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Spatial and temporal variations in chironomid assemblages in glaciated catchments of the Hohe Tauern NP

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Abstract

Alpine river ecosystems represent harsh environments (e.g. low temperatures, high dynamics, steep gradients, low nutrient availability) and will be affected by climate change and increasing anthropogenic impacts. Hydrological changes (e.g. melting glaciers and shrinking snow cover) will affect the invertebrate fauna in different types of alpine rivers (glacier-fed, spring-fed), and can even effect important food sources for fish and other vertebrates at lower elevations. Within the project 'Long-Term River Monitoring in the Hohe Tauern NP' we investigated over a three year time period pattern and processes of alpine river hydrology and morphology and their relationships to the benthic invertebrate assemblages. In this study the chironomid assemblages were investigated as these organisms are ubiquitous and most abundant in alpine river systems and most species are known to react sensitively to environmental gradients. We found different temporal and spatial patterns when non-glacial and glacial rivers as well as reaches above and below the tree line were compared, both in terms of structure and functional organization, respectively. Additionally, we elucidated correlations of abundant chironomid species with environmental key variables such as maximum water temperature, oxygen concentration and conductivity. This study demonstrates that in order to interpret and simulate future shifts in biodiversity and ecosystem structure, and function, knowledge about the ecological preferences of the noumerous alpine chironomid species is crucial.

Keywords

Chironomidae, high alpine, climate change, species preferences, indicator

Introduction

Alpine rivers represent extreme environments with low temperatures, high dynamics in discharge, low nutrient availability and increased ultraviolet radiation (Füreder 1999; Häder et al. 2007). These ecosystems traditionally have been usually regarded as pristine and clean systems of high biological integrity. Nowadays, these precious resources seem to become rare in the densely populated areas of the Alps. Besides various anthropogenic impacts of water use (irrigation, snow generation, power generation) and pollution, alterations due to climate change will affect those river ecosystems concerning hydrological (Zierl & Bugmann 2005) and biological (Jacobsen et al. 2012; Füreder 2012) aspects.

For this presentation, we focused on spatial and temporal variations in chironomid (non-biting midges) assemblages, regarding taxa richness, community composition, diversity and evenness in pristine alpine running waters with and without glacial influence. The results provide insight into the larval development in such extreme environments, as well as into the distribution of specialized taxa in alpine rivers. Whereas temporal variations in chironomid populations at lower altitudes seem to depend on the quantity of available food (Wright 1978; Drake 1982), abiotic parameters seem to be crucial for the formation of chironomid communities in high altitudes, especially during snow free periods (Füreder et al., 2001). As suggested by Füreder (2007), the biota of alpine running waters (esp. glacier-fed rivers) may serve as model to examine the impact of the proceeding climate change. Therefore, a precise knowledge of species preferences concerning a set of hydrological, thermal and biotic variables is needed.

Among stream invertebrates, chironomids represent the majority of invertebrate species in lotic habitats (Cranston 1995). They are known to be well adapted to a variety of extreme conditions (anoxic, dried or frozen habitats)(Oliver 1968; Danks & Oliver 1972), and consequently they form the dominant dipteran family in high elevated headwater ecosystems(Füreder 1999), making them suitable as potential indicators for corresponding variables. Highly resolving species identification is a prerequisite because many genera include species with different ecological demands (Rossaro & Mietto 1998). The main aims of the present study were: (1) to investigate Chironomid taxa assemblages at microhabitat scale in four different running water ecosystems, (2) to define species preferences for certain environmental parameters and (3) to detect the main community-regulating factors during the snow-free season in different river types.

Study Area, Methods

The study streams are located in the Hohe Tauern NP in Austria in the AnlaufValley near Böckstein, Salzburg. The glacial Anlaufbach is the main river in the AnlaufValley, where several spring-fed rivers discharge into it. Four sampling sites, defined among the monitoring sites of the project 'Long-Term River Monitoring in the Hohe Tauern NP', were chosen for this study: two above (1770 m a.s.l.) and two below the treeline (1360 m a.s.l.). At both altitudes, the glacier-fed Anlaufbach and a spring-fed tributary were sampled, respecitively.

A highly resolving set of physicochemical data at various scales (reach and site) was obtained by installing monitoring instruments at each study site and conducting point measurements. Quantitative samples of benthic invertebrates were obtained using a Surber-sampler; mesh size 100 µm. Six substrate-specific benthic samples were taken at every sampling site and date.

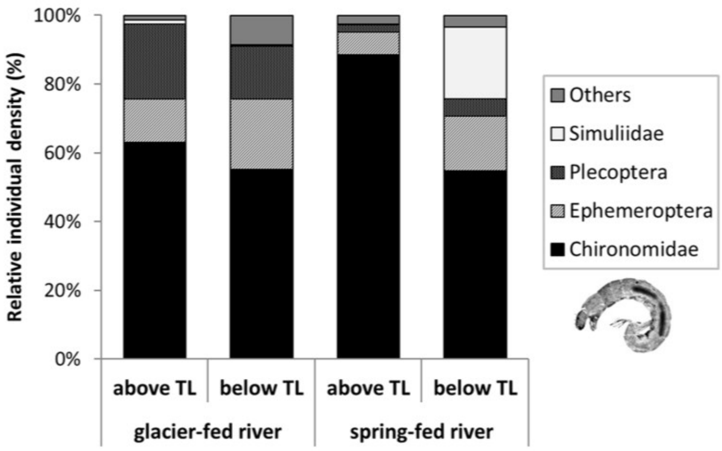

Figure 1: Relative abundance of stream invertebrates in four selected river reaches in the Anlauf Valley in summer 2011 (June, August, September). TL = tree line. (Georg Niedrist)

Results & Discussion

The results of this study confirm prior reports that chironomids are dominating rigorous alpine stream habitats in terms of individual densities (Fig. 1) and taxa number above and even below the tree line. Whereas the glacier-fed river site above the tree line is mainly colonized by *Diamesa* species, krenal assemblages showed a very diverse pattern with much more species. These more stable ecosystems provide suitable conditions for a more diverse chironomid community. Generally,with decreasing glacial influence, the diversity, species richness and abundance were increasing. We were able to conduct a spatial categorization of chironomids regarding their occurrence, whether they live only in glacier-fed, only in spring-fed, or in both habitats (Fig. 2). The majority of taxa (30) were found in both, glacier-fed and spring-fed rivers. However, both river types represent unique habitats for specialized taxa: we detected eleven taxa restricted to glacier-fed rivers and ten taxa living only in spring-fed rivers. *Larsia* sp., the unique taxa belonging to the subfamily Tanytarsinae, was only sampled in glacier-fed rivers.

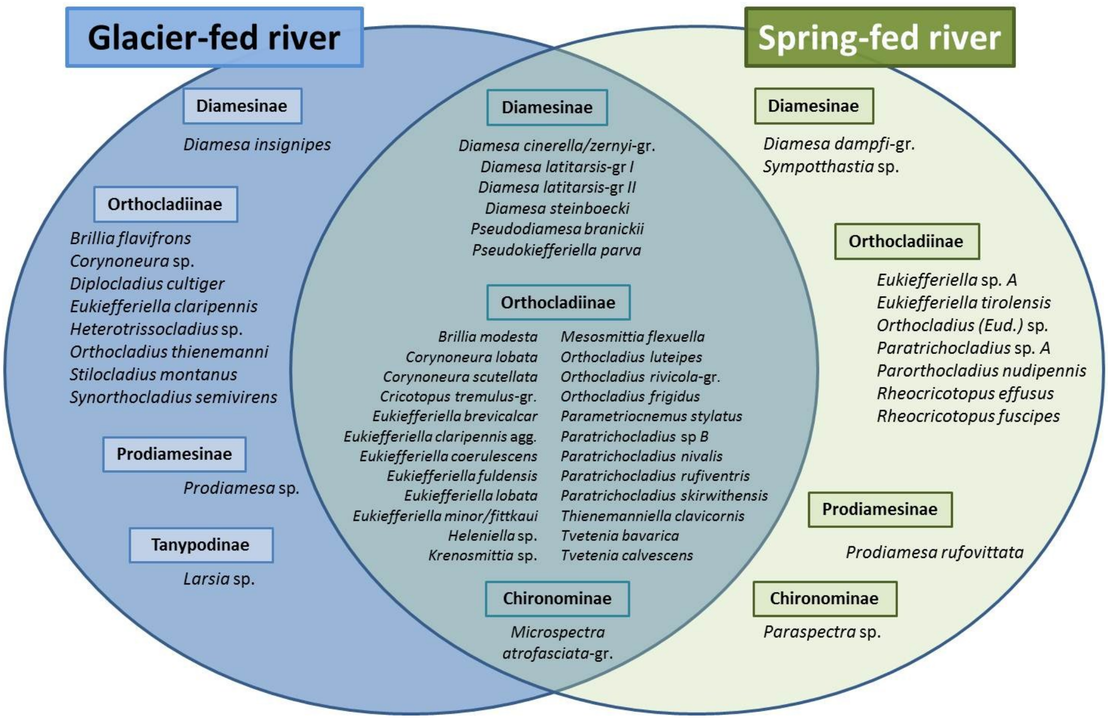

Figure 2: Spatial occurrence (only in glacier-fed rivers, only in spring-fed rivers, or in both river types) of all found chironomid taxa in the Anlauf Valley in summer 2011. (Georg Niedrist)

Correlation analyses highlighted several relationships of abundant taxa with environmental variables (Fig. 3). For example, *Diamesa cinerella/zernyi*-gr. showed a positive correlation with oxygen concentration (r_s = 0.710; p <0.001) and conductivity (r_s = 0.641; p <0.001), and a negative correlation with maximum water temperature (r_s = -0.644; p <0.001.). The taxa Diamesa latitarsis I showed negative correlations with chlorophyll a content in water (r_s = -0.504; p <0.001.). Although combined effects of important factors should not be neglected, dependencies of taxa to single factors could be shown. *Diamesacinerella/zernyi*-gr can be characterized as krypophil taxa preferring high oxygen concentrations. Our results allow the expansion of autecological knowledge of several alpine chironomid species due to preference analyses. Further work will be conducted to evaluate the indicator value and tolerances of such species. Research activities, targeting autecological knowledge for the identification of potential indicator species, have to be carried out in pristine or near-pristine ecosystems to get an uninfluenced reference status of ecological preferences and responses of species to natural environmental factors and changes. That is why protected areas as the national park Hohe Tauern provide optimal study areas with minimized anthropological influence on the ecosystem.

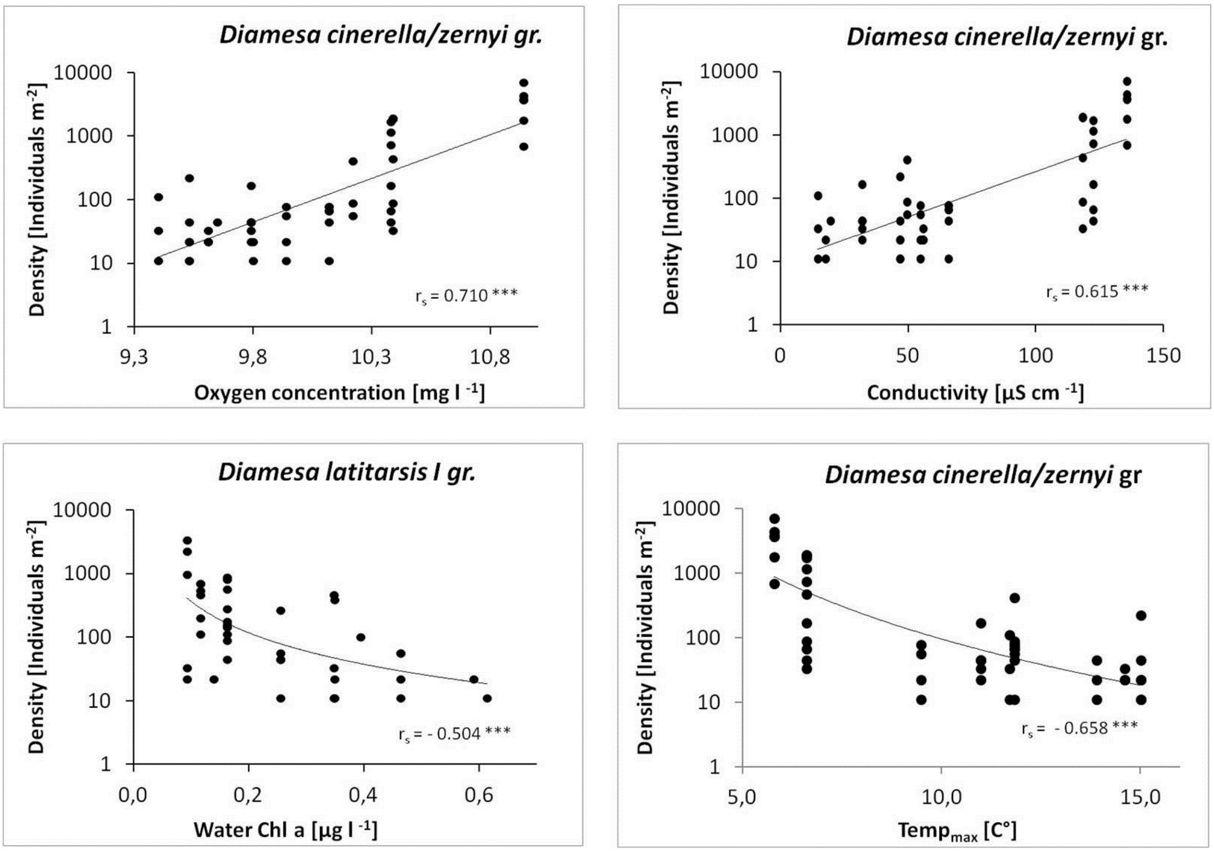

Figure 3: Best correlation of most abundant chironomid species (Individuals m^{-2}) and environmental factors with indication of Spearman correlation coefficient (r_s) and signifinance (*p <0,05; **<0.01; ***<0,001). $Temp_{max}$ represents the maximum water temperature of the past 3 months at each site. (Georg Niedrist)

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