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Feeding plasticity of alpine stream chironomids: evidence from river monitoring in the Hohe Tauern NP

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Abstract

Glacier retreat provides striking evidence of environmental change in alpine streams. Overall effects on the invertebrate community structure are largely understood, but potential alterations in functional strategies are not. Here we show how the flexibility in feeding and food exploitation might explain the dominance of larvae within the chironomid genus *Diamesa* in glacial headwaters. Our results indicate that glacier retreat not only affects macroinvertebrate community structure but also favors species that are able to be flexible in terms of functional traits for living in harshest environmental conditions.

Keywords

Trophic ecology, glacial streams, Bayesian Mixing Modelling, stable isotopes, omnivory, trophic niche, niche breadth.

Introduction

Glaciers, the most significant water source for streams in the Alps, retreat because of human-induced warming (IPCC 2014). Consequently, the physical living conditions for stream biota in glacier-fed streams are changing (MILNER et al. 2009). The relationship of different environmental conditions and the structure and composition of benthic communities is largely understood (e.g., LENCIONI & ROSSARO 2005, ROTT et al. 2006, UEHLINGER et al. 2010, NIEDRIST & FÜREDER 2016) and even used to indicate environmental change (FÜREDER & SCHÖNER 2013, SCHÜTZ & FÜREDER 2013). Although changes of community structures can be expected under the progression of climate change and glacier retreat (ZEMP et al. 2009), the functional consequences for stream ecosystems are difficult to predict due to the inadequate understanding of the functions and services of stream biota (NIEDRIST & FÜREDER 2017). The main function of alpine stream invertebrates, their trophic performance, remained poorly studied for long time (but see ZAH et al. 2001, FÜREDER et al. 2003). Recent studies, however, aimed to improve the general understanding of different aspects of invertebrates' trophic ecology (CLITHEROW et al. 2013, MÄTZLER & FÜREDER 2013, ROBINSON et al. 2015, KHAMIS et al. 2015, NIEDRIST & FÜREDER 2017).

This presentation presents the effects of in-stream habitat conditions on the feeding plasticity of dominant invertebrate taxa across a sequence of streams with differing glacial influence. In particular, we try to understand whether invertebrates' feeding performance in terms of their trophic niche extension and their trophic height is different in glacier-fed streams with divergent living conditions in the Hohe Tauern National Park. Usually, chironomid taxa (Diptera: Chironomidae) dominate glacial headwater streams (FÜREDER 1999, FÜREDER et al. 2001, LODS-CROZET et al. 2001, NIEDRIST & FÜREDER 2013, 2016) and are often the first connection between producers and consumers in these remote systems (NIEDRIST & FÜREDER 2017). We hypothesized that flexibility in feeding behavior ensures the survival and successful reproduction of chironomid populations in harsh glacier-fed streams, where food availability is usually low (UEHLINGER et al. 2010).

Methods

Samples were collected in six glacial streams in the Hohe Tauern National Park in 2014. All streams are continuously monitored in the long-term project 'monitoring alpine rivers' (Füreder & Schöner 2013), where data on water temperature, discharge, and sediment concentration were used for data analyses herein. We combined these environmental factors by performing a PCA and extracting the scores of component 1, which was defined as multifactorial environmental gradient, called 'environmental harshness', and ranging from 'benign' to 'harsh'. We analyzed stable isotope signatures of carbon and nitrogen in chironomid individuals belonging to a) *Diamesa steinboecki* and b) *D. latitarsis*-group. Bayesian Standard Ellipses and SIBER (Jackson et al. 2011) was used to quantify and compare their isotopic niche area (‰²) and their variability among glacial streams along the gradient of environmental harshness.

Results & discussion

We found that both chironomid taxa (*D. steinboecki* and *D. latitarsis*-group.) were the dominant invertebrates in all surveyed glacial streams and had similar patterns in their isotopic niche areas. The individual areas (standard ellipse area) of each population increased with increasing harshness of the in-stream environmental conditions (Fig. 1).

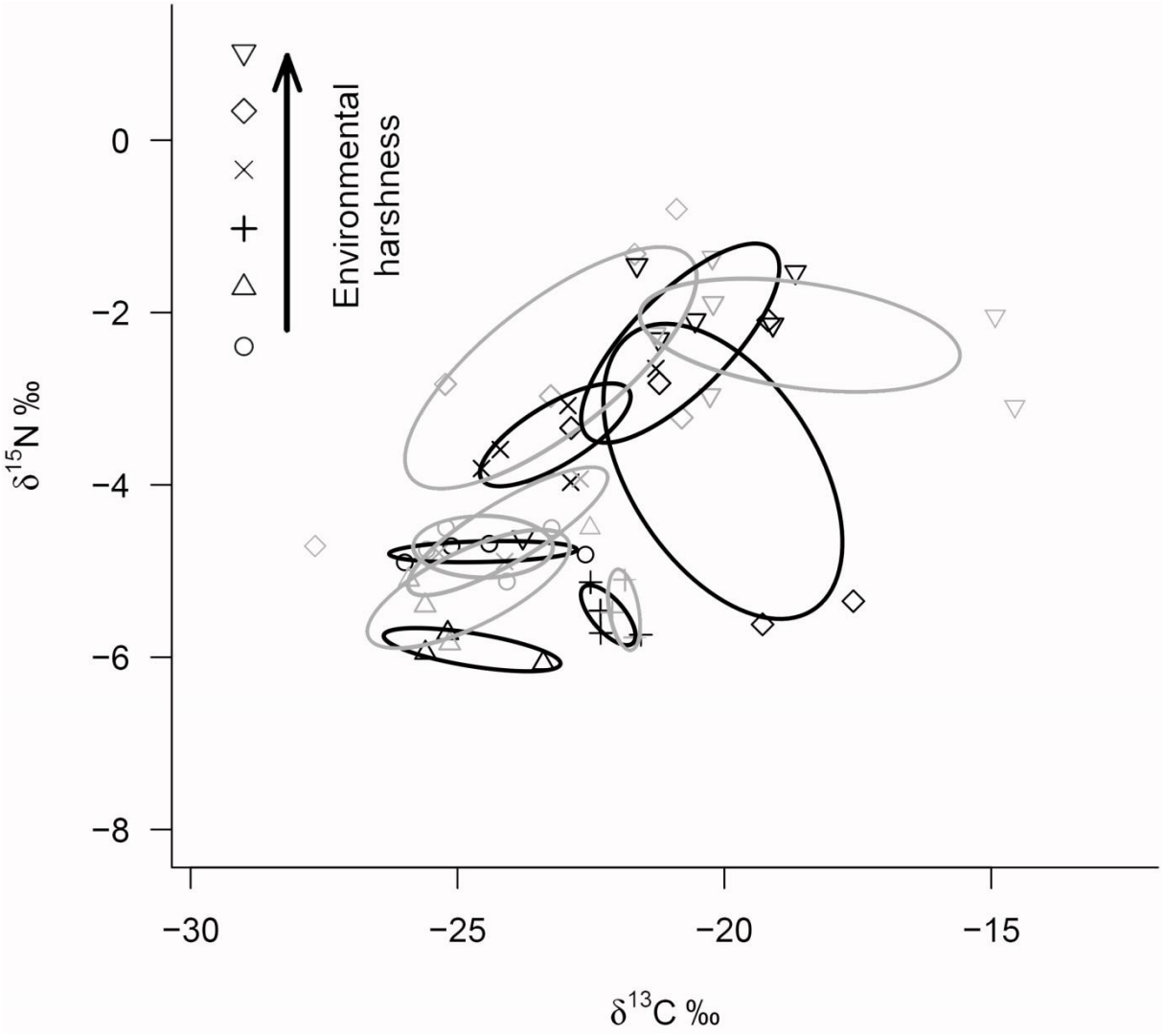

Figure 1: Standardized Ellipse Areas of individual A) *Diamesa steinboecki* (in black) and B) *D. latitarsis*-gr. (in grey) stable isotope data in glacier-fed streams with differing environmental harshness, which is related to glacial influence. Standard Ellipse Areas quantify the isotopic niche area of all site-specific populations, and allow conclusions about their feeding variability (the larger the niche, the higher the feeding flexibility).

Differences in the isotopic niche area can point to differences in the trophic breadth or trophic niche area of analyzed taxa (JACKSON et al. 2011). Hence, our results show that both chironomid taxa (*D. steinboecki* and *D. latitarsis*-group) enlarge their trophic niche area when conditions get harsh, meaning that each individual needs to feed on what it finds, which was already assumed by FÜREDER et al. (2003). In other words, invertebrates living in harsh glacier-fed streams seem to feed more variable on the available food sources. In contrary, individuals living in streams fed by smaller glaciers feed most likely on the same food sources.

Conclusion

We conclude that variable and opportunistic feeding behavior is an adaptation of organisms living in harsh ecosystems, such as streams fed by large glaciers. The detected ability of chironomid taxa to enlarge their food spectra and feeding flexibility might be a decisive mechanism aiding to survive in harsh ecosystems, where food availability is usually low and living conditions are tough. Additionally, such opportunistic feeding strategy of chironomid populations in glacial headwaters could explain their dominance in these systems.

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