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INSIDE JEB

High-voltage catfish immune to their own shocks

An electric catfish, *Malapterurus beniensis*. Photo credit: Georg Welzel.

Malapterurus beniensis may look like a harmless catfish lounging on the bottom of a tank, but these creatures are far from benign. Packing a powerful 300 V electric shock, the fish usually reserve their pyrotechnics for stunning prey. 'We always wear thick rubber gloves when handling the fish', chuckles Stefan Schuster from the University of Bayreuth, Germany, admitting that he and Georg Welzel once tried holding a small catfish without gloves: 'The shock was surprisingly strong and felt like touching an electric fence', he recalls. But how do electric catfish withstand their self-administered shocks, which knock out the hearts and nervous systems of their victims? Do the catfish brace themselves to withstand their own electrical discharges, or are they somehow immune? Intrigued by the fish's electrical resilience, Schuster and Welzel obtained two of the shocking creatures to find out how they and their victims deal with an electric jolt.

Turning the water to a slow flow to cajole the idle catfish off the bottom of the tank, Welzel gently brushed their tails with a paint brush to startle them into electrical action. But, when he scrutinised movies of the catfish's manoeuvres, they were completely unperturbed by their electric discharges. In contrast, goldfish swimming nearby went into a spasm, flinging their pectoral fins wide in addition to contracting their bodies, before recovering and going on their way. Even more surprisingly, the catfish were equally unconcerned when Welzel zapped the water with an electrofishing probe, never writhing nor twitching. 'It was surprising that they were equally immune to external discharges that they could not prepare for and were designed specifically to paralyse fish', Schuster recalls.

The catfish's muscles were unaffected by high-voltage electric fields, but it still wasn't clear whether their brain and nervous system were also protected from the effects of electricity. The duo needed to find a way of startling the fish into releasing a bolt of electricity, after sensing the disturbance and processing it in the brain. They reasoned that if the catfish's nervous system was not protected from electric fields, then the speed and timing of the catfish's electrical discharge would be affected if the animal was sitting in an external electric field when startled. However, if the catfish's brain and nervous system were somehow protected, the presence of an external electric field would make no difference to their startled electrical outburst.

'We tested various visual and acoustic stimuli', says Schuster, recalling how the pair eventually settled on a 300 Hz blast of sound, which reliably startled the fish into pulsing electrically. 'We had to wear ear defenders', Welzel laughs. Then, Welzel simultaneously gave the fish an external electric shock while startling them, in an attempt to get them to let their guard down. However, the catfish were completely impervious to the additional electric field, producing startled electric flashes that were indistinguishable from their usual shocking response. They were not steeling their nervous systems in preparation for the disruptive effects of their high-voltage pulses – they were somehow immune.

'Electric catfish show a remarkable degree of protection against high voltages', says Welzel, who suspects that the extraordinary fish are insulated in some way against their own electric fields. And Schuster adds that the catfish's high-voltage resilience is even more paradoxical, as they are also exquisitely fine-tuned to the weak electric currents generated by the bodies of their prey. A conventional insulator would prevent the catfish from sensing their food, presenting Schuster and Welzel with another mystery to solve.

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