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# Unexpected larval development in a highly glaciated headwater

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## Abstract

Glacier-fed alpine headwaters are inhabited by few insect species (mainly *chironomid* subfamily *Diamesinae*). Despite their regular occurrence, nothing is known about their life-cycle strategies in these relatively cold freshwaters. Over the summer months in 2015, samples were taken at the Schlatenbach in vicinity of the glacier Schlatenkees in the Hohe Tauern National Park, and the benthic larvae biometrically analyzed. We observed unexpected development patterns, indicating more favorable living conditions for key taxa closer to the glacier, expressed by larger larval size, biomass and biovolume.

## Keywords

life-cycle, *Diamesa*, biometric analyzes, glacier retreat

## Introduction

Glacier-fed streams are one of the most endangered (HANNAH et al. 2007) and extreme natural freshwater ecosystems with year-round low water temperature, fluctuating discharge, low channel stability, high turbidity and usually low nutrient availability (e.g. FÜREDER et al. 2005). Stream stretches close to the glacier snout are usually located in the high alpine zone and therefore additionally influenced by low air temperatures during summer, a short snow free season and scarce surrounding vegetation (e.g. BROWN et al. 2015). The community of cold adapted insects colonizing these harsh aquatic environments, dominated by the *chironomid* order *Diamesa* (ROBINSON et al. 2014), has to face and master the inhospitable conditions of glacially influenced streams. The life cycle strategies, cause effect relationships of these extreme environmental conditions on the benthic larval growth as well as the key factors limiting the larval life in kryal streams, are still unknown.

Former studies from temperate streams showed, that especially water temperature but also nutrient availability are important factors for benthic larval growth and development (e.g. REYNOLDS & BENKE 2005, SAND & BRITTAIN 2009). Many of these studies were set up as laboratory experiments, where an increase of the water temperature and/or a staggered nutrient availability lead to improved larval growth or faster development compared to the control conditions.

Based on this knowledge we hypothesized that i) water temperature and organic matter/nutrient availability will be higher with increasing distance from the glacier and ii) along a harshness gradient, *chironomid* key species will show higher larval size.

## Methods

Sampling was performed within the project 'Gletschertod und Gewässergeburt' at the Schlatenbach, a river draining the Schlatenkees, the largest glacier in the Venediger Gruppe, Hohe Tauern National Park (East Tirol, Austria). Three stream stretches in close vicinity to the glacier snout (Tab. 1) were sampled six times from August to September 2015 (for sampling dates see Tab. 2).

| | Coordinates | | Altitude [m.a.s.l.] | Distance from glacier [m] |
|---|---|---|---|---|
| | N | E | | |
| **Site 1** | 47°06`51.9`` | 12°24`36.7`` | 2166 | 20 |
| **Site 2** | 47°06`50.7`` | 12°24`40.2`` | 2158 | 55 |
| **Site 3** | 47°06`50.8`` | 12°24`46.1`` | 2150 | 90 |

Table 1: Sampling site characterization

At each expedition and site, three replicate semi-quantitative Surber Samples (900cm², 100µm mesh size) were taken and water temperature was measured using a WTW multi sensor probe. Benthic insect *larvae* and *pupae* were handpicked from the samples and determined to the best taxonomic level using relevant identification keys (JANECEK 1998, LANGTON 1991 and SCHMID 1993). Densities of the two species *Diamesa cinerella* (Meigen) and *Diamesa steinboecki* (Goetghebuer) were sufficient for growth and development analysis. For morphometric measurements, each larva was photographed laterally, then the head capsule was cut off and photographed dorsally. Using the software 'Jens Rüdigs Makroaufmaßprogramm'
(version 0.9.2; http://ruedig.de/tmp/messprogramm.htm) head capsule width, larval length and larval volume were measured for each individual. Larval weight was estimated following NOLTE (1990).

The remaining gravel material from the benthic samples was placed in weighed aluminum dishes, dried (60°C, 24h), weighed, burned (450°C, 2h) and weighed again to define the amount of benthic organic matter respectively available food for the inhabiting larvae. Mann Whitney U tests were used to check for significant differences of abiotic conditions between the three sampling sites. ANOVA with LSD Post-Hoc test was computed to discriminate *chironomid* sizes.

## Preliminary results

Abiotic measurements showed a trend of increasing water temperature with increasing distance from the glacier (Tab. 2). Mann Whitney U tests showed that temperatures at site 1 are statistically significantly higher than at site 3 (U=73.0, p=0.005). Benthic organic matter follows the contrary tendency with a decreasing amount of organic material with larger distance from the glacier (Tab. 2). Statistical comparisons with Mann Whitney U tests reveal that samples from site 1 contained significantly more organic matter compared to samples from site 2 (U=60.0, p=0.001) and site 3 (U=24.0, p=0.000). Samples from site2 also had a significantly higher amount of organic material compared to site 3 (U=68.0, p=0.003).

| Sampling | Site 1 | | Site 2 | | Site 3 | |
|---|---|---|---|---|---|---|
| | OM [g] | T [°C] | OM [g] | T [°C] | OM [g] | T [°C] |
| 11. Aug | 0.269 | 1.2 | 0.043 | 1.3 | 0.019 | 1.5 |
| | 0.226 | 1.2 | 0.030 | 1.4 | 0.019 | 1.5 |
| | 0.150 | 1.0 | 0.032 | 1.2 | 0.068 | 1.4 |
| 19. Aug | 0.380 | 0.7 | 0.020 | 1.0 | 0.014 | 1.0 |
| | 0.199 | 0.7 | 0.019 | 0.9 | 0.027 | 1.0 |
| | 0.020 | 0.6 | 0.023 | 0.9 | 0.014 | 0.9 |
| 26. Aug | 0.441 | 1.3 | 0.040 | 1.2 | 0.019 | 1.4 |
| | 0.284 | 1.1 | 0.047 | 1.3 | 0.206 | 1.4 |
| | 0.512 | 1.0 | 0.053 | 1.0 | 0.019 | 1.2 |
| 01. Sep | 0.403 | 0.8 | 0.061 | 0.9 | 0.025 | 1.0 |
| | 0.234 | 0.9 | 0.494 | 1.0 | 0.022 | 1.1 |
| | 0.271 | 0.7 | 0.036 | 0.8 | 0.008 | 0.9 |
| 24. Sep | 0.822 | 0.4 | 0.266 | 0.5 | 0.033 | 0.9 |
| | 1.457 | 0.4 | 0.801 | 0.6 | 0.010 | 0.9 |
| | 0.427 | 0.2 | 0.024 | 0.4 | 0.014 | 0.8 |
| 08. Oct | 1.195 | 0.3 | 0.151 | 0.5 | 0.628 | 1.0 |
| | 0.131 | 0.4 | 0.040 | 0.5 | 0.027 | 0.9 |
| | 1.518 | 0.2 | 0.428 | 0.4 | 0.017 | 0.8 |

Table 2: Single measures of water temperatures (T) and benthic organic matter in the samples (OM)

Head capsule widths of the latest larval instar (L4) of *Diamesa cinerella* throughout the sampling period were biggest at sampling site 1, followed by larvae of site 2 and site 3 (Fig. 1). ANOVA with following LSD Post-Hoc test displayed significant differences of larval head capsule width between site 1 and site 2 (p<0.000), site 1 and site 3 (p<0.000) and site 2 and site 3 (p=0.001). Head capsule widths of *Diamesa steinboecki* had the same tendency of decreasing head capsule width with increasing distance from the glacier. Size differences were only significant between site 1 and site 3 (p=0.026).

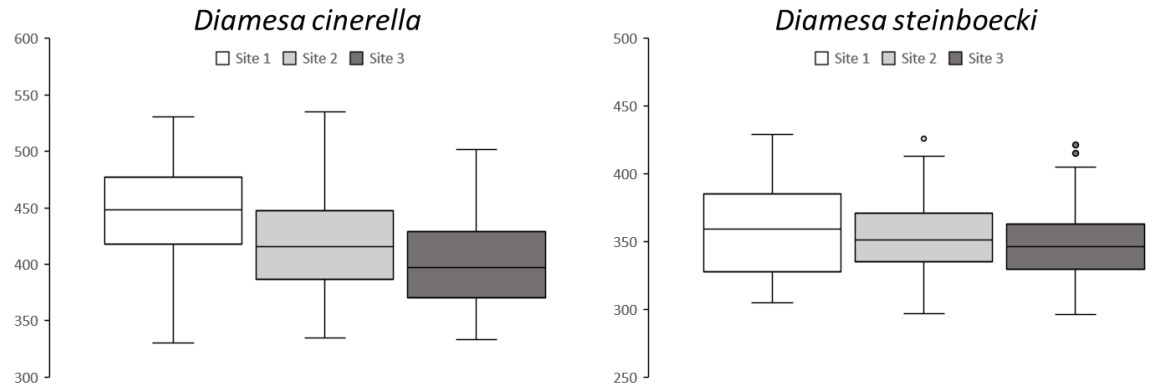


Figure 1: Comparison of L4 head capsule width of *D. cinerella* (left) and *D. steinboecki* (right) at the three sampling sites

Larval length, larval weight and biovolume show the same trend of decreasing values with increasing distance from the glacier snout for both *Diamesa* key species.

## Discussion & Conclusion

We expected that water temperature and organic matter increased with growing distance from the glacier. Statistical analysis confirmed our hypothesis for water temperature but proved the opposite for the organic material. Nutrient availability was highest at the glacier snout and significantly decreasing within the sampled stream stretch of about 90 meters. The high amount of organic material in the samples from site 1 and partially from site 2 is due to the presence of *Hydrurus foetidus*, a *Chrysophyceae*, known to occur in glacially influenced streams. Benthic larval size was highest at site 1, which is closest to the glacier and characterized by the lowest water temperatures but highest nutrient availability. With increasing temperature, but decreasing organic matter, larval size decreased for both key species. Our results show, in contrast to laboratory studies for temperate species (e.g. REYNOLDS & BENKE 2005), that nutrient availability and not water temperature seems to be the limiting growth factor for *chironomid* larvae in glacially influenced streams.

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