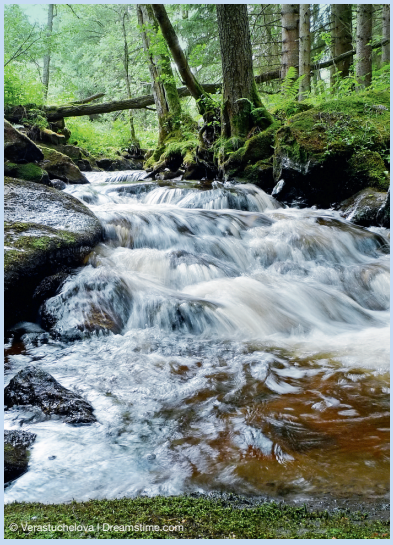
SULZER ANALOGY

Walkers in white water

One would think that the place where the mountain stream thunders down from the cliffs high above and dances foaming over the rocks would be no place for living organisms. However, larvae of a net-winged midge stroll about here on the slippery rocks, like some kind of micro-cow grazing on a lawn of algae.



Despite the foaming water, the larvae a species of a net-winged midge stroll over the rocks.

In the mid-1990s, Andreas Frutiger, then a water biologist at the Swiss Federal Institute of Aquatic Science and Technology (Eawag) in Dübendorf, was looking for such "blephs," as the family of the net-winged midges *(Blepharoceridae)* are called in researcher slang, in the white water of Swiss streams. In contrast to the assumption that these highly specialized insects are very rare, Frutiger found representatives of five different species at 400 locations.

Hapalothrix larvae live in raging waters, where no enemy can catch them. Six suction cups provide them with footing there.

Biophysical vacuum pump

Blephs have been studied for more than one hundred years in the Alps and in the Rocky Mountains. The solution to the mystery as to how the larvae move about in the raging water is really fascinating: They attach themselves to the slippery rock surface with a row of suction cups. Squids and cuttlefish also make use of adhesion through suction cups; these are pressed flat on contact and thereby stick to smooth surfaces due to the negative pressure. What the blephs have invented, however, is much more refined. In the middle of each of the six body segments, there is a biophysical vacuum pump in the form of a suction cup. After the application of the suction cup, muscles pull a plunger upwards in fixed tubular pipes made from chitin, thereby creating a vacuum in the pipes. The ring-shaped adhesion discs at the lower end of the tubular pipe stick unshakably to the surface.

There has also been speculation as to how the larvae release the suction cup as quickly as possible during their movement. Andreas Frutiger solved this mystery in 1998. In the artificial white water channel in Dübendorf, he filmed the larvae as they walked over a glass plate. Thereby, he saw that the animal already pushed the individual suction cups further while the plunger was still at the top of the tubular pipe—and was thus seemingly still in suction operation. Frutiger ultimately discovered, in the edge of the adhesive disc, a fine notch that opened like a mouth shortly before the end of the adhesion phase: a valve then flooded the vacuum chamber within a split second and quickly ended the adhesion. This is why the body segment can be moved even before the plunger has travelled back to the lower start position.

Mobile in all directions

Further analysis of the video sequences demonstrated the wide variety of this suction cup technique. Starting with the rearmost body segment, the animal moves one suction cup after the other in a wave-like action. The most common species in Switzerland, *Liponeura cinerascens minor*, which is found up to 2,300 meters above sea level, only requires one to two seconds for a cycle of all six suction cups, and can thereby travel up to five centimeters in a minute. In order to be able to move sideways, the larvae move some suction cups across their body axis. And, if they are in a particular hurry, they can release several suction cups at the same time and swing their front or rear parts to the side at an angle. Some blephs even have a "reverse gear" that they can select if they unexpectedly come across a weak flow, and want to get back into fast-moving water as quickly as possible.

But why go to all this trouble in the raging mountain stream when there is usually calmer water only a few meters away? With this specialization in extremely strong currents, the blephs have conquered an ecological niche where they are relatively safe from predators and from food competitors. If the current reduces with decreasing water levels, they detach themselves from their supporting rock and let themselves be carried along downstream until they find more lively water, where they immediately connect themselves to a rock again with their suction cups.

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