

Overview of temporary ponds in the Mediterranean region : Threats, management and conservation issues

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Abstract: Mediterranean temporary ponds (MTPs) comprise an endangered habitat with several endemic species that can be found in many countries, mainly in the Mediterranean region but are disappearing at a high rate. For designing optimal conservation and management strategies for the particular ecosystems, appropriate characterization and classification of these ponds is necessary based on the different type of habitats and on their varying environmental conditions. This paper presents the current ecological status and the threats of Mediterranean temporary ponds and summarizes some management and conservation issues based on the existing experience on a regional level. Emphasis is given in the Greek MTPs with respect to their characteristics and the pressures received mainly from human activities such as agriculture and water overexploitation. Restoration practices should be commenced immediately aiming at the reestablishment of the ponds' hydroperiod and water quality at the natural levels.

Key words: Mediterranean temporary ponds, Wetlands, Ecology, Typology

Introduction

Temporary ponds are shallow water bodies that remain flooded for a sufficiently long period of time during winter and spring to allow the development of (semi) aquatic vegetation and animal communities. In the Mediterranean region there are many types of temporary ponds. They vary from small copular ponds (<1 m² < 50 cm deep), hollowed out in rocks (e.g. Colle du Rouet, France) to almost permanent lakes, which sometimes cover an area of several hectares (e.g. Teppe Rosse, Corsica). They are usually inundated for at least a few months every year, dry out during the March – June period. Some temporary ponds may hold water for more than one year, whereas others may remain dry for more than one season, depending on the amount of rainfall. Thus, they present a significant variability in size, shape, depth, diversity among organisms (flora and fauna) and duration of flooding (Beja and Alcazar, 2003; Boix *et al.*, 2004; Boix *et al.*, 2001; European Commission DG Environment, 2003; Fahd *et al.*, 2000; Grillas *et al.*, 2004a; Jakob *et al.*, 2003; Lahr 1997; Rhazi *et al.*, 2004; Rhazi *et al.*, 2001a; Rhazi *et al.*, 2001b).

Temporary ponds are common in northern Europe (Angélibert *et al.*, 2004; Nicolet *et al.*, 2004; Williams, 1997), North America (Belk, 1998; Graham, 2002; Leidy and White, 1996; Roshier *et al.*, 2001), Australia (Warwick and Brock, 2003) and South Africa (Lahr *et al.*, 2000a; Lahr *et al.*, 2000b,

Rhazi *et al.*, 2001b) and are globally known under many different names (Table 1).

Mediterranean Temporary Ponds (MTPs) comprise a priority habitat according to the Natura 2000 network of the European Union (Natura code 3170, Habitats Directive 92/43/EC) located in various parts of Europe, primarily Mediterranean countries. In Greece there are 18 MTPs sites, 73% of which are encountered in Aegean islands due to the semi arid climatic conditions that facilitate their existence.

There is not yet a widely accepted typology system for temporary ponds to classify and characterize them with regard to specific environmental criteria. Therefore, comparative ecological assessments and studies cannot be implemented on the particular habitats, a fact which obstructs the accurate quantification of their environmental requirements. This, in addition to various threats introduced mainly by human activities, causes degradation of this habitat type at a high rate today.

The aim of this study is to present the characteristics, the threats and the current ecological status of the Mediterranean temporary ponds (MTPs) habitat, to illustrate some necessary conservation and management activities for their long term preservation, as well as to introduce a simple typology system based on morphological and water quality criteria.

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Table – 1: Various names for temporary aquatic habitats

Temporary aquatic habitats
Amphibious Mediterranean grasslands
Artificial/semi-natural temporary pools
Brumal pools
Cupular pools
Dayas
Ephemeral waters
Mediterranean temporary ponds
Padule
Poljes and dolines
Rain pools
Riparian pools
Seasonal wetlands
Vernal pools or potholes

Description of the habitat value: Mediterranean temporary ponds are of major conservation importance, regardless of their relatively small size, they often shelter many rare and endangered species. Another important reason for their protection is that these ponds have an alarming rate of loss and degradation, despite their importance (Blaustein and Schwartz, 2001; Collinson *et al.*, 1995). They support a diversity of species including vascular plants, amphibians, many microorganisms and macro invertebrates some of which are endemic. Temporary ponds are isolated habitats, which are also important environments for many migratory birds (Grillas *et al.*, 2004a; Madhyastha *et al.*, 2000). The flora and fauna are uniquely adapted and as a result can cope in a great variety of environmental changes. In some cases, species even depend on the hydrological changes of these ponds for their reproduction or for the completion of their life cycle. There is also a strong probability that temporary ponds contribute to maximizing the gene pool of species which exist in permanent, as well as, in temporary waters. This increased diversity may be crucial to the survival of species facing possible future changes of global environments (Beja and Alcazar, 2003; Grillas *et al.*, 2004b; Madhyastha *et al.*, 2000; Warwick and Brock, 2003; Williams, 1997).

Hydrology: Mediterranean temporary ponds present a significant variability regarding the length of their hydroperiod (the period during which ponds are flooded) and the initiation of their inundation period. Temporary ponds exhibit a self regulating hydrology. They often occur in shallow depressions with an impermeable ground and have a relatively small catchment area. However, they can be also found in karstic areas, where preferential groundwater flow originates outside of their catchment area, which can result in water level rise.

The substrates' permeability and slope determines the amount of water reaching the pond via surface runoff and groundwater. This affects the length of the hydroperiod and therewith the ecosystem composition.

According to Williams (1997) there are, two different types of temporary ponds:

1. Intermittent ponds – which are following a seasonal cyclic pattern of dryness and flooding
2. Episodic ponds- which will be flooded unpredictably

Grillas *et al.* (2004a and 2004b) reported that the seasonal and annual differences in the volume of water in a pond result from temporal differences in the water balance of inflows and outflows. Inflows can be direct precipitation, surface runoff, melting snow and inflows of groundwater. Outflows can be infiltration, overflow and evapotranspiration (Grillas *et al.*, 2004a; Keeley and Zedler, 1996).

Keely and Zedler (1996) mentioned that a temporary (vernal) pond consist of four stages;

1. A wetting phase
2. An aquatic or inundation phase
3. A waterlogged terrestrial phase
4. A drought phase

The length of the hydroperiod is a criterion for determining flora and fauna (Grillas *et al.*, 2004a; Keeley and Zedler, 1996; Spencer and Blaustein, 2001; Spencer *et al.*, 1999). These hydrological changes are completely natural and as water quantity changes, so do both the aquatic/ emergent vegetation and the invertebrate fauna. During flooding, an aquatic habitat with limited trophic resources becomes available and predation is low. During drying a higher density of fauna leads to greater competition and predation (Brendonck *et al.*, 2002; Grillas *et al.*, 2004a; Spencer *et al.*, 1999). From hydrologic observations of Cretan MTP habitats in Greece, the aforementioned concept of the significant variability in the length of hydroperiod, even within a few kilometers scale can be accredited. Particularly, the measured hydroperiods fluctuated from less than 5 days to several months in various MTP sites that exist in different altitudinal, geologic and meteorologic conditions.

Chemical characteristics: Temporary ponds differ from permanent waters in many ways. Physical and chemical characteristics often fluctuate considerably and may temporarily approach or exceed the biological limits that organisms can endure (Angélibert *et al.*, 2004; Eitam *et al.*, 2004; Lahr, 1997; Rhazi *et al.*, 2001b). The nitrate concentrations and the total phosphate vary significantly throughout the year but their concentration levels are relatively low. Salinity can be an important factor towards the end of wet periods in some temporary ponds, due to the concentration of dissolved ions by evaporation. Salinity tolerances vary between different groups of organisms found in temporary ponds (Keeley and Zedler, 1996; Lahr, 1997). These waters often undergo extreme changes in pH and levels of dissolved carbon dioxide, as well as oxygen. The pH is largely controlled by the carbon dioxide-bicarbonate system and thus, when waters experience photosynthetically-driven depletion of CO₂, pH may raise 2-3 units within few hours (Angélibert *et al.*, 2004; Keeley and Zedler, 1996; Rowe *et al.*, 1992). Oxygen levels are fluctuating and are frequently very low while due to the very

high surface to volume ratio of these shallow depressions, most experience extreme changes in temperature. Thus, early in the day they may present relatively rich growing conditions, but as light increases, photosynthesis is inhibited by carbon dioxide limitation, and potentially oxygen availability is reduced as a result of photorespiration (Keeley and Busch, 1984). The persistence of temporary ponds seems likely to be the result of rapid decay of organic matter during the dry phase, which largely reduces the rate of sediment accumulation (Collinson *et al.*, 1995). The research of the chemical characteristics of Mediterranean temporary ponds is limited. Specifically, little is known about the chemical changes occurring as ponds go through different succession stages (Angélibert *et al.*, 2004). Furthermore, the substrate of the MTPs plays a significant role in their chemical conditions. Particularly, in Greece 39% of the MTPs sites are located on silty and sandy sediments, 17% lay on calcareous rocks while the remaining sites' substrate consists of siliceous and volcanic formations.

Ecological status :

Temporary aquatic communities: Temporary ponds support groups that clearly differ from those of permanent ponds, and, in some cases, species of great conservation importance. Although many major taxonomic groups of aquatic animals can be found in temporary ponds, they are usually represented by only few, specialized species. The fauna of these ponds can be distinguished by their high colonization rates. Another characteristic of the fauna of temporary ponds is that many taxa can survive in the dry sediments and revive rapidly when temporary ponds are flooded (Graham, 2002; Jakob *et al.*, 2003; Ryan and Winne, 2001; Thiery 1997). Because of their relatively isolated status in comparison to permanent water bodies (rivers, marshes and lakes), their unpredictable date of flooding and their small size and shallow conditions, biodiversity in these ponds is high. Nevertheless, even though they have simple food webs (Beja and Alcazar, 2003; Eitam *et al.*, 2004; Nicolet *et al.*, 2004; Rhazi *et al.*, 2004), many temporary pond taxa remain unidentified and not adequately described. There is relatively little overlap between species in temporary ponds and permanent waters, although the degree of overlap may vary in different geographic locations (Williams, 1997). Recent studies have pointed out that the length of the hydroperiod and the seasonality are the main factors in determining the faunal composition and the structure of temporary aquatic communities (Boix *et al.*, 2001). The most influential factor affecting biota is the desiccation of the habitat during the dry season. Species richness normally increases as the length of the flooded period in ponds increases (Beja and Alcazar, 2003; Blaustein and Schwartz, 2001; Boix *et al.*, 2004; Eitam *et al.*, 2004; Nicolet *et al.*, 2004; Rhazi *et al.*, 2004).

The flora of temporary ponds survives during dry periods by building up a large seed bank in the soil during periods when water is available. Preservation of a seed bank is the main factor in the persistence of many temporary pond plants (Rhazi

et al., 2001a; Warwick and Brock, 2003). Several fauna species in these ponds survive by building up an egg bank. Egg banks are very important in the Mediterranean region, because the conditions might not be favourable to generate offspring every year. Thus, these banks do not only exist to bridge periods of drought but also as a buffer for the effect of environmental variability. The hatching success when the water level rises and the survival during the inundation phase mean that these organisms often dominate the existing fauna in the water column (Belk, 1998; Brendonck and Williams, 2000; Schwartz and Jenkins, 2000; Spencer and Blaustein, 2001; Williams, 1997).

Temporary waters usually have low oxygen levels and this causes many species to possess oxygen binding blood pigments, such as haemoglobin (phyllopoets, cladocerans and notonectidae). A behavioral response to oxygen depletion, such as swimming near the air water interface is also a method to survive low oxygen levels (fairy shrimps). Another way to cope with a low oxygen level is an increase in the ventilation activity, which is common among chironomid larvae (Lahr, 1997).

Flora: MTPs support plant communities that are very rich in rare and threatened species. There are temporary ponds which maintain a diverse assemblage of pteridophytes, which means that they have variable water requirements, like the *Isoetes*, *Marsilea* and *Pilularia*. Some plants, on the other hand, are strictly dependent on flooding, e.g. species of *Callitriche*, *Ranunculus*, *Lythrum*, *Eryngium* and *Solenopsis* (Grillas *et al.*, 2004a, Rhazi *et al.*, 2004; Warwick and Brock, 2003). A few of these are endemic species, e.g. *Eryngium atlanticum* in Morocco, *Isoetes heldreichii* in Greece, *Ranunculus revelieri* in Corsica and Provence, *Artemisia molinieri* in Provence and *Marsilea bartardae* and *Ranunculus longpipes* in the Iberian Peninsula. *Isoetes setacea* is a western Mediterranean species, found in Portugal, Spain UK and France and recently discovered in Morocco (Grillas *et al.*, 2004a; Rhazi *et al.*, 2004). In the Mediterranean region there are 38 of the rarest and most threatened plants of temporary ponds, for example *Benedictella benoistii*, endemic to north west Morocco, which has not been seen for several decades. *Callitriche* and *Elatine* are the most threatened plant species in MTPs (Grillas *et al.*, 2004a; Keeley and Zedler, 1996). In Greece, 95 plant species have been found and the most commonly encountered of them (*Callitriche brutia* Petagna, *Tillaea vaillantii* Willd., *Elatine macropoda* Guss, *Pilularia minuta* Durieu, *Isoetes hystrix* Bory) belong to the Isoetion phytocommunity. The Thero-Brachypodietalia community (*Plantago weldenii* Reichb. and *Trifolium tomentosum* L.) has the lowest occurrence in the particular MTPs habitats. The most commonly observed species in a site specific basis is the *Juncus bufonius* (Juncaceae) which is followed by *Lythrum hyssopifolia* L. (Lythraceae), *Plantago weldenii* (Plantaginaceae) and *Callitriche brutia* (Callitrichaceae). However, there is a significant variability in the species composition at each MTP site in Greece that can be assigned in

the substantial spatial fluctuation of geomorphologic, geologic and meteorological parameters.

Plants of temporary ponds are still subject to very limited and insufficient protection measures. Many pond species develop during either the wetting or the inundation phase. The key factor for determining community composition is the timing, as well as the duration of these phases. Also, during the inundation phase some taxa, e.g., *Marsilea vestita*, *Alopecurus howellii*, *Callitriche* spp., and *Orcuttia* spp., produce floating leaves that have a cuticula and are structurally distinct from the submerged parts. As the water level drops and the pools enter the waterlogged/ terrestrial phase, the soils are humid and plants endure in a terrestrial environment. For the majority of species, flowering is initiated during this phase (Keeley and Zedler, 1996). In the terrestrial phase most plants are not capable of surviving because of insufficient water availability.

Amphibians: Mediterranean temporary ponds have favourable characteristics for amphibians, because they are rich in phyto and zooplankton, which are consumed by larvae. Most species that breed in temporary ponds prefer an open or lightly wooded habitat. Because of the rich aquatic vegetation in temporary ponds, they also provide an advantage to egg laying. The hydroperiod is a key gradient for the offspring (Grillas et al., 2004a; Jakob et al., 2003; Ryan and Winne, 2001; Snodgrass et al., 2000). If the pond dries up too early or when there is water shortage conditions, the offspring cannot survive and there is a greater risk of reproduction failure. Therefore, reproductive success depends on the length of the hydroperiod and the delay or lack of annual rainfall. Most temporary ponds of the Mediterranean region dry out during spring, and amphibian terrestrial activity during summer is reduced (Beja and Alcazar, 2003; Boix et al., 2001; Grillas et al., 2004a; Jakob et al., 2003). In the Mediterranean region few amphibian species are common, these include the natterjack toad (*Bufo calamita*), the painted frog (*Discoglossus*), true salamanders (*Chioglossa*), the brook salamander (*Euproctus*), the Mediterranean treefrog (*Hyla meridionalis*), the spectacled salamanders (*Salamandrina*), spadefoot toads (*Pelobates*), parsley frogs (*Pelodytes*), sharp-ribbed newts (*Pleurodeles*), cave salamanders (*Speleomantes*), mid-wife toads (*Alytes*), the caucasian salamander (*Merntensiella*) and the marbled newts (*Triturus*) (Beja and Alcazar, 2003; Boix et al., 2001; Grillas et al., 2004a; Jakob et al., 2003; Rowe et al., 1992; Ryan and Winne 2001). On a global scale, a rapid and worrying decline of certain amphibian populations has been observed since the 1980s. The cause of the decline is unexplained (Beja and Alcazar, 2003; Boix et al., 2001; Grillas et al., 2004a; Rowe et al., 1992).

Invertebrates: Insects are an important part of the aquatic environment. In Morocco or Provence region of France, they constitute 60-70% of the total number of species, present over a complete hydrological cycle (Angélibert and Giani, 2003; Grillas

et al., 2004a). Because insect species richness depends on many characteristics, such as the development of macrophytes, the amount of dissolved organic material and the development of microbial populations, they need particular adaptations in order to survive. Some species burrow, in adult or larval form, in the substrate. Thereby they reduce their activity, in order to survive the drought periods (Grillas et al., 2004a). Mayflies (*Ephemeroptera*), dragonflies and damselflies (*Odonata*), caddisflies (*Trichoptera*) and flies (*Diptera*) are only present in water in their larval form; water bugs (*Heroptera*) and beetles (*Coleoptera*), on the other hand, also use the habitat in the adult state. The composition of the insect taxa fluctuates significantly and is determined to a large amount by the hydrology of their environment.

Crustaceans are the largest group of macroinvertebrates of temporary habitats. The species richness of the crustacean fauna is often higher in temporary waters than in permanent waters in the Mediterranean region. Many temporary pond faunas include large Branchiopods, such as the phyllopods, which includes large fairy shrimps (Anostraca), tadpole shrimps (Notostraca) and clam shrimps (Conchostraca). Among those phyllopods there are some endemic species, such as the *Chirocephalus ruffoi* (Anostraca), the *Triops cancriformis* (Notostraca), *Cyzicus bucheti*, *Cyzicus grubei*, *Maghrebetheria maroccana* (Conchostraca, Spinicaudata), etc.

Endemic species of this class are the *Ctenodaphnia chevreuxi*. These species, which have survived various climate crises without significant degradation, are currently under threat by anthropogenic activities (Belk, 1998; Keeley and Zedler, 1996; Kiflawi et al., 2003; Lahr et al., 2000; Nicolet et al., 2004). Macroinvertebrates, such as phyllopods, survive seasonally through resistant resting stages, such as diapausing eggs and cysts. For most species, the first stage larvae emerge soon after pond filling (Keeley and Zedler, 1996). Reproductive success in temporary pond invertebrates is influenced by the presence of predators and drought (Spencer and Blaustein, 2001). The main threat to all temporary pond invertebrates, globally, is habitat loss caused by land use impacts that destroy or severely damage this ecosystems (Belk, 1998). Mediterranean temporary ponds have generally a high productivity and low predation (Boix et al., 2001). In many temporary ponds, the predators are mainly insects, which colonize the ponds very slowly in contrast to aquatic organisms emerging from resting stages. As a result, the proportion of predatory species will increase in time (Blaustein et al., 2004; Brendonck et al., 2002; Eitam et al., 2004; Spencer et al., 1999). The predation of invertebrates is an important biotic stress factor, which regulates the temporary pond community. The most common invertebrate predators in temporary ponds are turbellarians (Brendonck et al., 2002; Eitam et al., 2004), notonectids, diving beetles (*Coleoptera*) and dragonfly larvae (*Odonata*) (Spencer et al., 1999). From these predators, only the turbellarian is able to produce resting eggs that survive

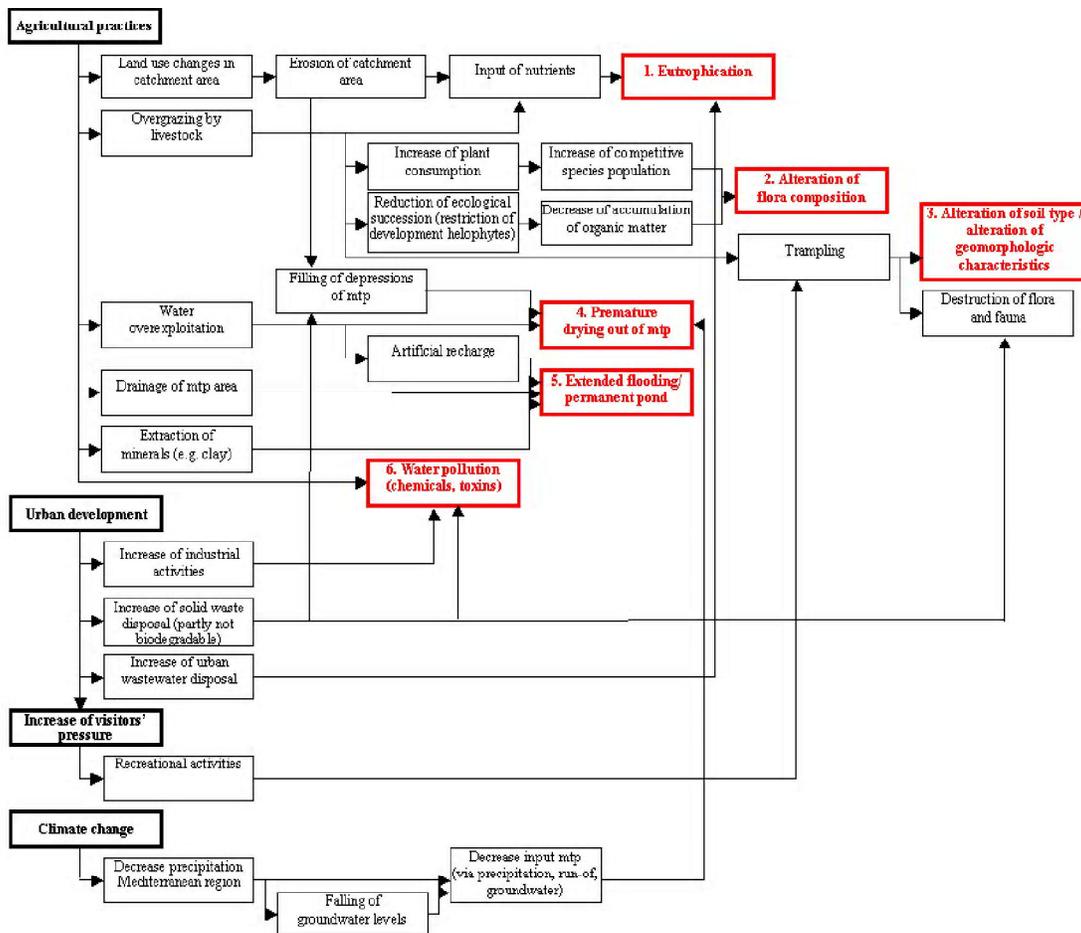


Fig. 1: Threats of the Mediterranean temporary pond habitat

the dry periods (Brendonck *et al.*, 2002). Pond type is the key factor to determine which predator is the most efficient (e.g. turbid versus clear ponds, ponds with or without vegetation, etc.). If there is a lack of larger predators the main advantage will be for the open water invertebrate species as the phyllopods (i.e the Conchostraca, the Notostraca and the Anostraca, Spencer *et al.*, 1999). Phyllopods are not well equipped to avoid fast swimming predators. These crustaceans, therefore, are not often encountered in waters with fish (Brendonck *et al.*, 2002; Eitam *et al.*, 2004; Lahr, 1997; Spencer *et al.*, 1999). Examples of microinvertebrate predators are flatworms and cyclopoid copepods.

Threats: Mediterranean temporary pond habitats are very vulnerable to human activities, due to their special physical and ecological characteristics. Their value is frequently overlooked (Beja and Alcazar, 2003; Rhazi *et al.*, 2001b; Schwatz and Jenkins, 2000) because of the habitat's small size, its seasonal occurrence and its unique appearance, which differs from most natural landscapes.

Even though in the Mediterranean region human influences were always present, MTPs' high biodiversity has been preserved for centuries in equilibrium with human activities (Beja and Alcazar, 2003; Grillas *et al.*, 2004a; Rhazi *et al.*, 2001b). There is no current research enabling the decline of temporary ponds to be measured (Grillas *et al.*, 2004a), but as agriculture and urban development play an increasing role in the Mediterranean region, numerous sites with temporary ponds are in danger of degradation (Beja and Alcazar, 2003; Blaustein and Schwartz, 2001; Brendonck and Williams, 2000; King, 1996).

Increased urbanisation in the Mediterranean region has led, through housing or road development projects, to the extinction of numerous temporary ponds, which also face less obvious threats (Fig. 1). Water from the ponds is often used for various purposes, such as irrigation of agricultural land, watering of livestock and domestic use. This can occur by direct extraction or by pumping close to the ponds frequently resulting in the premature drying off of the ponds (Brendonck and Williams, 2000; Serrano and Serrano, 1996). Artificial drainage of the ponds

catchment for human purposes in the dry season also shortens the inundation period, which is known to affect organisms that depend on the aquatic phase of the ponds for their reproduction and development (e.g. amphibians and Odonata species), (Grillas *et al.*, 2004a; Serrano and Serrano, 1996).

In some cases, there is also artificial recharge of temporary ponds as a restoration practice, which often results in extended flooding and can even make the ponds permanent. The effect of extended flooding may sometimes be positive; ponds that hold water for a longer period can support early, as well as late breeding fauna species (Beja and Alcazar, 2003). However, the extension of flooding period can also lead to a more intense competition of aquatic common plant species, replacing rare species that are characteristic for Mediterranean temporary ponds (Warwick and Brock, 2003).

Some of the ponds are deepened by farmers and used as reservoirs, which are water fed by irrigation channels. Exotic predators, such as certain fish and crayfish species (e.g. Small mouth bass (*Micropterus salmoides*) and American crayfish (*Procambarus clarkia*) are common in irrigation channels and frequently colonize the permanent reservoirs. These predators are known to eat amphibian eggs and larvae, thus reducing their populations (Beja and Alcazar, 2003; Grillas *et al.*, 2004a). A different reason for temporary ponds being transformed into permanent ponds is the extraction of minerals, such as clay and fertile soils from temporary ponds' surroundings. This has a destructive effect on pond seedbanks, reducing diversity of plant species. Yet another reason for shorter hydroperiods is the invasion of woody species, which will increase the evapotranspiration rate locally. Invasion of woody species can be a natural process, but it is considerably amplified by eutrophication and other processes which favour species with greater ability to compete (Grillas *et al.*, 2004a; Rhazi *et al.*, 2004).

Pollution levels of temporary ponds are generally increasing by intensified agricultural activities with extensive use of pesticides and fertilizers and by domestic and industrial waste and airborne pollutants (Everts, 1997; Lahr, 1997). Several ponds, e.g. in Morocco, are also used for washing, which adds phosphates from detergents to the ponds' water. Industrial activities and solid waste disposal may lead to increased wastewater discharge and acidification of water bodies. Exposure to (sub) lethal doses of pollutants will reduce the populations of vulnerable organisms by mortality or decreasing growth rates (Grillas *et al.*, 2004a, Lahr 1997; Rowe *et al.*, 1992). Significant pressure from agricultural effluents is also very common in the Greek MTPs that are usually located close to cropland areas where the excessive use of fertilizers leads to the eutrophication of surface waters. Furthermore, water abstractions directly from the ponds or from other water bodies that are hydrologically related to the MTPs often cause significant degradation in their hydroperiod, especially in the semi arid Greek islands.

Approximately, 29% of the Greek MTP sites are impacted from agricultural pressures while in 19% of the sites hydrologic disturbances are observed and 16% of the MTPs habitats are overgrazed.

In addition, the increasing number of tourists visiting the Mediterranean region often raises the stress applied to the habitat by activities, such as horseback riding, 4x4 vehicles crossing, picnic events and establishment of temporary car park areas during the dry season (Grillas *et al.*, 2004a, Serrano and Serrano, 1996). Visitor pressure in the dry season, as well as trampling by cattle, also changes the geomorphologic characteristics of the ponds' bed. This can make it impossible for some plants to germinate. Species like *Elatine brochonii* for example, are unable to germinate if their seeds have been covered with just a thin layer of soil (Grillas *et al.*, 2004b).

Fires can cause direct damage by burning vegetation and diminishing the seedbank and animal populations. The effect of burned vegetation may sometimes be positive in the sense that the destruction of woody species and the opening-up of the habitat favors Mediterranean species but fire in the catchment area is also known to have a significant impact on pond ecosystems, causing increased erosion and adding nutrients to the pond (Grillas *et al.*, 2004a).

Finally, future climate changes could affect the existence of Mediterranean temporary ponds. If these changes result in a reduced amount of precipitation in the Mediterranean region the hydroperiods of temporary ponds might become shorter, or might not even occur, because of falling groundwater levels and reduced input through rain and surface runoff water.

Typology: During the last 4 decades there has been a large number of publications within the context of ecosystem functions, services and structures but a respective systematic typology for most habitat types is missing (Groot *et al.*, 2002). Using a systematic classification contributes to assessing the variability of natural resources and selecting representative areas for conservation, so that diversity is captured and protected. Today, wetland classification is mainly based on the Ramsar Convention classification system, which comprises a general classification tool for facilitating communication between scientists and environmental managers. However, several inadequacies exist in this system, since it does not include all the types of wetlands and uses a large number of mixed criteria such as genetic, vegetative, climatic and geothermal, to separate the various habitats. Mediterranean temporary ponds are seasonal wetlands that largely depend on hydrology and thus many scientists have proposed classification systems that depend on hydrological aspects of the habitat including the source of the ponds water, the duration of inundation and dry periods and the timing of these stages (Keeley and Zedler, 1996). Other scientists have presented a combined geomorphic and hydrologic approach to the temporary pond classification based on the landform setting and

the hydroperiod, which are considered to be the major factors that differentiate the various types of ponds.

In this paper a slightly different approach is suggested for the classification of MTPs that incorporates all the main abiotic factors determining the ecological regime of the habitat. This approach follows the concept of European Commission's 2000/60 Directive that promotes the development of simple, unified classification systems for the assessment of water quality based on ecological indicators. Thus, morphological conditions such as altitude, geology setting, size and depth are considered, the aforementioned hydrologic aspects are also included, as well as water quality parameters (temperature, dissolved oxygen, pH, salinity, conductivity) and the habitat's trophic status (Table 2). This classification system covers all the key characteristics of the temporary pond habitat and discriminates adequately the many different types observed globally. Nevertheless, the development of a detailed and widely applicable classification system, as well as a respective effort to classify the temporary water habitats, in order to clarify the genuine differences and the unique characteristics of each type, is nowadays essential. Such an effort will contribute to designing the appropriate management activities and applying effective conservation measures on these important habitats.

Conservation and management:

Broad consensus among the stakeholders should be achieved regarding the protection and conservation of the ecologically important areas of temporary ponds and consequently effective implementation of conservation activities and relevant institutional measures should immediately initiate (Angélibert and Giani, 2003; Angélibert *et al.*, 2004; Boix *et al.*, 2001; Brendonck and Williams, 2000).

In general, there are some issues to be considered with regard to (Mediterranean) temporary pond management:

- Management should particularly aim at the protection of the pond water regime (hydroperiod characteristics) and water quality by preventing, for example, attempts to increase water abstraction or drainage of the area (Collinson *et al.*, 1995, Nicolet *et al.*, 2004). In the short term, vegetation of temporary ponds will react more to changes in the hydrological regime than to chemical changes in water quality (Rhazi *et al.*, 2001b). Therefore, management actions should be primarily focused on restoring or preserving the natural hydroperiod of the pond. Additionally, conservation measures should also include efforts to reduce polluting substances, because these will certainly have a negative effect, especially on the aquatic fauna and flora, in the long term.
- Actions such as deepening, removing decaying vegetation and leaf litter during the dry period (this may provide a refuge for macro invertebrates or plants that lack desiccation resistant life-stages, Nicolet *et al.*, 2004) often have a damaging effect on these fragile ecosystems.

Table - 2: Typology system for Mediterranean temporary ponds

Morphological		Water quality	
Altitude	high: > 800 m midaltitude: 200-800m lowland: < 200 m	Temperature	< 3°C 3-10°C 10-30°C > 30°C
Geology	Calcareous siliceous organic	Dissolved oxygen	< 5 mg/l 5-15 mg/l >15 mg/l
Size	< 0,5 m ² 0,5 m ² - 500 m ² 500 m ² – 1 ha > 1 ha	pH	< 5 05-Aug > 8
Depth	< 10 cm 10 - 50 cm 50 – 100 cm > 100 cm	Salinity	< 0.1 g/l 0.1 - 1 g/l 1 – 3 g/l saline > 3 g/l
Hydroperiod	< 20 days/ year 20 - 50 days/ year 50 – 100 days/year > 100 days/year irregular	Conductivity	< 200 µS/cm 200-500 µS/cm 500-1000µS/cm >1000µS/cm
Water supply	Entirely from rainfall Rainfall and groundwater Rainfall and melting snow Rainfall, melting snow and groundwater	Trophic levels	Oligotrophic Mesotrophic Eutrophic
Period of flooding	Autumn Winter early spring		

- Conservation actions should focus on a number of small ponds, which provide a variety of different microhabitats, and therefore a diversity of species,
- Rather than one large pond (Grillas *et al.*, 2004a). When planning a conservation strategy for water bodies in any area, it is therefore important to protect ponds with a range of depths and water regimes.
- In areas with a high density of temporary ponds, an average of ten ponds is needed to “capture” all the species of this area (Grillas *et al.*, 2004a).
- Particular attention should be paid to the presence of uncommon species (Collinson *et al.*, 1995, Nicolet *et al.*, 2004).

In order to implement the management plans in an area, increasing public awareness is necessary. Therefore, management measures should include actions to publicize the conservation value of temporary ponds (Angélibert *et al.*, 2004; Belk, 1998).



Temporary ponds are globally known under more than 30 different names; vernal pools, daya's, brumal pools, cupular pools, ephemeral waters, etc. (Table 1). The use of numerous names indicates the lack of unique classification system for temporary ponds, which has possibly led to the deficiency of information about the main characteristics and therewith the differences between the various types of these habitats. In the particular study a simple and comprehensive typology approach is suggested including a combination of hydromorphologic and water quality parameters that characterize the different types of temporary ponds.

Mediterranean temporary ponds incorporate unique and local hydrological conditions. The main characteristics of these ponds are the length and variation of the hydroperiod which is also closely connected to chemical conditions because when the pond dries out, the chemical characteristics fluctuate considerably.

Insects and other macroinvertebrates are the largest groups in these habitats while their reproduction success is influenced by predation and drought. Predation is low in comparison to permanent waters and occurs mainly by insects. As a result of colonization and emergence from resting stages, predation increases during the inundation phase. Temporary ponds that are not considerably impacted by anthropogenic activities comprise favourable conditions for amphibian species and therefore these constitute good parameters to describe the quality of the habitat.

Temporary ponds are more threatened than permanent waters. Relatively small changes in the regional hydrologic conditions can lead to major changes in the ecological regime of temporary ponds in that area. In addition, pollution through surface runoff can be a significant degradation factor and acidification is also encountered in many cases.

In Greece the most common threat of the habitat originates from intensive agriculture which either expands over the MTPs or pollutes their water with fertilizers. Hydroperiod destabilization is also another significant problem through direct water abstractions for human demands as well as in a long-term basis from the decrease in precipitation (climate change). Tourism can also be a harmful activity for MTPs if no precautionary measures are undertaken since most of the habitat sites are located in recreational areas.

For effective management of the temporary pond habitat, tackling the prevailing threats on a site specific basis, as well as protecting a wide range of microhabitats, hydroperiods and successional stages is very important. Such an approach will lead to the conservation of the maximum environmental variability possible and therefore the highest biodiversity in this habitat.

Mediterranean temporary ponds are one of the most threatened types of temporary ponds. They are located in many countries of the Mediterranean region, many of which do not belong to the EU and therefore the aforementioned Habitat Directive is not applicable there. However, conservation of the ponds outside the European Union is also very important and appropriate political and managerial measures should be immediately taken to avoid potential ecological degradation.

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