrum	.	1	.	.	.	1	.	2

is here reported for the first time for Umbria region. In Italy, so far, it has only been observed for Circeo National Park and Nettuno in Latium (Puglisi *et al*., 2015a). In the study site, this community is located in areas outside the ponds, where changes in the water level do not affect the soil humidity, which is only influenced by precipitation. In the surveyed system of Mediterranean temporary ponds this community is the only one without liverworts, being characterized only by the presence of acrocarpous mosses (*Polytrichum juniperinum*, *Campylopus atrovirens*, *Ptychostomum capillare*, *Archidium alternifolium* and *Atrichum undulatum*) and pleurocarpous creeping mosses (*Pseudoscleropodium purum* and *Hypnum cupressiforme* var. *cupressiforme*), in accordance with the remarks of Puglisi *et al*. (2015a).

The cover values of the surveyed bryo-community are generally very high (90-100%) and the number of bryophytic species is rather poor, ranging between 2 and 5. The dominant species is considered a characteristic taxon of the alliance *Campylopodion polytrichoidis* of the class *Ceratodonto purpurei-Polytrichetea piliferi* Mohan 1978 (Puglisi *et al*., 2015a; Mucina *et al*., 2016). The presence of vascular *taxa* is very sporadic (Figs. 3 and 4).

Comparing our data with the relevés carried out by Puglisi *et al*. (2015a) in Latium, a similarity can be noticed, as concerns structure, floristic composition and ecology, but more phytosociological data are needed to clarify the correct syntaxonomic placement of this community.

Other bryophytic recordings in the area

The seven species-poor or monospecific relevés not included in the statistic analyses can be mentioned as valuable records of the occurrence of some poorly known bryophytic *taxa* in the region. They are reported in Tab. 8 and are dominated by the species *Physcomitrium pyriforme* (rels. A, B), *Pseudoscleropodium purum* (rels. C, D, E), *Pleuridium acuminatum* (rels. F, G).

Physcomitrium pyriforme has a pioneer character and colonizes wet, muddy, nutrient-rich soils, and can frequently develop in disturbed, secondary sites (Puglisi & Privitera, 2012). In the study area it is not very frequent but has been observed in several locations, along the borders of small ditches, on sandy-muddy wet soils.

Pseudoscleropodium purum occupies the outermost zones of the surveyed ponds not directly affected by the water, near the *Campylopus introflexus*-dominated bryo-community, on acidic, seasonally moist sandy soils, on steep slopes. The species is always strongly dominant, as also reported by Von Hübschmann (1986) in similar environmental conditions, forming a dense, thick monospecific moss layer.

Pleuridium acuminatum is a pioneer species typical of bare soils, preferentially colonizing acidic substrata (Atherton *et al*., 2010). It has been observed along the banks of temporary rivulets, on wet clayey soils on very steep slopes, always developing a monodominated layer.

Discussion and conclusion

The present study represent the first phytosociological survey ever on bryophytic communities in inland Central Italy. The reported results provide a remarkable contribution to the knowledge of the bryophytic aspects of vegetation, a field which only recently came under the attention of vegetation scientists (Puglisi *et al*., 2015a). It should be said that this first overview was possible thanks to the huge work of syntaxonomic rearrangement carried out by Puglisi & Privitera (2012), since in former periods no reference frame for these peculiar types of phytocoenoses was available. More recently, a further improvement to their phytosociologic interpretation was provided by Mucina *et al*.

Tab. 8 - Other bryophytic recordings.

Relevé number	A	B	C	D	E	F	G
N° vascular species	0	0	5	5	8	1	2
N° bryophytic species	1	1	2	2	2	1	3
Slope (°)	55	60	85	70	75	10	70
Exposure (°)	40	20	300	40	320	240	250
Total cover (%)	95	100	75	95	95	70	75
Cover Bryophytes (%)	95	97	75	95	90	60	70
Cover Vascular (%)	3	3	1	0,1	5	15	5
Dominant species							
Pseudoscleropodium purum	5	5	.	.	.	.	.
Physcomitrium pyriforme	.	.	4	5	5	.	.
Pleuridium acuminatum Lindb.	.	.	.	.	.	4	3
Other species							
Archidium alternifolium	.	.	2a	.	.	.	.
Pseudoscleropodium purum	.	.	.	+	+	.	.
Archidium alternifolium (Hedw.) Mitt.	.	.	.	.	.	.	2a
Imbribryum alpinum (Huds. ex With.) N. Pedersen	.	.	.	.	.	.	2b

(2016), who validated, systematized and gave ecological interpretation to a huge number of bryo-*syntaxa*, at the European scale.

All the here analyzed *syntaxa* are reported for the first time for Umbria region. With reference to the other regions of Italy, *Riccietum canaliculatae*, *Riccio-Funarietum funarietosum* and *Riccietum gougetianae* were already known for Latium and/or Sicily (Lo Giudice, 1995; Privitera & Puglisi, 1996, 2004; Gueli *et al*., 2007; Lo Giudice & Bonanno, 2010; Puglisi *et al*., 2015a), and the present observations enlarge their distribution range. One association is newly described for the first time.

As a consequence of the fact that the study area is located in a transitional territory from the climatic point of view, and that the Mediterranean traits of its climate result rather smoothed (Gigante & Venanzoni, 2007; Pesaresi *et al*., 2014), the floristic composition of the observed bryo-communities is often impoverished, compared to occurrences of the same *syntaxa* in Mediterranean and subcoastal areas. This phenomenon, due to ecological and biogeographic reasons, is well known also for the vascular vegetation types colonizing the same habitat (Gigante *et al*., 2013) and even for very different vegetation types (see, *e.g.*, Venanzoni & Gigante, 2000, 2007; Biondi *et al*., 2003). It is also worth of interest the fact that some of these communities have been defined as Atlantic-Mediterranean (e.g. Puglisi & Privitera, 2004; Puglisi *et al*., 2012), a biogeographic trait that can be noticed also with reference to the vascular phytocoenoses of other types of habitat present in the same area, for instance the *Calluna vulgaris*-dominated heathlands (Pedrotti, 1982).

This study offers a contribution to knowledge and understanding of the Annex I priority habitat 3170* (Biondi *et al*., 2012), whose bryophytic component has often been neglected although representing an emblematic feature of the whole habitat type and a very important indicator, especially with reference to habitat monitoring and management (Bagella *et al*., 2007, 2009, 2013, 2016; Cogoni *et al*., 2009; Gigante *et al*., 2016). In particular, the observed bryophytic *taxa* showed very diverse phenology compared to vascular *taxa*. Some of them have an early development and tend to disappear before the optimal period to carry out phytosociological relevés of the vascular phytocoenoses, while others appear later in time and persist in late spring. On the other side, for other bryo-*taxa* the values of presence and coverage remain almost unchanged throughout the investigated period and longer. Several bryophytic species show an early, late-winter development and largely disappear or reduce their cover values before the vascular communities reach their maximum level of development (half/end of May). In many cases this has as a consequence the impossibility to include bryophytes in the vegetation relevés, or to detect their role in the ecosystem in a quantitative way. A possible solution in order to catch the whole biodiversity of these delicate environments would be to repeat relevés both in the early and late spring period.

The bryophyte *taxa* typically occurring in these delicate habitats are mostly represented by ephemeral liverworts (especially belonging to the genus *Riccia*), which have a life cycle dependent on variations of humidity and fluctuations in climatic conditions. Similar observation have been done also in other regions of Italy (Puglisi & Privitera, 2012) and France (Grillas *et al*., 2004a; Grillas *et al*., 2004b). These species are typically well-equipped for facing the extreme alternation of dry and wet condition which are by definition typical of the Mediterranean temporary ponds. For instance, the shuttle strategy is characteristic of all those species that have a short life cycle, closely dependent on the favorable environmental conditions of spring rains. However, drastic changes in the precipitation regime and net reduction of rainwater income can seriously affect their survival ability. The high dependance of these bryo-communities on the climatic conditions shows their high vulnerability towards climatic changes (Desamore *et al*., 2012). As emphasized by Álvarez-Cobelas *et al*. (2005), the changes in rainfall distribution would strongly alter the hydrogeological regime of temporary ponds. So it is necessary to monitor the frequency and intensity of the rains to prevent changes in these fragile ecosystems, in order to avoid the loss of their functions as temporary wetlands and their associated flora and fauna (Ruiz, 2008).

Syntaxonomic scheme

PSORETEA DECIPIENTIS Mattick ex Follmann 1974
BARBULETALIA UNGUICULATAE von Hübschmann 1960
Phascion cuspidati Waldheim 1944 nom. inval. ad interim
Entosthodono fascicularidis-Archidietum alternifolum ass. nova
Riccio sorocarpae-Funarietum fascicularis Lecointe 1978 *fossombronietosum* Lecointe 1978
Mannion androgynae Ros et Guerra 1987
Riccietum gougetianae Marstaller 1993
Riccietum canaliculatae Puglisi & Privitera in Puglisi, Minissale, Sciandrello & Privitera 2015

CLADONIO DIGITATAE-LEPIDOZIETEA REPTANTIS Jezek et Vondrácek 1962
DIPLOPHYLLETALIA ALBICANTIS Philippi 1963
Dicranellion heteromallae Philippi 1963
Gongylanthetum ericetorum Puglisi, Costa & Privitera 2012

CERATODONTO PURPUREI-POLYTRICHETEA piliferi Mohan 1978
POLYTRICHETALIA PILIFERI von Hübschmann 1975
Campylopodion polytrichoidis Giacomini 1951
Imbribryum alpinum-dominated community
Campylopus introflexus-dominated community

References

Aiello P., Dia M.G. & Raimondo F.M., 1997. Recherches synécologiques sur la bryoflore des milieux anthropisés de la Sicile. Bocconea 5: 895-904.

Aleffi M., 1992a. Associazioni di briofite ed alghe dei laghi artificiali di Campotosto e Barrea (Abruzzo, Italia centrale). Doc. Phytosoc. 14: 91-96.

Aleffi M., 1992b. Florula briologica dei boschi planiziari acidofili a sud del Lago Trasimeno (Umbria). Arch. Bot. Ital. 68(1/2): 1-8.

Aleffi M. & Schumacker R., 1995. Check-list and red-list of the liverworts (*Marchantiophyta*) and hornworts (*Anthocerotophyta*) of Italy. Fl. Medit. 5: 73-161.

Alvarez-Cobelas M., Catalan J. & García de Jalón D., 2005. Impacts on inland aquatic ecosystems. In: J.M. Moreno (ed.), Effects of Climate Change in Spain. Ministerio de Medio Ambiente, Madrid.

Atherton I., Bosanquet S. & Llawley M. (Eds.), 2010. Mosses and Liverworts of Britain and Ireland: A Field Guide. British Bryological Society. UK. pp.

Bagella S. & Caria M.C., 2012. Diversity and ecological characteristics of vascular flora in Mediterranean temporary pools. Comptes Rendus Biologies 335: 69-76.

Bagella S. & Caria M.C., 2013. Sensitivity of ephemeral wetland swards with *Isöetes histrix* Bory to environmental variables: implications for the conservation of Mediterranean temporary ponds. Aquatic Conservation: Marine and Freshwater Ecosystems 23(2): 277-290.

Bagella S., Caria M.C., Farris E. & Filigheddu R., 2007. Issues related to the classification of Mediterranean temporary wet habitats according with the European Union Habitats Directive. Fitosociologia 44(2) Suppl. 1: 245-249.

Bagella S., Caria M.C., Farris E. & Filigheddu R., 2009. Phytosociological analysis in Sardinian Mediterranean temporary wet habitats. Fitosociologia 46(1): 11-26.

Bagella S., Caria M.C., Farris M. & Filigheddu R., 2013. Spatial-time variability and conservation relevance of plant communities in Mediterranean temporary wet habitats: a case study in Sardinia. Plant Biosyst. 143(3): 435-442.

Bagella S., Caria M.C. & Zuccarello V., 2010. Patterns of emblematic habitat types in Mediterranean temporary wetlands. Comptes Rendus Biologies 333: 694-700.

Bagella S., Gascón S., Filigheddu R., Cogoni A. & Boix D., 2016. Mediterranean Temporary Ponds: new challenges from a neglected habitat. Hydrobiologia 782(1): 1-10.

Barbour M., Solomeshch A., Holland R., Witham C.W., Macdonald R., *et al*. (2005). Vernal pool vegetation of California: communities of long inundated deep habitats. Phytocoenologia 35: 177-200.

Barkman J.J., Doing H. & Segal S., 1964. Kritische Bemerkungen und Vorschläge zur quantitativen Vegetationsanalyse. Acta Bot. Neer. 13: 394-419.

BBS, 2010. BBS Field Guide online pages. Bryum alpinum. [available at http://rbg-web2.rbge.org.uk/bbs/Activities/mosses/Bryum%20alpinum.pdf, accessed on 2017, Dec 5]

Biondi E. & Blasi C., 2013. Prodromo della Vegetazione Italiana. MATTM. Società Botanica Italiana. [available online at: http://www.prodromo-vegetazioneitalia.org, accessed on 2017, Dec 10]

Biondi E., Blasi C., Allegrezza M., Anzellotti I., Azzella M.M., Carli E. *et al*., 2014. Plant communities of Italy: The Vegetation Prodrome. Plant Biosyst. 148(4): 728-814.

Biondi E., Gigante D., Pignattelli S. & Venanzoni R., 2001. I boschi a *Quercus frainetto* Ten. presenti nei territori centro-meridionali della penisola italiana. Fitosociologia 38(2): 97-111.

Braun-Blanquet J., 1979. Fitosociologia. Blume. Madrid.

Brullo S. & Minissale P., 1998. Considerazioni sintassonomiche sulla classe *Isoeto-Nanojuncetea*. Itinera Geobotanica 11: 263-290.

Cogoni A., Scrugli A. & Cortis P., 2009. Bryophyte flora of some temporary pools in Sardinia and Corsica. Plant Biosystems 143 Suppl. 1: 97-103.

Conti F., Abbate G., Alessandrini A. & Blasi C. (Eds.), 2005. An annotated checklist of Italian vascular flora, Roma, Italy. Palombi Editore.

Cortini Pedrotti C., 1982. Associazioni muscinali dell'alto percorso del fiume Nera. Excursion Inter-

nationale de Phytosociologie cn ltalie Centrale (2-11 juillet 1982). Guide Itinèrarire: 330-331.

Cortini Pedrotti C., 1985. La florule bryologique des collines sablonneuses a l'ouest du lac Trasimene (Ombrie). Cryptogamie, Bryol. Lichénol 6(1): 59-63.

Deil U., 1999. Synvikarianz und Symphylogenie. In: Evolution von Pflanzengesellschaften. Ber. d. Reinh. Tüxen-Ges. 11: 223-244. Hannover.

Deil U., 2005. Vegetation and ecology of ephemeral wetlands an introduction. Phytocoenologia 35(2-3): 171-175.

Dierßen K., 2001. Distribution, ecological amplitude and phytosociological characterization of European bryophytes. Bryophytorum Bibliotheca 56: 1-289.

Désamoré A., Laenen B., Stech M., Papp B., Hedenäs L., Mateo R.G. & Vanderpoorten A., 2012. How do temperate bryophytes face the challenge of a changing environment? Lessons from the past and predictions for the future. Global Change Biology 18: 2915-2924.

Ernandes P. & Marchiori S., 2013. Mediterranean temporary ponds in Puglia (South Italy): a "joyau floristique" to protect. Acta Bot. Gallica 160(1): 53-64.

Ernandes P., Beccarisi L., Medagli P. & Zuccarello V., 2006. Note sulle conoscenze floristiche degli "stagni temporanei mediterranei" della Puglia centro-meridionale. Inf. Bot. Ital. 38 Suppl. 1: 185-186.

Gams H., 1932. Bryo-Cenology (Moss-Societies). In: Verdoorn F. (Ed.) Manual of Bryology: 323 366. The Hague, Martin Us Nijmoff. [https://archive.org/stream/in.ernet.dli.2015.11885/2015.11885. Manual-Of-Bryology_djvu.txt]

Giacomini V., 1939. Studi Briogeografici. I. Associazioni di Briofite in Alta Valcamonica e in Valfurva (Alpi Retiche di Lombardia). Atti Ist. Bot. Pavia Ser. 4 Vol. 12: 1-139.

Gigante D. & Venanzoni R., 2007. Some remarks about the annual subnitrophilous vegetation of the *Thero-Brometalia* order in Umbria (central Italy). Lazaroa 28: 15-34.

Gigante D., Acosta A.T.R., Agrillo E., Attorre F., Cambria V.M., *et al*., 2012. VegItaly: Technical features, crucial issues and some solutions. Plant Sociology 49(2): 71-79.

Gigante D., Attorre F., Venanzoni R., Acosta A.T.R., Agrillo E., *et al*., 2016. A methodological protocol for Annex I Habitats monitoring: the contribution of Vegetation science. Plant Sociology 53(2): 77-87.

Gigante D., Landucci F. & Venanzoni R., 2013a. The reed dieback syndrome and its implications for floristic and vegetational traits of *Phragmitetum australis*, Plant Sociology 50(1): 3-16.

Gigante D., Maneli F. & Venanzoni R., 2007. L'ecomosaico degli stagni temporanei nella Piana di Ferretto (Perugia, Italia centrale): un Habitat prioritario della Direttiva 92/43/CEE. Riv. Idrobiol. 43(2004-2007): 148-158. Aracne Ed., Roma.

Gigante D., Maneli F. & Venanzoni R., 2013b. Mediterranean temporary wet systems in inland Central Italy: ecological and phytosociological features. Plant Sociology 50(2): 93-112.

Giovagnotti C., Calandra R., Leccese A. & Giovagnotti E., 2003. I paesaggi pedologici e la carta dei suoli dell'Umbria. Camera di Commercio, Industria, Artigianato e Agricoltura di Perugia. 191 pp.

Grillas P., Gauthier P., Yavercovski N. & Perennou C. 2004a. Les mares temporaires méditerranéennes. Enjeux de conservation, fonctionnement et gestion. Station biologique de la Tour du Volat, France. 1.

Grillas P., Gauthier P., Yavercovski N. & Perennou C. 2004b. Les mares temporaires méditerrnéennes. Fiches espèces. Station biologique de la Tour du Volat, France. 2.

Gueli L. & Lo Giudice R., 2007. La vegetazione briofitica e vascolare dell'area urbana e territorio extraurbano di Militello in Val di Catania (Sicilia orientale). Quad. Bot. Amb. Appl. 18: 259-302.

Hahn D., 2006. Neophyten der ostfriesischen Inseln. Schr-R Nationalpark Niedersächs Wattenmeer 9: 1-175.

Hébrard J.-P., 1978. Aperçu sur la végétation muscinale des montagnes calcaires dans la province italienne des Abruzzes. Revue bryologique et lichénologiquee 44: 7-45.

Hodgetts N.G., 2015. Checklist and country status of European bryophytes - towards a new Red List for Europe. Irish Wildlife Manuals, No. 84. Dublin: National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht.

Ellis L.T., Agcagil E., Kırmacı M., Aleffi M., Bakalin V.A., *et al*. 2016. New National and Regional Bryophyte Records, 49. Journal of Bryology 38(4): 327-347.

Ellis L.T., Ah-Peng C., Aleffi M., Baráth K., Brugués M., *et al*. 2017. New national and regional bryophyte records, 50. Journal of Bryology 39(1): 99-114.

Ellis L.T., Aleffi M., Bakalin V.A., Bednarek-Ochyra H., Bergamini A., *et al*., 2015. New national and regional bryophyte records, 42. Journal of Bryology 37(1): 68-85.

Klinck J., 2009. The alien invasive species *Campylopus introflexus* in the Danish coastal dune system. Master thesis. Department Biology, Section for Ecology and Evolution, Copenhagen University.

Jansen J. & Menezes de Sequeira M., 1999. The vegetation of shallow waters and seasonally inundated habitats (*Littorelletea* and *Isoëto-Nanojuncetea*) in the higher parts of the Serra da Estrela, Portugal. Mitt. Bad. Landesver. Naturkunde u. Naturschutz 17(2): 449-462.

Lambdon P.W., Pyšek P., Basnou C., Hejda M., Arianoutsou M. *et al*. 2008. Alien flora of Europe: spe-

cies diversity,temporal trends, geographical patterns and research needs. Preslia 80: 101-149.

Landucci F., Acosta A.T.R., Agrillo E., Attorre F., Biondi E., *et al*., 2012. VegItaly: The Italian collaborative project for a national vegetation database. Plant Biosyst. 146(4): 756-763.

Lecointe A., 1978. Les Associations Bryologiques des Éteules en Normandie (France). Doc. Pytosoc. 2: 281-298.

Lo Giudice R., 1991. Studio fitosocio1ogico sulla briovegetazione epifitica della Sicilia. Arch. Bot. Ital. 67(112): 76-98.

Lo Giudice R., 1995. Studio Fitosociologico sulle comunità briofitiche dell'ambiente urbano di Catania. Inf. Bot. Ital. 27(1): 111-124.

Lo Giudice R. & Bonanno G., 2010. Bryophyte and Bryo-Tracheophyte diversity, life forms and life strategies in urban areas of Sicily. Nova Hedwigia 90(1-2): 161-194.

Lucarini D., Gigante D., Landucci F., Panfili E. & Venanzoni R., 2015. The anArchive taxonomic Checklist for Italian botanical data banking and vegetation analysis: theoretical basis and advantages. Plant Biosyst. 149(6): 958-965.

Marstaller R., 1993. Die Moosgesellschaften des Villányer Gebirges in Südungarn. Phytocoenologia 22: 193-273.

Mucina L., Bültmann H., Dierßen K., Theurillat J.-P., Raus T., *et al*., 2016. Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. Applied Veg. Sci. 19 Suppl. 1: 3-264.

Orloci L., 1978. Multivariate analysis in vegetation research. Junk, The Hague.

Pesaresi S., Galdenzi D., Biondi E. & Casavecchia S., 2014. Bioclimate of Italy: application of the worldwide bioclimatic classification system. Journal of Maps 10: 538-553.

Philippi G., 1977. Klasse *Isoëto-Nanojuncetea*. In: Oberdorfer E. (Ed.) Süddeutsche Pflanzengesellschaften, Teil 1: 166-181. Gustav Fischer Verlag, Jena, Stuttgart, New York.

Pietsch W., 1973. Beitrag zur Gliederung der europäischen Zwergbinsengesellschaften (*Isoeto-Nanojuncetea* Br.-Bl. & Tx. 1943). Vegetatio 28: 401-438.

Pignatti S., 1982. Flora d'Italia. 3 voll. Edagricole.

Podani J., 1995. Syn-Tax 5.02 Mac. Computer Programs for Multivariate Data Analysis on the Macintosh system. Scientia Publishing, Budapest.

Poponessi S., Aleffi M., Gigante D. & Venanzoni R., 2016. Updates on the bryophyte flora of the lowland woods and temporary ponds west of Lake Trasimeno (Central Italy). Fl. Medit. 26 pp: 151-162.

Poponessi S., Mariotti M.G., Aleffi M. & Venanzoni R., 2014. Bryophytic similarity of the Italian regions with a focus on the Ligurian region. Plant Biosyst. 148(4): 851-856.

Privitera M. & Puglisi M., 2004. La vegetazione briofitica della Sicilia. Braun-Blanquetia 34: 129-141.

Privitera M., 1989. La vegetazione muscinale dei gessi dell'Agrigentino (Sicilia occidentale). Bollettino accademia Gioenia di scienze naturali 22(335): 105-113.

Privitera M., 1990. La classe *Platyhypnidio-Fontinaletea antipyreticae* Philippi 1956 in Sicilia. Bollettino accademia Gioenia di scienze naturali 23(336): 337-354.

Puglisi M., 1995. Note sulla briovegetazione basifila del versante meridionale dell'Aspromonte (Calabria). Archivio geobotanico I(1): 35-43.

Puglisi M. & Privitera M., 2012. A synopsis of the Italian bryophyte vegetation. Cryptogamie, Bryologie 33(4): 357-382

Puglisi, M., Campisi, P., Dia, M.G. & Privitera, M. 2015b. New or interesting regional bryophyte records for Italian bryoflora. Flora Mediterranea 25 Special issue: 193-198.

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: 309-323

Puglisi M., Lo Giuduce R. & Privitera M., 1991. Osservazioni sulla briovegetazione altomontana dell'Etna. Giornale botanico Italiano 125(3): 421

Puglisi M., Minissale P., Sciandrello S. & Privitera M. 2015a. The bryophyte vegetation of the Mediterranean temporary ponds in Italy. Plant Sociology 52(2): 69-78.

Puglisi M., Privitera M. & Ferro G., 2006. Outlines of the bryophyte vegetation of Vulcano (Aeolian Islands, Sicily). Fitosociologia 43(1): 85-95

Ramsar Convention, 1971. The Convention on Wetlands of International Importance, especially as Waterfowl Habitat. Ramsar, Iran, February 2, 1971, as amended by the Protocol of 3.12.1982 and the Amendments of 28.5.1987.

Ramsar Convention Bureau, 2002. Resolution VIII.33: Guidance for identifying, sustainably managing, and designating temporary pools as Wetlands of International Importance. "Wetlands: water, life, and culture", 8th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands (Ramsar, Iran, 1971), Valencia, Spain, 18-26 November 2002. [available online at http://archive.ramsar.org/pdf/res/key_res_viii_33_e.pdf]

Rodríguez Oubiña J., Reinoso Franco J. & Gómez Valverde M., 2001. *Pleuridio acuminati-Ophioglossetum lusitanici* una nueva asociación del afloreamiento de rocas ultrabásicas del centro de Galicia (NO de España). Nova Acta Científica Compostelana (Bioloxía) 11: 167-175.

Ros R.M., Mazimpaka V., Aleffi M., Blockeel T.L.,

Cano M.J., *et al*. 2007: Hepatics and Anthocerotes of the Mediterranean, an annotated checklist. Cryptogamie, Bryologie 28(4): 351-437.

Ros R.M., Mazimpaka V., Abou-Salama U., Aleffi M., Blockeel T.L., *et al*. 2013. Mosses of the Mediterranean, an annotated checklist. Cryptogamie, Bryologie 34(2): 99-283.

Ruiz E., 2008. Management of Natura 2000 habitats. 3170*Mediterranean temporary ponds. European Commission, Technical Report 2008 07/24. 19 pp.

Venanzoni R., Landucci F., Panfili E. & Gigante D., 2012. Toward an Italian national vegetation database: VegItaly. In: Dengler J., Oldeland J., Jansen F., Chytrý M., Ewald J., *et al*. (Eds.), Vegetation databases for the 21st century. Biodiversity & Ecology 4: 185-190.

von Hübschmann A., 1986. Prodromus der Moosgesellschaften Zentraleuropas. Bryophytorum Bibliotheca 32: 1-413.

Weber H.E., Moravec J. & Theurillat J.P., 2000. International Code of Phytosociological Nomenclature. 3rd ed. J. Veg. Sci. 11: 739-768.

Westoff V. & Maarel Van Der E., 1978. The Braun-Blanquet approach. 2nd ed. In: R.H. Whittarker (Ed.). Classification of Plant Community. Junk, The Hague.

Appendix: Localities and dates of the relevés

Tab. 1 - rels. 1-2, 5-9, 11-13: Podere Coccolargo, 2016-05-05; rel. 3, Podere Marella, 2015-04-01; rels. 4,10,14: Podere Monelli, 2016-05-12.

Tab. 2 - rel. 15: Podere Monelli, 2016-05-12; rels. 16-18: Podere Coccolargo, 2016-05-05; rels. 35-37: Podere Monelli, 2016-05-12.

Tab. 3 - rels. 19-20, 23-25: Podere Monelli, 12-05-2016; rels. 21-22, 26-27, 29: Le 7 Strade, 2016-05-05; rels. 28, 30: Podere Coccolargo, 2015-04-01.

Tab. 4 - rels. 31, 33: Podere Monelli, 2016-05-12; rels. 32, 34: Le 7 Strade, 2016-04-08.

Tab. 5 - rels. 38-39: Podere Monelli, 2016-05-12; rel. 40: Le 7 Strade, 2016-05-05.

Tab. 6 - rels. 41-45: Podere Monelli, 2016-05-12.

Tab. 7 - rels. 46-47: Podere Coccolargo, 2016-06-28; rels. 48-52: Podere Coccolargo, 2015-05-27.

Tab. 8 - rels. A-B: Podere Coccolargo, 2016-05-05; rels. C-E: Podere Monelli, 2016-05-12; rels. F-G: Le 7 Strade, 2016-05-05.