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The bryophyte vegetation of the Mediterranean temporary ponds in Italy

M. Puglisi[1], P. Minissale[1], S. Sciandrello[2], M. Privitera[1]
[1]*Department of Biological, Geological and Environmental Sciences, University of Catania, I-95125 Catania, Italy.*
[2]*Centre for the Conservation and Management of Nature and Agroecosystems (Cutgana), University of Catania, I-95123 Catania, Italy.*

Abstract
A phytosociological investigation on the bryophytes of the Mediterranean temporary ponds in some territories of the insular and Central-Southern peninsular Italy (Latium, Campania, Sicily, Sardinia) is here presented. By combination of multivariate and phytosociological analyses we detected the presence of six communities of which two new records from Italy and two new associations. They are *Riccietum gougetianae*, *Riccietum canaliculatae* ass. nova and *Riccio sorocarpae-Funarietum fascicularis* subass. *fossombronietosum*, referable to the class *Barbuletea unguiculatae, Pleuridio acuminati-Archidietum alternifolii* ass. nova of the class *Cladonio digitatae-Lepidozietea reptantis*, the community with *Campylopus introflexus* of to class *Ceratodono piliferi-Polytrichetea piliferi* and *Ricciocarpetum natantis* of the class *Lemnetea minoris*. For the peculiarity of the communities and the occurrence of some species of phytogeographycal interest, the bryophytes should be more considered in the management and conservation policies.

Key words: Bryophytes, phytosociology, syntaxonomy, temporary ponds.

Introduction

Mediterranean temporary ponds are small, shallow water bodies, isolated from permanent water bodies, which undergo a periodic cycle of flooding and drought. They host a peculiar and specialized flora well adapted to this water oscillation. According to the Natura 2000 network of the European Union (Habitats Directive 92/43/ EC), they comprise three Habitats referred to the "Standing waters" (code 31), including the prioritary Habitat 3170 "Mediterranean temporary ponds". In Europe, the Mediterranean temporary ponds are mainly distributed in the Mediterranean region along the coastal or subcoastal areas and rarely in the inland (e.g. Brullo & Minissale, 1998; Biondi *et al*., 2002, 2010; Gigante *et al*., 2007, 2013; Bagella *et al*., 2009, 2013; Minissale & Sciandrello, 2014). Syntaxonomically, the vegetation is mostly referable to the amphibious communities of the orders *Isoëtetalia durieui* Br.-Bl. 1936 and *Nanocyperetalia flavescentis* Klika 1935 of the class *Isoëto-Nanojuncetea* Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946, but also to other order and classes, e.g. *Littorelletalia uniflorae* Koch 1926 of the *Littorelletea uniflorae* Br.-Bl. & Tüxen ex Westhoff, Dijk & Passchier 1946, *Nasturtio officinalis-Glycerietalia fluitans* Pignatti 1953 of the class *Phragmito australis-Magnocaricetea elatae* Klika in Klika & Novák 1941 (e.g. Biondi & Bagella, 2005; Biondi *et al*., 2012; Bagella *et al*., 2013; Gigante *et al*., 2013; Minissale & Sciandrello, 2014).

As regards the bryophytes, only floristic studies are known to date on these intermittently flooded habitats, carried out in some territories of Italy and other Mediterranean Countries (e.g. Casas *et al*., 1998; Mandin & Hugonnot, 2001; Grillas *et al*., 2004; Hugonnot, 2004; Pericàs *et al*., 2009; Aleffi *et al*., 2009; Cogoni *et al*., 2009). Unlike flora, no information is known on the vegetation; for this reason we carried out this survey aimed to the knowledge of the bryophyte communities of the Mediterranean ponds.

Materials and Methods

The field work was carried out during many investigations regarding the bryophyte vegetation of Italy, in a long period ranging from 1995 to 2015. The season of the collection was spring or late spring which corresponds to the brief life cycle of many bryophytes colonizing the temporary ponds or to the period of sporification of the pauciannual species.

The phytosociological data refer to some territories of the regions Latium (central Italy), Campania (southern Italy), Sicily and Sardinia.

The study followed the plant sociological method of Braun-Blanquet (1964). Multivariate analysis on relevés was performed using SYN-TAX 2000 software (Podani, 2001). A hierarchical classification method (UPGMA) was performed. Dissimilarity of the rele-

Corresponding author: Marta Puglisi. *Department of Biological, Geological and Environmental Sciences, University of Catania, I-95125 Catania, Italy; e-mail: mpuglisi@unict.it*

vés was measured using the chord distance coefficient. The original Braun-Blanquet sampling scale was transformed into the ordinal scale according to Van der Maarel (1979).

The syntaxonomic arrangement and nomenclature follow Puglisi & Privitera (2012) and Biondi *et al.* (2014); the nomenclature of the taxa follows Ros *et al.* (2007) for liverworts and Ros *et al.* (2013) for mosses.

Results

The results of the cluster analysis show two main, well separated, vegetation groups (Fig. 1), each of them characterized by specific indicator species. The first one includes five groups of clusters (1, 2, 3, 4, 5), the second one only the cluster 6. This highest division separates the relevés regarding respectively the exclusively bryophyte and bryo-chormophytic communities. On the ground of their floristic and ecological features, the six detected clusters of relevés have been referred to four phytosociological classes. Clusters 1, 2 and 3 (18 relevés) assemble the bryophyte communities belonging to the *Barbuletea unguiculatae*. Cluster 4 (11 relevés) corresponds to a community of the class *Cladonio digitatae-Lepidozietea reptantis*, cluster 5 to a community of the *Ceratodonto purpurei-Polytrichetea piliferi*; finally cluster 6, the most separated cluster, corresponds to a bryo-chormophytic community of the *Lemnetea minoris* class. The clusters 1 and 2 are the most closely joined and correspond to two communities of the alliance *Mannion androgynae* (*Riccietum gougetianae and Riccietum canaliculatae*); these clusters are related to cluster 3 corresponding to a community of the *Phascion cuspidati* (*Riccio sorocarpae-Funarietum fascicularis* subass. *fossombronietosum*). As regards the floristic set, clusters 1 and 2 are closely joined by the occurrence of some thalloid liverwort species of the genus *Riccia*, widespread in the temporary ponds and characteristics of the alliance *Mannion androgynae*. Cluster B is characterized by other liverworts, such as *Fossombronia pusilla* and *F. caespitiformis* ssp. *multispira*, with thinner thallus forming rosettes. Clusters C and D are dominated by acrocarpous mosses, such as *Epipterygium tozeri*, *Archidium alternifolium*, *Pleuridium acuminatum*, the last two small size mosses with immersed, cleistocarpous capsules (cluster C), *Campylopus introflexus* and *Campylopus atrovirens*, robust mosses up to 5 cm high (cluster D). The most isolated and separated group is cluster D, characterized by the co-presence of the liverwort *Ricciocarpos natans* and some *Lemna* species, all free floating plants.

Cluster 1 - *RICCIETUM GOUGETIANAE* Marstaller 1993 (Table 1)

It is a community quite spread in this habitat, found on moist soil of some temporary ponds of Latium (Cerasella wood, Circeo National Park), Sardinia (Giara di Gesturi) and Sicily (Pollina), where often is associated to the presence of *Isoetes histrix* Bory (Latium, Sicily). Ecologically, *Riccietum gougetianae* behaves as a meso-hygrophytic, ephemeral association, colonizing acid or sub-acid sandy or clayey soil. The cover is low, as well as in other surveyed communities, with the average cover of 35%; the species number varies between 4 and 6.

This vegetation type consists of many *Ricciaceae* which mostly occur as isolated and scattered rosettes, giving the peculiar physiognomy to the community. Most species show a "shuttle" life strategy (e.g. *Riccia* spp., *Fossombronia* spp.), which mainly consists of production of large size spore (> 25 μm) leading a low dispersal capacity (short-range dispersal or achory). The shuttle species, largely present in this community as well in all other communities below reported, are well adapted to temporary habitats predictably recurring at the same site.

Characteristic species of the association is *Riccia gougetiana*, accompanied by a set of characteristics of higher units (alliance, order and class), with the dominance of some thalloid liverworts, such as *Riccia sorocarpa* var. *sorocarpa*, *R. nigrella* and *Corsinia coriandrina*. *Riccietum gougetianae* belongs to the Mediterranean alliance *Mannion androgynae* (order *Barbuletalia unguiculatae*, class *Barbuletea unguiculatae*) grouping exochomophytic and chasmochomophytic, spring associations (Puglisi & Privitera, 2012). *Riccietum gougetianae*, described by Marstaller (1993) for South Hungary, is here signaled for the first time for the bryophyte vegetation of Italy.

Cluster 2 - *RICCIETUM CANALICULATAE* Puglisi & Privitera ass. nova *hoc loco* (Table 2)

Holotypus: rel. 1

It is one of the most typical bryophyte community of the Mediterranean ponds found in correspondence of usually larger and deeper ponds (water depth up to 30 cm) than *Riccietum gougetianae*. It was detected on waterlogged, acid sandy or clayey soil, occupying the banks which are wet or sometimes flooded. It is sometimes related to the occurrence of *Isoetes longissima* Bory.

From an ecological point of view, it can be considered as a terricolous, meso-thermophytic, hygro-hydrophytic, ephemeral community. The finding sites are located in the Latium region, within the Cerasella wood (Circeo National Park) and within the Site of Community Importance IT6030028 "Castel Porziano (querceti igrofili), and in Sardina at the Giara of Gesturi. The surfaces vary from 20 dm^2 to 30 dm^2 and the sites are flat; the cover is low, ranging from 20% to 35%, exceptionally 60% in the relevé 3; the number

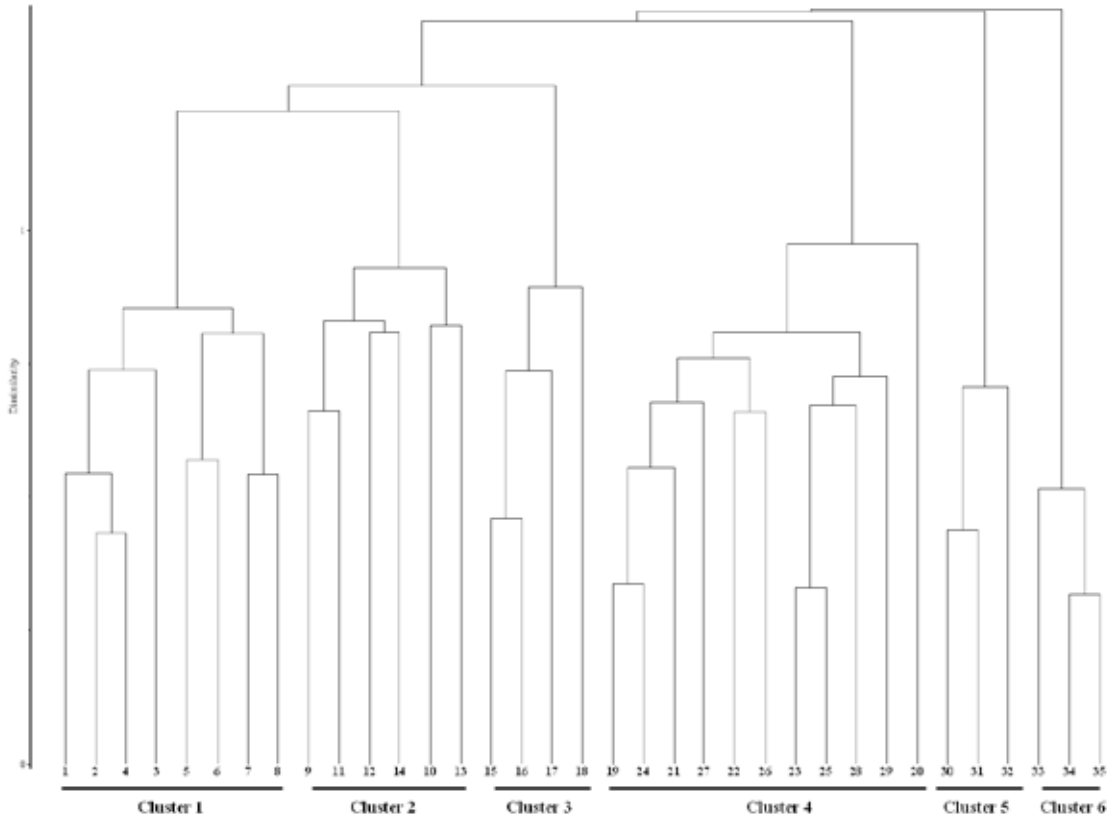

Fig. 1 - Dendrograms derived from the cluster analysis applied to the surveyed communities.

species is 3-6.

The physiognomy is linked to the occurrence of thalloid, annual or short-lived liverworts (*Riccia canaliculata*, *R. gougetiana*, *R. glauca*, *R. sorocarpa* var. *sorocarpa*), with *Riccia canaliculata* dominant, mixed to some robust, glossy acrocarpous mosses with caespitose habitus (*Imbribryum alpinum*, P*tychostomum pseudotriquetrum*). For its floristic and ecological peculiarity, it was not possible to attribute this community to any already described association. Therefore, a new association, named *Riccietum canaliculatae*, is here proposed. As concerns the higher syntaxonomic arrangement, the new association should be referred to the alliance *Mannion androgynae* of the order *Barbuletalia unguiculatae*, class *Barbuletea unguiculatae*. For its ecology and constant presence, *Riccia canaliculata* is indicated as characteristic species of the new association; it is associated to some characteristic species of higher units, such as *Riccia gougetiana*, *R. sorocarpa* var. *sorocarpa*, *Trichostomum brachydontium* and *Fossombronia caespitiformis* subsp. *multispira*.

Cluster 3 - *RICCIO SOROCARPAE-FUNARIETUM FASCICULARIS* Lecointe 1978 subass. *FOSSOMBRONIETOSUM* Lecointe 1978 (Table 3)

This ephemeral, terricolous, community was detected in eastern Sicily on moist volcanic soil at the outer margins of small, shallow ponds dried up in spring. It is one of the communities with fewer needs in water and most affected by human disturbance, behaving as mesophytic and euhemerobic. The cover is a little higher than that of the previous communities, with the average cover of about 46%; the species number varies between 6 and 9.

The physiognomy is heterogeneous for the occurrence of liverworts with thick thallus (*Riccia* spp., *Oxymitra incrassata*), some *Fossombronia* spp. which mark a transit between the thalloid and leafy liverworts, and mosses with caespitose habitus. The subassociation is characterized by *Fossombronia pusilla* and *F. caespitiformis* subsp. *multispira*, associated to the characteristics of the subassociation *typicum*, *Riccia sorocarpa* var. *sorocarpa* and *Entosodon fascicularis*, and to a set of species of higher units (alliance, order and class). The community is referred to the *Phascion cuspidati*, a nitrophytic, eutrophic alliance typical of cultivated soil with strong human impact. The subassociation typicum was signaled in Italy only from Sicily (Puglisi & Privitera, 2012); the subassociation fossombronietosum, described by Lecointe (1978) for Normandy (France), is here reported from Italy for the first time.

Tab. 1 - *Riccietum gougetianae* Marstaller 1993

Relevé number	1	2	3	4	5	6	7	8	
Altitude (m a.s.l.)	40	40	40	40	570	570	450	450	
Size of relevé (dm^2)	25	15	30	20	15	25	30	30	Presences
Cover (%)	20	45	35	50	45	40	25	20	
Inclination (°)	-	40	-	-	35	-	-	30	
Exposure	-	SE	-	-	S	-	-	S	
Number of species	4	4	5	6	4	5	6	6	
Character species of the association									
Riccia gougetiana	2	3	2	3	3	3	2	1	8
Character species of the alliance, order and class (*Mannion androgynae*, *Barbuletalia unguiculatae*, *Barbuletea unguiculatae*)									
Riccia sorocarpa var. sorocarpa	+	.	.	.	.	1	1	1	4
Corsinia coriandrina	.	.	1	+	.	.	+	1	4
Bryum dichotomum	.	1	1	+	.	.	+	.	4
Fossombronia caespitiformis subsp. multispira	1	+	.	1	.	.	.	.	3
Riccia nigrella	.	.	.	.	1	.	+	1	3
Bryum radiculosum	.	.	1	.	+	+	.	.	3
Transgressive species of the alliance *Phascion cuspidati*									
Riccia glauca	+	1	+	1	.	.	.	.	4
Other species									
Riccia michelii	.	.	.	.	1	+	.	+	3
Fossombronia caespitiformis subsp. caespitiformis	.	.	.	1	.	.	+	+	3
Hedwigia stellata	.	.	.	.	.	+	.	.	1

Tab. 2 - *Riccietum canaliculatae* ass. nova

Relevé number	1	2	3	4	5	6	
Altitude (m a.s.l.)	40	40	40	60	60	570	
Size of relevé (dm^2)	25	30	20	30	30	20	
Cover (%)	30	25	60	35	30	20	
Inclination (°)	20	-	-	-	-	-	
Exposure	E	-	-	-	-	-	Presences
Number of species	6	4	6	5	5	3	
Character species of the association							
Riccia canaliculata	2	2	3	2	1	2	6
Character species of the alliance, order and class (*Mannion androgynae*, *Barbuletalia unguiculatae*, *Barbuletea unguiculatae*)							
Riccia gougetiana	+	1	1	.	1	.	4
Fossombronia caespitiformis subsp. multispira	1	.	+	1	+	.	4
Trichostomum brachydontium	1	.	.	+	.	1	3
Riccia sorocarpa var. sorocarpa	.	.	.	.	1	+	2
Other species							
Imbribryum alpinum	.	+	1	.	2	.	3
Ptychostomum pseudotriquetrum	.	1	.	1	.	.	2
Fossombronia pusilla	.	.	1	1	.	.	2
Riccia glauca	1	.	2	.	.	.	2
Archidium alternifolium	+	.	.	.	.	.	1

Tab. 3 - *Riccio sorocarpae-Funarietum fascicularis* Lecointe 1978 *fossombronietosum* Lecointe 1978

Relevé number	1	2	3	4	
Altitude (m a.s.l.)	360	360	-	-	
Size of relevé (dm²)	15	25	25	20	Presences
Cover (%)	60	35	50	40	
Number of species	8	6	9	6	
Character species of the association					
Riccia sorocarpa var. sorocarpa	2	1	+	1	4
Entosthodon fascicularis	.	.	1	2	2
Diff. species of subass.					
Fossombronia pusilla	3	2	3	1	4
Fossombronia caespitiformis subsp. multispira	+	+	1	+	4
Character species of the alliance (*Phascion cuspidati*)					
Phaeoceros laevis	+	.	1	.	2
Pleuridium acuminatum	.	.	+	1	2
Riccia glauca	.	.	+	.	1
Transgressive species of the alliance *Mannion androgynae*					
Riccia nigrella	1	+	.	1	3
Oxymitra incrassata	.	.	+	.	1
Character species of the order and class (*Barbuletalia unguiculatae*, *Barbuletea unguiculatae*)					
Bryum dichotomum	+	1	1	.	3
Bryum radiculosum	1	.	.	.	1
Other species					
Riccia michelii	+	1	.	.	2

Cluster 4 - *PLEURIDIO ACUMINATI-ARCHIDIETUM ALTERNIFOLII* Puglisi & Privitera ass. nova *hoc loco* (Table 4)

Holotypus: rel. 1

This community was recognized in shallow ponds, sometimes together with I*soetes durieui*. It is the most widespread community, occurring in Latium (within two sites of Community Importance, i.e. the above mentioned Castel Porziano and IT6030047 "Bosco di Foglino"), Campania (Cilento and Diano National Park), Sardinia (Giara di Gesturi) and Sicily (Lipari Island of the Aeolian archipelago, and Mt Etna). As regards the ecological exigencies, the community prefers open, acid soil which are damp or temporarily flooded. It is more demanding in water than *Riccietum gougetianae* but less linked to water than *Riccietum canaliculatae*. On the whole, it behaves as terricolous, acidophytic, hygrophytic ephemeral community. The surfaces range from 20 dm² to 35 dm² and the cover from 20% to 55% with an average cover of about 34%. The number species varies from 3 to 7.

The physiognomy is due to a large presence of small acrocarpous mosses, as *Archidium alternifolium*, *Epipterygium tozeri* and *Pleuridium acuminatum*, to which some thalloid and small leafy liverworts are associated.

On the ground of the ecological exigencies and floristic composition, the new association *Pleuridio acuminati-Archidietum alternifolii* is proposed. As regards the syntaxonomic arrangement, it should be ascribed to the alliance *Dicranellion heteromallae*, order *Diplophylletalia albicantis*, class *Cladonio digitatae-Lepidozietea reptantis*. For their ecology and significant presence, *Archidium alternifolium* and *Pleuridium acuminatum* are proposed as characteristic species of the association; for their life strategy, the very large spore (up to 310 µm in *A. alternifolium*), immersed and cleistocarpous capsules, also these mosses are well adapted to the predictable temporary habitats. *Archidium alternifolium* is a species quite rare in Italy and considered threatened in several European Countries (Puglisi *et al*., 2015; Hodgetts, 2015). *Archidium alternifolium* and *Pleuridium acuminatum* are associated to *Epipterygium tozeri*, *Cephaloziella stellulifera*, *C. turneri*, F*ossombronia angulosa* and *Scapania compacta*, characteristics of higher ranks. Among the "other species" the occurrence of *Riccia beyrichiana* is to highlight since it is rare in Italy and in other Mediterranean Countries (Hodgetts, 2015; Puglisi *et al*., 2015) and reported as Critically Endangered in the Red list of the Italian bryophytes (Cortini Pedrotti & Aleffi 1992).

The analyzed vegetation shows some similarity with

Archidio-Isoetetum velatae Brullo & Minissale 1998 referred to the alliance *Cicendio filiformis-Solenopsion laurentiae* Brullo & Minissale 1998, detected in south-eastern Sicily, where the bryophyte set consists only of *Archidium alternifolium*. From this association, *Pleuridio acuminati-Archidietum alternifolii* differs for the floristic composition, missing completely the characteristic species of the *Cicendio filiformis-Solenopsion laurentiae*, *Isoëtalia durieui* and *Isoëto-Nanojuncetea*. With this regard, it is noted that the co-occurrence of bryophytes and chormophytes is quite rare, showing different development period, which is more anticipated in the bryophytes (Poponessi *et al*., 2015).

Cluster 5 - *CAMPYLOPUS INTROFLEXUS* community (Table 5)

This community occupies the outermost zones of the ponds not directly affected by the water; it was recognized only in the Latium region within the two sites of Community Importance above mentioned. The *Campylopus introflexus* community was found on acid, seasonally moist sandy soil, behaving as terricolous, mesophytic and acidophytic; it is the less demanding in water among all the detected communities. The average cover is 70% and the number species 3-5.

In the temporary ponds it is the only community consisting only by mosses. Some acrocarpous of large size characterize the physiognomy (e.g. *Campylopus introflexus*, *C. atrovirens*, *Ptychostomum pseudotriquetrum*), mixed to creeping pleurocarpous (*Sematophyllum substrumulosum*, *Hypnum cupressiforme var. cupressiforme*). The community is floristically characterized by *Campylopus introflexus*, indicated as guide species for its ecology and high cover values. *Campylopus introflexus* is constantly associated to *Campylopus atrovirens*, characteristic species of the alliance *Campylopodion polytrichoidis* Giacomini 1950 of the class *Ceratodonto purpurei-Polytrichetea piliferi* Mohan 1978 to which the community is referred. Both *Campylopus* species are rare in Italy (Puglisi *et al*., 2015).

Cluster 6 - *RICCIOCARPETUM NATANTIS* Segal 1963 em. Tüxen 1974 (Table 6)

This association, floristically very poor, was found floating within the pool "Piscina della Verdesca", a seasonally flooded depression within the Circeo National Park (Latium). *Ricciocarpetum natantis* shows a low tolerance to the pollution, behaving as a sensitive community and confirming the good state of "health" of the site. The average is 75% with a number species of 3-4. It is floristically characterized by *Ricciocarpos natans*, a small liverwort floating on meso-eutrophic, still waters, accompanied by some *Lemna* species and the hygro-hydrophytic mosses *Drepanocladus aduncus* and *Dialytrichia mucronata*. In Italy, it is known from Latium, Umbria and Trentino Alto Adige regions (Privitera & Puglisi, 2009).

Tab. 4 - *Pleuridio acuminati-Archidietum alternifolii* ass. nova

Relevé number	1	2	3	4	5	6	7	8	9	10	11	
Altitude (m a.s.l.)	580	580	350	710	160	160	160	40	40	60	570	
Size of relevé (dm^2)	25	30	20	25	30	35	30	30	25	20	30	
Cover (%)	55	35	30	40	55	30	20	30	30	30	25	
Inclination (°)	-	-	30	-	35	-	-	25	30	-	-	
Exposure	-	-	S	-	SE	-	-	SW	S	-	-	
Number of species	6	5	7	6	4	4	5	5	6	5	3	Presences
Character species of the association												
Archidium alternifolium	3	1	2	1	3	2	2	2	2	2	2	11
Pleuridium acuminatum (D)	2	2	+	1	.	1	+	.	1	.	.	7
Character species of higher units *(Fissidenti serrulati-Fossombronienion angulosae*, *Dicranellion heteromallae*, *Diplophylletalia albicantis*)												
Epipterygium tozeri	1	.	1	2	+	1	+	1	+	1	1	10
Fossombronia angulosa	.	1	.	+	1	.	+	.	.	+	.	5
Cephaloziella turneri	+	1	.	.	.	.	.	+	1	.	.	4
Scapania compacta	.	.	+	1	.	.	.	+	+	.	.	4
Cephaloziella stellulifera	+	.	1	.	.	.	.	.	.	.	.	2
Other species												
Entosthodon attenuatus	.	.	+	1	.	.	.	1	.	.	.	3
Trichostomum brachydontium	1	.	+	.	.	1	.	.	.	.	.	3
Riccia beyrichiana	.	.	.	.	1	.	+	.	.	.	.	2
Phaeoceros laevis	.	+	.	.	.	.	.	.	.	+	.	2
Plagiomnium elatum	.	.	.	.	.	.	.	.	+	1	.	2
Riccia michelii	.	.	.	.	.	.	.	.	.	.	1	1

Tab. 5 - *Campylopus introflexus* community

Relevé number	1	2	3	
Altitude (m a.s.l.)	65	65	45	
Size of relevé (dm^2)	20	25	25	Presences
Cover (%)	65	70	75	
Number of species	3	4	5	
Campylopus introflexus	3	3	4	3
Character species of the alliance, order and class (*Ceratodonto-Polytrichetea piliferi*)				
Campylopus atrovirens	2	1	1	3
Other species				
Sematophyllum substrumulosum	1	2	.	2
Hedwigia stellata	.	.	1	1
Hypnum cupressiforme var. cupressiforme	.	.	1	1
Ptychostomum capillare	.	1	.	1
Ptychostomum pseudotriquetrum	.	.	+	1

Tab. 6 - *Ricciocarpetum natantis* Segal 1963 em. Tüxen 1974

Relevé number	1	2	3	
Altitude (m a.s.l.)	35	35	35	
Size of relevé (dm^2)	20	10	10	Presences
Cover (%)	80	70	75	
Number species	3	3	4	
Characteristic species of the association				
Ricciocarpos natans	5	4	4	3
Characteristic species of higher units				
Lemna minor	.	1	1	2
Lemna trisulca	1	.	.	1
Other species				
Drepanocladus aduncus	+	1	1	3
Dialytrichia mucronata	.	.	1	1

Discussion and conclusion

The investigated temporary ponds host different bryophyte communities which can be recognized on the emerged soil after the water evaporates. They consist of many liverworts, normally poorly represented in a typical bryophyte flora of the Mediterranean territories, and acrocarpous mosses, lacking almost completely the pleurocarpous component. According to an increasing moisture gradient, it is possible to recognize *Riccio sorocarpae-Funarietum fascicularis* subass. *fossombronietosum*, *Riccietum gougetianae*, *Pleuridio acuminatae-Archidietum alternifolii*, *Riccietum canaliculatae* and the floating *Ricciocarpetum natantis*. In more marginal areas the moss community with *Campylopus introflexus* can be found. Moreover, the detected communities are affected by the type of substrate, the depth of the ponds and some of them can tolerate an anthropic disturbance.

These bryophyte communities, even if different for ecological features and floristic composition, share the same peculiar strategies of survival. In fact, they are characterized by species with shuttle life strategy, producing large spores (> 25 μm in diameter) within sporophytes enclosed in the thallus, as in *Riccia* spp., or cleistocarpous capsules on very short seta, such as

in *Archidium alternifolium* and *Pleuridium acuminatum*; in both cases the long-range dispersal capacity is strongly reduced and the germination in the same site is favored. The shuttle species are characteristic of unstable and often anthropogeneous sites that do recur predictably within the same community or in the surroundings. In the temporary ponds the life cycle of the shuttle species is related to the seasonal fluctuations, alternations between dry and moist seasons and a severe stress period which is avoided by being present in the spore stage. The shuttle life strategy allows the colonization of this temporary and predictable habitat. Therefore, the bryophyte flora, as well as the chormophytic flora, is characterized by peculiar and highly specialized species.

On the whole, the Mediterranean temporary ponds in Italy show a high degree of bryophyte floristic and coenotic diversity, offering peculiar habitats for the survival and conservation of rare and endangered species, such as *Riccia beyrichiana*, *Hedwigia stellata*, *Campylopus introflexus*, *Archidium alternifolium*, floristic regional records of conservation interest (Puglisi *et al*., 2015). Considering the importance of these species and the hosting communities, the development of management plans and the design of conservation actions for the Italian temporary ponds should take into account also the bryophyte component, both flora and vegetation, found in these fragile habitats.

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Syntaxonomic scheme

BARBULETEA UNGUICULATAE Mohan 1978
BARBULETALIA UNGUICULATAE v. Hübschmann 1960
Mannion androgynae Ros & Guerra 1987
Riccietum gougetianae Marstaller 1993
Riccietum canaliculatae ass. nova
Phascion cuspidati Waldheim ex v. Krusenstjerna 1945
Riccio sorocarpae-Funarietum fascicularis Lecointe 1978 subass. fossombronietosum Lecointe 1978

CLADONIO DIGITATAE-LEPIDOZIETEA REPTANTIS Ježek & Vondrácek 1962
DIPLOPHYLLETALIA ALBICANTIS Philippi 1963
Dicranellion heteromallae Philippi 1963
Pleuridio acuminati-Archidietum alternifolii ass. nov.

CERATODONTO-POLYTRICHETEA PILIFERI Mohan 1978
POLYTRICHETALIA PILIFERI v. Hübschmann 1975
Campylopodion polytrichoidis Giacomini 1950
Campylopus introflexus community

LEMNETEA MINORIS O. Bolòs & Masclans 1955
LEMNETALIA MINORIS O. Bolòs & Masclans 1955
Lemnion trisulcae Den Hartog & Segal 1964
Ricciocarpetum natantis Segal 1963 em. Tüxen 1974

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Appendix I: Localities and dates of the relevés

Tab. 1 - Rels. 1-3: Bosco della Cerasella (Circeo National Park, Latium), 1997-05-01; Rel. 4: Bosco della Cerasella (Circeo National Park, Latium), 2006-03-19; Rels. 5, 6: Pauli Bartili (Giara di Gesturi, Sardinia), 2010-04-04; Rels. 7, 8: Contrada Montagnola (Pollina, Sicily), 2014-03-15.

Tab. 2 - Rel. 1: Bosco della Cerasella (Circeo National Park, Latium), 1997-05-01; Rels. 2, 3: Bosco della Cerasella (Circeo National Park, Latium), 2006-03-19; Rels. 4, 5: Castel Porziano (Rome, Latium), 1995-05-05; Rel. 6: Pauli ‘e Fenu (Giara di Gesturi, Sardinia), 2010-04-04.

Tab. 3 - Rels. 1, 2: S. Maria la Stella (Mt Etna, Sicily), 2014-04-01; Rels. 3, 4: Capo Mulini (Sicily), 2014-04-01.

Tab. 4 - Rels. 1, 2: Mt S. Angelo (Island of Lipari, Aeolian archipelago), 2006-03-13; Rel. 3: Cave di Caolino (Island of Lipari, Aeolian archipelago), 2013-03-27; Rel. 4: Mt Ilice (Mt Etna, Sicily), 2015-04-10; Rels. 5-7: Palinuro al Faro (Cilento and Vallo di Diano National Park, Campania), 2010-04-07; Rels. 8, 9: Bosco di Foglino (Nettuno, Latium), 1995-05-05; Rel. 10: Castel Porziano (Rome, Latium), 1995-05-05; Rel. 11: Pauli Bartili (Giara di Gesturi, Sardegna), 2010-04-04.

Tab. 5 - Rels. 1, 2: Bosco della Cerasella (Circeo National Park, Latium), 2006-03-19; Rel. 3: Bosco di Foglino (Nettuno, Latium), 1995-05-05.

Tab. 6 - Rels. 1, 2: pool “Piscina della Verdesca” (Circeo National Park, Latium), from Privitera & Puglisi (2009); Rel. 3: pool “Piscina della Verdesca” (Circeo National Park, Latium), 2006-03-19.