

Effects of floodplain dynamics on richness, abundance, composition and functional diversity of grasshopper assemblages in the Donau-Auen National Park (Austria)



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Abstract

Inundation events are shaping arthropod communities of floodplain ecosystems. This study from the Donau-Auen National Park (Lower Austria) investigated to what extent species richness, abundance, and functional diversity of grasshopper communities on meadows are affected by annual floods. Hence, grasshoppers were sampled from June to September 2012 on meadows prone to yearly summer inundations (N = 12) and meadows protected from inundation (N = 13) by a levee. Grasshopper abundance was negatively affected by flooding. Species richness, functional diversity and relative abundances of hygrophilous grasshoppers and generalist species did not differ significantly between both meadow types. In contrast, the relative abundance of xerophilous species was significantly higher on non-flooded meadows. This study shows that natural floodplain dynamics still have an impact on grasshopper assemblages of meadows in the Donau-Auen National Park.

Keywords

grasshoppers, Caelifera, Ensifera, species richness, abundance, functional diversity, Donau-Auen National Park, floodplain ecosystem

Introduction

The community structure of aquatic and terrestrial plant and animal communities of floodplain ecosystems is shaped by hydrological dynamics (BALLINGER et al. 2005, VAN DIGGELEN et al. 2006, RECKENDORFER et al. 2006; but: TRUXA & FIEDLER 2012). In this study, conducted in the Donau-Auen National Park, we analyzed to what extent species richness, abundance and functional diversity of grasshopper communities on meadows are shaped by summer inundations. So far, effects of flood events on grasshopper communities have been only rarely investigated (FISCHER & WITSACK 2009, DZIOCK et al. 2011). Grasshoppers have high conservation relevance because a substantial fraction of species is highly bonded to specific habitats and is reacting sensitively to environmental changes. Hence, they are frequently used as 'bioindicators' (REICH 1991, GERLACH et al. 2013, BAZELET & SAMWAYS 2012).

Methods

Study area

This study was conducted in the Donau-Auen National Park (IUCN Category II, 1997), which is still influenced by the dynamics of the river Danube due to water level fluctuations of up to 7 m amplitude throughout the year, causing periodic and stochastic overbank flows (NATIONALPARK DONAU-AUEN 2013). Study sites were located north of the river Danube between the villages Mannsdorf and Bad Deutsch Altenburg. The study area is divided by a levee high protects the area situated to the north against flooding during periods of high water level. In contrast, meadows south of the levee are still flooded almost every year. Grasshoppers were sampled on twelve meadows south of the levee, and 13 meadows north of it (Fig. 1).

Grasshopper sampling

On each meadow grasshoppers were sampled in five sampling rounds in Summer 2012. All visually and acoustically detected grasshoppers were counted. Identification was facilitated by available field guides and song recordings. In our analyses *Phaneroptera falcata*, which is not associated with meadows (ZUNA-KRATKY et al. 2009), and all *Tetrix*-species which cannot be reliably surveyed with our sampling method, were excluded. Additionally, mowing frequency, dominance of grasses and vegetation height was recorded for each meadow. For classification of species according to their habitat preferences compare DEMETZ et al. (2013).

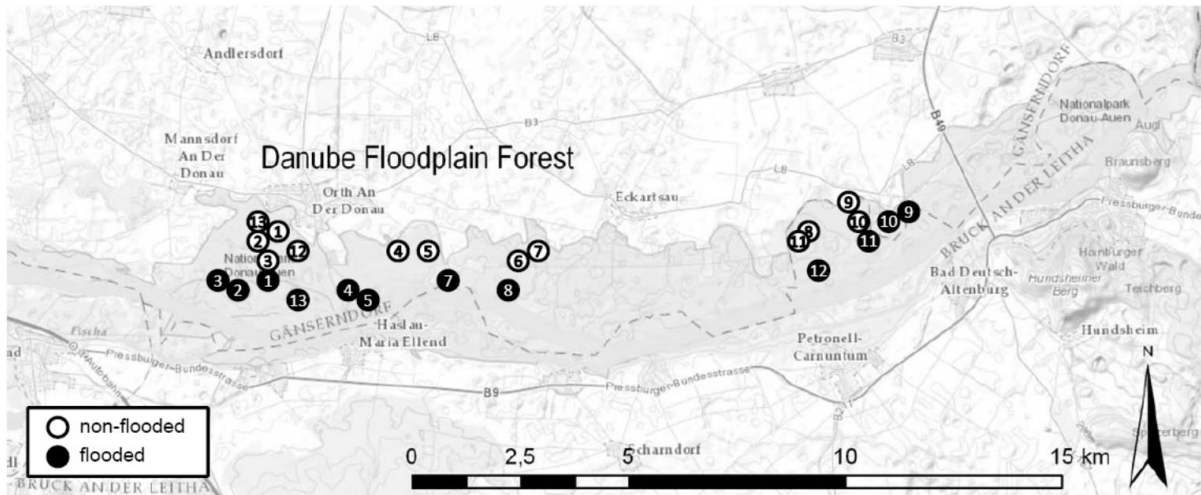


Figure 1: Map of the study area indicating sampled regularly flooded and non-flooded meadows

Results

Species richness and abundance

A total of 22 grasshopper species were recorded on flood-prone and non-flooded meadows, respectively. A generalized linear model (GLM) testing for effects of flooding, mowing frequency, dominance of grasses, herb layer height and plant species richness on the number of grasshopper species recorded per sampled meadow did not achieve a significant level. In contrast, a GLM testing for effects on total grasshopper abundance indicated a strong effect of flooding regime. The abundance of grasshoppers per 10 m transect was higher on non-flooded than flooded meadows (Fig. 2).

Effects on grasshoppers with different habitat preferences

While the relative abundance of hygrophilous species and grasshopper with indifferent habitat preferences did not differ significantly between flooded and non-flooded meadows (Fig. 3a-b), the relative abundance of xerophilous grasshoppers was higher on non-flooded meadows (Fig. 3c).

Functional diversity

GLMs testing for effects of meadow variables on functional diversity measures (functional richness, functional evenness, functional vivergence; e.g. LALIBERTÉ & LEGENDRE 2010) did not indicate any significant effects.

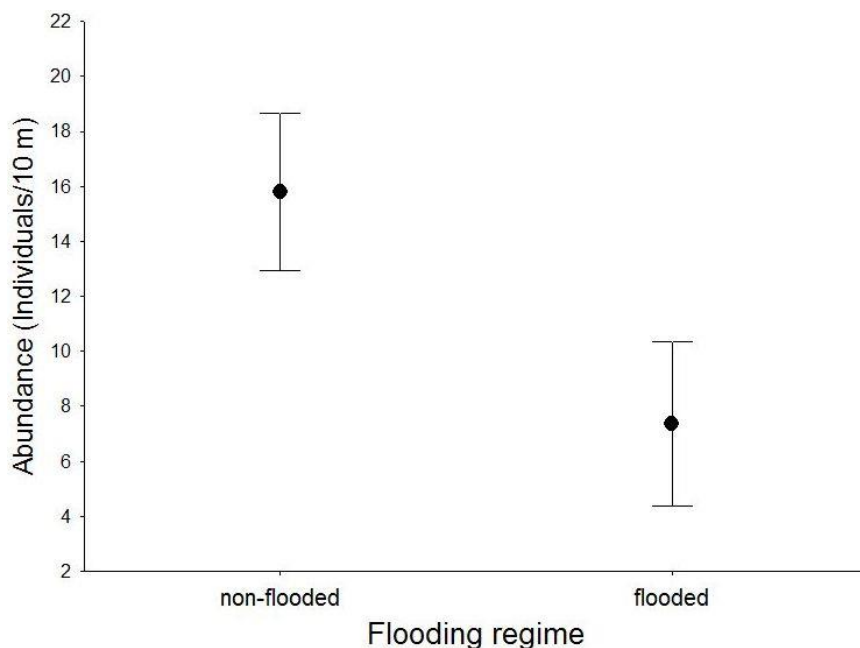


Figure 2: Mean abundance of grasshoppers on flooded and non-flooded meadows.

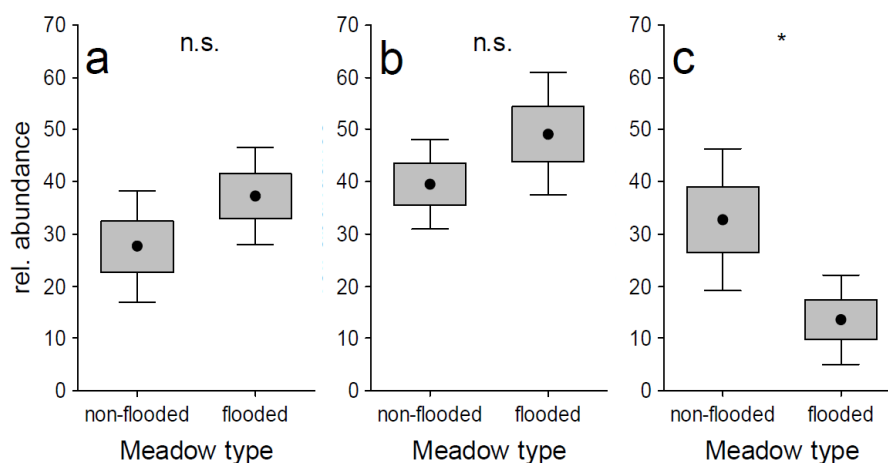


Figure 3: Mean relative abundance \pm SE (box) and 95% CI (whiskers) of (a) hygrophilous, (b) indifferent and (c) xerophilous species on flooded and non-flooded meadows. Results of t-tests: n.s. – non-significant, * – $p < 0.05$.

Discussion

Species richness and abundance

Regular flood events did not prove to affect species richness of grasshopper assemblages on meadows in the Donau-Auen National Park. In contrast, flooding appeared to have the major impact on grasshopper abundance. Most likely, a large number of grasshoppers drown in the flood. The only way to survive a flooding event is in the egg-phase or by flying away (macropterous species). Although macropterous species can repopulate areas after a flood event, this apparently cannot compensate for the increased mortality during flooding events. Overlapping egg-generations are necessary for grasshopper populations to survive (FISCHER & WITSACK 2009). In 2012 there was a flooding event in the middle of June, which could have had a big influence on grasshoppers species as most of the species are in the last larval stage at this time. Grasshopper larvae have the least chance of surviving a flood, because they are not able to escape the inundation by flight.

Species composition and habitat preferences of species

While inundation did not prove to affect species richness in our study, it had a strong effect on the composition of grasshopper species assemblages (DEMETZ et al. 2013).

While the relative abundance of hygrophilous grasshoppers and species without pronounced habitat preferences did not prove to differ between flooded and non-flooded meadows, xerophilous species were negatively affected by inundation. VAN WINGERDEN et al. (1991) found differences in the duration of postdiapause development (PDD) of grasshoppers, which takes place in spring until hatch, according to the temperature and humidity of the habitats. In humid habitats the PDD was shorter and in dry habitats longer. Wet sites were colder than dry ones and xerophilous species showed longer PDDs than hygrophilous species. The maximum temperature in the egg environment is a selective factor in habitat determination (van WINGERDEN et al. 1991). Hygrophilous species were found more often at flooded meadows, but the result was not significant. FISCHER & WITSACK (2009), who compared grasshopper assemblages of regularly flooded and non-flooded meadows along the river Elbe, documented that grasshopper species were more connected to the type of meadow, than to the flooding regime.

Effects of flooding on functional diversity

Our study did not provide any evidence that functional diversity of grasshopper assemblages was negatively affected by disturbance caused by flooding events. In contrast, GERISCH et al. (2012) found a decline in functional diversity from non-flooded to flooded meadows for ground beetle communities on periodically flooded grasslands along the Elbe River in Germany. In our study the ecological niches of regularly flooded and non-flooded meadows seemed to be similarly filled by grasshopper species. Most likely a rapid recolonization of meadows after the flooding through dispersal appears to prevent a decline in functional diversity.

Conclusion

Although species richness and the relative abundance of hygrophilous and generalist grasshoppers appears to be not severely affected by flooding events, natural floodplain dynamics still have a significant impact on species composition (DEMETZ et al. 2013) and the abundance of xerophilous grasshoppers on meadows in the Donau-Auen National Park (this study).

Acknowledgements

We like to thank the Donau-Auen National Park and the University of Vienna for logistic and financial support of our research project. In particular, we are grateful to Christian Baumgartner and Christian Fraissl for fruitful discussions and help with the selection of study sites. Tobias Dreschke, Helene Holzweber, Ulrich Kurrle and Karin Neunteufl assisted with field surveys.

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