ENDPAPER

Aqua-Rock Climbers

By Jeremy B. Monroe and Julian D. Olden

A fear of falling limits most people to Earth's gentler slopes. Yet there are those among us who venture onto cliff faces and stone spires, armed with ropes, harnesses, and anchoring devices, to challenge the unforgiving force of gravity. As soggy-shoed graduate students studying insect behavior in the streams that drain Colorado's Rocky Mountains, we occasionally looked up to marvel at the rock climbers ascending the crags and cliffs of this rugged area. Curiously, the insects we study brave an equally unforgiving force—flowing water—and have found a similar solution to their own "falling" problem.

Nearly 12,000 caddisfly species (order Trichoptera) pass their early life stages in freshwater lakes, streams, and wetlands around the world. The insects typically spend one or two years in these environments, completing their larval and pupal stages. Then they emerge from the water to briefly live and mate as winged adults [*see photograph above*].

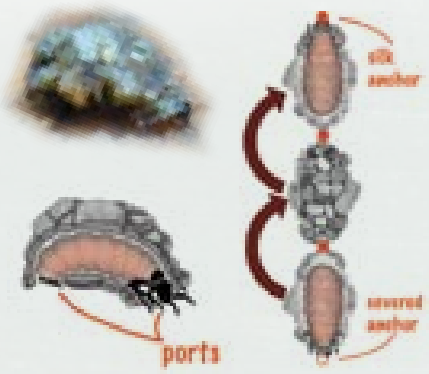
Before growing wings that offer total freedom from falling, caddisflies rely on glands near their mouths to produce an ultra-useful silk—nature's duct tape. Silk is best known as an adaptive tool in silkworms and spiders, but caddisflies use it in ways that are crucial to life underwater. They create all sorts of aquatic gear with silk, from nets that filter food particles, to wearable protective shelters, to pupal cases in which they metamorphose.

Larvae of one family of caddisflies, the Glossosomatidae, use silk to bind together tiny rock fragments into a mobile home of sorts. The portable case resembles a tortoise shell and features two small openings on the underside through which a larva can stick its front legs and its rear claws.

The case protects the soft-bodied larva, just as a suit of armor might protect a rock climber from giant predators, but consider the energetic cost of lugging it around! The drag exerted by the current and the friction between the case and the rocks, appears to slow larvae down substantially. The glossosomatids' movement is clunky, with top speeds of only a few inches per hour, but they can crawl freely in slow currents without threat of being washed away. Remarkably, though, the larvae are also found in swift, turbulent currents. How is that possible?

To find out, we recently observed a particular glossosomatid, *Agapetus boulderensis*, in the swift-flowing headwaters of the Colorado River. The species appears to have combined its gymnastic flexibility with a clever way of belaying using silken anchors. Facing upstream, an *A. boulderensis* larva will affix a small silk "line" to a rock. Once anchored, the larva turns completely around inside its case. It then sticks its front legs out the back opening and crawls around, pivoting its case 90 to 180 degrees on the silk anchor until it is facing upstream again. Then the larva places another anchor, turns around inside its case, and severs the old anchor [*see illustrations on this page*]. With a succession of pivots, *A. boulderensis* thus moves slowly but safely against hazardous currents—as a mountaineer would maneuver up a rock face. Interestingly, much as mountaineers are wary of downclimbing, we have yet to see a larva make pivoting movements in the downstream direction.

Spinning silk anchors takes energy, though, and pivoting is even slower than the usual forward scrabble in calm currents. So why risk the swift ones? For food, most likely. Faster-flowing environments often host algal mats that are nutritious and rapidly replenished. And indeed, pivoting movements are often punctuated by bouts of eating, in which larvae graze in arcs around anchor points.



Caddisfly larva encased in armor (exterior and cutaway views, above left) uses silk anchors to pivot upstream (above right).

The motives of pivoting caddisflies may differ from those of mountaineers, yet we wonder whether to chalk their convergent strategies up to simple coincidence. Perhaps some early climbers were closet entomologists? Either way, we have learned this: gravity's a downer, current's a drag, and wise climbers anchor their rope to the crag!

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