Catfish use complex coordination to suck in prey

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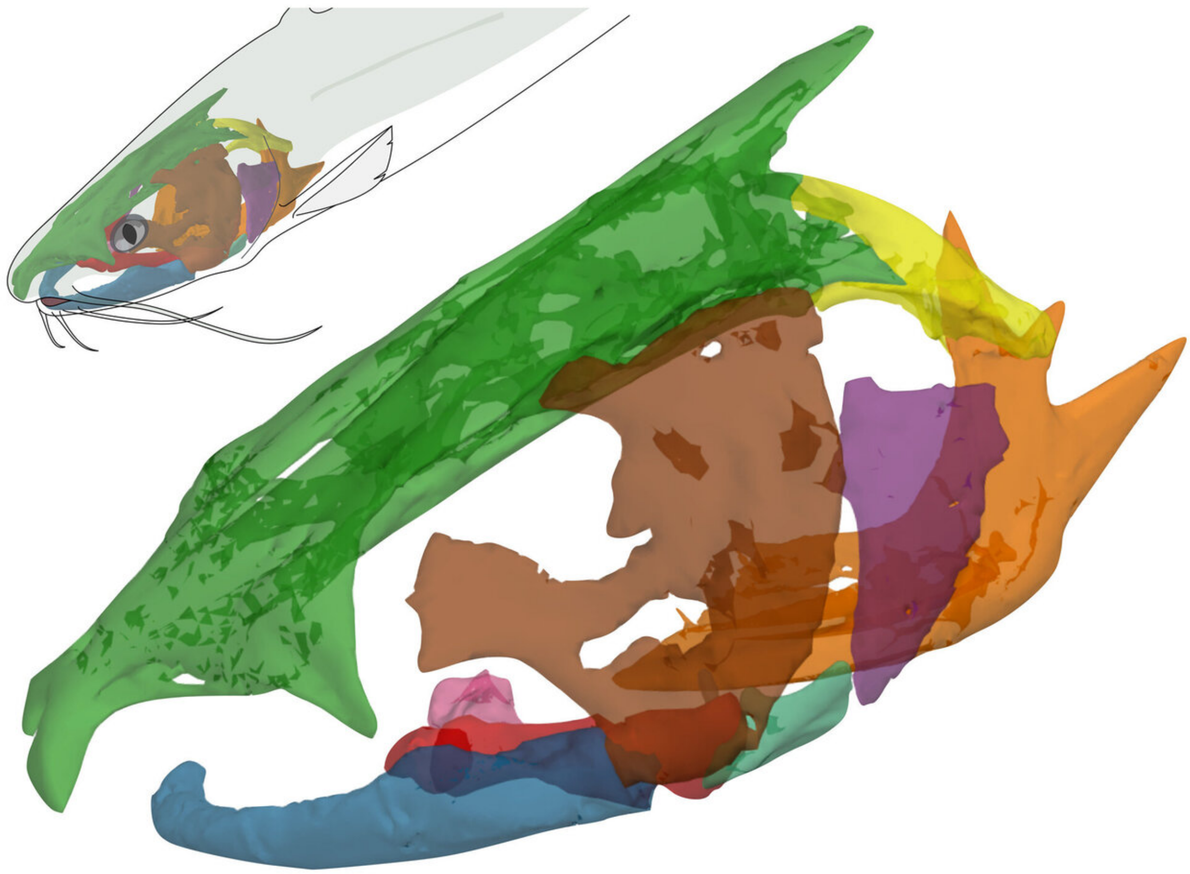

A model of a catfish skull with each bone highlighted in a different color. Catfish have over a dozen moving pieces in their skull. Brown University researchers found four primary bones that surround a catfish's mouth and throat expand outward in a consistent and coordinated manner to form the suction necessary to catch its prey. Credit: Aaron Olsen/Brainerd lab

Catfish do not have arms or tongues to help them catch and swallow their prey—instead, a catfish ready to strike moves its head.

Using a powerful X-ray-based technology, Brown University scientists tracked catfish as they caught and swallowed prey to develop a precise understanding of the complex set of motions required to create the suction necessary to eat. They found that many of the bones in the catfish skull work in a coordinated manner to catch food. However, the bones move more independently when the fish swallow.

"Fish have the most mobile skulls of vertebrates," said Aaron Olsen, a postdoctoral research associate in Brown's Department of Ecology and Evolutionary Biology. "Fish have over a dozen moving pieces in their skull, and they're all connected together by joints and ligaments in these closed loops called 'linkages' in engineering. In comparison, humans have moving lower jaws and middle ear bones, but that's it. The heads of fishes also have very diverse shapes, so we can study how these complex systems evolved in lots of different linages of fishes."

The findings were published on Wednesday, April 17, in the journal *Proceedings of the Royal Society B*.

To make the observations, Olsen and his colleagues used a 3-D-imaging technology called X-ray Reconstruction of Moving Morphology (XROMM), which was developed at Brown. The technology combines CT scans of a skeleton with high-speed X-ray video, aided by tiny implanted metal markers, to create visualizations of how bones and muscles move inside humans and animals. The technique is so precise that scientists can track movements with errors equivalent to only the width of a human hair.

"XROMM basically gives us X-ray vision to watch how multiple bones move within an animal as they perform a behavior," Olsen said.

In this study, the team used XROMM to watch three catfish catch and swallow prey—including food pellets, bits of squid and earthworms. First, the fish move their whisker-like barbels back and forth in the tank. Immediately after a barbel touches a piece of food, four primary bones that surround the mouth and throat expand outward in a consistent and coordinated manner to form the suction necessary to catch it.

On the other hand, these bones move more independently and less consistently as the fish swallow. Olsen isn't certain why swallowing is less coordinated.

"It seems like different tasks need different levels of coordination," Olsen said. "But what determines a good level of coordination for a specific task is an open question. What our study shows is that these natural behaviors have different levels of coordination. We're not sure if they strictly require different levels of coordination."

Previous research from the lab of Brown professor and senior researcher Elizabeth Brainerd has used XROMM to study the feeding behavior of other fish, including bass and sharks. Largemouth bass protrude their jaws, which helps to catch their prey. Catfish cannot protrude their jaws in that manner, Olsen said. Instead, the bone critical for that action in bass evolved into the base of the whisker-like barbels in catfish, he added.

Bamboo sharks are distantly related to all bony fish, including catfish. However, both bamboo sharks and catfish have powerful shoulders, or pectoral girdles, that both species move extensively during feeding, Olsen said.

Comparing different species of fish with different body shapes, skull structures and feeding behaviors can provide insights into how fish with different body shapes evolved different structures and mechanisms to solve similar tasks, Olsen said.

Members of the research team are currently using XROMM to track the characteristic "vacuum-like" behavior of koi. Other members of the Brainerd lab are studying the feeding behaviors of other species of fish.

Olsen is in the process of constructing a model to explain how the bones and ligaments that comprise the catfish skull move together as a complex system.

More information: Channel catfish use higher coordination to capture prey than to swallow, *Proceedings of the Royal Society B*, rspb.royalsocietypublishing.or … .1098/rspb.2019.0507

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