Electric fish charges up research on animal behavior

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An electric eel can generate enough current to stun its prey, just like a Taser. Weakly electric fish can also generate electricity, but not enough to do any harm. "Weakly electric fish are unique in that they produce and detect electric fields. They use these electric fields in social communication and to detect objects," explains Johns Hopkins University neuroethologist Eric Fortune.

Fortune has traveled to Ecuador to study weakly electric knifefish in their native habitat, even placing acoustical instruments underwater so he could listen to and record their electrical hums.

Back at Johns Hopkins University, research collaborator and mechanical engineer Noah Cowan and the rest of the team use Fortune's field data to help with their observations and experiments in the lab. With support from the National Science Foundation (NSF), they are studying the knifefish to learn more about how the brains of animals work to control their behavior.

"We see how they interact in the wild and then we create very controlled experiments in the lab that allow us to probe specific scientific questions. Researchers want to better understand how these fish use their electric field as a sixth sense, not only to communicate with each other, but to navigate their surroundings and find their next meal," explains Cowan.

"There's a small organ in the tail of the weakly electric fish that generates an electric field that envelops the entire animal," continues Cowan. When an object passes through the field, the fish has receptors on its skin to detect the object. "There are little voltage sensors all over the surface of the skin and as an object comes by, the voltage changes and it says, 'Ah-ha, lunch,' or it says, 'I'm going to be lunch,' and it swims away."

Each knifefish can generate its own frequency that, in some cases, can change when another knifefish comes near. One reason may be to avoid jamming each others' signals, and another may be to communicate. "When two fish come near each other, their two pitches begin to interact much like two singers' pitches would interact," says Cowan.

The researchers also want to study what happens when more than two interact. When their electric fields overlap, does it heighten or reduce their ability to detect predators and prey? If grouping together is a benefit, a chorus of hums might prove more beneficial for these fish than going solo. "The fact that there are multiple frequencies present at the same time and they're moving around together is a complicated puzzle that we haven't yet figured out," says Cowan.

"The power of this research lies in the combination of field studies with analytical laboratory experiments. Few researchers so clearly excel in both domains," says Elizabeth Cropper, a program director in NSF's Biological Sciences Directorate, which funded the research.

Another piece of the research puzzle is learning when the fish relies on its electro-sense over its other five senses. When the lights go out and it's hard for the fish to see, they seem to rely on it more for navigation. Their electro-sense is a lot better than vision in places where the water gets turbid. The electric field goes right through it. Knifefish are also agile swimmers propelled by long ribbon fins. "They can swim forward, backward, and rotate rapidly," notes Cowan.

Their sixth sense and enhanced agility are making them good role models in the development of small submersible robots. Malcolm MacIver, a mechanical and biomedical engineer at Northwestern University, and his team are developing a nimble robot that can swim backwards and forwards. It may one day be able to use a similar "sixth sense" to monitor the health of coral reefs, or to navigate the dark, murky waters of an oil spill.

Provided by National Science Foundation

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