Biodiversity of Zoobenthos in Alpine Streams: The Val Roseg

Alpine glacial streams are common although highly sensitive features of high mountain landscapes. We gaze at their raw and untamed nature in wonder, but are little aware of the diverse and characteristic biota inhabiting these harsh environments. However, the biodiversity of alpine streams is in danger because of their particular sensitivity to climate change and the ever increasing pressure stemming from human activities.

The integrity and biodiversity of alpine stream ecosystems are facing many hazards such as climate change, habitat degradation and loss through land use changes, and generation of hydroelectric power [1]. The assessment and mitigation of these effects requires a good understanding of the complex interplay between environmental conditions and zoobenthic distribution. Despite a well-documented interest in the fauna of high mountain streams at the beginning of the 20th century, [e.g., 2], comprehensive year-round studies are scarce [3]. Therefore, we examined the spatio-temporal patterns of macroinvertebrate distributions in different glacial streams of the Val Roseg (see article p. 12).

Species Inventory in the Roseg River

Currently about 150 benthic macroinvertebrate species have been identified in the glacial flood plain of Val Roseg (Fig. 1). Non-insect species comprise 35 %, with oligochaetes, water mites and Ostracoda having the highest proportions. Insects are dominated by midges with 35 species, whereas the species richness of other groups is distinctly lower. Nevertheless, the number of 8 identified black fly species was higher than expected because glacier-fed streams are considered poor habitats for these animals.

Spatial Phenomena

During the melting season in summer, we observed a longitudinal sequence of macroinvertebrate taxa that typically colonize glacier-fed streams. Chironomids of the cold-stenotherm genus *Diamesa* dominated the fauna in the proglacial reach, making up to 95 % of the community. They remained abundant along the course of the Roseg River. Species richness and density progressively increased with distance from the glacier terminus. Common taxa included other chironomids (Orthocladiinae and Tanytarsini), mayflies *(Baetis alpinus* and *Rhithrogena* spp.), stoneflies *(Leuctra* spp. and *Protonemura* spp.), blackflies and oligochaetes. This longitudinal pattern is most likely attributable to reduced environmental harshness with increasing distance from the glacier and is thus in accordance with the conceptual model of Milner et al. (see box). In contrast to this longitudinal perspective, the spatial dynamics of streams within glacial flood plains have received little attention. The Val Roseg flood plain is characterized by a remarkable degree of aquatic habitat heterogeneity due to the shifting dominance of water sources and flow paths (see article p. 14). We compared the zoobenthic communities of three different channel types reflecting a gradient of increasing channel stability: the main channel, intermittently-connected channels and groundwater channels (see Tab. 1 p. 15). Although alpine streams are extreme environments located on the declining limb of a harshness-diversity curve [4] (Fig. 2), it is this heterogenous mosaic of channel types that enhances overall biodiversity by providing numerous refugia for benthic macroinverte-

Conceptual Model Describing the Zoobenthic Distribution in Glacial Streams

Based on recent research and a literature synthesis, Milner et al. [8] proposed a conceptual model describing macroinvertebrate zonation with increasing distance from the glacier margin and thus decreasing environmental harshness. The model depicts that zoobenthic distribution is controlled by two principle variables, i.e., water temperature and channel stability. Specifically, with increasing water temperature and channel stability also the number of zoobenthic taxa and zoobenthic biomass increase.

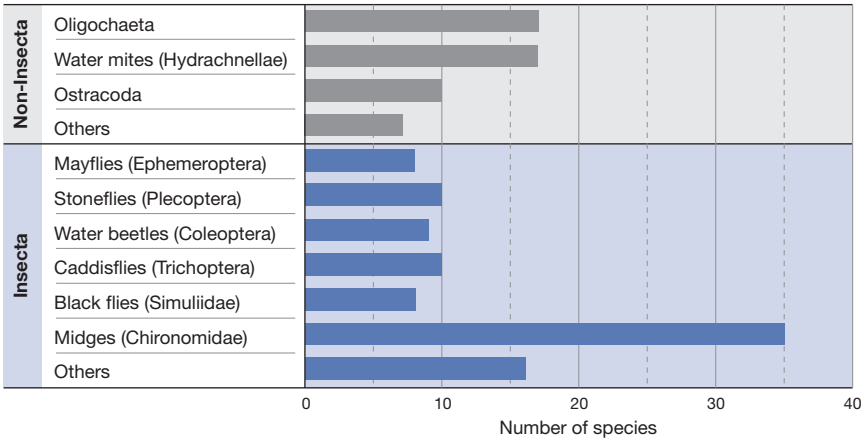


Fig. 1: Species richness and proportions of various taxonomic groups in the Val Roseg flood plain.

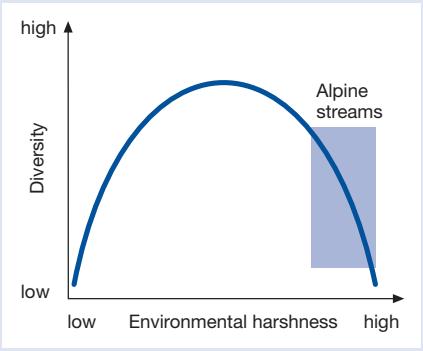


Fig. 2: Alpine streams are positioned on the descending limb of the harshness-diversity curve.

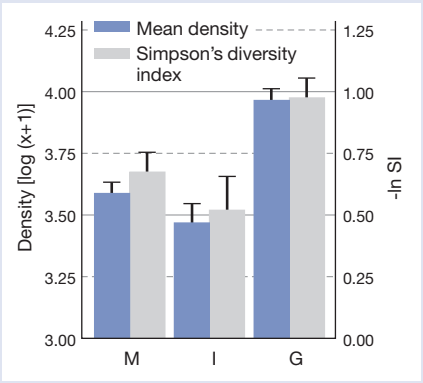


Fig. 3: Mean density and Simpson's index of diversity for the main channel (M), intermittently-connected channels (I), and groundwater channels (G). Error bars represent +1 standard error.

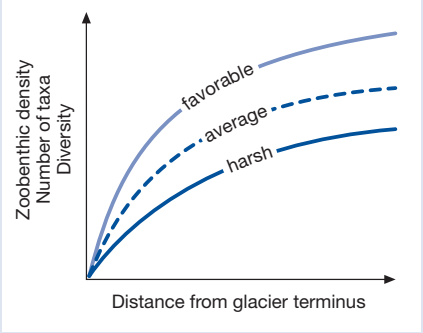


Fig. 4: Conceptual view of changes in density and diversity of zoobenthic communities with increasing distance from glacier terminus. Solid curves represent endpoints when environmental conditions are most harsh or most favorable, whereas the dotted curve is indicative of a theoretical average over an annual cycle.

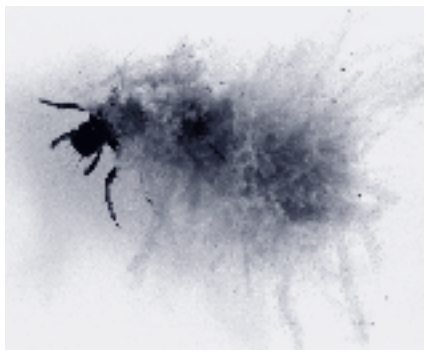
brates. For example, highly stable habitats such as groundwater channels exhibited high macroinvertebrate density and diversity (Fig. 3), combined with low temporal variability.

Temporal Phenomena

The conceptual model of Milner et al. (see box) predicts macroinvertebrate distribution patterns accurately during glacial melt in summer but does not account for seasonal changes in glacial influence. We found that the longitudinal patterns of zoobenthic distribution varied across seasons. For example, especially in October and November, Ephemeroptera and Plecoptera were found closer to the glacier terminus than predicted by the conceptual model. In addition, maximum species density and diversity occurred during periods of favorable environmental conditions, i.e. in spring and late autumn/ early winter (Fig. 4).

Threats to Biodiversity in Alpine Stream Ecosystems

In summary, our results suggest that, besides water temperature and channel stability, a complex interplay of factors determine the distribution of macroinvertebrates in glacial streams [e.g., 5]. Some climate scenarios predict that up to 95% of Alpine glacier mass could disappear by 2100 [6]. However, impacts to alpine streams are difficult to estimate because many of the most significant consequences will result from changes at the scale of small catchments and are still unresolved by Global Circulating Models. Additionally, about 90% of all streams and rivers in the Alps are affected by human developments [7]. These activities often promote fragmentation of natural and species-rich habitats (see article p. 24). Therefore, more holistic studies like the Val Roseg Project are needed to understand the subtle relationship between habitat changes and biodiversity at various scales.



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***Acrophylax zerberus* is a common caddisfly in a variety of habitat types in the Val Roseg flood plain.**

P. Burgherr completed his PhD in the Limnology Department of EAWAG in 2000 examining zoobenthic distribution patterns in an alpine glacial stream ecosystem. Since 2001, he has been working at the Paul Scherrer Institute.

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