The biomechanics of information: Going more miles per gallon with your brain

June 3 2010

Image credit: Northwestern University

The hunting strategy of a slender fish from the Amazon is giving researchers more insight into how to balance the metabolic cost of information with the metabolic cost of moving around to get that information.

A new study from Northwestern University's McCormick School of Engineering and Applied Science answers the question: In behaviors in which you have to move to get information, when should the animal spend more energy on locomotion versus spending more energy on getting more information?

The study is published by the journal PLoS Computational Biology.

Malcolm MacIver, assistant professor of mechanical engineering and of biomedical engineering at McCormick, led a team that analyzed the hunting behavior of the weakly electric black ghost knifefish, native to the Amazon. It hunts at night using a self-generated electric field to sense its surroundings, like a bat uses sonar. This particular animal has become the fruit fly of studies on how animals process sensory information. (The fruit fly has been used extensively to study genetics and developmental biology.)

The fish hunts while its body is tilted downward, which, much like standing up on the pedals of a bicycle while going downhill, causes more than twice as much resistance to movement than if the fish were swimming with no tilt. However, this posture allows the fish to scan a wider area of fresh water and encounter more prey. The researchers found that the increased cost of movement caused by body tilting was more than counterbalanced by increased sensory performance. Past a certain angle of tilt beyond what was naturally observed, the additional cost of moving with the body tilted was greater than the energy gained by sensing more prey.

Neelesh Patankar, associate professor of mechanical engineering at Northwestern, worked with MacIver to develop a hydrodynamic simulation code to calculate the drag forces of the fish when it's hunting and when it's just cruising.

"Once we do simulations we can analyze the hydrodynamics of the fish and come up with an understanding as to why it has to spend energy in this scenario and what is the optimal situation where it can spend minimum energy, for example," said Patankar, a co-author of the study.

"That the fish tilts to be able to scan a larger area for prey despite the energy expense is a very interesting result," MacIver said. "To better understand the way animals are the way they are, we need to not look only at neurological function or only at sensory function -- we have to look at mechanics. We need to think of the intelligence of the body as a central component to our overall intelligence and think of energy saving as cleverness."

The results of the study also suggest that hunting at a drag-inducing position could be the basis for fish's unusual, elongated body.

These findings give insight into certain patterns in animal evolution, such as why we and most other animals have moveable sensory systems like eyes, fingers and arms, MacIver said. "If the fish was able to swivel its region of prey sensitivity, like a vision-based animal can shift its gaze, it would save even more energy," he said. "This conclusion helps us understand why animals like us can move our eyes."

More information: Reference: PLoS Computational Biology
dx.doi.org/10.1371/journal.pcbi.1000769

Provided by Northwestern University