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INSIDE JEB

Sharpshooting archerfish brake to overcome recoil

An archerfish (*Toxotes chatareus*) squirting a jet of water. Photo credit: Animal Physiology, University of Bayreuth, Germany.

Assassins come in all shapes and forms; some lurk, while others prowl. Archerfish, in contrast, simply float benignly in their mangrove homes until a tasty fly catches their eye. Then they transform into lethal marksmen. 'Archerfish down a variety of aerial prey from a range of distances using water jets that they adjust to the size and distance', says Stefan Schuster from the University of Bayreuth, Germany, who has spent much of the past two decades painstakingly unravelling how the meticulous sharpshooters target their victims. It was only when Schuster and Peggy Gerullis were investigating how the fish manoeuvre their mouths to optimise the lethal pulse of water that they noticed that the fishy snipers shimmy their pectoral fins at the precise instant they let fly a jet of water. 'Their rapid forward flap appeared quite silly', laughs Schuster, recalling how the fish only initiated the movement once stationary. Most intriguingly, the fin manoeuvre appeared to be in the wrong direction to prevent the fish from shooting backward. They appeared to be braking, but in the wrong direction. 'There was something curious that needed a closer look', says Gerullis.

Fortunately, she had already trained two of the fish to take fire at tiny target spheres from a channel in their tank, where she could film their fin movements in 3D. 'Archerfish are wonderful to work with – they readily shoot at everything, including things you did not intend to be targets', Gerullis laughs. Painstakingly reconstructing the fin movements during 278 archerfish hits, she, Schuster and Caroline Reinel realised that the fish begin to sweep their pectoral fins forward in the final 40 ms before water starts spouting from their mouths, with the fins reaching their fastest rotation, ~1000 deg s^{-1}, just after the jet begins to emerge. And, as Gerullis raised the targets and the fish adjusted their aim, the animals swung the pectoral fins faster and returned them to their sides sooner, in addition to synchronising the pectoral fins' movements perfectly. In contrast, the fish rotated their pelvic fins wide for stability well in advance of letting rip with a gush of water and coordinated their dorsal and tail fin sweeps in opposite directions in time with the jet. 'We were impressed that all of the fish's fins were involved', Schuster recalls.

So how were the fish able to remain perfectly static at the water's surface while their fins were working in harmony at the precise instant when letting loose a bolt of water? Looking at the upward-directed jet, Schuster realised that the fish weren't only in danger of being blown backward by the recoil, they were at an even greater risk of being submerged as the blast threw them down in the water. 'The forces produced during the forward flap must produce sufficient lift to keep the shooter at the surface', Gerullis explains.

But was this just a neat party trick by Gerullis's well trained sharpshooters, or would archerfish that were free to choose when and where they took aim also perform a fin shimmy? Fortunately, Reinel had hours of fin manoeuvre movies that she had never scrutinised, collected while she investigated the fish's fly-retrieval strategy. 'Caroline scrutinised an impressive number of her recordings', Schuster says. Sure enough, her free-form archerfish also performed the enigmatic fin flaps that allowed their trained cousins to remain in position at the surface.

So, squirting archerfish keep themselves in place with a quick lift-generating wave of the fins and Schuster is eager to find out how they fine-tune the fin manoeuvre when taking high and low pot shots.

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