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Hydrophyte community structure affects the presence and abundance of the water beetle family Dytiscidae in water bodies along the Drava River

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ABSTRACT

Here, we examine the relationships between the macrophyte community structure and the presence and abundance of the water beetle family Dytiscidae in 35 water bodies along the Drava River (Slovenia). In addition, selected water quality parameters were examined. The surveyed water bodies differed in altitude, type, size and distance from the Drava River. With the exception of a weak size effect on the water beetles, these parameters did not significantly affect the community structure. For hydrophyte plants, the community structure was significantly related to water quality parameters, which explained 38% ($p \leq 0.05$) of the variability of species presence and abundance. For the water beetles, the oxygen concentration, and the sodium, potassium and chlorine ion concentrations were significant, together explaining 24% ($p \leq 0.05$) of the species variability. Redundancy analysis revealed the importance of the presence and abundance of the low-growth plant species *Potamogeton trychoides* for the occurrence of *Cybister lateralimarginalis, Dytiscus marginalis, Graphoderus cinereus, Graphoderus austriacus, Hydaticus seminiger* and *Acilius canaliculatus*, while other water beetle species were more related to floating leaf plant species. Altogether, the presence and abundance of hydrophytes explained 35% of the variability of the Dytiscidae water beetle species presence and abundance. This study demonstrates the importance of selected natant plant species and submerged plant species, with low-growth forms for the occurrence of large and medium sized Dytiscidae water beetle species. Therefore, correct management of the macrophyte vegetation can positively affect the richness of these Dytiscidae species.

1. Introduction

Aquatic macrophytes are important structural and functional elements of many aquatic habitats (Baattrup-Pedersen and Riis, 1999). The presence and diversity of macrophytes in a water body depend on the depth and quality of the water, and the water movement and substrate characteristics (Bornette et al., 1994). Macrophytes have multiple functions in aquatic ecosystems. They are involved in the energy flow and nutrient cycling, they affect sedimentation processes, and they provide habitats, food, breeding locations and safe refuge for aquatic invertebrates, fish and a range of other organisms (Nichols and Shaw, 1986; Sand-Jensen, 1997; Madsen et al., 2001). High habitat variability due to macrophyte species and structural diversity has positive effects on the diversity of other groups of organisms (Dibble et al., 1997; Jeppesen et al., 1998; Thomaz and da Cunha, 2010), while degradation of the macrophyte communities results in degradation of the communities of the associated organisms (Hansen et al., 2011). Increased biodiversity in macrophyte-rich communities is due to the co-existence of a variety of organisms with different habitat requirements (Watson and Rose, 1985; Celewicz-Gołdyn and Kuczyńska-Kippen, 2017).

Macrophytes also affect their abiotic environment, and therefore other levels of the biotic community. They can improve water quality (Madsen et al., 2001) by taking up nutrients from the water and sediment, and thus contributing to the self-purification efficiency of the ecosystem (Karpati and Pomogyi, 1979). Abundant macrophyte communities can have significant impact on the daily dissolved oxygen dynamics and other water quality parameters of a water body (Desmet et al., 2011). Due to different environmental demands and sensitivities, their presence and abundance also indicates water and sediment quality (Haslam, 1987; Carbiener et al., 1990). Several investigations have revealed that the composition of the macroinvertebrate community that dwells within macrophyte beds is determined by the water quality and the structure, density and condition of this vegetation (Brock and Van Der Velde, 1996).

Lancaster and Downes (2013) reported that representatives of *Hydradephaga* account for around one third of the total aquatic and semi-aquatic beetles described to date, with the diving beetles (i.e., Dytiscidae) as the largest group. They represent one of the largest and

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most commonly encountered groups of aquatic insects (Yee, 2014). In many habitats dytiscids represent one of the most diverse and abundant Coleoptera taxon (Gioria, 2014). These dytiscid beetles colonise both temporary and permanent water bodies (Foster, 2010). They are important predators in water bodies, as they consume a variety of benthic and pelagic invertebrates as well as vertebrates (Beutel and Leschen, 2005; Culler et al., 2014). The winged adults of many dytiscid species can fly long distances, and hence move between water bodies in response to seasonal droughts and disperse actively. This strategy is common for the inhabitants of small, temporary lentic waters (Bilton, 2014). Some dytiscids are poor fliers or they are even not able to fly (Jackson, 1973; Kehl and Dettner, 2007).

Dytiscid beetle have proven to be good bioindicators of water quality due to their high sensitivity to environmental changes (Foster et al., 1992), and therefore they reflect the structure of the wider aquatic community. As they are predators, they are an important group in the functioning of many aquatic systems (Perissinotto et al., 2016). An increase in species diversity of dytiscid larvae has been attributed to an increase in submerged macrophyte abundance (Fikáček et al., 2008). The presence of aquatic vegetation increases the heterogeneity of their habitats, and thus their presence and abundance (Nilsson and Soderberg, 1996). Yee (2010) reported that as well as the macrophyte community, differences in larval behaviour are important in mitigating the predation in natural aquatic systems. Dytiscidae are large predators that predominantly prey upon smaller aquatic invertebrates (Klausnitzer, 1996), and thus they also represent a natural control for mosquito larvae (Lundkvist et al., 2003).

Rivers are dynamic systems that are shaped by geomorphological and ecological processes (Hynes, 1979). There are generally many different small sized water bodies found along rivers, such as river lakes, backwaters, side channels, ox-bows, side arms and ponds (Molnár, 2013). These water bodies hold great potential for the conservation of biological diversity (Kubiak and Krawczyk, 2014; Walon-Ruzionek, 2017) and for flood protection (Hudson et al., 2012), although they receive relatively little recognition and protection. As well as being a habitat for a variety of species, they might also have positive effects on water quality in rivers (Glińska-Lewczuk and Burandt, 2011). These small sized water bodies are subjected to pronounced fluctuations in their water levels that depend on their connectivity with a river. In some cases, the hydraulic isolation of these water bodies can lead to accelerated succession of these habitats (Van Geest et al., 2005). Among these, ox-bow lakes appear to be of particular interest as they represent a transition between lotic and lentic ecosystems (Obolewski, 2011).

In the present study, we examined how the presence and abundance of macrophytes affects representatives of the dytiscid beetle species in natural and man-made water bodies along the Drava River (Slovenia). We focussed on the dytiscid species due to the limited information on this group in terms of their habitat demands (Foster, 2010) and because certain species from this family depend on macrophytes for oviposition and pupation (Paula-Buenoa and Fonseca-Gessner, 2015). We hypothesised that differences in the macrophyte community structures of the water bodies examined would result in differences in the presence and abundance of the organisms of higher trophic levels. Macrophytes are the first target in the management of water bodies, and therefore knowledge of these relationships can provide the basis for actions aimed at biodiversity protection, which is a key priority in Europe due to the rapid ongoing decline in biodiversity (Gee et al., 1997; De Meester et al., 2005).

2. Material and methods

2.1. Site description

The studied water bodies are located along the Drava River in the northeastern part of Slovenia (Fig. 1). The Drava River is in southern central Europe. It has a length of 707 km, and arises from its source in the South Tyrol (Italy). The river flows eastwards through Italy, Austria, Slovenia and Croatia, and along the border between Croatia and Hungary, before it joins the Danube near Osijek (Croatia). A series of 22 hydroelectric power plants has fundamentally changed the hydrogeographic characteristics of the Drava River. Along its course from Villach (Austria) to Varaždin (Croatia), there are 10 hydroelectric power plants in Austria, eight in Slovenia, and three in Croatia. Prior to the construction of the hydroelectric power plants, the Drava River mainly flooded in its middle and lower parts (Statistical Office of the Republic of Slovenia, 2002). The first peak of water level usually occurs in May or June while the second is a consequence of rainy period in October and November (Perko and Orožen Adamič, 1998). In some stretches from the city of Maribor to the settlement Središče ob Dravi the lowland, meandering flow of the Drava River is preserved in natural conditions. Downstreams hydro-morphological processes permanently removes gravel and creates steep eroded banks. The network of various aquatic habitats i.e. oxbows and channels are present along the Drava River. They depend on water form the river and create favourable habitats for many endangered species (Perko and Orožen Adamič, 1998).

We systematically examined 35 water bodies within the Natura 2000 site Drava River (SI3000220) between Maribor and Središče ob Dravi (Slovenia), (Fig. 1, numbered). The measurements of water chemistry and surveys of macrophytes and dytiscid beetles were carried out from 2013 to 2016. We performed one sampling per water body. The project area thus covered the area of Natura 2000 and the wider area along the Drava River, to include a large number of water bodies, along a sampling length of 163 km. Four main types of water bodies were defined within the survey area using the criteria of classification described in Table 1: pond; channel > 2 m wide; channel < 2 m wide; ox-bow (see Table 1 for full definitions).

2.2. Macrophyte surveys

Macrophytes were sampled in the peak season in August in the years 2015 and 2016. In each water body, the macrophytes were recorded, with evaluation of their abundance. For the free floating taxa, the cover ratio of the water body was estimated. In addition, the entire water body cover with macrophytes was estimated, and the riparian vegetation along a belt up to 2 m from the shore was also recorded. The frequency of submerged and floating species (hydrophytes) and of emergent species (helophytes) was evaluated separately. The growth forms of the macrophytes at the time of sampling were also recorded.

Here, the methods used for national monitoring of rivers and lakes were combined, as the water bodies examined were very diverse. The entire areas of small water bodies (< 100 m in length) were examined, while for ox-bows or channels, a section of at least 100 m was examined (Kuhar et al., 2011), and for ponds the method of transects was used, as defined for lakes (Pall and Moser, 2009). The plant species present and the abundance of macrophytes were evaluated using a boat and a rake with hooks. Relative abundance was evaluated using a five-point estimation scale based on the Water Frame Directive (Kohler and Janauer, 1995; European Standard EN 14184, 2003): 1, very rare; 2, infrequent; 3, common; 4, frequent; 5, abundant, predominant.

2.3. Dytiscid beetle survey

We systematically examined water bodies along the Drava River between the city Maribor and the settlement Središče ob Dravi (Fig. 1). The sampling was carried out using water funnel trap, a plastic funnel immersed in water and baited with a cat food, which is proved to be the best bait (Cuppen et al., 2006). Ten traps were set in a water body for one night. The collected material was sorted and examined in the laboratory and species determined according to the identification keys (Friday, 1988; Freude et al., 2006). The comparative material is available in entomological collections of Natural Hystory Museum in Ljubljana (Slovenia).