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Plant diversity and conservation value of continental temporary pools

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ABSTRACT

Temporary pools are unusual habitats because they share features of aquatic and terrestrial ecosystems. They are habitats of community interests according to the Natura 2000 network (Natura code: 3130 and 3170), and can be found in several climatic regions where they harbours various wetland habitats. Whereas Mediterranean temporary pools are well studied, only a few papers deal with their continental counterparts, probably because they are mainly found on arable fields often displaying decades-lasting dormancy. This study aims at filling this gap in our knowledge by evaluating plant species composition, habitat types and diversity of temporary pools in a region of continental climate. We analysed data from 185 phytosociological relevés (79 historical and 106 contemporary data) from different types of waterlogged arable fields, including rice paddy fields, from the Pannonian Ecoregion. We found significant differentiations of rice paddy fields from 'other' waterlogged arable fields according to ordination, classification and regression analyses. Diversity partitioning of species abundance data showed that these habitats have a very high alpha (species number, Simpson and Shannon) and beta diversity, which means that all the sites have high importance in habitat conservation. We found many vascular plants listed in IUCN and national red lists among the indicator and characteristic species of continental temporary pools. Our results demonstrate the conservation importance of continental temporary pools in relation to habitat and biodiversity management and conservation planning.

1. Introduction

Temporary pools (vernal pools) are small and shallow wetlands characterised by mostly annual amphibious plants (Pinto-Cruz et al., 2009). Temporary pools are widespread on a global scale; they can be found in the Mediterranean (Zacharias and Zamparas, 2010; Grillas et al., 2004), in the tropics (Bambaradeniya et al., 2004) and in continental climates as well. In Europe they are considered to be habitats of community interest and harbour many endangered and red list species. Seasonal wetlands in Europe, especially in the Mediterranean, encompass a wide range of vegetation and community type richness that include annual and perennial vegetation (Deil, 2005; Pinto-Cruz et al., 2009). The general ecology (Zacharias and Zamparas, 2010; Pinto-Cruz et al., 2011; Bagella and Caria, 2012), threatening factors (Rhazi et al., 2001), conservational aspects (Rhazi et al., 2004; Pinto-Cruz et al., 2009), and diversity of Mediterranean temporary pools are well understood and intensively investigated. It is currently recognised as one of the most interesting habitats in the Mediterranean bioclimatic region, which maintain numerous extremely rare and isolated taxa (Médail, 2004).

Under continental climatic conditions, temporary wetlands are very shallow water bodies, which appear in the floodplains of rivers or any kind of water-saturated or submerged places where astatic water conditions (i.e. temporal overdominance of water) can easily arise; such conditions normally occur on arable fields (Deil, 2005). Temporary pools on arable fields have different names in the literature: "farmland ponds" (Giora et al., 2010), "segetal fields with inland water" (Csiky and Oláh, 2006), "vernal pools on soils with bad water balance" (Pál et al., 2006), "ephemeral mudflat vegetation" (Bissels et al., 2005), and dwarf plant communities (Deil, 2005); or named according to a phytosociological taxon name (Nanocyperion; Isoëto-Nanojuncetea vegetation; Ellenberg, 1988). Mediterranean temporary pools and temporary pools on arable fields have many similar characters: floods, precipitation,

Abbreviations: AIC, Akaike's Information Criterion; AF, arable fields; CTP, continental temporary pool; GLS, Generalised Least Square model; PCA, Principal Components Analysis; RPF, rice paddy fields; TWINSPAN, two-way indicator species analysis.

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raised ground water in winter, at spring or sometimes at the beginning of summer are the major factors that determine the formation of these habitats (Zacharias and Zamparas, 2010). Hence, similar to Mediterranean temporary pools, we propose here to classify temporary wetlands in continental climate into a common habitat type to be called to continental temporary pools (CTPs).

Similarly to Mediterranean temporary pools, CTPs have a largely autonomous hydrology, inundated and dry periods are alternating, and usually occupy small pools, we should rather refer to them as depressions, which are flooded for a sufficiently long period to allow for the development of hydromorphic soils and aquatic or amphibious plant communities (Bagella and Caria, 2012). If they persist until mid-summer for an adequate period, special vegetation dominated by amphibious plant communities will develop. Drying in summer eliminates more common aquatic plants and helophyte communities, which are characteristic elements of more permanent waters (Zacharias and Zamparas, 2010). CTPs are likely to appear in the former floodplain of rivers, which are cut from direct floods due to river regulation, but situated in lower reliefs. A major difference between Mediterranean and continental temporary pools is that CTPs mostly (but not exclusively) develops in waterlogged arable fields. Soil management and plant protection is nearly impossible in these temporary pools during inundation, wherefore very special vegetation develops (Albrecht, 1999; Baumann and Täuber, 1999; Täuber, 2000; Täuber and Petersen, 2000). Most of them seemingly appears randomly and can reappear after decades of dormancy (Popiela, 2005).

The appearance of waterlogged arable fields is sporadic and irregular; it often happens that fields are not covered by water for decades, but in some years significant floods appear because of high precipitation. According to Hoffmann et al. (2000), the vegetation of CTPs needs special climatic variables such as high precipitation in the previous year, relatively cool spring, and relatively warm and wet summer days. The species connected to CTPs have well-adapted to long-lasting dormancy. They have a long-term persistent seed bank, high plasticity in germination, and high vegetative plasticity of adults (Poschlod et al., 1999). Seeds are viable for decades or even more than 100 years (Deil, 2005) and many of the species of CTPs have a persistent seed bank and produce enormous number of seeds (Bissels et al., 2005). Rare and endangered species that are apparently absent in the vegetation for decades can be recorded in the seed bank (Poschlod, 1993).

Freshwaters in general are among the most diverse and yet threatened components of global biodiversity (Dudgeon et al., 2006). Within an agricultural landscape, freshwater ponds are proven to be biodiversity hotspots (Davies et al., 2008; Thiere et al., 2009), and their conservation of continental freshwater flora and fauna requires urgent information on the ecological quality of its habitat (Oertli et al., 2005). Agricultural fields have replaced natural floodplain habitats in the Pannonian Ecoregion (i.e. the Central European plain region stretching from southern Czech Republic to central Serbia mainly including present day territory of Hungary) after large-scale river regulations; therefore, freshwater biodiversity has become isolated and endangered. Because of the present intensive agricultural land use, medium and small sized ponds and marshes are less frequent in the former floodplain along river valleys; hence, freshwater diversity can only survive in other habitat-types occupying small endorheic basins and depressions. Nonetheless, they appear seasonally, and temporary pools represent characteristic and important freshwater habitat-type in this agricultural landscape. CTPs are highly vulnerable due to their shallow water, small surface area, and the intensive agricultural and hydrographical modifications of its habitat.

Our work was intended to objectively assess the conservational value of CTPs. One of the most influential approaches for assessing the conservation value of different habitat types to depict landscape diversity, and therefore linking patterns in biological diversity to landscape level environmental heterogeneity, is additive partitioning of species diversity (Veech et al., 2002; Erős, 2007). Briefly, additive diversity partitioning allows the decomposition of total (gamma) diversity into its local, within-habitat/community (alpha) and between-habitat/community (beta) components at a hierarchical scale and for a variety of measures of species diversity (e.g. number of species, Shannon diversity). The aims of our study were: (i) to identify temporary pond types according to their vegetation composition; (ii) to define plant community diversity in terms of floristic composition of CTPs.

2. Materials and methods

2.1. Study area

The study was carried out in the Tisza and Drava Plains which are the tributaries of the Danube and located in the Pannonian Ecoregion, in Central Europe (EEA, 2002; Fig. 1). Basically this Ecoregion belongs to seven countries (Austria, Czech Republic, Hungary, Slovakia, Serbia, Ukraine and Romania), and 90% of its area is found in Hungary. The large-scale river regulation here was performed in the 19th century, which redrew the hydrological features of the whole area. The landscape of the Ecoregion became highly influenced by human impact, and these perturbations resulted in the severe alteration or even in the extinction of indigenous natural habitats, and development of new aquatic systems. Hundreds of new standing waters were created along rivers (e.g. oxbow-lakes), while other habitat-types became scarcer (e.g. alkali ponds), transformed, or disappeared (e.g. marshes). In spite of their highly transformed nature, the environmental conditions underpinning the original hydrological characters still exist, as it is can be seen after heavy rains or floods which unravel the shape of the former swamps, marshes, lakes and canals. Such weather conditions can create thousands of hectares of waterlogged arable fields, which vary in size between 1 m^2 and 10 ha, and are usually waterlogged for 2–3 months.

2.2. Data collection and data analysis

Vascular plant abundance data was collected from 17 sites with characteristic Isoëto-Nanojuncetea vegetation using 2 m × 2 m sized randomly arranged phytosociological relevés (Braun-Blanquet, 1951). Literature data of phytosociological relevés of the same dwarf plant communities from the Tisza and Drava Plains were also collected from 55 sites (Timár, 1952, 1957; Ubrizsy, 1961; Pál et al., 2006). Altogether, 183 relevés in 72 seasonally inundated arable fields were included in our analyses. A–D scores of literature data were transformed into per-cent values (Dierschke, 1994). All sampling sites were characterised by very shallow water and different kind of human influence. They were situated in waterlogged arable fields (AF, $n = 143$; field sampling data: 103; literature data: 40) and rice paddy fields (RPF, $n = 42$; field sampling data: 3; literature data: 39) what we treated as 'a priori' habitat types. Vascular plants were identified to species level using the handbook of Király (2009). *Characeae* was only identified to genus level. The raw matrix was analysed for synthetic parameters. Species constancy from abundance data and species conservational value (IUCN, 2011; Király, 2007) was assessed. Plant species were categorised into growth-form (den Hartog and Segal, 1964): hydrophyte (i.e. plants that mainly grows under water), hygrophyte (i.e. plants that mainly grows in wet or waterlogged soil), helophyte (i.e. plants that mainly grows in marshy soils) and 'other' categories (i.e. all other categories present at the site).