The response of ground beetles to passive restoration of a mountain river

Comment les carabes réagissent à la restauration d'une rivière de montagne

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RÉSUMÉ

Dans la rivière Raba dans les Carpates polonaises, les effets de l'arrêt de l'entretien du chenal a été étudié en observant les population de carabes (Coleoptera: Carabidae) et en les comparant des 6 sections de rivières entretenues et 6 sections laissées libres. Dans les tronçons qui ne sont plus entretenus, la largeur de la rivière a triplé en certains endroits en l'espace de quelques années. Près de 4000 individus de 78 espèces différentes ont été échantillonnés au cours du printemps, de l'été et de l'automne 2015. Les échantillons les plus abondants et les plus riches en espèces ont été récoltés dans les sections non entretenues. Les indices de diversité sont cependant assez semblables dans les deux types de section parce que l'établissement de communautés stables dans les secteurs restaurés demande une durée plus grande.

ABSTRACT

The effects of a recovery of the Raba River, Polish Carpathians, after cessation of the maintenance of its channelization scheme on ground beetle (Coleoptera: Carabidae) assemblages of exposed riverine sediments were studied by comparing 6 unmanaged cross-sections and 6 cross-sections from adjacent channelized reaches. Within a few years after abandonment of its channelization scheme, the river increased its width up to three times. In total, 3992 individuals from 78 taxa were collected from all cross-sections during three sampling occasions (spring, summer and autumn) in 2015. The ground beetle assemblages were significantly more abundant and richer in species in the unmanaged than in the channelized cross-sections. However, no significant differences in carabid diversity indices were found between the two cross-section types of the Raba. The results indicated that increased availability of exposed sediments in the widened river reaches favoured an increase in number of individuals and species richness within a few years after the onset of river restoration, but more time may be needed for establishing more diverse beetle communities in the restored reaches.

KEYWORDS

Carabids, community structure, flood, species diversity, riparian habitats

1 INTRODUCTION

Flood events are one of the main driving forces for the passive river restoration enabling and supporting dynamic processes in the riverbed, which can lead to highly heterogeneous spatial patterns and valuable river ecosystems within a few years after the implementation of the restoration measure (Groll, 2017). Although some studies on the effects of flood-induced habitat changes on ground beetles were done for lowland rivers (e.g., Gerisch et al., 2012), similar studies in mountain rivers are still rare. In the years 2005–2010, abandonment of maintenance of bank reinforcements in the upper Raba, Polish Carpathians, enabled recovery of the river promoted by the passage of two moderately large floods – one in 2010 and the second in 2014. This gave us an opportunity to fill the gap in the knowledge on the effects of passive river restoration on ground beetle assemblages. To do this, in 2015 physical habitats and ground beetle communities in the restored reaches of the upper Raba were investigated and compared with those in the nearby channelized reaches.

2 METHODS

2.1. Study design

The study was carried out in an 11-km-long section of the upper Raba (southern Poland) consisting of two wider, unmanaged reaches and two narrow, channelized reaches. In the section, 12 cross-sections were investigated, with 6 of these cross-sections located in the unmanaged reaches and 6 in the channelized reaches. In each cross-section, 12 sampling sites of 1 m^2 each were selected at various elevations above the low-flow water level and at various distances from the low-flow channels to cover the whole range of microhabitats.

2.2. Environmental variables

Altogether, 8 habitat parameters characterizing the cross-sections and sampling sites were determined. The width of active channel/river zone, the number of low-flow channels and the number of eroding cutbanks were determined for each cross-section and the surface slope, the distance from and the height above the nearest low-flow channel, sediment size class and the degree of plant cover were established for each sampling site.

2.3. Ground beetle sampling

Adult ground beetles were sampled within each of the twelve 1 m^2 sampling sites at each study cross-section during low-flow conditions in spring (mid-May), summer (turn of June and July) and autumn (turn of September and October) of 2015. The beetles were sampled using motor driven suction apparatus and by hand-picking. The collected beetles were preserved in ethanol, sorted and kept at 4 °C until they were identified to the species level with use of the keys of Hurka (1996).

3 RESULTS

Within a few years after abandonment of the Raba River channelization scheme, the width of this gravel-bed river increased up to three times and its multi-thread pattern became re-established. Consequently, unmanaged river cross-sections had significantly larger channel width and more low-flow channels and eroding cutbanks than channelized cross-sections ($p \leq 0.002$). Moreover, sampling sites in the unmanaged cross-sections were typified by significantly steeper average surface slope and larger average distance from low-flow channels than the sites in channelized cross-sections ($p \leq 0.04$).

Unmanaged cross-sections were richer in beetle species than channelized cross-sections as they supported from 23 to 41 species (mean 31.2), whereas 16 to 30 species (mean 21.8) were found in channelized cross-sections (Mann–Whitney test, $p = 0.037$) (Fig. 1). The number of individuals was also significantly higher ($p = 0.013$) in the unmanaged cross-sections (mean 465) than in the channelized cross-sections (mean 199, Fig. 1). However, none of three diversity indices (Berger–Parker, Margalef and Shannon–Wiener) differed between the two cross-section types (Fig. 1).

Overall, 40 species, and 87% of all individuals, were characteristic of exposed riverine sediments subjected to frequent inundation (i.e., small-sized species with high dispersal power and spring breeding). Unmanaged cross-sections were significantly richer in the species combining these life traits than channelized cross-sections ($p = 0.005$), and they also supported a greater number of individuals belonging to these species ($p = 0.03$). Nevertheless, nestedness analysis did not indicate any distinct trend in the taxonomic composition of beetle assemblages along the study section –

particular species were recorded both in unmanaged and channelized cross-sections.

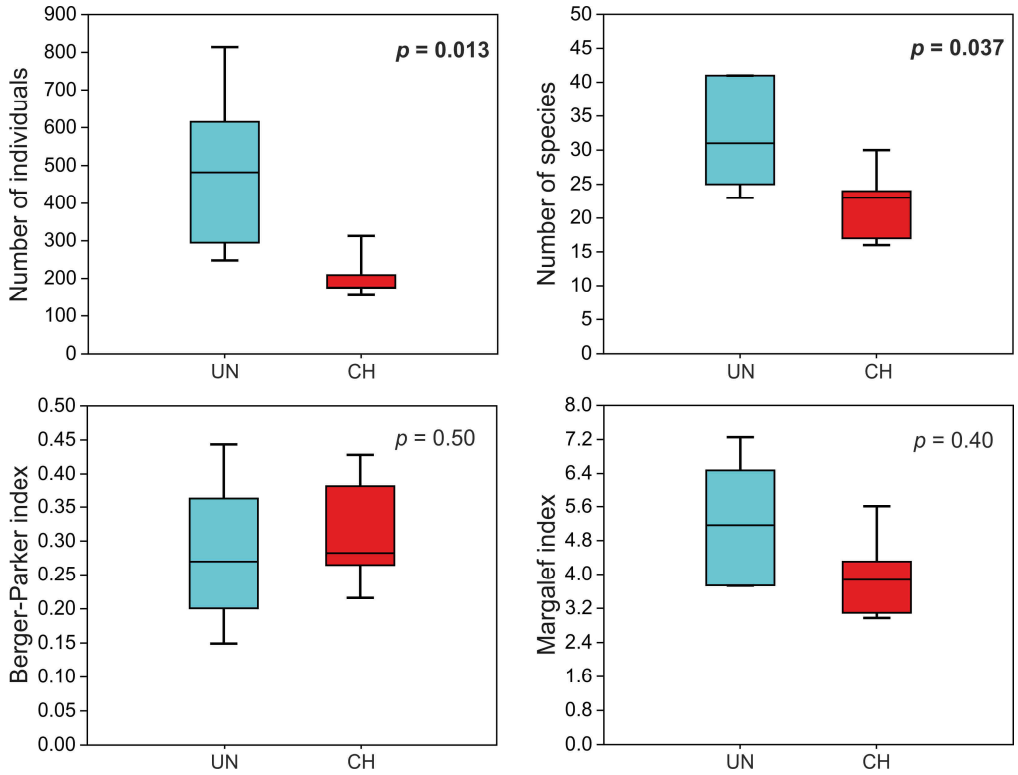

Figure 1. Box-and-whisker plots and the results of the Mann-Whitney test for the significance of differences between unmanaged (UN) and channelized (CH) cross-sections in the number of individuals, the number of species, and the Berger-Parker and Margalef indices of ground beetle assemblages of the Raba River. The line inside the boxes is the median, the bottom and top of the boxes indicate the first and the third quartiles, respectively, and whiskers show minimum and maximum values.

4 CONCLUSIONS

The recovery of the Raba River has been largely an effect of the disturbance caused by two moderately large floods that destroyed bank reinforcements and were the main driving force of the development of habitat diversity. As a result, the composition, size, availability and position of habitat patches providing important resources for ground beetles have changed. These changes had positive effects on ground beetle communities as we observed significantly greater species richness and abundance of beetles in unmanaged than in channelized cross-sections. However, the 5-year period after the first large flood was insufficient to enable the formation of a high environmental heterogeneity that would offer a high variety of microhabitats. Instead, what we observed was rather characteristic of the early stage of riparian habitat diversification, including vegetation succession. The early stage of habitat diversification was clearly reflected in the lack of significant differences in biodiversity indices between the two cross-section types.

This study was completed within the scope of the restoration project KIK/37 ‘The Upper Raba River Spawning Grounds’ supported by a grant from Switzerland through the Swiss Contribution to the Enlarged European Union.

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