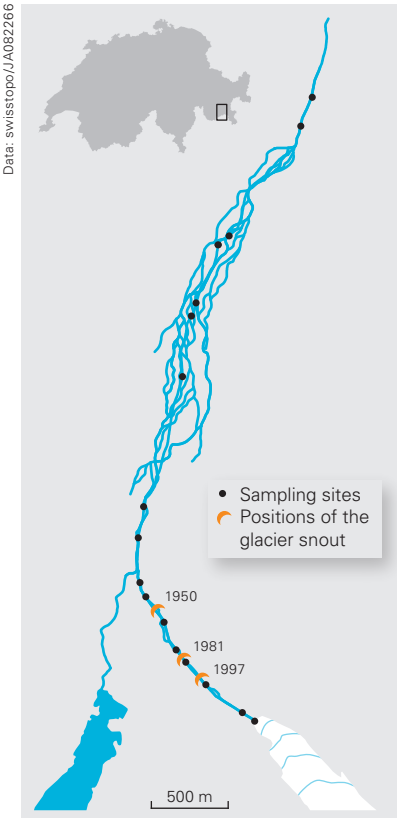
# As glaciers retreat, so do Alpine specialists

**When glaciers recede, they leave behind a rough, rocky landscape. However, newly formed glacial streams are rapidly colonized by cold-adapted organisms. Researchers from the Aquatic Ecology department are investigating whether Alpine specialists can adjust to the changing environmental conditions or are ultimately displaced by low elevation generalists.**

The warmer the climate becomes, the more Switzerland's glaciers recede – currently by an average 10 m a year in the Swiss Alps. A retreating glacier leaves behind an apparently inhospitable area, drained by an ice-cold glacial stream. Interestingly, it only takes a few years or even less for the so-called proglacial stream reach to be colonized by alpine flora and fauna. Cold-adapted species occupy the new habitats, extending their altitudinal range. But as warm-adapted species from low elevation areas also advance upstream, entire biological communities successively shift to ever-higher altitudes along the watercourse. However, they are not exact copies of the original communities since warmer temperatures influence a variety of physical environmental factors, such as water balance and soil formation, which will continuously provide new interactions between the communities and their habitats. To find out more about these processes, a team of Eawag researchers from the Aquatic Ecology department studied a section of the glacial stream below the Tschierva Glacier. The glacial source lies at an altitude of more than 3000 m in the Val Roseg, above Pontresina (Canton Graubünden). Debra Finn, Katja Räsänen and group leader Christopher Robinson compared physical and biological data from 2007 and 2008 with data collected in the same area in 1997.

## Rapid response of organisms

Over this 10-year period, the Tschierva Glacier receded by ca. 480 m. As expected, the researchers noted a marked increase in water temperature: While the highest temperature measured in 1997 was 4.7 °C, in 2007/08 it was 6.6 °C. Christopher Robinson comments: "The organisms' response to their changing environment was surprisingly rapid." As well as shifting upstream, the community changed its structure: Among 21 species of aquatic insects – the predominant local class of fauna – the researchers identified 4 species not previously recorded. These species, coming from low elevation habitats, are mostly generalists, thriving in a variety of environmental conditions. In 1997, they were presumably limited by the harsh environmental conditions in the glacier stream. Ten years later the situation has reversed: The highly specialized




The study area on the Roseg stream below the Tschierva Glacier. Sampling sites and earlier positions of the glacier snout are shown.

## Temperature: A key factor

Left: Larva of the mayfly *Baetis alpinus*, a typical cold-water specialist capable of thriving at altitudes over 2000 m a.s.l. and at water temperatures below 4 °C. Right: The mayfly *Ecdyonurus* sp., a generalist species occurring in most streams and rivers, but generally found well below 2000 m a.s.l. In 2008, it was observed by Eawag researchers at altitudes up to 2200 m a.s.l. in the mainstem glacial stream of the Val Roseg. Larvae of both species feed on the same fine algal layers on the surfaces of stones (periphyton). Aquatic ecologist Chris Robinson therefore expects that *Ecdyonurus* will soon spread even further upstream. Unlike in 1997, water temperatures of 4 °C or more are now measured 1.5 km below the glacier snout in the broad Roseg floodplain between 2000 and 2100 m a.s.l. In 1997, water temperatures never exceeded this value even 5 km further downstream.

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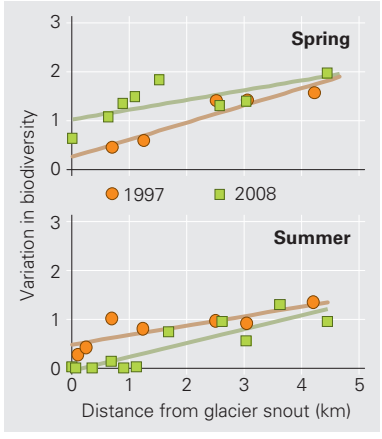
The retreating Tschierva Glacier, pictured around 1875 (left) and in 2004 (right).

species cannot adapt quickly enough to rapidly changing conditions and are increasingly losing out to species with less demanding requirements (i.e. generalists). As Robinson explains, "This development is typical of an ecosystem which is in a state of transition." As a result, the incoming species initially increase local biodiversity. Robinson says: "The highly specialized species migrate to higher altitudes – but at some point that's no longer possible." He predicts that genetic diversity and thus also biodiversity will decline in the long term.

## Stream life in flux

To investigate the physical changes in the glacial stream, Robinson and his colleagues analysed hydrological data for the period 1955 – 2007. They found that, over the years, streamflow variation increased between spring/summer and autumn/winter. A shift in precipitation was observed from winter to spring and, in addition, the onset of spring runoff occurred earlier in the year. The altered hydrological regime in the glacial stream affects both the life cycles of individual species and overall species composition – depending on the various species' ability to adapt. In spring 2008, for example, biodiversity was higher than in 1997: This may be attributable to higher survival of larvae in the winter in 2008. Conversely, summer became a more stressful season in 2008, as streamflows were regularly higher and more turbulent than only a few years previously. Consequently, biodiversity was lower in summer 2008 than in summer 1997.




Variation in biodiversity (Shannon index) in the Roseg stream in spring (top) and summer (bottom) between 1997 ● and 2008 ■ as a function of downstream distance from the glacier snout.

## Alpine pastures left high and dry?

The impacts of retreating glaciers extend far beyond alpine habitats: Changing precipitation patterns and decreasing winter precipitation influence all those areas that depend on water reserves in the mountains. Today, some mountain cabins and pastures already have to rethink the provision of water supplies, as the runoff that used to flow throughout the summer now dries up when the snowmelt is over. Looking ahead to the next 100 – 200 years, Christopher Robinson expects that glaciers worldwide will only persist at altitudes over 3000 m above sea level. By way of comparison, as recently as 1870 – at the time of their last maximum extent – the snout of certain Swiss glaciers lay below 1700 m.

**Specialist species migrate upslope, but that can't go on forever.**

The shifting of habitats to higher altitudes is not confined to the Alps. Robinson's team is therefore currently extending the scope of its research to include North America and possibly the Andes, so as to permit comparisons between the world's major mountain ranges. ○○○

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