

THE RESPONSE OF GROUND BEETLES TO PASSIVE RESTORATION OF A MOUNTAIN RIVER

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



INTRODUCTION 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 in 2010 and 2014. This gave us an opportunity to study the effects of passive river restoration on ground beetle assemblages. In 2015 physical habitats and ground beetles in the restored reaches of the upper Raba were investigated and compared with those in the nearby channelized reaches.

BEETLE SAMPLING Beetles were sampled within each of the twelve 1 m² sampling sites at each study cross-section during low-flow conditions in spring, summer and autumn of 2015 using motor-driven suction apparatus and by hand-picking. The beetles collected in a given cross-section were combined into one sample and described with the number of collected species, the number of individuals, the Margalef richness index, the Berger-Parker dominance index and the Shannon–Wiener diversity index.

GROUND BEETLE ASSEMBLAGES UN cross-sections were richer in beetle species than CH cross-sections as they supported from 23 to 41 species (mean 31.2), whereas 16 to 30 species (mean 21.8) were found in CH cross-sections ($p = 0.037$) (Fig. 2). The number of individuals was also significantly higher ($p = 0.013$) in UN (mean 465) than in CH (mean 199) cross-sections. None of diversity indices differed between the cross-section types (Fig. 2). Among 78 species, the most numerous were *B. decorum*, *B. varicolor*, *B. cruciatum* sp. and *B. testaceum* and three of them were significantly more abundant in UN cross-sections (Fig. 3).

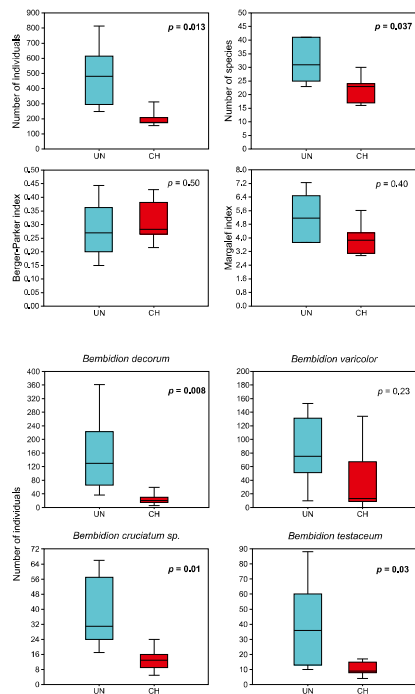


Fig. 2. Box-and-whisker plots and the results of the Mann-Whitney test for the significance of differences between UN and CH cross-sections. The line inside the boxes is the median, the bottom and top of the boxes indicate the first and the third quartiles, respectively, and whiskers show minimum and maximum values.

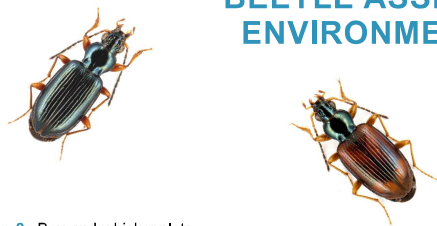


Fig. 3. Box-and-whisker plots and the results of the Mann-Whitney test for the significance of differences between UN and CH cross-sections for four most abundant species in ground beetle assemblages.

CONCLUSIONS 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.

STUDY DESIGN Six unmanaged (UN) cross-sections and six channelized (CH) cross-sections were surveyed (Fig. 1). In each cross-section, 12 sampling sites of 1 m² each were selected to cover the whole range of microhabitats. The width of active 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, substrate size class and the degree of plant cover were established for each sampling site.

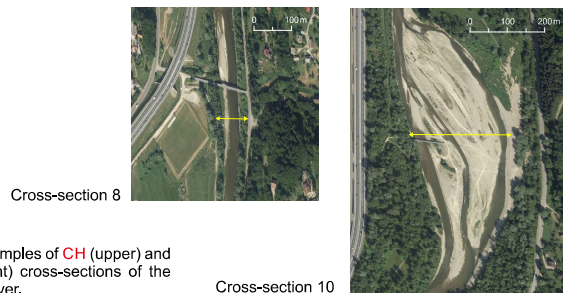


Fig. 1. Examples of CH (upper) and UN (right) cross-sections of the Raba River.

RIVERINE HABITATS Principal component analysis showed the presence of three main gradients of environmental variables among the study cross-sections (Fig. 4B).

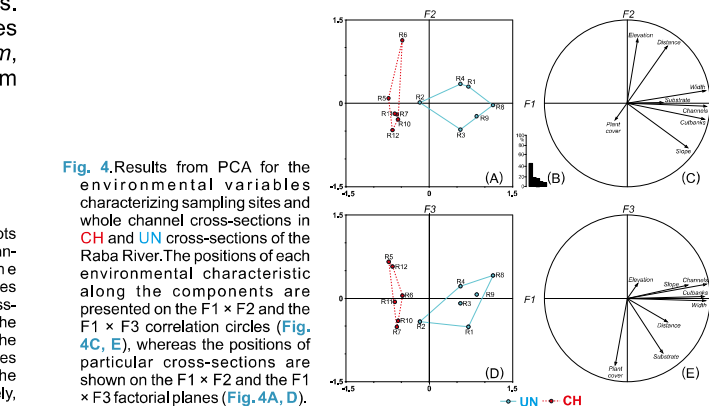


Fig. 4. Results from PCA for the environmental variables characterizing sampling sites and whole channel cross-sections in CH and UN cross-sections of the Raba River. The positions of each environmental characteristic along the components are presented on the F1 × F2 and the F1 × F3 correlation circles (Fig. 4C, E), whereas the positions of particular cross-sections are shown on the F1 × F2 and the F1 × F3 factorial planes (Fig. 4A, D).

BEETLE ASSEMBLAGES IN RELATION TO ENVIRONMENTAL VARIABLES

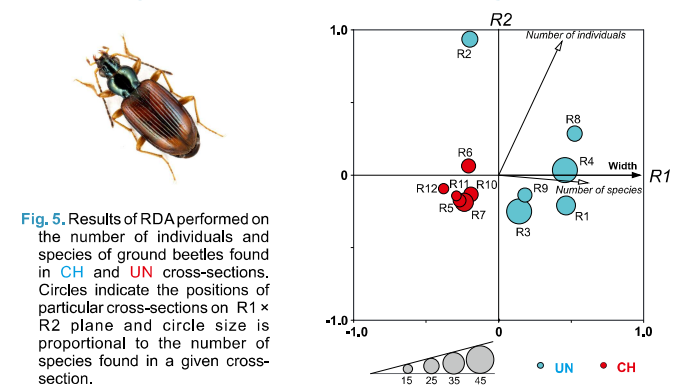


Fig. 5. Results of RDA performed on the number of individuals and species of ground beetles found in CH and UN cross-sections. Circles indicate the positions of particular cross-sections on R1 × R2 plane and circle size is proportional to the number of species found in a given cross-section.

A stepwise forward selection of the environmental variables in the redundancy analysis indicated active river zone width as the only significant variable ($p = 0.03$) explaining the variation in numbers of beetle species and individuals among the cross-sections (Fig. 5).

