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Who is eating what?
Functional feeding-group composition in Alpine rivers

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Abstract

Alpine rivers are extreme ecosystems with harsh abiotic conditions, causing a low biodiversity of a generally well adapted fauna. This is especially the case for glacier-fed streams. In rivers, where glacial influence is low or non-existent, environmental conditions are less severe. Within the long-term program "River-Monitoring in Hohe Tauern National Park" we investigate catchment- and reach-scale conditions and their influence on the riverine fauna together with their potential to indicate climate change effects. We studied 16 river sections in four large catchments from 2009 until 2010 in Alpine spring, summer and autumn. In this study, we explored the composition of Functional Feeding-Groups along a glacial/non-glacial gradient in order to see, if they follow a specific pattern. All abiotic parameters and biotic samples were collected and processed according to developed protocols, the definition of feeding relationships were based on a solid taxonomy. We applied cluster and redundancy analysis to evaluate the results. Nearly all river sections show a dominance of the detritivore feeding guild, somewhat less dominant are grazers. Also in glacier-fed rivers autochthonous primary-production obviously is adequate for grazers to dominate second. In lower sections shredders do not gain importance, although organic-matter availability as their optimal food resource was high. Underlying factors for the functional structure in research sites are (i) glaciation in catchment, (ii) pasture, and (iii) moss as microhabitat. It seems that in extreme environments autochthonous processes are more important for the fauna than allochthonous ones. But in lower regions, where glacial conditions are less severe, the allochthonous influence came to the fore.

Keywords

Aquatic insects, Ephemeroptera, Plecoptera, indicators, environmental influence

Introduction

Alpine river ecosystems are characterized by high discharge, high channel dynamics, and harsh environmental conditions including low water temperatures (e.g. FÜREDER et al. 2001; FÜREDER 2012). Therefore macroinvertebrates living in Alpine streams have to be specialists with adaptations to constantly changing environmental conditions. This is especially relevant for glacier-fed streams (BRITTAIN & MILNER 2001, BURGHERR & WARD 2001, FÜREDER et al. 2001, FÜREDER 2007). On the other hand they have to be generalists in their nutrition because of the limited availability of food resources in these extreme habitats (ZAH et al. 2001, FÜREDER et al. 2003a, 2003b, ROBINSON et al. 2008).

For exploring the feeding ecology of stream invertebrates and functional structure of ecosystems the classification concept of Functional Feeding-Groups (FFG) generally is used (e.g. MERRIT & CUMMINS 2006, COMPIN & CÉRÉGHINO 2007, VON FUMETTI & NAGEL 2011). This method is based on the (i) morphology of mouthparts, (ii) feeding habits, and (iii) the use of similar food classes (CUMMINS & KLUG 1979, MERRIT & CUMMINS 2006). Main food items are benthic organic matter (coarse or fine particulate), periphyton, and prey; functional classes, divided by feeding mechanisms, are scrapers/grazers (herbivores), shredders (herbivores or detritivores), gatherers (detritivores), filterers (detritivores), and predators (carnivores). Following a longitudinal gradient from headwater to downstream, the composition of FFGs demonstrates different terms of organic-matter distribution and energy flow (VANNOTE et al. 1980). As the food resources are limited in Alpine glacier- and spring-fed streams, most benthic invertebrates are detritivores (MIHUC & TOETZ 1994, ZAH et al 2001, FÜREDER et al. 2003a, 2003b, ROBINSON et al. 2008).

This study is integral part of the "River Monitoring Program" (River Monitoring Hohe Tauern National Park, project leader: Prof. Dr. L. Füreder) of the working group "River Ecology and Invertebrate Biology" at the Institute of Ecology (University of Innsbruck). Herein we investigate reach- and catchment-scale conditions and their influence on the riverine fauna together with their potential to indicate climate change effects. The understanding of ecosystem function and its modifications caused by environmental conditions is essential for predicting effects from climate change (PARMESAN & YOHE 2003, BENISTON 2005). Particularly food resources are expected to depend on climate/environmental factors and occurring taxa portrait potential links between climate and biodiversity (BROWN et al. 2007) in their feeding mode (HERSHEY et al. 2006).

In this presentation, we were interested in the functional relationship of key species in Alpine headwaters and compared functional communities by means of FFGs along a glacial/non-glacial gradient in order to see, if they follow a specific pattern.

Methods

Study Area

The study sites were situated in the Hohe Tauern National Park, which is characterized by a wide range of typical high Alpine stream types (FÜREDER 2007). Furthermore, the conservation status of this protected area guarantees for low human impact. Four glacier- and four spring-fed streams were sampled above the timberline, another four glacier- and four spring-fed streams below. These 16 sites were investigated September 2009 and July, August, September 2010 (Table 1).

Table 1: General characteristics of the studied catchments in Hohe Tauern National Park (Austria).

Catchments	Innergschlöß (Tyrol)	Seebach Valley (Carinthia)	Anlauf Valley (Salzburg)	Krimmler Achen Valley (Salzburg)
Catchment area (ha)	3362	1837	2193	5062
Highest point (m a.s.l.)	3666	3360	3252	3499
Mean gradient (°)	25	31	33	28
Glacier area (ha)	1449	82	84	710

Physico-Chemical Parameters

Conductivity, Oxygen saturation/concentration, pH and water temperature were measured by the portable measurement equipment WTW (Wissenschaftlich-Technische Werkstätten GmbH, Austria) in the field. Additionally water samples were taken to analyse conductivity, pH, alkalinity, Na+, K+, Ca2+, Mg2+, NH4+, NO3±, Cl± , SO42±, total phosphorus, and dissolved organic carbon in the laboratory. Discharge was derived from a calibrated water-level gauge (depth±velocity±transects; JENS 1968).

Macroinvertebrate Taxa and Functional Groups

For each study site, three replicate benthic samples were collected by kick sampling with a Surber sampler (sampling area 0.09 m^2, 100 µm mesh) and preserved in 75 % ethanol. Invertebrates were sorted in the laboratory and identified to species level, where possible, using current taxonomic identification keys. The definition to FFGs is based on MOOG (1995) and SCHMIDT-KLOIBER & HERING (2012).

Organic Matter in Substratum

Benthic organic matter was expressed as ash-free dry matter (g m^{-2}) of the pooled material, remaining from the benthic samples after the invertebrates had been removed. The substrate material had three grain sizes: Coarse Particulate Organic Matter (CPOM) > 1 mm, Fine Particulate Organic Matter (FPOM) < 1mm to >500 µm, and < 500 µm to > 100 µm. The substrate material has been dried at 60° for 24 h and ashed in a muffle furnace at 450° C for 2 h (WALLACE et al. 2006).

Data Analysis

For statistics we used the software packages PC-ORD 6 (Cluster Analysis; distance measure: relative Euclidean, group linkage method: Ward's method) and Canoco for Windows 5 (Redundancy Analysis). For normal distribution benthic invertebrate data were log (x + 1) transformed.

Results

All river sections show a dominance of detritivorous invertebrates (gatherers, filterers); somewhat less dominant are grazers (Fig. 1a-c). Also in glacier-fed rivers, with their high discharge dynamics and turbidity, autochthonous primary-production obviously is adequate for grazers to (nearly) dominate the feeding guilds (Fig. 1a, b). In lower river sections shredders do not gain importance (Fig. 1b, d), despite the high organic matter input as optimal food resource.

First results in cluster analysis and ordinations (RDA) demonstrate the environmental factors (i) glaciation in catchment, (ii) pasture, and (iii) moss as microhabitat to be the underlying factors for FFG composition in research sites.

Discussion

The particular aim of this work was, to compare functional communities by means of FFGs along a glacial/non-glacial gradient in order to see, if they follow a specific pattern. It seems that in extreme environments autochthonous processes are more important for the fauna than allochthonous ones. But in lower regions, where glacial conditions are less severe, the allochthonous influence (e.g. pasture) gets more important.

In the RCC canopied headwaters are dominated by shredders and canopy-free river sections by the grazer feeding-guild (VANNOTE et al. 1980). In our study the proportion of the detritivore and herbivore feeding-guild in headwaters goes along with the RCC. But most downstream sections are still dominated by gatherers and grazers, despite the high degree of canopy cover.

Earlier investigations of stable isotope analyses (SIA) proofed the classification of taxa into general FFGs in Alpine river-ecosystems (FÜREDER et al. 2003a). As the food resources are limited in Alpine glacier- and spring-fed streams, most benthic invertebrates are omnivorous, while detritivores dominate in spring food webs (ROBINSON et al. 2008). This was also supported by MIHUC & TOETZ (1994) and FÜREDER et al. (2003a), who detected most taxa being detritivores in high Alpine streams. Mayfly species considered as detritivorous, such as *Rhithrogena* sp., or grazers like *Ecdyonurus* sp. seem to be highly omnivorous in these systems (ZAH et al. 2001). With the application of SIA, FÜREDER et al. (2003b) defined several Ephemeropteran and Plecopteran species being extreme opportunistic and omnivorous in Alpine streams. Opportunistic and omnivorous feeding seems to be an adaptation on these harsh environmental conditions.

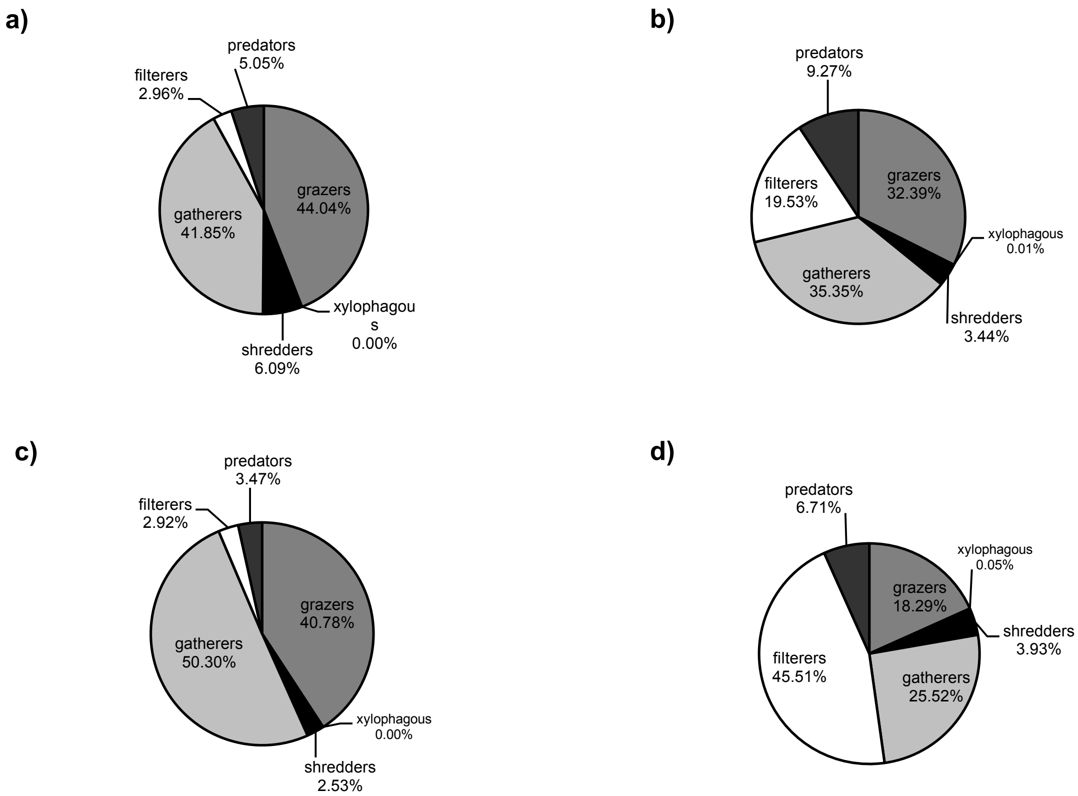

Figure 1: Functional Feeding-Group composition of macroinvertebrates along a glacial/non-glacial gradient: a) kryon (n=49), b) glacio-rhithral (n=44), c) krenon (n=41), and d) rhithral stream sections (n=33).

Furthermore our results confirm that food webs and their interactions reflect environmental conditions in riverine landscapes (COMPIN & CÉRÉGHINO 2007, VON FUMETTI & NAGEL 2011). Based on FFG composition, COMPIN & CÉRÉGHINO (2007) defined major clusters of anthropogenically modified and natural areas in south western France. In Swiss Jura Mountains VON FUMETTI & NAGEL (2011) developed a classification system to characterize crenic springs by their FFG composition. The FFG composition in our study underlies above all the influence of glaciation in the catchment.

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References

BENISTON, M. 2005. Mountain climates and climatic change: an overview of processes focusing on the European Alps. Pure Appl. Geophys. 162: 1587-1606.

BRITTAIN, J.E. & A.M. MILNER 2001. Ecology of glacier-fed rivers: current status and concepts. Freshwater Biologie 46: 1571-1578.

BROWN, L.E., HANNAH, D.M. & A.M. MILNER 2007. Vulnerability of alpine stream biodiversity to shrinking glaciers and snowpacks. Global Change Biology 13: 958-966.

BURGHERR, P. & J.V. WARD 2001. Longitudinal and seasonal distribution patterns of the benthic fauna of an Alpine glacial stream (Val Roseg, Swiss Alps). Freshwater Biology 46: 1705-1721.

COMPIN, A. & R. CÉRÉGHINO 2007. Spatial patterns of macroinvertebrate functional feeding groups in streams in relation to physical variables and land-cover in Southwestern France. Landscape Ecol. 22: 1215-1225.

CUMMINS, K.W. & M.J. KLUG 1979. Feeding ecology of stream invertebrates. Ann. Rev. Ecol. Syst. 10: 147-172.

FÜREDER, L., SCHÜTZ, C., WALLINGER, M. & R. BURGER 2001. Physico-chemistry and aquatic insects of a glacier-fed and a spring-fed Alpine stream. Freshwater Biology 46: 1673-1690.

FÜREDER, L., WELTER, C. & J.K. JACKSON 2003a. Dietary and stable isotope (δ 13C, δ 15N) analyses in Alpine stream insects. Internat. Rev. Hydrobiol. 88 (3–4): 314–331.

FÜREDER, L., WELTER, C. & J.K. JACKSON 2003b. Dietary and stable isotope (δ 13C, δ 15N) analyses in Alpine Ephemeroptera and Plecoptera. Research update on Ephemeroptera & Plecoptera: 39–46.

FÜREDER, L. 2007. Life at the edge: habitat condition and bottom fauna of Alpine Running Waters. Internat. Rev. Hydrobiol. 92 (4-5): 491-513.

FÜREDER, L. 2012. Melting biodiversity. Nature Climate Change 2: 318-319.

HERSHEY, A.E., FORTINO, K., PETERSON, B.J. & A.J. ULSETH 2006. Stream food webs. In: HAUER, F.R. & G.A. LAMBERTI (eds.), Methods in stream ecology: 637-659.

JENS, G. 1968. Tauchstäbe zum Messen der Strömungsgeschwindigkeit und des Abflusses. Deutsche Gewässerkundliche Mitteilungen 12: 90-95.

MERRIT, R.W. & K.W. CUMMINS 2006. Trophic relationships of macroinvertebrates. In: HAUER, F.R. & G.A. LAMBERTI (eds.), Methods in stream ecology: 585-601.

MIHUC, T. & D. TOETZ 1994. Determination of diets of alpine aquatic insects using stable isotopes and gut analysis. Am. Midl. Nat. 131: 146-155.

MOOG, O. 1995. Fauna Aquatica Austriaca. Wasserwirtschaftskataster, Bundesministerium für Land- und Forstwirtschaft, Vienna.

PARMESAN, C. & G. YOHE 2003. A globally coherent fingerprint of climate change impacts across natural systems. Nature 421: 37-42.

ROBINSON, C.T., SCHMID, D., SVOBODA, M. & S.M. BERNASCONI 2008. Functional measures and food webs of high elevation springs in the Swiss Alps. Aquat. Sci. 70: 432-445.

SCHMIDT-KLOIBER, A. & D. HERING (eds.) 2012. The taxa and autecology database for freshwater organisms, version 5.0. Available at: http://www.freshwaterecology.info/(accessed: 04/03/13)

VANNOTE, R.L., MINSHALL, G.W., CUMMINS, K.W., SEDELL, J.R. & C.E. CUSHING 1980. The river continuum concept. Can. J. Fish. Aquat. Sci. 37: 130-136.

VON FUMETTI, S. & P. NAGEL 2011. A first approach to a faunistic crenon typology based on functional feeding groups. J. Limnol. 70 (Suppl. 1): 147-154.

WALLACE, B.J., HUTCHENS, J.J. & J.W. GRUBAUGH 2006. Transport and storage of FPOM. In: HAUER, F.R. & LAMBERTI, G.A. (eds.), Methods in stream ecology: 249-271.

ZAH, R., BURGHERR, P., BERNASCONI, S.M. & U. UEHLINGER 2001. Stable isotope analysis of macroinvertebrates and their food sources in a glacier stream. Freshwater Biology 46: 871-882.

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