Diversity of beetle communities from ground level to canopy in the Danube floodplain forests between Neuburg and Ingolstadt (Germany)

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1 Introduction

In Germany, most of the floodplain forests along the Danube River lost their typical character since the 19th century due to river regulations and embankment. Flooding periods were drastically reduced and became rare events. As a consequence and supported by forest management, tree stand structure developed into moist hardwood forests. Starting in 2010, a former floodplain forest between Neuburg and Ingolstadt will be restored by installing a new permanent watercourse and following natural river flow dynamics (Stammel et al. 2008). The combination of a permanent watercourse with additional flooding ranging from one flooding period in several years to repeated floodings in one year will cause significant alterations in water balance, thus effecting directly and indirectly all strata of the ecosystem. Environmental conditions relevant to plant and animal communities will be modified, but the dimension is hardly predictable. At the restoration area current stands are dominated by mature ash and oak trees, whereas sycamore, Norway spruce and Scots pine are scattered as admixed tree species.

Intact floodplain ecosystems are characterized by very high diversity of habitats on a very small spatial scale, and marshy areas are in close vicinity to dry soils. Moreover, forests in general exhibit high vertical diversity (Unterseher et al. 2007). The gradient from forest floor to the canopy implies not only pronounced differences in abiotic factors such as radiation, humidity, air movement etc., but also a high variability in living plant biomass, plant structures, epiphyte cover and necromass. High diversity of abiotic and biotic conditions in horizontal and vertical direction in floodplain forests should result in a richness of arthropod communities (Gruppe et al. 2008). In general it is well known that arthropod communities and particularly certain groups of insects play an important role as sensible indicators for alterations in ecosystems. Especially beetles are a highly suitable insect order for monitoring programs describing differences in the environment (Ammer et al. 2003, Müller et al. 2005). They frequently occur in all kinds of habitat, respond quickly on changes of abiotic factors, have a high diversity in species number, and can easily be identified; therefore, a comparison of similar projects in Central Europe is possible (Bonn & Kleinwächter 1999, Schröder et al. 2003, Strätz et al. 2006, Bail & Schmidl 2008). Moreover, beetles exhibit a broad range of ecological demands. Many species are restricted to distinct conditions of humidity in their environment. Thus, beetles are an ideal taxon to study ecological consequences of restoration of floodplain dynamics.

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2 Concept of beetle monitoring

The monitoring approach is developed to investigate alterations in zoocoenoses, particularly in beetle coenoses, caused by hydrological change through restoration measures. Short- and long-term effects of these measures will be compared to base line data. We started with the definition of four habitat classes according to expected increase of soil moisture, caused by a newly established permanent watercourse, and expected frequency of flooding. These predicted changes in hydrology defining the habitat classes base on a model of the surface relief (Haas unpublished): (a) habitats close to the new watercourse, (b) habitats flooded up to four times per year depending on the Danube water level, (c) habitats flooded only once in 100 years, and (d) habitats on dry stands due to gravel deposits (so called “Brenne”) (Fig.1). Each habitat class was monitored in five replicas leading to a complete block design with twenty plots.

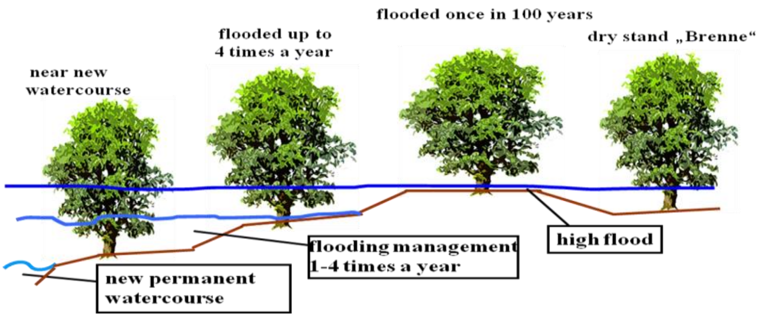

Figure 1. *Habitat classes according to expected increase of soil moisture and frequency of flooding, modelled from surface relief.*

Each plot is represented by three mature oak trees (*Quercus petraea*). On these trees and on the forest ground close to them, different types of traps are used to collect arthropods (Gruppe et al. 2008). Surface active species are captured with: (i) pitfall traps (PT) and emergence traps (ET) on the forest ground, (ii) trunk traps (TT) at approx. 2m above ground, and (iii) branch traps (BT) close to the trunk in the canopy (on average 11m above ground). Each trap type intended for surface active species is installed on an individual tree within each plot to avoid experimental interference. Flying arthropods are captured by flight interception traps (FIT) close to the ground (2m above ground) and in the core of the tree crown (on average 15.1m above ground) at the same tree (Fig.2). This set of traps allows analysis of arthropod communities within each vertical stratum (surface, trunk and canopy) as well as analysis of migration between strata. All traps are active during the whole season from end of March to end of October. Copper sulphate solution (3% w/v) is used as conservation fluid and traps were emptied monthly. Thus, samples represent activity densities of the coenoses throughout the vegetation period.

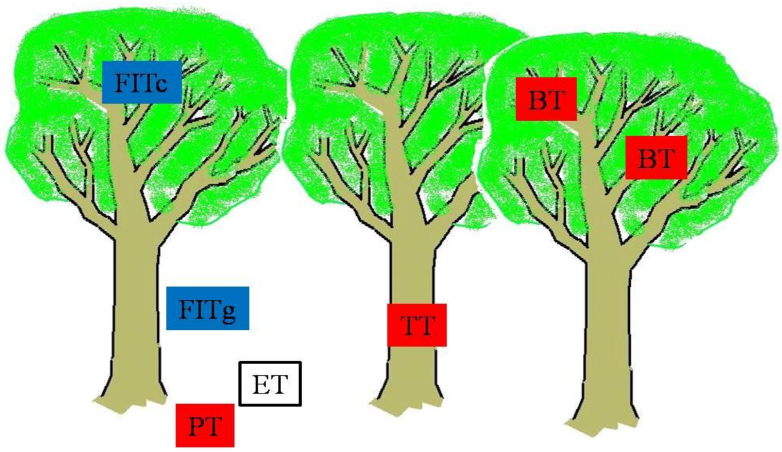

Figure 2. *Experimental design: pitfall trap (PT), emergence trap (ET), trunk trap (TT), flight interception trap ground (FITg), flight interception trap crown (FITc) and branch trap (BT).*

3 Preliminary results 2007

Since changes in flooding dynamics were expected to begin in 2010, we started assessment of beetle communities in 2007. Thus we are able to establish base line data for at least three years. Up to now (February 2010) samples obtained were sorted to order level. In total, 99,661 specimens of arthropods (excl. Collembola) were captured in 2007. Here we present data on the vertical distribution of beetles within arthropod communities pooled over all plots and habitat classes (Tab.1). In total beetles were one of the dominant arthropod taxa (12,612 specimens = 12.6 %; total rank sum: 35). Regardless of whether surface active (Fig.3; $H = 47.06$; $p<0.01$, Kruskal-Wallis-Test) or flight active (Fig.4; $Z = -3.35$; $p<0.01$, Mann-Whitney-Test), percentage of beetles is significantly higher on or near the forest floor than in higher strata.

Table 1. *Percentage of ten most common arthropod taxa per trap system and evaluated rank numbers (0-10). Rank numbers in sum for surface (PT, TT, BT) and flight (FITg, FITc) actives and total rank sum. Highest rank sum in total for Coleoptera and Araneae.*

	PT		TT		BT		FITg		FITc		rank sum of surface actives	rank sum of flight actives	rank sum total
	%	rank	%	rank	%	rank	%	rank	%	rank			
Coleoptera	26.8	10	4.9	4	4.0	4	17.6	9	10.3	8	18	17	35
Araneae	12.2	8	21.3	10	40.2	10	4.1	3	4.0	4	28	7	35
Nematocera		0	9.0	8	7.1	6	21.0	10	15.3	9	14	19	33
Brachycera	6.0	5		0	10.4	8	12.7	7	35.6	10	13	17	30
Apocrita	6.4	6	3.9	2	11.9	9	5.0	5	7.6	7	17	12	29
Formicidae	10.4	7	15.6	9	7.1	7	4.9	4		0	23	4	27
Heteroptera		0	6.5	7	1.6	1	5.7	6	5.7	5	8	11	19
Acarina	14.6	9	4.1	3		0	4.0	2		0	12	2	14
Thysanoptera		0		0		0	12.9	8	5.7	6	0	14	14
Isopoda	5.6	4	5.5	5	1.8	2		0		0	11	0	11
Larvae	4.3	3	3.5	1	4.3	5	2.8	1	2.0	1	9	2	11
Cicadina		0		6		0		0		0	6	0	6
Trichoptera		0		0	2.9	3		0	2.5	2	3	2	5
Lepidoptera		0		0		0		0	2.7	3	0	3	3
Chilopoda	2.9	2		0		0		0		0	2	0	2
Diplopoda	2.9	1		0		0		0		0	1	0	1

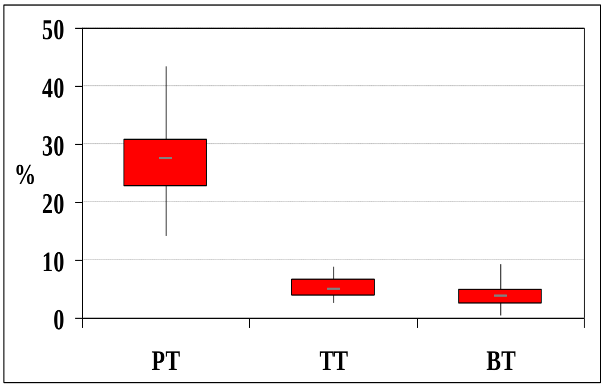

Figure 3. *Percentage of beetles from surface active traps decreased with increasing height*

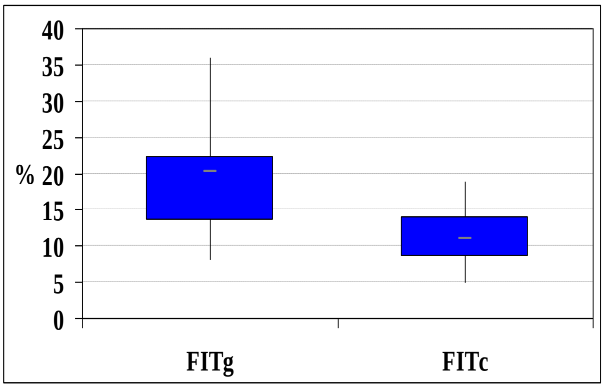

Figure 4. *Percentage of beetles from flight active traps is higher close to the forest floor than in canopy*

4 Outlook

Effects on beetle communities during hydrological restoration of the floodplain will be evaluated in short- (2010, 2011) and long-term (2015, 2016) periods. The alteration of communities will be studied for defined habitat classes, vertical stratification and mode of locomotion (surface- or flight active). We will test following three null hypotheses (H1-3): H1) Restoration of floodplain dynamics causes changes in beetle communities of all habitat classes. We expect an increase of species adapted to moisture in the two most affected habitat classes (near new permanent watercourse, flooded up to four times a year). Occurrence of species preferring dry stands will decrease in these habitat classes, but not in drier ones. H2) Changes do not depend on vertical distribution, and beetle communities near ground or on forest floor respond in the same way as communities in canopy. We assume that beetle communities on forest floor respond stronger than communities in the canopy on hydrological changes. Communities of the upper vertical stratum (tree crown) are not directly affected and changes will be hardly detectable. H3) Communities of surface active and flight active beetle species are influenced in the same way. Flight active species have a better chance to survive flooding by changing strata or leaving the area. Surface active beetles will have less chance to leave flooded areas and need more time to reintroduce. Therefore adaptation on periodical flooding within the community of surface active beetles will occur earlier and to a larger extend. At present, baseline data on order level are available from the year 2007 only, and species level data of beetles from 2007 to 2009 will be ascertained late 2010.

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