Ecological Engineering 118 (2018) 1–11

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

Stormwater ponds promote dragonfly (Odonata) species richness and density in urban areas

Lisa Holtmann[a,b,*], Marvin Juchem[a,b], Jonas Brüggeshemke[a,b], Antje Möhlmeyer[c], Thomas Fartmann[a,b]

[a] *Department of Biodiversity and Landscape Ecology, Osnabrück University, Barbarastraße 11, 49076 Osnabrück, Germany*
[b] *Institute of Biodiversity and Landscape Ecology (IBL), Hafenweg 31, 48155 Münster, Germany*
[c] *Department of Ecology, Osnabrück University, Barbarastraße 13, 49076 Osnabrück, Germany*

ARTICLE INFO

Keywords:
Aquatic connectivity
Fragmented landscape
Global change
Insect community
Landscape structure
Retention pond

ABSTRACT

The loss of global biodiversity is one of the major challenges of our time and urbanisation is seen as a main cause of this. The aim of this study was to determine whether artificial stormwater ponds, designed to control water flow, can act as refuges for Odonata in urban areas. Moreover, we analysed the influence of habitat and landscape quality on dragonfly species richness and density of 35 stormwater ponds (STOPON) in comparison to 35 control ponds (CONTROL).

Our study revealed significant differences in environmental conditions between STOPON and CONTROL. At the habitat level, STOPON were larger, had a warmer microclimate, and lower concentrations of phosphate. STOPON were predominantly situated in suburbs, while CONTROL occurred mostly in rural areas. Accordingly, at the landscape level, STOPON had greater cover of built-up area as well as a lower cover of arable land and woodland. In line with this, the dragonfly assemblages at STOPON and CONTROL differed. Overall species richness was greater at STOPON than at CONTROL, and indicator species were only identified for STOPON. Especially threatened species benefited from STOPON, having higher species richness as well as higher adult and exuviae densities than CONTROL.

In conclusion, our study shows that stormwater ponds in urban areas play an important role in the conservation of dragonflies in general and threatened species in particular. At STOPON, as a result of regular management, the habitat quality was high and compensated for the low landscape quality stemming from significant urbanisation effects.

1. Introduction

For terrestrial biomes, land-use change is assumed to be the main cause of the recent biodiversity crisis (Sala et al., 2000). Worldwide, the greatest increase of a land-use type has been documented for urban areas (United Nations, 2010). Current scenarios assume a growth in the urban population from the present 3.5 billion to 6.3 billion in 2050. Urbanisation is a major reason for the extinction of species and for biotic homogenisation (McKinney, 2006; Grimm et al., 2008). Urbanisation leads directly to a loss of natural and semi-natural habitats (Balmford et al., 2003; McKinney, 2006; Steele and Heffernan, 2014). Indirectly, the fragmentation of the remaining habitat patches increases while the size of the habitats decreases (Lambin et al., 2001; Fahrig, 2003; Donnelly and Marzluff, 2006).

Water systems in cities are heavily modified, either for domestic and industrial use (Booth and Jackson, 1997; Paul and Meyer, 2001; Hassall, 2014; Hill et al., 2016) or for flood control (Hassall, 2014). In combination with a greater area of impervious surfaces through urbanisation, the hydrologic balance is disturbed and a higher magnitude of runoff as well as an increase in flood frequency are the results (Ehrenfeld, 2000; Steele and Heffernan, 2014).

To counteract the negative effects of urbanisation on the hydrologic balance, stormwater ponds have been constructed with increasing frequency over recent decades (Herrmann, 2012). Stormwater ponds are designed to mitigate runoff from impervious surfaces, as they are able to temporarily detain large amounts of water (Villareal et al., 2004; Gallagher, 2011).

A growing number of studies indicate that stormwater ponds not only fulfil a retention function but also attract aquatic and semi-aquatic species (Germany: Holtmann et al., 2017; USA: Birx-Raybuck et al., 2010; Canada: Hassall and Anderson, 2015; France: Scher and Thièry, 2005; Le Viol et al., 2009, 2012; Australia: Hamer et al., 2012).

* Corresponding author at: Department of Biodiversity and Landscape Ecology, Osnabrück University, Barbarastraße 11, 49076 Osnabrück, Germany.
E-mail address: liholtmann@uni-osnabrueck.de (L. Holtmann).

https://doi.org/10.1016/j.ecoleng.2017.12.028
Received 9 October 2017; Received in revised form 28 November 2017; Accepted 21 December 2017

However, for Central Europe there are virtually no studies on the conservation value of stormwater ponds in urban areas.

Having a bipartite life cycle with aquatic and terrestrial stages, Odonata are good indicators of the habitat quality of both aquatic and terrestrial habitats (Sahlén and Ekestubbe, 2001; Foote and Hornung, 2005; Samways, 2008). As prominent predators and prey in a variety of aquatic and terrestrial habitats, they have a high ecological significance (Samways and Steytler, 1996; Knight et al., 2005). Due to their high dispersal ability, Odonata are able to colonize newly created habitats quickly (Corbet, 2004; Clausnitzer et al., 2009). In addition, their taxonomy and distribution are well known and sampling them with standard methods is manageable (D'Amico et al., 2004).

The aim of this study is to determine whether artificial stormwater ponds, designed to control water flow, can act as refuges for Odonata in urban areas. Moreover, we analyse the influence of habitat and landscape quality on dragonfly species richness and density in stormwater ponds in comparison to control ponds. Lastly, we develop recommendations for the management and construction of stormwater ponds as dragonfly habitats in urban areas.

2. Material and methods

2.1. Study area

The study area comprises the municipal area of the city of Münster (51°58′N, 7°38′E; 39–99 m a.s.l.) in the north of the German Federal State of North Rhine-Westphalia (Fig. 1). The city has about 305,000 inhabitants and covers an area of 303 km^2 (City of Münster, 2016). Of the total area, 34% consists of built-up and traffic areas; agricultural land covers 46%, forests 18% and bodies of water 2%. Biogeographically, the city is as a part of the Westphalian Basin located in the North German Plain. The climate is suboceanic with an annual precipitation of approximately 780 mm and a mean annual temperature of 9.9 °C (1981–2010; climate station Münster/Osnabrück; DWD, 2017).

Currently, 79 stormwater ponds exist in the study area (Möhring personal communication, Civil Engineering Office Münster). Their banks are usually not paved or concreted and all ponds are regularly managed to ensure a maximum volume of water retention. Management includes cutting of woody riparian plants and desludging of ponds every couple of years. The herb layer is usually cut every year, in the winter.

2.2. Sampling design

The study was conducted during the growing season in 2015. From the end of April to the beginning of September we investigated a total of 70 waterbodies, 35 stormwater ponds (STOPON) and 35 control ponds (CONTROL). A control pond was defined as the next pond in the vicinity of each STOPON (mean distance 781 m ± 99 m SE), regardless of whether it was man-made or of natural origin. Every pond was

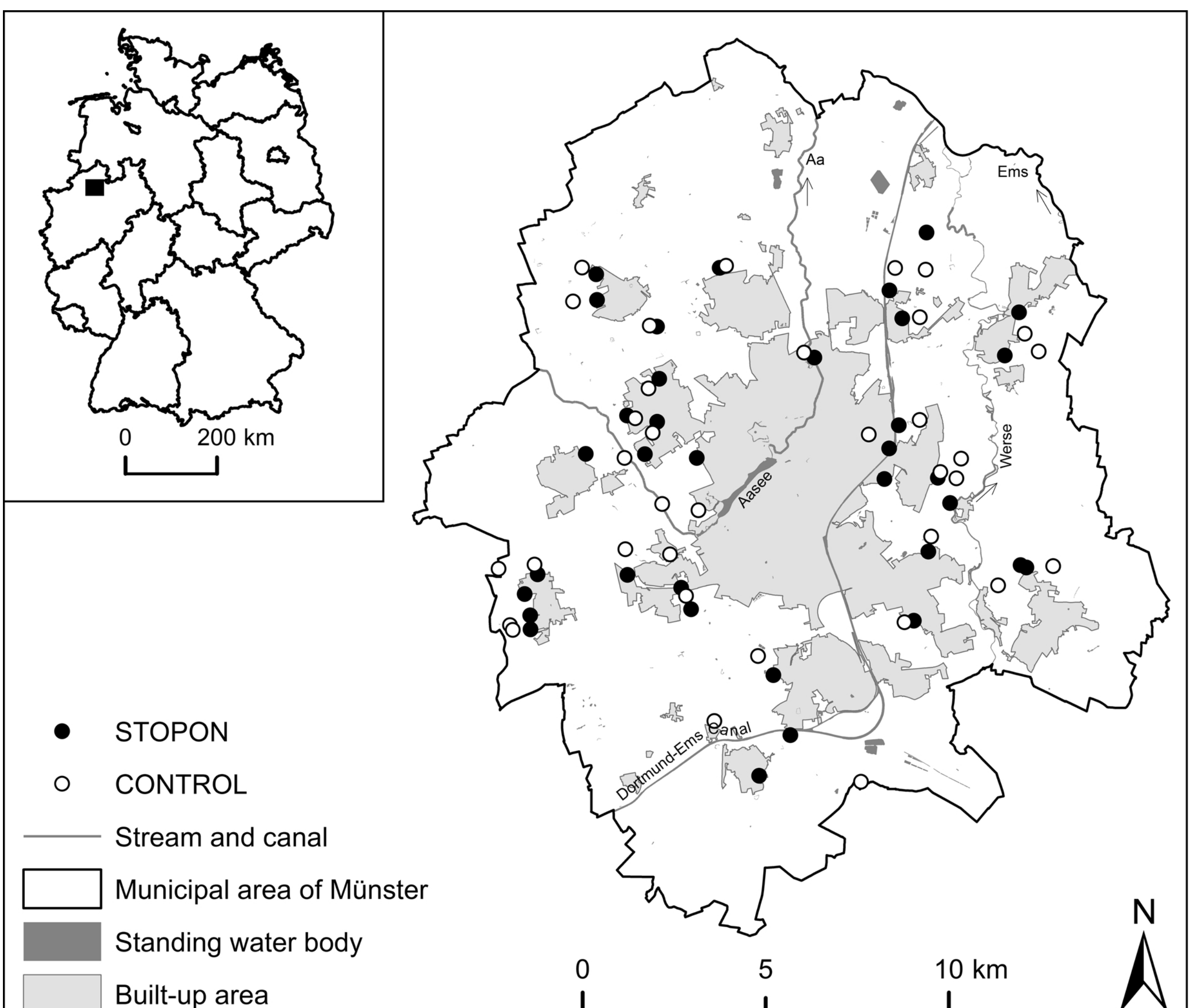

Fig. 1. Location of surveyed stormwater ponds (STOPON) and control ponds (CONTROL) in the municipal area of Münster (NW Germany). The inlay (upper left corner of the graph) shows the German Federal states and the location of the study area (black square) in Germany.