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MEDITERRANEAN TEMPORARY PONDS

Mediterranean Temporary Ponds: new challenges from a neglected habitat

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Mediterranean Temporary Ponds: values and threats

Fauna and flora of temporary ponds, including those of the Mediterranean areas (e.g., Gurney, 1909; Ghigi, 1921; Gauthier, 1928; Braun-Blanquet, 1936; Yaron, 1964) have been the subject of scientific interest since the beginning of the twentieth century (e.g., Murray, 1911; Mozley, 1932; Rzóska, 1961; Stout, 1964). However, the number of scientific publications on Mediterranean Temporary Ponds (MTPs) is not proportional to their ecological importance (Grillas et al., 2010) and only in recent years have they increased significantly (Boix et al., 2012) with the vegetation and fauna of Mediterranean wetlands being included in treatises of worldwide wetlands (e.g., Deil, 2005; Boix et al., 2016b). Also, the organization of specific scientific meetings (some of them listed in Box 1) and the release of research monographs or educational publications (examples in Box 2) from the end of the twentieth and beginning of the twenty first centuries reflects the growing interest in this habitat. All these efforts have highlighted the importance, abundance, functioning and biodiversity of MTPs and the need to develop conservation plans. MTPs have at least four characteristics that make the communities living in these environments interesting. Firstly, they are generally small, and ecological functioning of small waterbodies has been distinguished from those of large ones (Oertli et al., 2002; Søndergaard et al., 2005), e.g., their higher perimeter-to-area ratio enhances biogeochemical functions (Downing, 2010; Marton et al., 2015; Cohen et al., 2016). It is also noteworthy that small waterbodies on a global scale cover a total greater area than lakes (Downing et al., 2006), Secondly, as Mediterranean ecosystems, they are characterized by a combination of environmental features which imply a peculiar structure and dynamics of communities which show differences with respect to other temperate ecosystems (e.g., Coma et al., 2000; Peñuelas et al., 2007). Thirdly, they are

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Box 1 Workshops, symposia and conferences on (or including) MTPs

(1) *Ecology*, *Conservation*, *and Management of Vernal Pool Ecosystems*. Sacramento, 19–21 June 1996. Published proceedings: Witham CW (ed.), California Native Plant Society (1998)

(2) *Ecologie et conservation des mares temporaires mediterraneennes*: *l'exemple des mares de la reserve naturelle de Roque-Haute*. Montpellier, 9 July 1997. Published proceedings: Ecologia Mediterranea 24: 105–240 (1998)

(3) *Les mares temporaires méditerranéennes*: *de la connaissance à la gestion et la restauration*. Roquebrune-sur-Argens, 25–28 May 2004

(4) *Mares Temporaires de Méditerranée*. Portovecchio, 23–24 May 2006

(5) *Conservació*, *problemática i gestió de les llacunes temporànies mediterrànies*. Banyoles, 19–21 March 2007. Published electronic proceedings: Vila X, Campos M, Feo C (eds), Consorci de l'Estany (2008)

(6) Special session on *Mediterranean ponds* in the Framework of the 3rd European Pond Conservation Network Workshop. València, 14–16 May 2008

(7) *International conference on Mediterranean temporary ponds*. Maó, 5–8 May 2009. Published proceedings: Fraga P (ed.), Institut Menorquí d'Estudis & Consell Insular de Menorca

(8) *Journées d'échanges mares temporaries*. Bonifacio, 15–16 May 2012

(9) *Biodiversity*, *ecology and management of Mediterranean ponds*. Symposium of the International Conference Wetlands 2014. Huesca, 14–18 September 2014

(10) *International symposium on Mediterranean Temporary Ponds*. Sassari 15–17 April 2015. Published proceedings: Pisanu S, Bagella S (eds), P.Ass.I.Flora Ambiente, Bolotana, Italy (2015)

Box 2 Special monographs or educational publications on MTPs

(1) Blaustein L, Schwartz SS (eds), *Ecology of temporary pools*. 2001. Israel Journal of Zoology, 47 (4): 303–528

(2) Grillas P, Gauthier P, Yavercovski N, Perennou C (eds), 2004. *Mediterranean Temporary Pools* (vols. 1 and 2). Station biologique de la Tour du Valat

(3) Fraga P, Estaún I, Cardona E. 2010. *Basses temporals mediterrànies. LIFE BASSES*: *gestió I conservació a Menorca*. Institut Menorquí d'Estudis & Consell Insular de Menorca

(4) Sancho V, Lacomba JI (eds) (2010). *Conservación y restauración de puntos de agua para la biodiversidad*. Generalitat Valenciana, Conselleria de Medi Ambient, Aigua, Urbanisme i Habitatge

(5) Alfonso G, Belmonte G, Ernandes P, Zuccarello V. (2011). *Stagni temporanei mediterranei in Puglia. Biodiversità e aspetti di un habitat poco conosciuto*. Edizioni Grifo

(6) Caramujo MJ, Cunha C, de Carvalho CCCR, Luís C. (2012). *Presos no charco. Biodiversidade de crustáceos em charcos temporários*. Universidade de Lisboa, Centro de Biologia Ambiental, Instituto de Buiotecnologia e Bioengenharia

included in the Mediterranean biome which covers a very small area, about 5% of the earth's surface (Olson et al., 2001), but is identified as one of the worldwide biodiversity hotspots (Myers et al., 2000). Finally, they are associated with a highly distinctive (i.e., biodiversity value) flora and fauna (e.g., Giudicelli & Thiéry, 1998; Médail et al., 1998; Boix et al., 2001; Deil, 2005; Bagella & Caria, 2012), including some iconic or flagship taxa such as aquatic ferns, amphibians or large branchiopods and groups which achieved high species richness such as amphibious plant species, bryophytes, aquatic beetles or microcrustaceans (e.g., Ribera & Aguilera, 1996; Boix et al., 2008; Cogoni et al., 2009; Bagella & Caria, 2013).

From a global perspective, the conservation of the temporary aquatic environments is highly precarious, because their recognition has been historically neglected, and moreover, their degradation and disappearance have increased continuously during the last centuries (Brown, 1998; Rhazi et al., 2012). In MTPs, these issues are magnified due to the shallow water and the frequently small surface areas typical of these habitats (Boix et al., 2016b). Indeed, despite an improving public perception of wetlands over recent years, they are overlooked and exposed to perturbations or to total destruction (e.g., Grillas et al., 2004; Schwartz & Jenkins, 2000; Vendlinski, 2000) due to anthropogenic pressures, such as intensification of

agriculture or land abandonment, overgrazing, hydrological perturbations, touristic/recreational uses, fires, introduction of exotic species and climate changes (Grillas et al., 2004; Zacharias et al., 2007). Over the years under these pressures, thousands of MTPs and entire pond landscapes have disappeared (Rhazi et al., 2012). Nevertheless, traditional land use is a key factor for MTP conservation. It is widely documented that plant diversity in these habitats has been maintained over the centuries by extensive human activities and land abandonment has negative effects on plant assemblages (Rhazi et al., 2001; Crosslé & Brock, 2002; Bagella et al., 2010b). Also, moderate disturbances by cattle are very important for plants (Bagella et al., 2010b) because they help to maintain diverse communities (Marty, 2005) and to control the colonization of shrubs and of opportunistic species from the surrounding areas (Rhazi et al., 2001; Ferchichi-Ben Jamaa et al., 2014). On the other hand overgrazing, particularly by cattle, causes water eutrophication, direct damage to the vegetation and physical disturbance (Bouahim et al., 2014). These perturbations also result in an impoverishment of the characteristic fauna of the habitat (e.g., Brown, 1998; Beja & Alcazar, 2003; Gascón et al., 2012).

The main threats connected with intensive agriculture are the drainage of lands, the pollution of water due to the use of pesticides and fertilizers and sediment deposition due to the ploughing in the catchment area (Lahr et al., 2000; Zacharias & Zamparas, 2010). Hydrological perturbations in MTPs are related not only to drainage for mosquitoes control, to gain new lands for urban development or agricultural activities, to collect water for irrigation, watering of livestock or domestic use (Aponte et al., 2010; Zacharias & Zamparas, 2010), but also to the extraction of raw materials which causes an increase in the duration of flooding (Grillas et al., 2004). MTPs are often stressed by inappropriate touristic/recreational uses such us horse riding, passage of cars and motorbike, establishment of car parking areas or even golf courses (Serrano & Serrano, 1996; Beja & Alcazar, 2003; Grillas et al., 2004; Serrano et al., 2006; Bouahim et al., 2010; Zacharias & Zamparas, 2010). The impact of fire is poorly studied. Certainly it favours perennial plant species with rhizomes or bulbs, whilst seed bank and animal populations could be positively or negatively affected (Grillas et al., 2004). The introduction of exotic plants contributes to the loss of habitat and sometimes seriously affects most low-altitude wetland areas (Grillas et al., 2004). Finally climate changes, resulting in modification of the seasonal and annual temperatures and in precipitation patterns and amounts, have a negative effect on MTPs. Indeed these climatic elements drive important hydrological processes which in turn control the ecology of MTPs (Dimitriou et al., 2009; Sim et al., 2013; Kneitel, 2014) and their modification, in the long term, puts the persistence plant and animal species at risk (Pyke, 2005).

PAULIS project: knowing biodiversity of Mediterranean Temporary Ponds

The opportunity for the organization of the International Symposium on MTPs was offered by the 3-year project "Vascular plants, bryophytes and aquatic fauna in Sardinian Mediterranean Temporary Ponds: biodiversity, ecology and conservation", acronym PAULIS. The project, funded in 2012 by the local Administration of Sardinia (CRP-24943), was aimed at focusing interest on these neglected habitats through the implementation of scientific and educational products. The main objectives were: to quantify and characterize the taxonomical and functional diversity of vascular plants, bryophytes and aquatic fauna; to assess the main drivers of space–time variability of the habitat and the related biodiversity; to provide synthetic results to improve the effectiveness of conservation actions as well as to provide educational tools and products. The interdisciplinary team was formed from the Universities of Sassari (Italy), Cagliari (Italy) and Girona (Spain).

The prevalence of the toponym "paulis", used in the Sardinian language to name MTPs, suggests that these habitats were formerly more abundant, with a strong perception at a local scale in the past. In spite of this, the lack of information on their ecology, biodiversity, temporal dynamics and spatial distribution on a regional scale has made their adequate consideration in conservation programmes more difficult. The opportunities provided by the Nature 2000 network was not adequately exploited because habitats 3110, 3120 and 3170*—to which MTPs could be referred—were rarely recognized inside the Sites of Community Importance and protected areas, or even left outside their boundaries. Moreover, the available scientific literature was scarce and difficult to access.

Almost 100 MTPs were monitored during the 3 years of the project (2012–2014). Three hundred and fifty species of vascular plants were found, of which 81 typical of MTPs (Bagella & Caria, 2012). Rare ferns, characteristic of the habitat were better represented than previously reported (Caria et al., 2013; Mascia et al., 2013; Bagella et al., 2015). Two hundred and twenty eight animal taxa were identified, of which 24% were referred to Diptera, 22% to Coleoptera, 14% to Branchiopoda and 8% to Ostracoda. Besides, some Turbellaria, Oligochaeta, Hirudinea, Gastropoda, Anostraca, Copepoda, Hydracarina, Ephemeroptera, Odonata, and Trichoptera were identified. Three species of amphibians were also found. Noteworthy records include the ostracod *Paralimnocythere* cf. *messanai* (first record from Sardinia); the corixid *Cymatia rogenhoferi* (third record for Italy), and the cladoceran *Leydigia korovchinskyi* (first record from Italy, J. Compte unpublished data). One hundred and thirty-nine bryophytes were also listed, of which two were new to Sardinia: *Riccia huebeneriana* Lindenb. and *Hypnum revolutum* (Mitt.) Lindb. var. *revolutum*.

Space–time variability of the habitat and the related biodiversity were evaluated at different spatial scales. The relevance of hydroperiod duration for the composition of vascular plant assemblages and species replacement throughout the season was emphasized (Bagella & Caria, 2013). The definition of the small-scale patterns of plant functional types and soil was one of the findings of the project: a positive correlation was found between Alfisols, aquatic and amphibious species, maximum water depth and hydroperiod and between Entisols, shallow water and terrestrial species (Caria et al., 2015). Differences in spatial and temporal patterns between plants and faunal groups in MTPs were only analyzed by a few studies in the past (see Rouissi et al., 2014; Ruhí et al., 2014). In contrast, this was one of the main goals of PAULIS project. Thus, variability of composition of plant assemblages was mainly related to space, whereas in the case of crustaceans, it was more related to time (Bagella et al., 2010b). Bryophyte distribution was instead controlled by hydroperiod and grazing livestock (Bagella, 2014; Marignani et al., 2015). Moreover, plants showed the lowest level of successional changes, coleopterans the highest and whilst in crustaceans this was intermediate (Bagella et al., 2011). Similarly, the effects of water, pond, and landscape variables on composition and taxa richness differed among phytoplankton, vascular plants, macroinvertebrates and amphibians, being environmental control group specific (Boix et al., 2016a). Datasets of Sardinian MTPs were also joined with those of a larger pond network in order to study general patterns in space and time. Basing on these data, Ballón et al. (2016) concluded that the environmental characteristics of MTPs are strongly influenced by their location, whereas their size has only a weak influence. Finally Ruhí et al. (2013) using a space-for-time substitution approach suggested that the invertebrate biodiversity embedded in MTPs could be affected by long-term climate changes.

MTPs are ideal habitats for engaging the public in practical actions, which could be strongly encouraged with the support of interactive identification guides. In the framework of the PAULIS project, an online interactive guide for the identification of plants growing in the MTPs http://dryades.units.it/stagnisardi_en/ was created. The guide, created with program FRIDA (FRiendly IDentificAtion), consists of two query interfaces: a multi-entry query permitting to specify several easily observable characters is followed by a richly illustrated dichotomous key to the species sharing those characters. Experts can also use the first interface to create keys to all species of a given taxon. The key is also available as a stand-alone application for Apple and Android mobile devices. The dissemination of the information and an increased awareness amongst the public, environmental managers and wardens is being promoted through the presentation of communications and posters in congress and seminars, the participation in 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, and the organization of the International Symposium on MTPs http://paulisproject.jimdo.com/english/international-symposium-sassari-april-15-16-17-2015/.

The International Symposium on Mediterranean Temporary Ponds

The International Symposium on MTPs, attended by 84 people from 14 countries, was aimed at offering an opportunity to researchers with different cultural backgrounds, students, practitioners, policy makers and other stakeholders for exchanging of experiences

and information on the ecology, the biodiversity and the management of this type of habitat with the aim to promote effective practical conservation and to improve public awareness. The keynote presentations (4), oral (17) and poster contributions (44) were distributed among four sessions that covered the multi-faceted aspects of relevant knowledge about ponds in the fields of ecology and conservation issues, restoration and dissemination of the knowledge (Pisanu & Bagella, 2015). During the meeting, a public photo contest on MTPs involving 55 participants and 156 photos was also held http://paulisproject.jimdo.com/english/photo-contest/.

The results of an open questionnaire filled in the last day of the Symposium by the participants (Fig. 1) show the high level of cooperation between scientists, many of whom were young. At the same time, an urgency for effective conservation actions emerges, as well as the need to improve communication between science and society. The contents of communication and poster presentations, the papers published in the special issue, the key messages that emerged from the questionnaires and the results and deliverables of the PAULIS project suggest new challenges for the studies and the management of MTPs. Firstly, the scientific community focalized on the study of these habitats is very consistent, growing in the last years, distributed in several countries, and can rely on the contribution of the young generation. The cooperation for a multi-taxon approach also represents a strength and demonstrated a good attitude to interdisciplinarity of the scientists devoted to this habitat. The level of knowledge of taxonomic groups is unbalanced; nevertheless, specialists of neglected groups in the studies on MTPs, such as butterflies, flatworms, sponges and bryophytes, are now developing their researchers in this habitat (Pisanu & Bagella, 2015). All these aspects give high hopes for future cooperative research projects targeted to identify the key issues for their conservation, in order to provide tools for contrasting the high rate of disturbance which particularly affects non-European Mediterranean countries where the MTPs are not protected by legislation. Nevertheless, in matters of legislation, there is still much to do also in the European Union (Bagella, 2013). Indeed, the Habitats Directive (Council Directive 92/43/CEE) recognize only a small part of MTPs basing on the presence of target plant communities and excluding all the other ponds (Bagella et al., 2010a) which often host amphibians, macrocrustaceans and other organisms which need conservation measures. Moreover, the Water Framework Directive could represent a chance for the protection of MTPs in Europe, but unfortunately the local legislation of many states fixed 50 ha as the minimum size of a waterbody for its application. An answer to the destruction or degradation of ponds is offered by the creation of new ones, a relatively cheap and easy tool, as demonstrated by the Million Ponds Project http://freshwaterhabitats.org.uk/projects/million-ponds/. The difficulty to communicate with public and policy makers is another relevant barrier to the promotion of effective activities for conservation of MTPs, which requires a great effort for the dissemination of information and the increasing of awareness for the importance of this habitat. The sharing of some effective activities already launched is certainly a good starting point to reduce this gap.

Special issue content

This special issue of *Hydrobiologia* contains a selection of 14 contributions presented during the conference. The precarious situation of conservation of temporary ponds in Mediterranean climate areas and the fact that temporary waters have been less studied than permanent, explain why this selection of papers contains manuscripts that focus on both management and research. Moreover, this selection also put in evidence the strong relationship between scientific researches and management in MTPs, since several of them include relevant information on both topics.

The effects of the existence of a dry phase make the temporary waters an excellent framework to study biotic adaptations of aquatic organisms, metacommunity dynamics and aquatic ecosystem functioning. In this sense, two papers, Manconi & Pronzato (2016) and Carta (2016), analyze the key adaptive strategies of sponges and the seed germination of plants in MTPs, respectively. At community level, four studies investigate the distribution and composition of assemblages, three of them taking crustaceans as the target group. Stoch et al. (2016) suggest that both dispersal limitation and species response to spatially structured environmental gradients might be involved in determining large branchiopod distribution in Tunisia. Alfonso et al. (2016) showed that in Apulia,

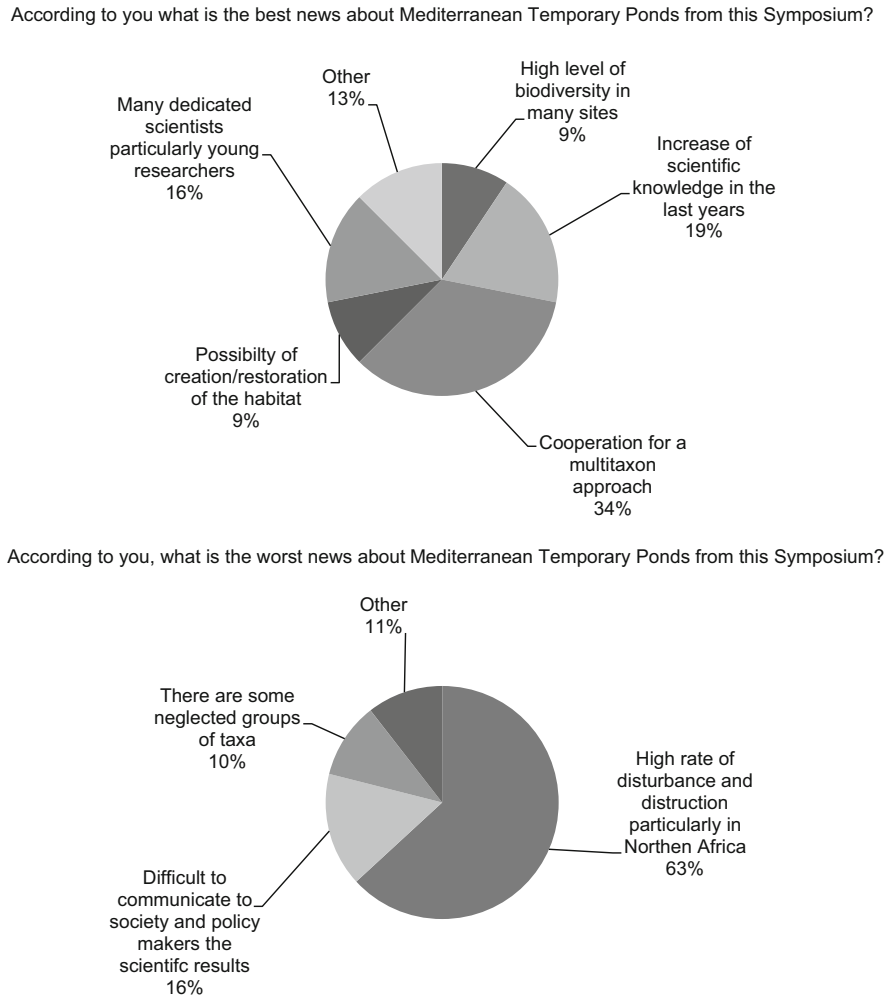

Fig. 1 Key messages for researchers and managers from the participants to the International Symposium on Mediterranean Temporary Ponds

crustaceans, in addition to macrophytes, can be used as an effective tool for identification of different pond types related to hydroperiod length. Similarly, Seminara et al. (2016) in Latium validated the use of crustaceans as an indicator of hydroperiod length, copepods being more effective in discriminating ponds with different wet phase duration. Cogoni et al. (2016) explain the influence of environmental variables on the distribution of a less-studied organism group in MTPs, bryophytes, and their tolerance to floods. Finally, at ecosystem level, Romo et al. (2016), Pinna et al. (2016) and Àvila et al. (2016) evaluated the differences in nutrient content between restored temporary and permanent dune ponds, the effect of summer droughts on leaf litter breakdown in temporary waters and the relative abundance of autotrophic and heterotrophic organisms in microbial food webs of temporary ponds located in the northeast of the Iberian Peninsula, respectively.

The effects of hydrology on community composition and adaptation and ecosystem functioning are included in several of the contributions referred to previously. However, two other papers of this selection focus on hydrology. Rodríguez-Rodríguez et al. (2016b) evaluated the temporal pattern of piezometric levels in a temporary playa lake in southern Spain, concluding that an urgent limitation of the ground water extraction from the carbonate aquifers is needed, and the usefulness of piezometric indicators in the management of MTPs. The use of hydrological models in the management of MTPs was also tested by Rodríguez-Rodríguez et al. (2016a), providing a result of a significant reduction of the hydroperiod under IPCC scenarios which, adding groundwater

withdrawal within basin, predicts a high impact in the hydroperiod. Another example of human disturbance over MTPs located in Cape Town (Bird & Day, 2016) was also included in the selection. In this study, macroinvertebrates and microcrustaceans showed clear gradational changes in assemblage composition in relation to the surrounding cover of indigenous vegetation. Management proposals and tools were presented in two papers. Lumbreras et al. (2016) proposed a new tool to assess the conservation status of MTP based on 18 indicator species (including plants, large branchiopods and amphibians). A second proposal of a tool for monitoring long-term changes in plant community structure in Malta rock pools using phylogenetic patterns was done by Lanfranco et al. (2016). They proposed the calculus of some relatedness parameters for the early detection of long-term environmental changes.

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References

Alfonso, G., L. Beccarisi, V. Pieri, A. Frassanito & G. Belmonte, 2016. Using crustaceans to identify different pond types. A case study from the Alta Murgia National Park, Apulia (South-eastern Italy). Hydrobiologia. doi:10.1007/s10750-016-2669-y.

Aponte, C., G. Kazakis, D. Ghosn & V. P. Papanastasis, 2010. Characteristics of the soil seed bank in Mediterranean temporary ponds and its role in ecosystem dynamics. Wetlands Ecology and Management 18(3): 243–253.

Àvila, N., R. López-Flores, D. Boix, S. Gascón & X. D. Quintana, 2016. Environmental factors affecting the balance of autotrophs versus heterotrophs in the microbial food web of temporary ponds. Hydrobiologia. doi:10.1007/s10750-016-2897-1.

Bagella, S., 2014. Does cross-taxon analysis show similarity in diversity patterns between vascular plants and bryophytes? Some answers from a literature review. Comptes Rendus Biologies 337(4): 276–282.

Bagella, S. & M. C. Caria, 2012. Diversity and ecological characteristics of vascular flora in Mediterranean temporary pools. Comptes Rendus Biologies 335(1): 69–76.

Bagella, S. & M. C. Caria, 2013. Sensitivity of ephemeral wetland swards with *Isoetes 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., M. C. Caria & V. Zuccarello, 2010a. Patterns of emblematic habitat types in Mediterranean temporary wetlands. Comptes Rendus Biologies 333: 694–700.

Bagella, S., S. Gascón, M. C. Caria, J. Sala, M. A. Mariani & D. Boix, 2010b. Identifying key environmental factors related to plant and crustacean assemblages in Mediterranean temporary ponds. Biodiversity and Conservation 19(6): 1749–1768.

Bagella, S., S. Gascón, M. C. Caria, J. Sala & D. Boix, 2011. Cross-taxon congruence in Mediterranean temporary wetlands: vascular plants, crustaceans, and coleopterans. Community Ecology 12(1): 40–50.

Bagella, S., M. C. Caria & R. Filigheddu, 2013. Gap analysis revealed a low efficiency of Natura 2000 network for the conservation of endemic species in Mediterranean temporary wet habitats. Plant Biosystems 147(4): 1092–1094.

Bagella, S., L. Peruzzi, M. C. Caria & R. Filigheddu, 2015. Unraveling the taxonomy and nomenclature of *Isoetes histrix* Bory species complex (Isoetaceae, Lycopodiidae). Turkish Journal of Botany 39: 383–387.

Ballón, C., N. Àvila, D. Boix, R. López-Flores, S. Romo, J. Sala, X. D. Quintana & S. Gascón, 2016. Is ecosystem size more important than locality in determining the environmental characteristics of temporary ponds? Limnetica 35(1): 73–88.

Beja, P. & R. Alcazar, 2003. Conservation of Mediterranean temporary ponds under agricultural intensification: an evaluation using amphibians. Biological Conservation 114(3): 317–326.

Bird, M. S. & J. A. Day, 2016. Impacts of terrestrial habitat transformation on temporary wetland invertebrates in a sclerophyllous Sand fynbos landscape. Hydrobiologia. doi:10.1007/s10750-016-2804-9.

Boix, D., J. Sala & R. Moreno-Amich, 2001. The faunal composition of Espolla pond (NE Iberian Peninsula): the neglected biodiversity of temporary waters. Wetlands 21(4): 577–592.

Boix, D., S. Gascón, J. Sala, A. Badosa, S. Brucet, R. López-Flores, M. Martinoy, J. Gifre & X. Quintana, 2008. Patterns of composition and species richness of crustaceans and aquatic insects along environmental gradients in Mediterranean water bodies. Hydrobiologia 597(1): 53–69.

Boix, D., J. Biggs, R. Céréghino, A. P. Hull, T. Kalettka & B. Oertli, 2012. Pond research and management in Europe: "Small is Beautiful". Hydrobiologia 689(1): 1–9.

Boix, D., M. C. Caria, S. Gascón, M. A. Mariani, J. Sala, A. Ruhí, J. Compte & S. Bagella, 2016a. Contrasting intra-annual patterns of six biotic groups with different dispersal mode and ability in Mediterranean temporary ponds. Marine and Freshwater Research. doi:10.1071/MF15435.

Boix, D., J. Kneitel, B. J. Robson, C. Duchet, L. Zúñiga, J. Day, S. Gascón, J. Sala, X. D. Quintana & L. Blaustein, 2016b. Invertebrates of Freshwater Temporary Ponds in Mediterranean Climates Invertebrates in Freshwater Wetlands. Springer, New York: 141–189.

Bouahim, S., L. Rhazi, B. Amami, N. Sahib, M. Rhazi, A. Waterkeyn, A. Zouahri, F. Mesleard, S. D. Muller & P. Grillas, 2010. Impact of grazing on the species richness of plant communities in Mediterranean temporary pools (western Morocco). Comptes Rendus Biologies 333(9): 670–679.

Bouahim, S., L. Rhazi, B. Amami, A. Waterkeyn, M. Rhazi, E.-R. Saber, A. Zouahri, M. Van den Broeck, S. D. Muller & L. Brendonck, 2014. Unravelling the impact of

anthropogenic pressure on plant communities in Mediterranean temporary ponds. Marine and Freshwater Research 65(10): 918–929.
Braun-Blanquet, J., 1936. Un joyau floristique et phytosociologique "l'isoetion" mediterraneen. Station Internationale de Géobotanique Méditerranéenne et Alpine.
Brown, K. S., 1998. Vanishing pools taking species with them. Science 281(5377): 626.
Caria, M. C., S. Bagella, G. Calvia, F. Mascia, A. Pilotto, S. Pisanu & G. Bacchetta, 2013. Schede per una Lista Rossa della Flora vascolare e crittogamica Italiana. *Marsilea strigosa* Willd. Informatore Botanico Italiano 45(1): 187–189.
Caria, M. C., G. F. Capra, A. Buondonno, G. Seddaiu, S. Vacca & S. Bagella, 2015. Small-scale patterns of plant functional types and soil features within Mediterranean temporary ponds. Plant Biosystems 149(2): 384–394.
Carta, A., 2016. Seed regeneration in Mediterranean temporary ponds: germination ecophysiology and vegetation processes. Hydrobiologia. doi:10.1007/s10750-016-2808-5.
Cogoni, A., A. Scrugli & P. Cortis, 2009. Bryophyte flora of some temporary pools in Sardinia and Corsica. Plant Biosystems 143: 97–103.
Cogoni, A., G. Filippino & M. Marignani, 2016. Small-scale pattern of bryoflora in Mediterranean temporary ponds: hints for monitoring. Hydrobiologia. doi:10.1007/s10750-015-2635-0.
Cohen, M. J., I. F. Creed, L. Alexander, N. B. Basu, A. J. Calhoun, C. Craft, E. D'Amico, E. DeKeyser, L. Fowler & H. E. Golden, 2016. Do geographically isolated wetlands influence landscape functions? Proceedings of the National Academy of Sciences of USA 113(8): 1978–1986.
Coma, R., M. Ribes, J.-M. Gili & M. Zabala, 2000. Seasonality in coastal benthic ecosystems. Trends in Ecology and Evolution 15(11): 448–453.
Crosslé, K. & M. A. Brock, 2002. How do water regime and clipping influence wetland plant establishment from seed banks and subsequent reproduction? Aquatic Botany 74(1): 43–56.
Deil, U., 2005. A review on habitats, plant traits and vegetation of ephemeral wetlands – a global perspective. Phytocoenologia 35(2–3): 533–705.
Dimitriou, E., E. Moussoulis, F. Stamati & N. Nikolaidis, 2009. Modelling hydrological characteristics of Mediterranean Temporary Ponds and potential impacts from climate change. Hydrobiologia 634(1): 195–208.
Downing, J. A., 2010. Emerging global role of small lakes and ponds: little things mean a lot. Limnetica 1(29): 9–24.
Downing, J., Y. Prairie, J. Cole, C. Duarte, L. Tranvik, R. Striegl, W. McDowell, P. Kortelainen, N. Caraco & J. Melack, 2006. The global abundance and size distribution of lakes, ponds, and impoundments. Limnology and Oceanography 51(5): 2388–2397.
Ferchichi-Ben Jamaa, H., S. D. Muller, Z. Ghrabi-Gammar, L. Rhazi, I. Soulie-Marsche, A. M. Gammar, M. Oual, S. Ben-Saad-Limam & A. Daoud-Bouattour, 2014. Influence du pâturage sur la structure, la composition et la dynamique de la végétation de mares temporaires méditerranéennes (Tunisie septentrionale). Revue d'écologie 69(3–4): 196–213.
Gascón, S., M. Machado, J. Sala, L. Cancela Da Fonseca, M. Cristo & D. Boix, 2012. Spatial characteristics and species niche attributes modulate the response by aquatic passive dispersers to habitat degradation. Marine and Freshwater Research 63: 232–245.
Gauthier, H., 1928. Recherches sur la faune des eaux continentales de l'Algérie et de la Tunisie. PhD Thesis, Faculté des Sciences de l'Université de Paris.
Ghigi, A., 1921. Ricerche sui Notostraci di Cirenaica e di altri paesi del Mediterraneo. Atti della Società Italiana di Scienze Naturali 60: 161–188.
Giudicelli, J. & A. Thiéry, 1998. La faune des mares temporaires, son originalité et son intérêt pour la biodiversité des eaux continentales méditerranéennes. Ecologia Mediterranea 24(2): 135–143.
Grillas, P., P. Gauthier, N. Yaverkovski & C. Perennou, 2004. Mediterranean Temporary Pools 1. Station Biologique de la Tour du Valat, Arles.
Grillas, P., A. Waterkeyn, L. Brendonck & L. Rhazi, 2010. Basses temporals mediterrànies arreu del món. In Fraga, P., I. Estaún & E. Cardona (eds), Basses temporals mediterrànies. Life Basses: gestió i conservació a Menorca. Consell Insular de Menorca, Maó: 23–40.
Gurney, R., 1909. On the fresh-water crustacea of Algeria and Tunisia. Journal of the Royal Microscopical Society 29(3): 273–305.
Kneitel, J. M., 2014. Inundation timing, more than duration, affects the community structure of California vernal pool mesocosms. Hydrobiologia 732: 71–83.
Lahr, J., A. O. Diallo, B. Gadji, P. S. Diouf, J. J. Bedaux, A. Badji, K. B. Ndour, J. E. Andreasen & N. M. van Straalen, 2000. Ecological effects of experimental insecticide applications on invertebrates in Sahelian temporary ponds. Environmental Toxicology and Chemistry 19(5): 1278–1289.
Lanfranco, S., C. Grima & L. Galea, 2016. A preliminary appraisal of phylogenetic patterns as a tool for long-term monitoring of plant communities in temporary freshwater rockpools. Hydrobiologia. doi:10.1007/s10750-016-2829-0.
Lumbreras, A., T. J. Marques, A. F. Belo, M. Cristo, M. Fernandes, D. Galioto, M. Machado, A. Mira, P. Sá-Sousa, R. Silva, L. G. Sousa & C. Pinto-Cruz, 2016. Assessing the conservation status of Mediterranean temporary ponds using biodiversity: a new tool for practitioners. Hydrobiologia. doi:10.1007/s10750-016-2697-7.
Manconi, R. & R. Pronzato, 2016. How to survive and persist in temporary freshwater? Adaptive traits of sponges (Porifera: Spongillida): a review. Hydrobiologia. doi:10.1007/s10750-016-2714-x.
Marignani, M., G. Filippino & A. Cogoni, 2015. Seasonal trends and spatial pattern of bryophytes in Mediterranean temporary ponds. International Congress SITE-EEF. Ecology at the Interface. Book of Abstracts, 21–25 settembre 2015, Roma, Italy.
Marton, J. M., I. F. Creed, D. B. Lewis, C. R. Lane, N. B. Basu, M. J. Cohen & C. B. Craft, 2015. Geographically isolated wetlands are important biogeochemical reactors on the landscape. Bioscience 65(4): 408–418.
Marty, J. T., 2005. Effects of cattle grazing on diversity in ephemeral wetlands. Conservation Biology 19(5): 1626–1632.

Mascia, F., G. Bacchetta, S. Bagella & M. C. Caria, 2013. Schede per una Lista Rossa della Flora vascolare e crittogamica Italiana. *Pilularia minuta* Durieu. Informatore Botanico Italiano 45(1): 190–193.

Médail, F., H. Michaud, J. Molina, G. Paradis & R. Loisel, 1998. Conservation de la flore et de la végétation des mares temporaires dulçaquicoles et oligotrophes de France méditerranéenne. Ecologia Mediterranea 24(2): 119–134.

Mozley, A., 1932. A biological study of a temporary pond in western Canada. The American Naturalist 66(704): 235–249.

Murray, J., 1911. The annual history of a periodic pond. Internationale Revue der gesamten Hydrobiologie und Hydrographie 4(3–4): 300–310.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. Da Fonseca & J. Kent, 2000. Biodiversity hotspots for conservation priorities. Nature 403(6772): 853–858.

Oertli, B., D. A. Joye, E. Castella, R. Juge, D. Cambin & J.-B. Lachavanne, 2002. Does size matter? The relationship between pond area and biodiversity. Biological Conservation 104(1): 59–70.

Olson, D. M., E. Dinerstein, E. D. Wikramanayake, N. D. Burgess, G. V. Powell, E. C. Underwood, J. A. D'Amico, I. Itoua, H. E. Strand & J. C. Morrison, 2001. Terrestrial ecoregions of the world: a new map of life on earth, a new global map of terrestrial ecoregions provides an innovative tool for conserving biodiversity. Bioscience 51(11): 933–938.

Peñuelas, J., P. Prieto, C. Beier, C. Cesaraccio, P. De Angelis, G. de Dato, B. A. Emmett, M. Estiarte, J. Garadnai & A. Gorissen, 2007. Response of plant species richness and primary productivity in shrublands along a north–south gradient in Europe to seven years of experimental warming and drought: reductions in primary productivity in the heat and drought year of 2003. Global Change Biology 13(12): 2563–2581.

Pinna, M., G. Marini, G. Cristiano, L. Mazzotta, P. Vignini, B. Cicolani & A. Di Sabatino, 2016. Influence of aperiodic summer droughts on leaf litter breakdown and macroinvertebrate assemblages: testing the drying memory in a Central Apennines River (Aterno River. Hydrobiologia. doi:10.1007/s10750-016-2854-z.

Pisanu, S. & S. Bagella, 2015. International Symposium on Mediterranean Temporary Ponds: Book of Abstracts. P.Ass.I.Flora Ambiente, Bolotana, Italy.

Pyke, C. R., 2005. Interactions between habitat loss and climate change: implications for fairy shrimp in the Central Valley Ecoregion of California, USA. Climatic Change 68: 199–218.

Rhazi, L., P. Grillas, A. Mounirou Toure & L. Tan Ham, 2001. Impact of land use in catchment and human activities on water, sediment and vegetation of Mediterranean temporary pools. Comptes Rendus de l'Academie des Sciences, Serie III 324(2): 165–177.

Rhazi, L., P. Grillas, E.-R. Saber, M. Rhazi, L. Brendonck & A. Waterkeyn, 2012. Vegetation of Mediterranean temporary pools: a fading jewel? Hydrobiologia 689(1): 23–36.

Ribera, I. & P. Aguilera, 1996. Els Estanys de Capmany: the missing Spanish pingo (or palsa) fens. Latissimus 7: 2–6.

Rodríguez-Rodríguez, M., A. Fernández & F. Moral, 2016a. Hydrological regime and modeling of three ponds of the Mediterranean area (south of Córdoba, Spain). Hydrobiologia. doi:10.1007/s10750-016-2820-9.

Rodríguez-Rodríguez, M., S. Martos, A. Pedrera & M. Cruz, 2016b. Applying piezometric evolution indicators to facilitate stakeholder's participation in the management of groundwater-dependent ecosystems. Case study: Fuente de Piedra playa lake (southern Spain). Hydrobiologia. doi:10.1007/s10750-016-2670-5.

Romo, S., J. Soria, C. Olmo, J. Flor, S. Calvo, R. Ortells & X. Armengol, 2016. Nutrients and carbon in some Mediterranean dune ponds. Hydrobiologia. doi:10.1007/s10750-016-2692-z.

Rouissi, M., D. Boix, S. D. Muller, S. Gascón, A. Ruhí, J. Sala, A. Bouattour, I. Ben Haj Jilani, Z. Ghrabi-Gammar, S. Ben Saad-Limam & A. Daoud-Bouattour, 2014. Spatio-temporal variability of faunal and floral assemblages in Mediterranean temporary wetlands. Comptes Rendus Biologies 337: 695–708.

Ruhí, A., D. Boix, S. Gascón, J. Sala & D. P. Batzer, 2013. Functional and phylogenetic relatedness in temporary wetland invertebrates: current macroecological patterns and implications for future climatic change scenarios. PLoS One 8(11): e81739.

Ruhí, A., E. Chappuis, D. Escoriza, M. Jover, J. Sala, D. Boix, S. Gascón & E. Gacia, 2014. Environmental filtering determines community patterns in temporary wetlands: a multitaxon approach. Hydrobiologia 723: 25–39.

Rzóska, J., 1961. Observations on tropical rainpools and general remarks on temporary waters. Hydrobiologia 17(4): 265–286.

Schwartz, S. S. & D. G. Jenkins, 2000. Temporary aquatic habitats: constraints and opportunities. Aquatic Ecology 34(1): 3–8.

Seminara, M., D. Vagaggini & F. Stoch, 2016. A comparison of Cladocera and Copepoda as indicators of hydroperiod length in Mediterranean ponds. Hydrobiologia. doi:10.1007/s10750-016-2693-y.

Serrano, L. & L. Serrano, 1996. Influence of groundwater exploitation for urban water supply on temporary ponds from the Doñana National Park (SW Spain). Journal of Environmental Management 46(3): 229–238.

Serrano, L., M. Reina, G. Martín, I. Reyes, A. Arechederra, D. León & J. Toja, 2006. The aquatic systems of Donana (SW Spain): watersheds and frontiers. Limnetica 25(1): 11–32.

Sim, L. L., J. A. Davis, K. Strehlow, M. McGuire, K. M. Trayler, S. Wild, P. J. Papas & J. O'Connor, 2013. The influence of changing hydroregime on the invertebrate communities of temporary seasonal wetlands. Freshwater Science 32: 327–342.

Søndergaard, M., E. Jeppesen & J. P. Jensen, 2005. Pond or lake: Does it make any difference? Archiv für Hydrobiologie 162(2): 143–165.

Stoch, F., M. Korn, S. Turki, L. Naselli-Flores & F. Marrone, 2016. The role of spatial environmental factors as determinants of large branchiopod distribution in Tunisian temporary ponds. Hydrobiologia. doi:10.1007/s10750-015-2637-y.

Stout, V., 1964. Studies on temporary ponds in Canterbury, New Zealand. Verhandlungen der Internationalen Vereingung für theoretische und angewandte Limnologie 15: 209–214.

Vendlinski, T., 2000. California's vernal pools: accomplishments and conservation strategies. Fremontia 27: 19–27.
Yaron, Z., 1964. Notes on the ecology and entomostracan fauna of temporary rainpools of in Israel. Hydrobiologia 24(3–4): 489–513.
Zacharias, I. & M. Zamparas, 2010. Mediterranean temporary ponds. A disappearing ecosystem. Biodiversity and Conservation 19(14): 3827–3834.
Zacharias, I., E. Dimitriou, A. Dekker & E. Dorsman, 2007. Overview of temporary ponds in the Mediterranean region: threats, management and conservation issues. Journal of Environmental Biology 28: 1–9.