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Effect of anthropogenic transformations of mountain stream habitats on the structure of macrozoobenthos and ichthyofauna

The research was conducted in the Kamionka and Turnica Streams. The Kamionka Stream is a tributary of Turnica, and flows through the area of Pogórze Przemyskie. The forest cover of the catchment is very high, and the area is subject to forest management. In the 1970's, the Kamionka Stream channel was transformed by building anti-rubble barriers and round concrete culverts. With time, downstream the culverts, erosional waterfalls have formed, and the structures have become barriers for fish moving upstream. The bottom substrate in the upper course of Kamionka was largely fine-grained, in up to 40% composed of sand and gravel supplied as a result of erosion from exploited forests. In 2012 in the Bircza Forest District operating in the Kamionka catchment area, a project was implemented for an increase in water retention in mountain areas. It involved the renaturalisation of the Kamionka Stream channel. Barriers were removed, erosional waterfalls were transformed into boulder ramps, and the round culverts were replaced with arched structures with high capacity. The study objective was the assessment of the response of aquatic fauna to anthropogenic transformations of habitat parameters in a mountain stream. It was assumed that the obtained results will permit the development of models of response of fish and invertebrates inhabiting lotic systems to the removal of transverse barriers and reconstruction of habitats. The research was conducted in two periods, i.e., before the renaturalisation of the stream (2009), and after the renaturalisation (2014-2021). At each site, hydromorphological parameters of the channel and physical and chemical water properties were measured. In each year of the study, fish were captured at the designated sites by means of a back-pack unit for electrofishing, and after dusk all animals were released at the place of their capturing. Macrozoobenthos was sampled at all sites in 2009, 2014, and 2019, three times in each year of the study (in spring, summer, and autumn). Moreover, in research season 2017/2018, in each season of the year, benthos samples were collected in microhabitats, with detailed description of each of them. Statistical analyses of results were performed by means of multivariate analyses such as: permutational multivariate analysis of variance (PERMANOVA), principal component analysis (PCA), principal

coordinates analysis (PCO), or redundancy analysis (RDA). Key consequences for the functioning of the fish fauna of the Kamionka Stream resulted from the effect of a barrier with a height of more than 1 m, approximately 0.5 km from the mouth of the stream, that blocked movement of fish and contributed to their disappearance above. After removal of migratory barriers and undertaking activities aimed at the reconstruction of the stream bottom and habitats, natural recolonisation mechanisms were launched, and fish communities began to restore. After the renaturalisation, four species occurred in the Kamionka Stream: Siberian sculpin (*Cottus poecilopus*), brown trout (*Salmo trutta m. fario*), common minnow (*Phoxinus phoxinus*), and Carpathian barbel (*Barbus carpathicus*). The restored channel sections, i.e. sequences of anthropogenic rapids with concreted boulders and pools, offered favourable habitats for fish, providing both hiding places, including seasonal refugia, and spawning grounds and places for fry growth. The renaturalisation works in the stream also contributed to the variability of macrozoobenthos. Factors considerably affecting the structure of the benthic invertebrate community included: the character of substrate, including the presence of boulders cemented into the bottom, and presence of organic matter on the bottom. The analysis of microhabitats showed among others that oligochaetes and some chironomids were positively correlated with the presence of fine-grained sediment on the bottom. Organic matter was correlated with the occurrence of among others caddisflies Sericostomatidae, mayflies *Ephemera*, and alderflies *Sialis*. Concreted boulders were correlated the strongest with beetles Elmidae or mayflies Baetidae. It was evidenced that if the bottom of a stream was transformed as a result of introduction of hydrotechnical infrastructure reconstructed with the application of appropriately selected renaturalisation techniques, the aquatic invertebrate fauna inhabiting the area can be abundant and diverse – in both taxonomic and functional terms. The effect of small objects on mountain channels, i.e. low anti-rubble barriers or culverts, is still a weakly investigated problem. The conducted research expands knowledge concerning this issue, presenting the response of fish and invertebrate communities to the renaturalisation of channels of mountain streams. Current legal regulations (among others the Framework Water Directive) specify new requirements in the scope of acceptable degree of interference in channels of rivers and streams. Therefore, renaturalisation measures are increasingly frequently applied, aimed at the restoration of the ecological continuity of the stream and restoration of the habitat mosaic approximate to the natural conditions.