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# Vulnerability of alpine stream biodiversity to shrinking glaciers and snowpacks

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Climate change poses a considerable threat to the biodiversity of high latitude and altitude ecosystems, with alpine regions across the world already showing responses to warming. However, despite probable hydrological change as alpine glaciers and snowpacks shrink, links between alpine stream biota and reduced meltwater input are virtually unknown.

Using data from the French Pyrénées, we demonstrate that taxonomic richness and total abundance of stream macroinvertebrates increase significantly as meltwater (snow- and glacier-melt) contributions to river flow decrease. Macroinvertebrate species showed a gradation of optimum meltwater conditions at which they persist. For example: *Habroleptoides berthelemyi* (Ephemeroptera), *Perla grandis* (Plecoptera) and *Rhithrogena* spp. (Ephemeroptera) increased in abundance when meltwater contributions to streamflow decrease, whereas in contrast, *Rhyacophila angelieri* (Trichoptera) and *Diamesa latitarsis* spp. (Diptera) decreased in abundance. Changes in alpine stream macroinvertebrate community composition as meltwater contributions decline were associated with lower suspended sediment concentration, and higher water temperature, electrical conductivity and pH.

Our results suggest $\alpha$ diversity (at a site) of streams presently fed by meltwaters will increase with future meltwater reductions. However, $\beta$ diversity (between-sites) will be reduced as snow- and glacier-melt decrease because the habitat heterogeneity associated with spatiotemporal variability of water source contributions will become lower as meltwater contributions decline. Extinction of some endemic alpine aquatic species (such as the Pyrenean caddis fly *R. angelieri*) is predicted with reduced meltwater

inputs, leading to decreases in $\gamma$ diversity (region).

Our identification of significant links between meltwater production and stream macroinvertebrate biodiversity has wider implications for the conservation of alpine river ecosystems under scenarios of climate change induced glacier and snowpack loss.