Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 755 - 760

Vertical stratification of xylobiontic beetles in floodplain forests of the Donau-Auen National Park and potential effects of box elder control measures

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Abstract

Xylobiontic beetles represent a substantial fraction of the biodiversity of forest ecosystems and are useful bioindicators for evaluating effects of forest management measures. This study conducted in the Donau-Auen National Park (Lower Austria) sampled xylobiontic beetles in one of the largest remaining floodplain forests in Central Europe. Besides using a standardized method of inventorying the fauna of xylobiontic beetles in two forest strata (understory and canopy layer), we studied how the community of dead wood feeding beetles responds to an abrupt increase of dead wood volume due to measures to control the neophytic Box Elder *Acer negundo*. Therefore, flight interception traps were installed at twelve sites where measures to control the neophytic box elder had previously been taken, as well as at twelve reference sites without removal of box elder trees. At each site one trap was placed in the understorey and one in the canopy. So far, approximately 1/3 of the sampled beetle are sorted and identified to species level. In total 242 species of xylobiontic beetles (of 42 families) were recorded. Species composition of xylobiontic beetles differed significantly between vegetation strata. However, our data does not indicate any effect of box elder control measures on species richness and species composition. Three different factors may account for this observation. (1) The time lag was too short for xylobiontic beetles, even for species feeding on fresh dead wood, to respond to the increased availability of dead wood. (2) Dead wood of the neophytic Box Elder represents a resource of low quality for a large fraction of the native xylobiontic beetles. (3) The sample size was too small to detect effects of box elder removal.

Keywords

Dead wood, floodplain ecosystem, functional groups, neophyte, xylobiontic Coleoptera, vertical stratification

Introduction

The floodplain system along the Danube river between Vienna and the Slovakian border represents one of the largest remaining semi-natural alluvial landscapes in Central Europe (Tockner et al. 1998). The region's floodplain forests are characterized by a high biodiversity and are therefore considered as areas of major conservation concern. Floodplain forests typically contain a high amount of dead wood representing an important microhabitat for xylobiontic insects (Gentry & Whitford 1982; Polit & Brown 1996). Studies from other regions in Central Europe have reported a particularly high diversity of xylobiontic beetle in this forest type (e.g. Bense et al. 2000; Bail 2007).

In this study we sampled xylobiontic beetles in the understory and canopy of a floodplain forest in the Donau-Auen National Park, Eastern Austria. Our study provides a first estimate of the species richness of this ecologically important group for the national park. Besides collecting beetles in two different vegetation strata, we studied effect of measures aiming to control the box elder (*Acer negundo*). The box elder represents a neophyte which already contributes significantly to the vegetation cover of floodplain forests in our study area (Walter et al. 2005). Consequently, management measures (girdling, felling) aiming to control this neophyte produce a significant amount of additional dead wood.

In particular, our study addressed the following questions:

(1.) How does the community of xylobiontic beetles differ between understorey and canopy in floodplain forests of the Donau-Auen National Park? Studies from tropical forests reported a distinct vertical stratification in forest insect assemblages (e.g. Schulze et al. 2001), including beetles (e.g. Charles & Basset 2005, Stork & Grimbacher 2006, Davis et al. 2011, Bouget et al. 2011). We expect that xylobiontic beetles are more abundant and show a higher species richness at lower vegetation levels due to their naturally higher amount of available dead wood.

(2.) How do box elder control measures affect xylobiontic beetles? We expect that the abundance of xylobiontic beetles is higher at forest sites were such measures (girdling and felling of box elder trees) have been implemented due to an increased amount of dead wood. Because the sampling was conducted just after the control measures were applied, we expect that particularly beetles feeding on fresh dead wood will benefit.

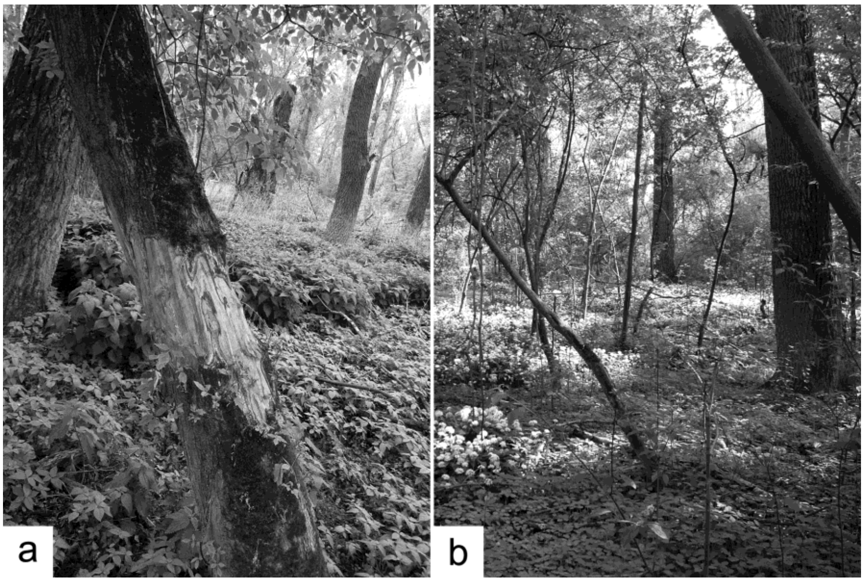

Figure 1: Floodplain forest sites at the eastern part of the Donau-Auen National Park (a) with and (b) without box elder removal (box elder stem in front damaged due to girdling).

Methods

Study area

The study was conducted in the Donau-Auen National Park in Lower Austria, south-east of Vienna in the area "Stopfenreuther Au". The average slope of the Danube is 0.04% and the average discharge in the area of the national park is 1500-1900m^3 s^{-1} (Nationalpark Donau-Auen 2013). The mean annual temperature of the study area is 9.5°C and the mean annual precipitation is 525 $l \cdot m^{-2}$ (averages of years 1971-2000; ZAMG 2013). Our study area was located in the regularly flooded part of the forest (dominated by *Populus*, *Salix* and *Alnus* trees). Assemblages of xylobiontic beetles were compared between forest sites where management measures had been applied to control box elder (AC sites) and forest sites which remained unaffected (R sites) (Figure 1). A total of twelve replicate sites per forest type were selected. All sampling sites were located between E 016°54'31" and E016°56'12" and N 48°09'03" and N48°09'38". The minimum distance between two sampling sites was 200 m. So far samples were sorted and analyzed for the 4 AC and 4 R sites indicated in Figure 2.

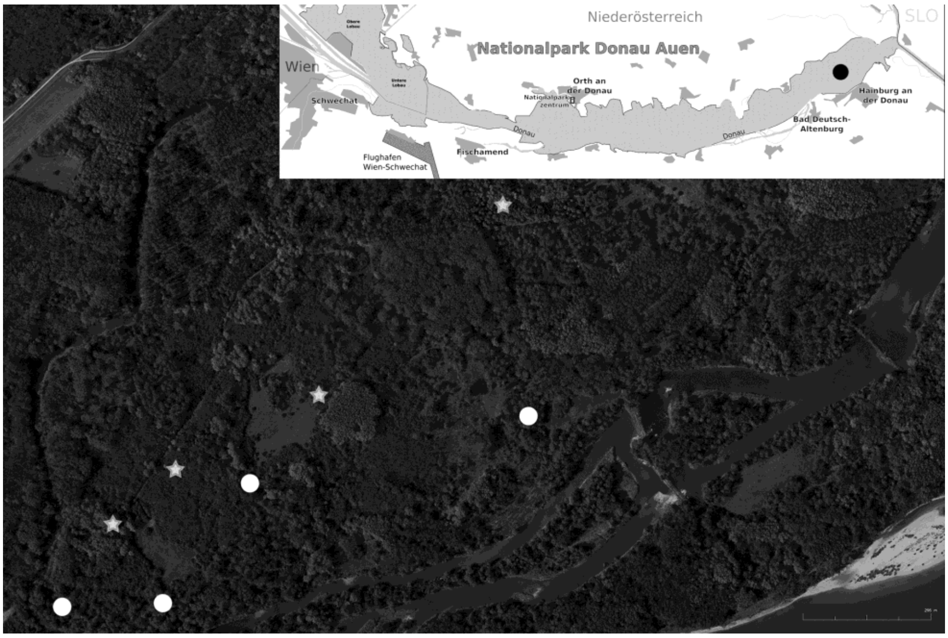

Figure 2: Map of study area indicating sampled with (white circles) and without Box Elder control measures (grey stars). The black spot marks of the study area in the Donau-Auen National Park.

Sampling and identification of beetles

At each study site beetles were sampled with two flight interception traps (e.g. BAIL 2007; see also Fig. 3), one placed in the understorey (at ca. 1.5 m height) and one in the canopy (height: 10 to 15 m). The traps were controlled every 2 to 3 weeks between May and September 2012 resulting in a total of 8 samples per trap. Beetles were identified to species level according to FREUDE et al. (1964-83). Classification of xylobiontic beetles in substrate-guilds was done according to SCHMIDL & BUSSLER (2004).

Figure 3: Flight interception trap used to sample xylobiontic beetles in understory and canopy of floodplain forest.

Data analysis

Species accumulation curves and estimates of total species richness were calculated for the total sample of xylobiontic beetles using the software EstimateS vers. 9 (COLWELL 2013). Samples of individual traps from one sampling round represent the sampling units. Furthermore, abundance-based species accumulation curves (± 95 % CI) were calculated with the software Past (HAMMER et al. 2001) for xylobiontic beetles sampled in canopy and understorey layer by pooling all canopy and understorey sites, respectively, To evaluate the effect of box elder control measures on species richness, abundance-based species accumulation curves (± 95 % CI) were also calculated separately for forest sites with and without applied control measures (by pooling canopy and understorey sites). To test for effects of forest type (AC vs. R sites) and vegetation stratum (canopy vs. understorey) on the total abundance of xylobiontic beetles caught per trap and the relative abundance of beetles feeding on fresh dead wood, a two-way ANOVA was calculated with the software Statistica 7.1 (StatSoft, Inc. 2005).

Bray-Curtis similarities were calculated (using √x transformed abundances) for all combination of traps to evaluate effects of forest stratum and box elder control measures on species composition of xylobiontic beetles. Subsequently, similarity relationships were visualized with a non-metric multidimensional scaling scaling (NMDS) ordination. An associated stress value of <0.20 was considered as reliably displaying the similarity relationships in the resulting two-dimensional ordination (CLARKE 1993). Analyses of similarity (ANOSIMs; with 999 permutations) were calculated with the program Primer v5 (CLARKE & GORLEY 2001) to test for differences in xylobiontic beetle composition between forest types (AC vs. R sites) and vegetation strata (understory vs. canopy).

Results

Abundance and species richness

So far 5,531 of the beetles caught with the flight interception traps were examined (about a third of the whole dataset). These individuals could be assigned to 398 species in 51 families. The majority of beetles were xylobiontic species. They represented 242 species (42 families) and 82% of all trapped beetles. The calculated species accumulation curve for the total sample of xylobiontic beetles indicates a still very incomplete species inventory. The total richness of beetles feeding on deed wood predicted by the richness estimator Chao2 is nearly 400 species (Fig. 4).

The total abundance of xylobiontic beetles per trap did not differ between forest types (AC vs. R sites) and vegetation strata (canopy vs. understorey) (two-way ANOVA: $r_{\text{multiple}} = 0.37$, $F_{2,13} = 1.03$, $p = 0.386$). As indicated by the respective species accumulation curves, species richness was similar between R and AC sites (Fig. 5a) as well as between both forest strata (Fig 5b).

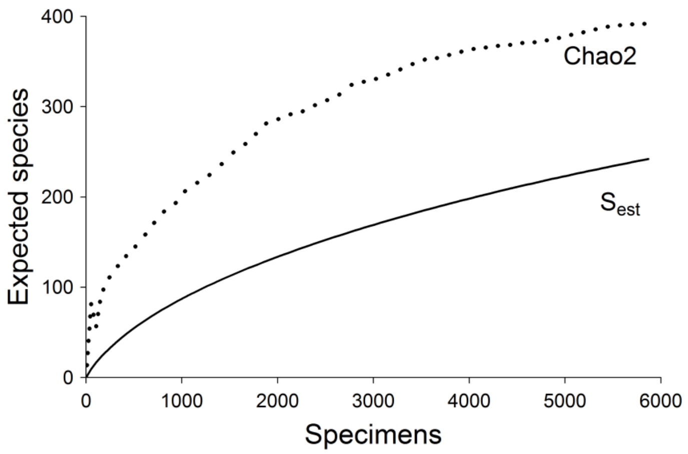

Figure 4: Species accumulation curve for the fauna of xylobiontic beetles collected by 8 understory and 8 canopy traps in floodplain forests of Donau-Auen National Park.

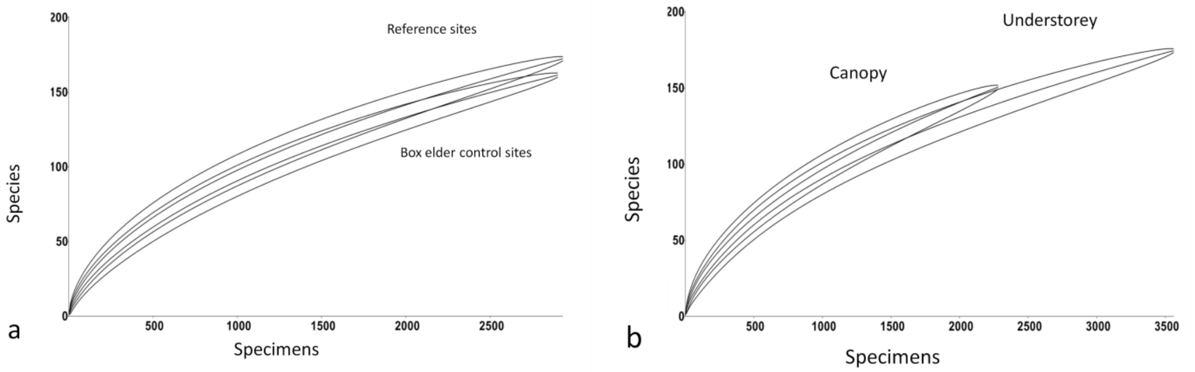

Figure 5: Species accumulation curves for xylobiontic beetles collected at (a) R and AC sites and (b) in understory and canopy.

Species composition

The NMDS ordination (based on Bray-Curtis similarities) visualizing similarity relationships between beetle assemblages sampled by flight interception traps does not indicate an obvious effect of box elder control on species composition. However, a weak difference apparently exists between understory and canopy traps, which are plotted predominantly in the right and left half of the NMDS plot, respectively. Indeed, the calculated one-way ANOSIM indicated a significant effect of vegetation stratum on species composition (global $R = 0.257$, $p = 0.001$).

Functional groups

A two-way ANOVA testing for effects of vegetation stratum (understory vs. canopy) and forest type (AC vs. R sites) on the relative abundance of xylobiontic beetles colonizing fresh dead wood did not indicate any significant effect (Stratum: $F_1 = 0.55$, $p = 0.473$; forest type: $F_1 = 2.05$, $p = 0.175$).

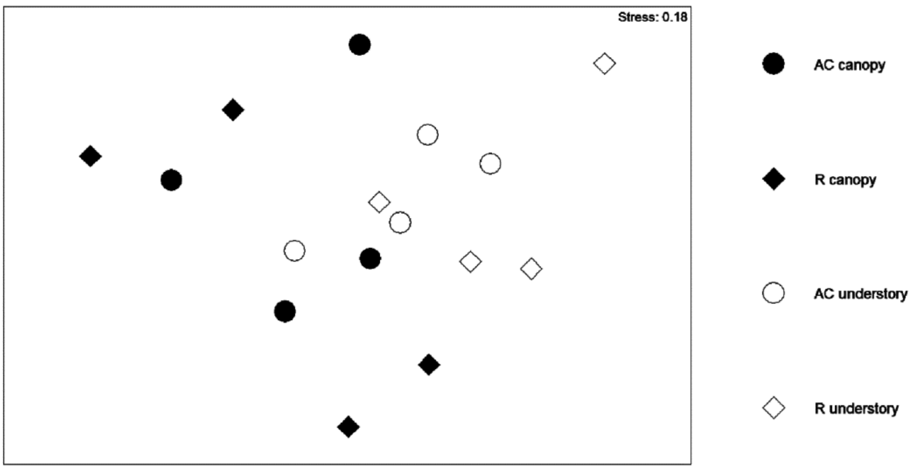

Figure 6: Similarity relationships between xylobiontic beetle assemblages collected with flight interception traps at canopy and understorey layer of sites affected by box elder control measures (AC) and sites without any forest management measures (R). Similarities quantified as Bray-Curtis index values (calculated using √x transformed abundances) are visualized by a non-metric multidimensional scaling ordination.

Discussion

In comparison to other studies on xylobiontic beetles in Central European floodplain ecosystems, our results from a floodplain forest in Donau-Auen National Park indicate an exceptionally high richness of this beetle group with so far nearly 250 recorded species. At other floodplain forest areas in Central Europe only up to <140 species were recorded although not only flight interception traps but also canopy fogging and manual collecting were used to sample xylobiontic beetles (compare Table 5.1-2 in Bail 2007). To our knowledge, in Europe similar or even slightly higher species numbers of xylobiontic beetles were only found in other forest types, e.g. in a deciduous forests with a high proportion of oaks in Northern France (280 species; Bouget et al. 2012). However, calculated species accumulation curves and the Chao 2 richness estimator both indicate an even higher richness of xylobiontic beetles in our study area; a total of ca. 400 species was estimated by the Chao 2 extrapolation method.

So far vertical stratification of beetles in temporal forests was rarely considered as factor structuring beetle communities on a local scale. In general, vertical stratification is common in forest arthropods due to strongly differing habitat conditions in understory and canopy layer (Ulyshen 2011). Our study found partly distinct assemblages of xylobiontic beetles in understory and canopy of the sampled floodplain forest. However, in contrast to studies from other forest types (e.g. Bouget et al. 2011), neither species richness nor abundance of beetles showed any significant differences between vegetation layers.

Ulyshen et al. (2010) found that the removal of an invasive shrub from a floodplain forest in Georgia (USA) had far reaching consequences on richness and species composition of beetles. Remarkably, we did not find any effect of box elder control measures in our study area. Perhaps the time lag (less than 1 year) between the control measures and the sampling was too short for xylobiontic beetles (even for species feeding on fresh dead wood) to respond to the abrupt increase of dead wood volume. Furthermore, the neophyte could represent a less suitable resource for xylobiontic beetles than autochthonous relatives of the same genus, as previously shown for beetle assemblages in a floodplain forest in Germany (Schmidt et al. 2007). It remains to be seen if effects of box elder removal on beetle assemblages can be detected when a larger dataset will be available for analysis.

Conclusions

Arthropods depending on dead wood constitute an exceptionally diverse ecological group. Unfortunately, they also belong to one of the most rapidly declining groups in Europe (Nieto & Alexander 2010). The high species richness already documented by our preliminary data underlines the conservation value of floodplain forests in the Donau-Auen National Park. In fact, our data indicates that the floodplain forests east of Vienna may have the highest richness of xylobiontic beetles so far recorded in any Central European floodplain forest area. Therefore, further studies on the ecology of this ecologically important group are urgently needed, for example, to evaluate the potentially negative effects of neophyte tree species (such as Box Elder) on the beetle fauna associated with dead wood.

Acknowledgements

We want to thank the Nationalpark Donau-Auen 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. Thanks also to Perica Brodaric who constructed and build the used flight interception traps.

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