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Natural floodplain dynamics shape grasshopper assemblages of meadows in the Donau-Auen National Park (Austria)

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Abstract

Flooding events are an important factor shaping arthropod communities on riverine meadows. We investigated to what extent species diversity and species composition of grasshopper assemblages on meadows in the Donau-Auen National Park (Lower Austria) are affected by annual floods. Grasshoppers were sampled between June and September 2012 on 12 meadows prone to yearly summer inundations, and 13 meadows protected from such floods by a levee. All acoustically and visually detected individuals were counted. Excluding one stray species not associated to meadows and representatives of the genus *Tetrix*, which cannot be recorded reliably with our sampling method, a total of 24 grasshopper species were recorded. Species richness was nearly identical on both meadow types. However, species composition differed prominently between regularly flooded and non-flooded meadows. Furthermore, we compared local incidence of all 24 species (quantified as percentage of colonized meadows) with their regional occurrence (quantified as percentage of 6250 m x 5550 m grids with records in Eastern Austria). Accordingly, hygrophilous species are more prevalent in the Donau-Auen National Park than expected from their regional occurrence. Our study provides strong evidence that natural floodplain dynamics still have a significant impact on species composition of meadow grasshopper assemblages in the Donau-Auen National Park. Hence, maintaining high hydrological dynamics (e.g. by river restoration measures) will be a precondition to successfully protect the characteristic fauna of floodplain meadows.

Keywords

Caelifera, Ensifera, species richness, species composition, habitat preferences, Danube floodplain, Eastern Austria

Introduction

Hydrological dynamics are important to shape the community structure of aquatic and terrestrial plant and animal communities of floodplain ecosystems (Ballinger et al. 2005, van Diggelen et al. 2006, Reckendorfer et al. 2006; but: Truxa & Fiedler 2012). So far only few studies have addressed potential effects of flood events on richness and composition of grasshopper communities (Fischer & Witsack 2009, Dziock et al. 2011). In the present study, conducted in one of Europe's largest remaining floodplain ecosystems located in the Donau-Auen National Park (Lower Austria, east of Vienna), we investigated whether grasshopper communities on meadows prone to summer inundations differ from those on meadows that are no longer subject to natural river dynamics.

Particularly, we addressed the two following questions:

(1) *To what extent are local grasshopper assemblages shaped by flooding events?* We expect that regularly flooded meadows show a lower species richness than non-flooded meadows and are characterized by a different species composition due to a higher dominance of hygrophilous flood-resistant habitat specialists.

(2) *Are hygrophilous grasshopper species more prevalent on a local scale (Donau-Auen National Park) compared to their incidence on a regional scale (Eastern Austria)?* Local abundance of species is often correlated with their regional occupancy (Gaston et al. 2000). Due to flooding of large areas at high water levels of the river Danube, we expect that hygrophilous species are relatively more abundant in the national park than xerophilous species, when compared to their regional incidence in Eastern Austria.

Methods

<u>Study area and study sites</u>

This study was conducted in the Donau-Auen National Park north of the river Danube between the villages Schönau and Stopfenreuth (Fig. 1). The river-floodplain system of the national park has been constrained due to major river regulation measures since 1875 (Reckendorfer et al. 2006). However, it is still influenced by the dynamics of the river Danube due to water level fluctuations of up to 7 m amplitude throughout the year, which cause periodic and aperiodic overbank flows. Periodic floods occur from late spring to high summer due to the snowmelt in the Alps. Aperiodic floods can be caused by heavy rainfall (Nationalpark Donau-Auen 2013).

The study area is divided by a levee which 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. Twelve meadows were selected south of the levee, and 13 meadows north of it. Mean size (± SD) of the selected meadows was 2.97 ± 1.54 ha (north of the levee) and 2.67 ± 1.61 ha (south), respectively, and did not differ significantly (t-test: $t = 0.46$, $p = 0.648$) between both groups of meadows.

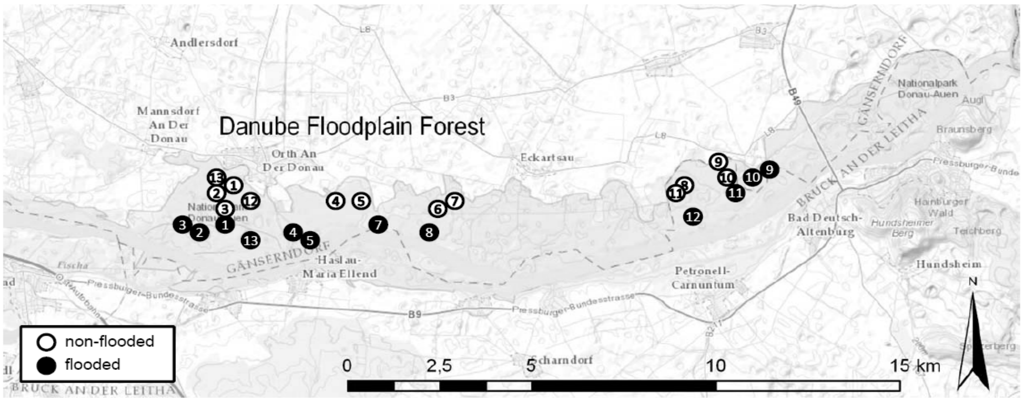

Figure 1: Map of the study area indicating regularly flooded and non-flooded meadows.

Grasshopper sampling

On each meadow grasshoppers were sampled once during each of the five sampling rounds: 18-22 June (sampling round A), 2-6 July (B), 23-27 July (C), 2-6 August (D) and 10-17 September 2012 (E). During sampling rounds A and C, grasshoppers were surveyed visually and acoustically for 15-30 minutes depending on meadow size by a group of 4 recorders who walked the entire meadow area. During the other three sampling rounds the first author counted all visually and acoustically detected grasshoppers along transects (50 m transect length per ha meadow area). All visually detected grasshoppers were caught for identification with a sweep net. Identification was facilitated by available field guides (BELLMANN 2006, BAUR et al. 2006) and song recordings (ROESTI & KEIST 2009). For each meadow, data from all five sampling rounds were combined as units of analysis. We excluded one stray species not associated with meadows (*Phaneroptera falcata,* one single recorded nymph) and all *Tetrix* species which cannot be reliably surveyed with our sampling method.

Table 1: Classification of habitat preferences of recorded grasshopper species and their Red List status in Austria (RL Austria) (BERG et al. 2005).

Habitat preferences	Species	RL Austria
hygrophilous	*Chorthippus albomarginatus*	NT
	Chrysochraon dispar	NT
	Mecostethus parapleurus	NT
	Ruspolia nitidula	NT
	Stethophyma grossum	VU
xerophilous	*Calliptamus italicus*	VU
	Chorthippus apricarius	
	Chorthippus biguttulus	
	Chorthippus brunneus	
	Euchorthippus declivus	
	Gryllus campestris	
	Leptophyes albovittata	NT
	Metrioptera bicolor	NT
	Omocestus haemorrhoidalis	VU
	Platycleis albopunctata grisea	NT
	Stenobothrus lineatus	
indifferent	*Chorthippus dorsatus*	
	Chorthippus mollis	NT
	Chorthippus parallelus	
	Conocephalus fuscus	NT
	Euthystira brachyptera	
	Metrioptera roeselii	
	Pholidoptera griseoaptera	
	Tettigonia viridissima	

Data analysis

To compare species richness of grasshopper assemblages, randomized species accumulation curves were calculated for regularly flooded and non-flooded meadows using the software EstimateS (COLWELL 2013).

Similarities between species assemblages were quantified by Bray-Curtis similarities (calculated using square-root transformed abundances) for all combinations of meadows. Then, similarity relationships between grasshopper assemblages of sampled meadows were visualized in a non-metric twodimensional scaling (NMDS) ordination (CLARKE 1993). To test for differences in species composition of grasshopper assemblages between flooded and non-flooded meadows, an analysis of similarity (ANOSIM; with 999 permutations) was calculated with the program Primer (CLARKE & GORLEY 2001).

Regional occupancy of grasshopper species was quantified as the percentage of occupied grids (6250 m x 5550 m) from the distribution atlas for Eastern Austria (ZUNA-KRATKY et al. 2009). Local occupancy of species was quantified by our surveys as the percentage of meadows in the Donau-Auen National Park, where the respective species had been recorded. Then, local occupancy of species was plotted against their regional incidence. Subsequently, for each species the deviation of its local occupancy from the expected value if local occupancy were equal to regional occupancy was measured. Positive deviations indicate a higher local occupancy than expected by chance, and negative values a lower local occupancy compared to the species' regional occupancy. Finally, we calculated a Kruskal-Wallis ANOVA to test for differences in these deviations of local from regional occupancy across three classes of grasshopper species: hygrophilous species, xerophilous species, and species with no clear habitat preference relative to humidity ("indifferent species"). Classification of species according to their habitat preferences was based on the information provided by ZUNA-KRATKY et al. (2009) (Table 1).

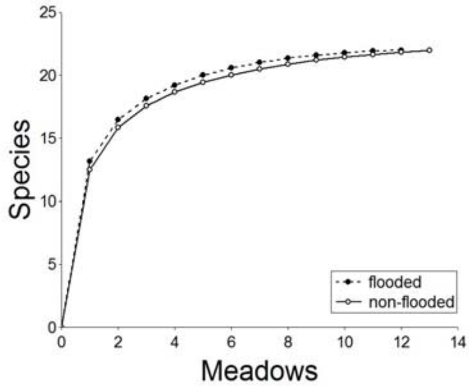

Figure 2: Randomized species accumulation curves for grasshopper assemblages on flooded and non-flooded meadows.

Results

Species richness and species composition on flooded vs. non-flooded meadows

A total of 24 grasshopper species (excluding *Phaneroptera falcata* and *Tetrix* species) were recorded (Table 1): 22 species on flood-prone and non-flooded meadows, respectively. Species accumulation curves calculated for regularly flooded and non-flooded meadows also indicate near identical species richness (Fig. 2). Species composition, however, differed markedly between flooded and non-flooded meadows (one-way ANOSIM: R = 0.34, p < 0.001). Distinct grasshopper assemblages on both meadow types were also indicated by the NMDS ordination based on Bray-Curtis similarities. Grasshopper assemblages of flooded meadows aggregate in the left half, those of non-flooded meadows in the right half of the ordination plot (Fig. 3).

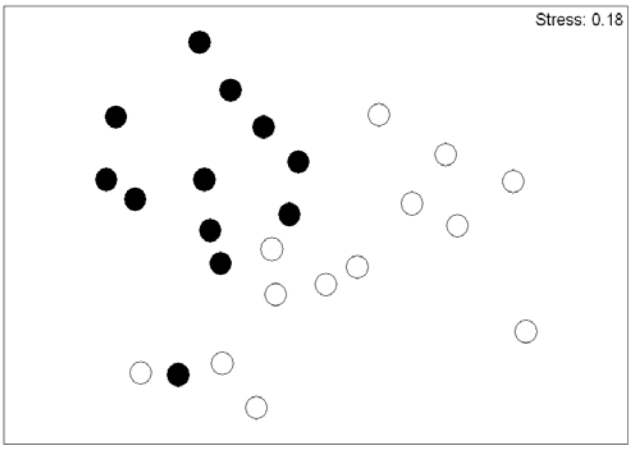

Figure 3: Similarity relationships between grasshopper assemblages sampled on flooded (filled circles) and non-flooded meadows (empty circles), visualized in a non-metric twodimensional scaling ordination. Similarities between species assemblages were quantified by Bray-Curtis similarities calculated using square-root transformed abundances. The low stress value (<0.20) indicates acceptable representation of the similarity relationships in the two-dimensional ordination.

Local vs. regional incidence of species

Deviations between species' local occupancy and regional incidence (Fig. 4) differed significantly between grasshopper species with contrasting habitat preferences (Kruskal-Wallis ANOVA, H_{2df} = 9.09, p = 0.011). Hygrophilous species were characterized by a higher local occupancy than expected, whereas species classified as xerophilous or indifferent had a lower occupancy than predicted (Fig. 5). The only xerophilous species which occurred on a higher fraction of meadows than predicted was *Stenobothrus lineatus* with a regional occupancy of 55% and a local incidence of 97% (Fig. 5).

Discussion

Remarkably, regular flood events did not prove to affect species richness of grasshopper assemblages on meadows in the Donau-Auen National Park. Also FISCHER & WITSACK (2009) found a high similarity of grasshopper assemblages on flooded and non-flooded meadows of the Elbe floodplains (Germany). However, in our study inundation had a strong effect on the species composition of grasshopper assemblages. Some hygrophilous species were more abundant or exclusively occurred on regularly flooded meadows, while the opposite was true for several xerophilous species. For example, the two xerophilous species *Chorthippus apricarius* (recorded on one meadow) and *Platycleis albopunctata grisea* (four meadows) were only found on non-flooded meadows. Examples for hygrophilous grasshopper species exclusively observed on flooded meadows were *Euchorthippus declivus* (2 meadows) and *Stethophyma grossum* (3 meadows). In contrast to our study area, where flood events typically occur in early summer, the Elbe floodplains are usually flooded in spring, when the majority of grasshopper larvae still have not hatched from the eggs. The egg phase is the only life-history stage for most grasshoppers to survive flood events (FISCHER & WITSACK 2009). Hence, summer floods as typical for the Danube floodplains have a much higher potential in shaping the composition of grasshopper assemblages, resulting in a higher prevalence of hygrophilous species on flooded meadows.

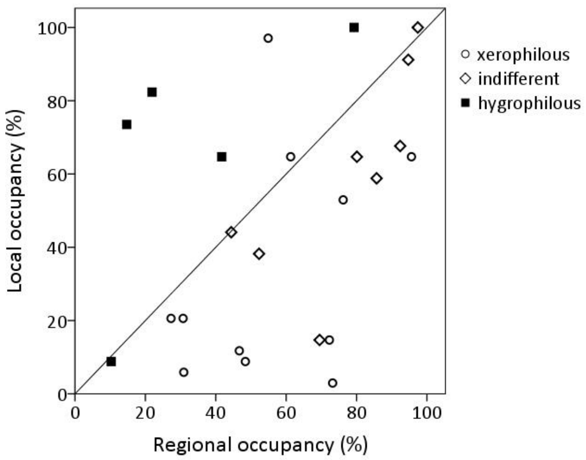

Figure 4: Relationship between local and regional occupancy of 24 grasshopper species, classified into three types of habitat affiliation. Local occupancy was quantified as the percentage of colonized meadows in the Donau-Auen National Park (own data), regional occupancy in Eastern Austria was quantified as percentage of 6250 m × 5550 m grids, from which the species had been recorded (ZUNA-KRATKY et al. 2009). An identical local and regional occupancy is indicated by the line.

The importance of the Danube floodplains for hygrophilous species was confirmed by the comparison of local to regional occupancy. Hygrophilous species proved to show a higher local incidence on meadows in the Donau-Auen National Park, compared to their regional occupancy in Eastern Austria. In contrast, xerophilous and indifferent species were less abundant in comparison to their representation on a regional scale.

The high conservation value of meadows in the Donau-Auen National Park is highlighted by the large number of recorded species which are classified as near threatened (9 species) or vulnerable (3 species) according to the Red List for grasshoppers in Austria (BERG et al. 2005). Of the five hygrophilous species recorded in this study, all are near threatened or vulnerable on a national scale; *Stethophyma grossum* was the only species classified as vulnerable (Table 1). Crucial habitat requirements for *S. grossum* are high humidity near the ground and in the soil and a heterogeneous vertical vegetation structure (SONNECK et al. 2008). The eggs are laid near the ground and require high soil humidity (INGRISCH 1983, MARZELLI 1997). The larvae hatch from June until September in the following year. First adults appear at the end of June (INGRISCH & KÖHLER 1998). The species' dispersal capacity is very low with median male and female dispersal distances of 37 and 27 m, respectively (BÖNSEL & SONNECK 2011). In our study area, the species was only recorded on three annually flooded meadows. Like many other grasshopper species also *S. grossum* may face a severely increased mortality during summer floods. However, some larvae hatch very late in summer ensuring that at least a fraction of the population will be able to survive summer floods in the egg stage. Nevertheless, the small number of only 8 recorded individuals may indicate a relatively low habitat quality for this threatened species.

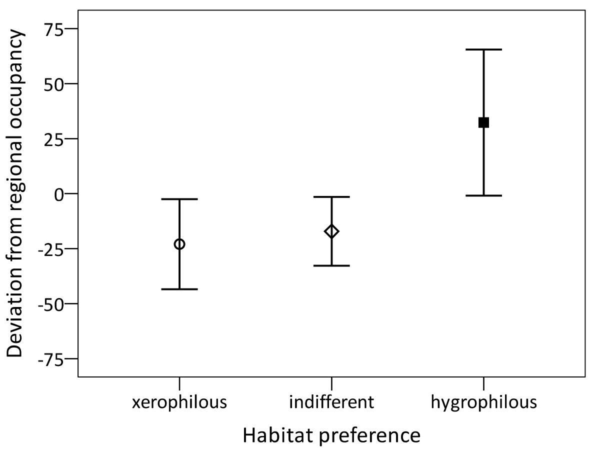

Figure 5: Deviation (mean ± 95% CI) of species' local occupancies (Donau-Auen National Park) from their regional occupancies (Eastern Austria), grouped according to habitat preferences of grasshopper species. Positive values indicate over-representation, negative values under-representation at the local habitat scale.

Conclusion

Our study provides strong evidence that natural floodplain dynamics still have a significant impact on the grasshopper fauna of meadows in the Donau-Auen National Park. Hence, maintaining high hydrological dynamics (e.g. by river restoration measures) will be a precondition to successfully protect the fauna of floodplain meadows, characterized by a high proportion of regionally threatened hygrophilous species.

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References

BALLINGER, A., MAC NALLY, R. & P.S. LAKE 2005. Immediate and longer-term effects of managed flooding on floodplain invertebrate assemblages in south-eastern Australia: generation and maintenance of a mosaic landscape. Freshwater Biology 50: 1190-1205.

BAUR, B., BAUR, H., ROESTI, C. & D. ROESTI 2006. Die Heuschrecken der Schweiz. Bern.

BELLMANN, H. 2006. Der Kosmos Heuschreckenführer. Stuttgart.

BERG, H.M., BIERINGER, G. & L. ZECHNER 2005. Rote Liste der Heuschrecken (Orthoptera) Österreichs. In: ZULKA, K.P. (ed.), Rote Liste gefährdeter Tiere Österreichs. Checklisten, Gefährdungsanalysen, Handlungsbedarf. Teil 1. Grüne Reihe des Lebensministeriums: 167-209. Wien.

BÖNSEL, A.B. & A.-G. SONNECK 2011. Habitat use and dispersal characteristic by *Stethophyma grossum*: the role of habitat isolation and stable habitat conditions towards low dispersal. Journal of Insect Conservation 15: 455-463.

CLARKE, K.R. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18: 117-143.

CLARKE, K.R. & R.N. GORLEY 2001. Primer v5: user manual/tutorial. Primer-E, Plymouth, UK.

COLWELL, R.K. 2013. EstimateS: Statistical estimation of richness and shared species from samples. Version 9. Available at: http://purl.oclc.org/estimates (accessed: 02/04/2013).

DZIOCK, F., GERISCH, M., SIEGERT, M., HERING, I., SCHOLZ, M. & R. ERNST 2011. Reproducing or dispersing? Using trait based habitat templet models to analyse Orthoptera response to flooding and land use. Agriculture, Ecosystems and Environment 145: 85-94.

FISCHER, N. & W. WITSACK 2009. Untersuchungen zum Überleben der Heuschrecken (Caelifera et Ensifera) in der Überschwemmungsaue der Elbe bei Dessau (Sachsen-Anhalt). Hercynia N. F. 42: 255-304.

GASTON, K.J., BLACKBURN, T.M., GREENWOODS, J.D., GREGORY, R.D., QUINN, R.M. & J.H. LAWTON 2000. Abundance-occupancy relationships. Journal of Applied Ecology 37: 39-59.

INGRISCH, S. 1983. Zum Einfluß der Feuchte auf die Schlupfrate und Entwicklungsdauer der Eier mitteleuropäischer Feldheuschrecken. Deutsche Entomologische Zeitschrift 30:1-15.

INGRISCH, S. & G. KÖHLER 1998. Die Heuschrecken Mitteleuropas. Magdeburg.

MARZELLI, M. 1997. Untersuchungen zu den Habitatansprüchen der Sumpfschrecke (*Stethophyma grossum*) und ihre Bedeutung für das Habitatmanagement. Articulata 12: 107-121.

NATIONALPARK DONAU-AUEN 2013. Der Nationalpark Donau-Auen. Available at: http://www.donauauen.at/?area=nationalpark (accessed: 17/04/2013).

RECKENDORFER, W., BARANYI, C., FUNK, A. & F. SCHIEMER 2006. Floodplain restoration by reinforcing hydrological connectivity: expected effects on aquatic mollusc communities. Journal of Applied Ecology 43: 474-484.

ROESTI, C. & B. KEIST 2009. Die Stimmen der Heuschrecken. Bern.

SONNECK, A.-G., BÖNSEL, A. & J. MATTHES 2008. Der Einfluss von Landnutzung auf die Habitate von *Stethophyma grossum* (Linnaeus, 1758) an Beispielen aus Mecklenburg-Vorpommern. Articulata 23:15–30

TRUXA, C. & K. FIEDLER 2012. Down in the flood? How moth communities are shaped in temperate floodplain forests. Insect Conservation and Diversity 5: 389–397.

VAN DIGGELEN, R., MIDDLETON, B., BAKKER, J., GROOTJANS, A. & M. WASSEN 2006. Fens and floodplains of the temperate zone: present status, threats, conservation and restoration. Applied Vegetation Science 9: 157-162.

ZUNA-KRATKY, T., KARNER-RANNER, E., LEDERER, E., BRAUN, B., BERG, H.-M., DENNER, M., BIERINGER, G., RANNER, A. & L. ZECHNER 2009. Verbreitungsatlas der Heuschrecken und Fangschrecken Ostösterreichs. Verlag Naturhistorisches Museum Wien, Wien.

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