

Bass use body's swimming muscles to suck in food

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Striped Bass. Credit: Timothy Knepp/public domain

Fish are power eaters. In many species, large muscles running along their backs and bellies provide bursts of speed for chasing down prey. Then, at the very instant they close in, they vacuum victims into their suddenly gaping mouths with overwhelming suction. It turns out that these power surges are no anatomical coincidence. A new study shows that

largemouth bass get their slurping power from the very same muscles that provide their swimming power.

In the *Proceedings of the National Academy of Sciences*, Brown University researchers show that the muscles in a bass's head contribute virtually none of the power needed (at its peak it's 15 watts) for the doubling of [mouth](#) volume that produces the overwhelming vacuum. Instead, the fish's elaborate arrangement of mouth bones acts more like the passive spokes of an umbrella, driven by the pull of the body's swimming muscles. An evolved linkage between the body and the head transfers the same brawn available for propulsion to the mouth for capturing prey.

In the 1950s, researchers first posited that the body might contribute to suction feeding, but that idea had never been tested and measured in fish as they feed.

"People have been tossing this around for as long as they've been playing with fish heads, which is a surprisingly long time," said study lead author Ariel Camp, who earned her Brown Ph.D. this spring based on the research.

Moreover, in the debate about how fish generate their suction, few if any scientists have given the swimming muscles this much of a role.

"I think everyone would be surprised by the extent to which the swimming muscles are really the source of power," said co-author Elizabeth Brainerd, professor of ecology and [evolutionary biology](#).

The researchers suspect that the same thing is going on in many of the more than 30,000 species of ray-finned fishes.

Voracious vacuum's volume

Camp, Brainerd, and co-author Thomas Roberts, professor of ecology and evolutionary biology, were able to make their findings by recording highly precise 3-D X-ray videos of three bass as they gulped down goldfish in the X-ray Reconstruction of Moving Morphology lab at Brown.

The instrument allowed the researchers to track and visualize how all the bones in each fish's head were moving around. That gave them the means to calculate the change in volume of the mouth many times a second as a fish captured its prey. Those measurements, combined with more conventional data on the water pressure in the mouth, allowed them to calculate the power involved over the course of feeding.

Then the researchers calculated the power produced by each of the muscles in the mouth, as well as the swimming muscles in the body, during the suction action. Their analysis showed that up to 95 percent of the power required for the suction came from the swimming muscles, rather than the mouth. The mouth muscles were simply too weak to produce anything but small amounts of suction.

Evolutionary implications

The findings have intriguing implications for fish evolution and neurobiology and illustrate the limits of muscle in many species.

For example, the results may explain why these fish have evolved the rather complex arrangement of bones in their mouths the way they have. The array apparently works quite well for rapidly opening when yanked upon by those big body muscles via the linkage.

"Our paper is the starting point for answering that question: With the fundamental design of the fish head, should it really be primarily explained on the basis of transmitting this power from the swimming

muscles to the head?" Brainerd said.

Meanwhile in the paper, the researchers marvel at the feat of the neuromuscular control that the fish must achieve to be able to abruptly switch from swimming in pursuit of prey to using the very same muscles for producing suction. The muscles must execute very different movements for each activity.

"It's like they are doing a stomach crunch to open their mouth," Roberts said.

In broader considerations of anatomy, the study highlights a point made not only by bass, but by baseball. Smaller muscles can only do so much on their own, Roberts said. Just as bass apparently evolved to draw upon their body's swimming muscles to produce suction, so, too, do pitchers and hitters learn how to move much more than just their arms to throw and hit as powerfully as possible.

"There's only so much [power](#) you can get out of muscle," Roberts said. "If you need a really powerful activity, as these [fish](#) do, you need a really elaborate pattern of evolution that allows you to recruit more muscles from outside of the head."

Apparently eating, for bass, is a whole body sport.

More information: Swimming muscles power suction feeding in largemouth bass, *PNAS*,
www.pnas.org/cgi/doi/10.1073/pnas.1508055112

Provided by Brown University

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