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Can artificial waterways provide a refuge for floodplain biodiversity? A case study from North Western Germany

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ABSTRACT

Rivers and floodplains are among the most species-rich ecosystems in Middle Europe. Intensive anthropogenic influence has led to a loss of floodplain area and threatens their ecological functionality. This is especially the case for waterways, which have been subject to river engineering due to their economic importance and thus have lost a significant amount of their original floodplains and biodiversity. Canals as artificial waterways have been in the focus of reconciliation ecology, and they have been proven to serve as a refuge for several aquatic species groups where their original habitat is impaired or lost. However, the potential to preserve terrestrial macrophytes and biodiversity along their banks has rarely been considered. Thus the question arises whether canals can provide, at least partly, suitable habitat space to sustain species diversity and functionality of floodplains. In the present case study, we compared the floristic, functional and structural diversity of the floodplain and the respective adjacent areas of the river Ems and the Dortmund–Ems canal in North Western Germany, since both waterways run in parallel and are hydrologically connected. Species composition shows distinct differences between both waterways. Most species along the canal are mainly generalists adapted to anthropogenic influence, while species along the river are characteristic for floodplain systems. Species diversity is up to 10% higher along the canal due to higher lateral heterogeneity, while functional divergence and landscape structure diversity are up to 5% higher along the natural river. Diversity distribution patterns are mainly influenced by landscape structure and land use patterns. Numbers of endangered species did not differ significantly. Thus, the canal can serve as a habitat for single endangered floodplain species but it cannot substitute the functions of a natural dynamic floodplain. Increasing structural diversity and preserving the habitat function of the canal banks by an adapted management regime might enhance the ecological value of a heavily used artificial waterway within the given economic limitations.

1. Introduction

Rivers and floodplains are of high ecological value, yet they are highly endangered ecosystems (e.g., Palmer et al., 2010; Stanford et al., 1996; Ward, 1998). This is especially true for waterways, which are intensely managed and used for transportation (Wolter and Vilcinskas, 1997). By the end of the last century, 77% of the rivers in Europe, the Commonwealth of Independent States (CIS) and North America were seriously modified (Cowx and Welcomme, 1998). In Germany, modification and flood control measures led to a loss of two thirds of the original floodplain area (Brunotte et al., 2009). Also the floodplains remaining are of low ecological value: only ten percent of them are in an ecologically functional state (Brunotte et al., 2009).

This is alarming since riparian zones provide important ecosystem functions and services such as sediment transport and deposition, flood retention, groundwater re- and discharge, nutrient filtration and storage as well as carbon sequestration (Maltby et al., 2009; Naiman and Decamps, 1997; Scholz et al.,

Abbreviations: DEK, Dortmund–Ems Canal; CIS, Commonwealth of Independent States; MEA, Millennium Ecosystem Assessment; CBD, Convention on Biodiversity; BfG, German Federal Institute of Hydrology; WSA, Waterways and Shipping Office; WSV, German Waterways and Shipping Administration; P/A, Presence/Absence; Abun, Abundance; ATKIS, German Official Topographic Cartografic Information System; DLM, Digital Landscape Model; NMS, Non-Metric Multidimensional Scaling; ED, Edge Density; IV, Indicator Value; FRic, Functional Richness; FEve, Functional Evenness; FDiv, Functional Divergence; FDis, Functional Dispersion; Rao's Q, Rao's Quadratic Entropy.

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2012). They serve as ecological corridors for species dispersal and they provide habitat space, which results in exceptionally high levels of biodiversity (Naiman and Decamps, 1997). Vice versa, biodiversity is an important driver of ecosystem functionality (MEA, 2005; Naeem et al., 1994) and therefore the functional biodiversity approach has received increasing attention during the last few years (Petchey and Gaston, 2006). Ecosystem functioning is rather driven by the traits and characteristics of species than by mere species numbers (Díaz and Cabido, 2001). In functional diversity research, the range and value of those traits (e.g., ability to fix nitrogen, growth form, dispersal mode) is studied and used as a measure of biodiversity. This approach has been widely acknowledged and is now integrated as a further essential aspect of biodiversity next to genetic, species and ecosystem diversity (Díaz and Cabido, 2001).

Biodiversity and functionality of riparian systems are strongly influenced by human activities, which change the river body itself, such as hydromorphological changes, river impoundment and water management (Naiman and Decamps, 1997). In addition, change and intensification of human land use influences riparian systems (Méndez-Toribio et al., 2014). In concert, these activities caused the aforementioned loss in floodplain space and functionality. This has brought riparian systems to the attention of policy makers, starting with the Ramsar Convention on Wetlands (United Nations, 1971), the European Habitats Directive (92/43/EEC, The Council of the European Communities, 1992), the Convention on Biodiversity (CBD, United Nations, 1992) and the Millennium Ecosystem Assessment (MEA, 2005). The European Water Framework Directive (2000/60/EC, The European Parliament, 2000) aims at a good ecological status of both natural and artificial water bodies like rivers and canals.

The resemblance between artificial water bodies and rivers is merely superficial (Annett 1998; Hatcher et al., 1999). Canals have a regular structure, a negligible flow velocity, regulated water levels and therefore lack the dynamics of rivers (e.g., Hatcher et al., 1999; Willby et al., 2001). Due to those differences, they cannot provide the same functions like riparian systems in respect to e.g., nutrient cycling or flood retention. Still they provide habitat space, increase the connectivity within a landscape and thus might serve as migration corridors (Jesus Casas et al., 2011). Canals are known to serve as secondary habitats for several fish (Waltham and Connolly, 2007; Wolter and Vilcinskas, 1997; Wolter, 2001), invertebrate (Grumiaux & Dhainaut-Courtois, 1996) and aquatic macrophyte species (Weber et al., 2012; Willby and Eaton, 1996; Willby et al., 2001) and rescue them from extinction when their natural habitat is impaired or lost, as described e.g., for *Margaritifera auricularia* in the Ebro River Basin by Gómez and Araujo (2008).

Even though the habitat function of canals seems to be well-studied, the existing literature mainly considers aquatic species. To our knowledge, studies concerning semiterrestrial and terrestrial macrophytes are scarce (Chester and Robson, 2013; but see Willby and Eaton, 1996; Goulder, 2008). It remains unclear if the banks and adjacent areas along a canal can provide secondary habitats for floodplain species and whether they can take over similar ecological functions as floodplains or if they form novel or

Fig. 1. Photographs of the study areas, i.e., the structure of the canal (a), the banks of the canal with rip rap and tall perennials (b), the structure of the Ems (c) and the bank vegetation of the Ems (d).