Submitted Abstract

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Abstract

Global warming intensifies environmental change in high-altitude ecosystems worldwide, with rising air temperature among the main stressors. While past research in Alpine river ecology has primarily focused on how retreating glaciers might affect the ecology of glacier-fed streams on the long-run and mostly used space-for-time substituted study designs, observations of real-time alterations in such pristine environments are scarce.

This study presents observations of stream temperature and invertebrate communities in 18 sites in 14 different streams with distinct water sources (glacial and non-glacial) and found that all studied alpine streams are warming consistently and at high rates, linked to size of the rivers. Using benthic datasets from these streams over several years (2011, 2014, and 2015), this study is the first to demonstrate real-time shifting community metrics, and group-specific changes in relative and absolute abundance within the invertebrates. Further, this work demonstrates partial discrepancies between results derived from space-for-time substitutions and real-time observations of these communities.

This study identifies that the rate of recently reported fast warming of alpine rivers during summer highly depends on the size of rivers with smaller rivers showing maximum rates beyond 7°C decade-1. Besides this, we revealed that cold-adapted invertebrate species (i.e., Diamesinae) unexpectedly expand their dominance over the observed years, while other groups (e.g., Ephemeroptera, Plecoptera, Trichoptera) remained stable or increased only marginally. These observed changes, which remain hidden in space-for-time substituted study designs, therefore demonstrate that milder conditions during summer generally alter benthic habitat conditions and population densities, but that group-specific adaptations lead to differently strong responses to these changes.

The observation of this coherent warming of all investigated streams makes clear that this is a general pattern and will affect lowland and high-order streams as the atmospheric warming continues and accelerates in the near future. In particular, however, it is the aquatic communities in smaller rivers that will experience the greatest summer warming and consequential changes within the next years.