Biodiversity in a Glacial Hyporheic Corridor

Despite the recognition of the hyporheic zone as a key component of stream ecosystems, studies on the diversity and distribution of glacial stream invertebrates have focused on the ecology of surface benthos. Due to the harsh environmental conditions prevailing in the benthic layer, we expected the hyporheic zone to contribute significantly to the diversity of invertebrate assemblages in glacial streams. Recent investigations carried out in the hyporheic zone of the Roseg River revealed the presence of a number of permanent aquatic taxa. Our data suggest that the hyporheic zone acts as the main upstream migration pathway and as a source area from which benthic habitats can be colonized.

The hyporheic zone is the interstitial area extending beneath the stream bed and into the stream banks. It contains a mix of stream water and ground water [1]. Because large amounts of sediments are transported and deposited by glacial water along Alpine valleys, the hyporheic zone forms a corridor that may extend metres vertically beneath the channel and hundreds of meters away from the channel. Surface glacial water downwells into the sediment, travels for some distance (i.e. from cm to km) beneath or along the stream, eventually mixes with ground water, and then returns to the stream [2]. Surface-subsurface hydrological exchanges in streams affect the diversity, production, and distribution of invertebrate communities. However, most of the recent studies on the diversity of glacial stream invertebrates, have focused on the ecology of the surface benthos [3]. In the Val Roseg, we examined the longitudinal pattern of hyporheic invertebrate assemblages. The purpose of the present study was threefold:

- to determine the contribution of the hyporheic zone to the diversity of invertebrate assemblages in a glacial stream,
- to identify key factors affecting the distribution of taxa,
- to examine major differences in the upstream colonization by hyporheic and benthic invertebrates (see also p. 22).

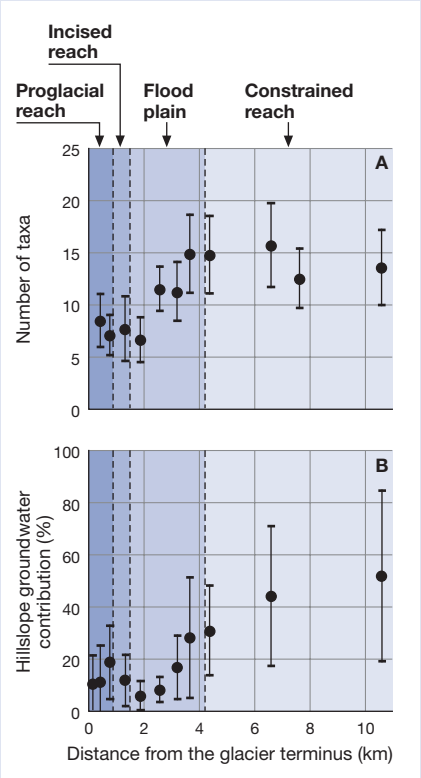

Fig. 1: Longitudinal changes in taxonomic richness of the hyporheos (A, n = 15 samples), average contribution of hillslope ground water to the flow of surface water (B, n = 12 dates). See Fig. 2, p. 12 for the location of the proglacial and incised reaches, the flood plain, and the constrained reach.

Sampling Strategy

Faunal sampling was carried out in September 1996 and in June, August, September and November 1997. Three hyporheic replicate samples were collected at 11 sites located over a distance of 11 km from the glacier terminus in the proglacial and incised reach, the flood plain, and the constrained reaches (see Fig. 2, p. 12). Invertebrates were collected by driving a mobile pipe to a depth of 30 cm below the streambed. Ten liters of interstitial water were immediately extracted using a hand piston pump and filtered through a 100-µm-mesh net. Animals were identified and counted under a dissecting microscope.

The Flood Plain is a Source of Species

A total of 46 taxa were collected from the hyporheic zone of the main channel in the Val Roseg. However, total species richness was strongly underestimated because insect larvae could only be identified to the family level. The number of taxa increased markedly as the main channel entered the lower floodplain reach (Fig. 1A) where groundwater influence also becomes more important (Fig. 1B). This suggests that floodplain habitats originating from the upwelling of ground water act as a major source of species. Sampling at multiple sites within the flood plain showed that the diversity of benthic and hyporheic invertebrate assemblages was distinctly higher in groundwater-fed channels [4; F. Malard, unpublished data]. In addition, at least 12 species of micro-crustaceans collected in the hyporheic layer of the main channel did not occur in the benthic layer and several species of oligochaetes were found to colonize more upstream sites in the hyporheic zone than in the surface stream [5]. These results strongly suggest that the hyporheic corridor acts both as the main upstream migration pathway and as a refuge for several permanent aquatic taxa during the colonization of glacial forelands.

Species are Distributed Along a Gradient of Decreasing Glacial Influence

Longitudinal changes in key environmental factors (e.g., temperature, bed stability, organic matter content of bed sediments) with

distance from the glacier terminus are driving forces for glacial stream organisms [3]. In the Roseg River, the spatial niche of 18 hyporheic taxa (out of 42 taxa) deviated significantly from a uniform distribution along a gradient of decreasing glacial influence with distance from the glacier terminus (Fig. 2). Only 2 taxa, the turbellarian *Crenobia alpina* and the harpacticoid copepod *Maraenobiotus insignipes* preferentially colonized the upstream proglacial reach. Most of the taxa present in the proglacial reach were distributed over the entire longitudinal gradient (data not shown). In contrast, several taxa were either restricted to or occurred preferentially in the lower reaches of the River.

In the Val Roseg, temperature has a major influence on the diversity and abundance of hyporheic assemblages. The temperature of hyporheic water is strongly influenced by the direction and intensity of surface water-groundwater exchanges [6]. In particular, inputs of ground water substantially increase mean summer temperatures in the hyporheic zone of the main kryal channel. Higher temperature and physical stability in the hyporheic zone than in the benthic layer enable taxa to persist in glacial-fed channels where they would otherwise be eliminated.

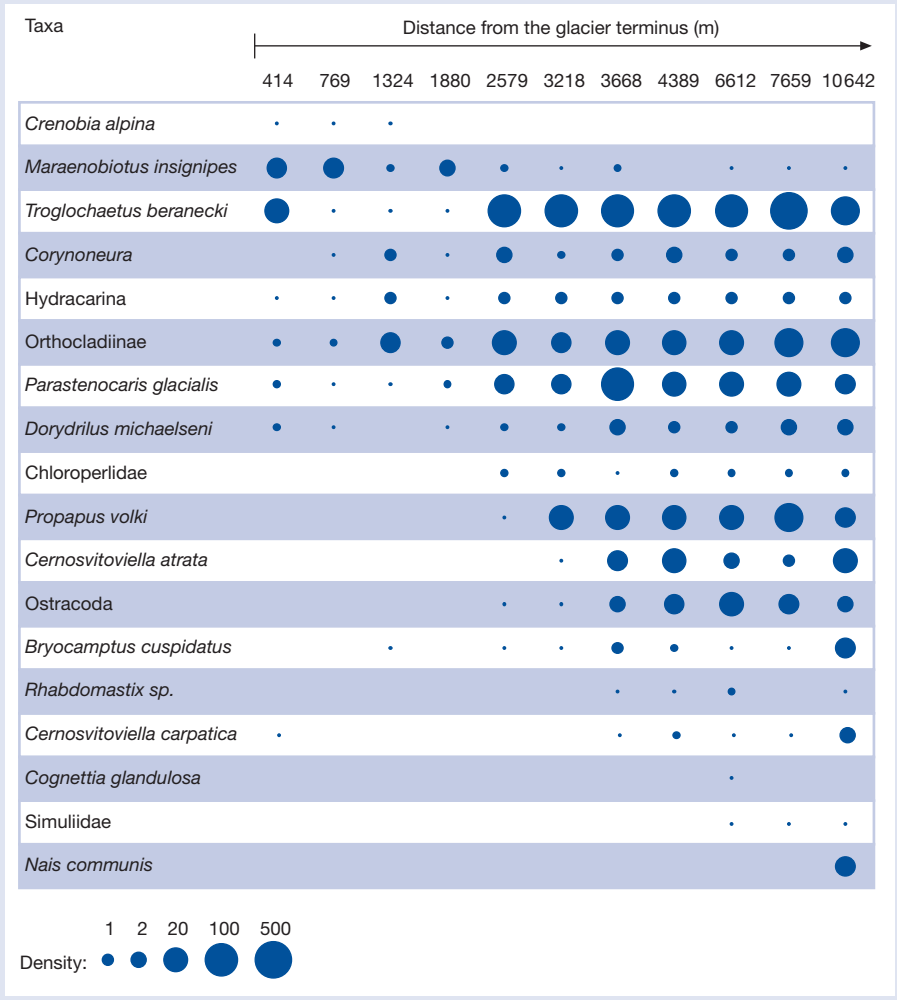

Fig. 2: Longitudinal distribution of 18 taxa in the hyporheic zone of the Roseg River. The size of circles is proportional to the common logarithm (base 10) of the average number of individuals (n >10 samples) in 10 l of intertitial water.

Perspectives

The present study suggests that the colonization process depends partly on the quantity and porosity of alluvium deposited during the glacial retreat. In order to test this hypothesis, similar faunal investigations are being carried out at present. The movement of glaciers and resulting changes in the downstream extent of glacial water influence would modify the distribution range of species. Taxa that are actually restricted to the lower reaches of the Roseg River are expected to colonize more upstream sites if the Roseg and Tschierva glaciers continue to retreat. The present data set can serve as a basis for developing a predictive model of changes in biodiversity induced by the retreat of glaciers. Monitoring long term changes in the longitudinal pattern of hyporheic and benthic assemblages of invertebrates in the Val Roseg would enable us to test our predictions.

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