DISTRIBUTION, ECOLOGY AND CONSERVATION OF BRYOFLORA IN THE MEDITERRANEAN TEMPORARY PONDS

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1. Introduction and objectives

In the Mediterranean region temporary ponds are classified among the most biologically and biogeographically interesting ecosystems. The elevated biodiversity found in temporary ponds has been attributed to their high spatio-temporal variability (Florencio et al. 2009; Bagella et al. 2010). Moreover, even if they cover little areas, these habitats are home of a rich biodiversity caused by a typical small-scale zonation (Bagella et al. 2009b; Caria et al. 2013). In each pond, three belts can usually be identified: an internal belt (I) in the toe slope, a central belt (C) in the foot/back slope and an outer belt (O) in the upper slope position (Casas et al. 1998; Rhazi et al. 2001).

The damp habitats with a seasonal presence of surface water are potential bryophyte habitats. This is especially true in the Mediterranean areas where water availability is a key factor for those plant groups, requiring it for the completion of their life cycle at the reproductive stage. Despite their important ecological functions in those fragile environments, bryophytes are neglected or undervalued in most monitoring and conservation actions.

The objectives of the research project to conduct during the PhD program will follow a multiscale approach:

MACROSCALE - The Mediterranean basin context

i) compile the first bryoflora of Mediterranean temporary ponds define a list of bryophyte species typical of the habitat “3170* Mediterranean temporary pond” to be used as a reference list to complete the habitat description

ii) REGIONAL SCALE – The island context determine the impacts of the main environmental factors on bryophyte richness and composition in Mediterranean temporary ponds

LOCAL SCALE – Spatial distribution and spore bank

iii) study the spatial distribution of bryophytes within the temporary ponds.
iv) analyse bryophyte’s spores in Mediterranean temporary ponds to identify what are the species that show a better fitness for survival and adaptation to these environments.

The activities carried out during the first year of doctorate include i) compile the first bryoflora of Mediterranean temporary ponds, ii) determine the impacts of the main environmental factors on bryophyte composition in Mediterranean temporary ponds ii) study the spatial distribution of bryophytes within the temporary ponds.

2. Materials and methods

2.1 Compile the first bryoflora of Mediterranean temporary ponds

To compile the first bryoflora of Mediterranean temporary ponds, we compared the bryoflora composition of temporary ponds in Sardinia (Italy) with the available bibliographical data on temporary ponds in the Mediterranean (Spain, France and main Mediterranean islands such as Balearic Islands, Corsica, Sicily) (Casas et al. 1998; Hugonnot 2002; Cogoni et al. 2009; Pericàs et al. 2010). We created a georeferenced database of 212 bryophyte species, which included 166 Bryophyta, 44 Marchantiophyta and 2 Antocerophyta.

2.2 Determine the impacts of the main environmental factors on bryophyte composition in Mediterranean temporary ponds.

To determine the impacts of the main environmental factors on bryophyte composition in Mediterranean temporary ponds and study the small-scale spatial zonation distribution of bryophytes within the ponds we selected the island of Sardinia (Italy), the second largest island in the Mediterranean basin. To obtain an even distribution of representative sites on the island, we selected nine sites from the existing literature (Cogoni et al. 2006, Desfayes 2008; Bagella et al.
2009a, 2009b, 2009c, 2013), choosing ponds meeting the Habitats Directive’s criteria for “Mediterranean temporary ponds, 3170*” (Williams 1987; 2006; Keeley and Zedler 1998; Yaverkovsky et al. 2004). In the selected sites, a total of 33 temporary ponds of natural origin covering a range of altitudes and substrates were surveyed (Zoccheddu, unpublished data). For the bryophytes sampling we utilized the method adopted for the vascular flora surveys of the Mediterranean temporary ponds (Bagella et al., 2009b).

To describe the bryoflora of Mediterranean temporary ponds in Sardinia we analyzed the flora in terms of species richness and composition, chorological and ecological elements. To test if there are differences among sites and ponds, in terms of species composition, we performed a PERMANOVA (non-parametric multivariate analysis of variance, Anderson 2001), using a nested design (factors: Belts (Pond(Sites), 999 permutation, Unrestricted permutation of raw data, Jaccard resemblance). To understand if environmental variables have an influence on the composition of bryophytes in temporary ponds in Sardinia and quantify the proportion of variance that can be explained by these variables, we performed a distance-based redundancy analysis (dbRDA), using Jaccard similarity, using a set of environmental predictors.

2.3 Study the spatial distribution of bryophytes within the temporary ponds

To study the spatial distribution of bryophytes within the temporary ponds, we followed the zonation scheme proposed for Moroccan ponds and for les basses de l’Albera (Casas et al. 1998; Rhazi et al. 2006) which is based on water depth at the beginning of the season, morphology of the pond and type of vegetation present. Accordingly, three belts were recognized in the temporary ponds: a central belt (C), an intermediate belt (I), and an outer belt (O). To test if bryophytes respond to the water table fluctuation, showing a typical small-scale spatial zonation and understand if there are species or life form/strategies typical of those belts, we performed a Principal
Coordinates Analysis (PCoA) on the composition of the three belts in the different sites using species, chorotypes, life form, life strategy and the ecological character “humidity”

The contribution of a particular species as indicator of a specific belt was assessed by performing an indicator species analysis (Dufrêne and Legendre 1997).

Analysis were performed using the R package indicspecies version 1.7.4 (De Cáceres and Legendre 2009; De Cáceres et al. 2010, 2013).

3. Results of the first year

First results were reported in the attached paper, currently under review, and presented at international congresses.

Paper under review


Abstract

In the Mediterranean region temporary ponds are classified among the most biologically and biogeographically interesting ecosystems. Despite their important ecological functions in those fragile environments, bryophytes are neglected or undervalued in most monitoring and conservation actions. We studied the composition and the small-scale spatial zonation of bryophytes within Mediterranean temporary ponds, to identify indicator species useful to characterize the spatio-temporal variability observed, and suggest elements to carry out simple monitoring based on
dominant life form and strategy. Bryophytes are distributed in concentric belts (outer, central, inner) according to their tolerance to floods: we observed a gradient from the outer belt, mainly composed by colonist and perennial such as Pottiaceae and Brachytheciaceae, to the more humid inner one where annual shuttle such as Ricciaceae dominate. We found significant species associated with belts, such as *Tortella squarrosa* in the outer belt, *Fossombronia caespitiformis* in the central belt and *Riccia canaliculata* in the inner belt. Bryophytes can be used as bioindicators of the state of conservation of Mediterranean temporary ponds: the presence of indicator species and the distribution of dominant life form/strategies in the different belts allow to monitor over time the changes in the flood level.

*Oral presentations at international conferences*

1) Bagella Simonetta, Boix Dani, Caria Maria Carmela, Compte Jordi, Gascón Stéphanie, Filippino Giorgia, Pisanu Stefania, Pittao Elena, Sala Jordi, Cogoni Annalena. “Paulis”


**Abstract**

The widespread of the toponym “Paule” and of other vernacular names such as “Piskina”, “Padule”, “Lakku” used in the Sardinian languages for designing temporary wetlands suggest a high number and a strong perception at local scale of these habitats in the past. In spite of this, the lack of information on their ecology, biodiversity, temporal dynamics and spatial distribution at regional scale, has made it difficult an adequate consideration in conservation programs. The opportunity of Nature 2000 network was not been adequately exploited because the habitats 3110, 3120 and 3170*,
to which Mediterranean Temporary Wetland could be referred, were rarely recognized inside SIC and protected areas, or left outside their boundaries. Moreover the available scientific literature was little and difficult to access.

“Paulis” project, funded in 2012 by the Region of Sardinia - Regional Law 7 August 2007, n. 7: 'Promotion of scientific research and technological innovation in Sardinia', was aimed to capturing the interest on these neglected habitats through the implementation of scientific and educational products.

The researches carried out by the team of the project have provided the following deliverables:

- scientific papers on: taxonomic and functional diversity of vascular plants, bryophytes and macroinvertebrates living in Sardinian Mediterranean Temporary Ponds; spatial and temporal variability of the habitat and the biotic communities; main drivers of biodiversity; seed and spore soil bank as reserve of biodiversity;
- map of habitat distribution at regional scale;
- data-base of vascular plants, bryophytes and macroinvertebrates;
- interactive guide to the flora http://dryades.units.it/stagnisardi_en/;
- assessment of several species according to IUCN categories and criteria;
- priority lists for the conservation of sites and species.

The dissemination of the information and an increased awareness of public, environmental managers and policemen is being promoted through the presentation of communications and posters in congress and seminars, the participation to public events, the engagement of students, the creation of a website http://paulisproject.jimdo.com/english/ and a facebook community https://www.facebook.com/paulisproject?ref=hl, the organization of a photo contest and of the present International Symposium on Mediterranean Temporary Ponds.
Will these actions effective for containing the threats on this habitat in Sardinia


International Symposium of Mediterranean Temporary Ponds, Sassari, April 15-16-17, 2015.

Abstract
In the Mediterranean region temporary ponds are classified among the most biologically and biogeographically interesting ecosystems. Despite the important ecological functions of bryophytes in those fragile environments, they are neglected or undervalued in most management actions. We surveyed the bryoflora composition and distribution within 33 Mediterranean temporary ponds in Sardinia (Italy). The bryoflora is composed by 139 taxa, (119 Bryophyta, 19 Marchantiophyta and 1 Antocerosphyta), accounting for 28% of the total Island bryoflora. Among those, Petalophyllum ralfsii, Cephalozia calyculata and Fossombronia pusilla are critically endangered and Riccia huebeneriana and Hypnum revolutum var. revolutum, are reported for the first time in Sardinia.

Three belts were recognized in temporary ponds: a central belt, an intermediate belt, and an outer belt. Species showed a spatial pattern within the temporary ponds, from species Pottiaceae and Brachytheciaceae, with the life strategy colonist and perennial, to species Ricciaceae with life strategy annual shuttle. Species as Scleropodium touretti and Tortella squarrosa are significantly associated with the outer belt, however the Riccia canaliculata is significantly associated with the central belt, because it occurs in these belt only. Those information are useful to build up a scientifically sound knowledge useful for future effective conservation actions. Posters presentations at international conferences


Abstract

In Europe, Mediterranean temporary ponds are indicated as priority natural habitats under the Habitats Directive 92/43/EEC: despite in those habitats bryophytes are recognized to have an
important ecological function, there are very few studies on the chorological and ecological characteristics driving bryophytes diversity and on the biogeographical factors influencing species' variability. We compared the bryoflora composition of temporary ponds in Sardinia (Italy) with the available bibliographical data on temporary ponds in the Mediterranean (Spain, France and main Mediterranean islands such as Balearic Islands, Corsica, Sicily) to define their characteristic floristic composition. A total of 212 bryophyte species, which included 166 Bryophyta, 44 Marchantiophyta and 2 Antocerophyta are reported. Among these species, those most typically connected with such habitats are: *Archidium alternifolium*, *Bryum dichotomum*, *Imbrybryum alpinum*, *Fossombronia caespitiformis*, *Ptychostomum capillare*, *Ptychostomum pseudotriquetrum*, *Riccia beyrichiana*, *Tortella squarrosa* and *Trichostomum brachydontium*. In particular, *Archidium alternifolium* and *Bryum dichotomum* are the most common species found in Mediterranean temporary ponds, being surveyed in more than 83% of the investigated ponds. The strictly hydrophytic taxa are: *Drepanocladus aduncus*, *Leptodictyum riparium*, *Riccia fluitans* and *Riella helicophylla*. The genus Riccia is common in these habitats. In a distinctly Mediterranean climatic context the presence of a large number of Pottiaceae is predictable: they are characterized by species with a short lifecycle, making them more competitive in areas with a Mediterranean climate. Several species of conservation concern are present (7 species) highlighting the conservation importance of this habitat, e.g. *Petalophyllum ralfsii* in Sardinia. Due to the fragility of the habitat and its unique ecology, *P. ralfsii* is potentially threatened by a number of factors including pressure from tourism, removal, or drying of the thallus due to the reduction of water level or reforestation.

Abstract

Despite the important ecological functions of bryophytes in the Mediterranean temporary ponds, they often are neglected or undervalued. Mediterranean temporary ponds present a small-scale zonation arranged in inner, central, and outer belt. Bryophytes are distributed in the belts according to their tolerance floods: we observed a gradient from the outer belt (O), mainly composed by colonist and perennial such as Pottiaceae and Brachytheciaceae, to the inner one (I) with annual shuttle such as Ricciaceae. We found significant species associated with belts, such as *Tortella squarrosa* in the outer belt, *Fossombronia caespitiformis* in the central belt and *Riccia canaliculata* in the inner belt. The distribution analysis of bryophytes in the belts within the ponds allows us to suggest the bryophytes as useful bioindicators of the state of conservation of Mediterranean temporary ponds, since the presence of indicator species in the different belts enables us to monitor over time the changes in the flood level. Those information are useful to build up a scientifically sound knowledge useful for future effective conservation actions. Results contribute to the use of bryophytes as bioindicators in Mediterranean temporary wetland ecosystem and provide a helpful benchmark to plan effective conservation actions in those fragile environments.
Other activities

A summary of the activities undertaken during the first year of doctorate is here reported:

- Doctoral course: "Introduzione alla statistica" (Prof.ssa Monica Musio).
- Conferences attended: project presentation ENPI ECOPLANMED and project presentation ENPI GREATMED, Edificio Sali scelti (Italy) 17-11-2015.
- Tutoring course: Botanica generale e sistematica - 1° semestre – Corso di Laurea in Biologia e Farmacia.
- Research collaboration with the “Saras Ricerche e Tecnologie” Macchiareddu (Assemini) Cagliari. 23/07-23/10/2015.

4. Planning for the next years

For the next years we will follow the analyses of bryophytes spores in Mediterranean temporary ponds, to identify what are the species that show a better fitness for survival and adaptation to these environments. In october 2015, we proceeded with a random sampling in two temporary ponds in Sardinia and we are optimizing the germination method.
5. References


