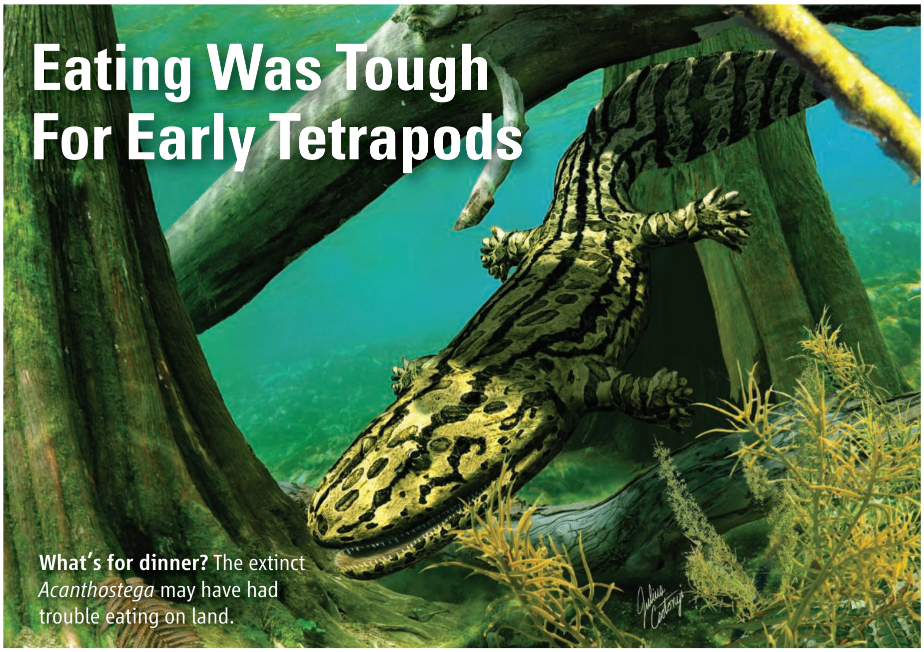
2013 SOCIETY FOR INTEGRATIVE AND COMPARATIVE BIOLOGY ANNUAL MEETING | 3–7 JANUARY | SAN FRANCISCO, CA

Eating Was Tough For Early Tetrapods



What's for dinner? The extinct *Acanthostega* may have had trouble eating on land.

While a fin-to-limb transition made possible the first steps on land for vertebrates 390 million years ago, it took a long time for ancient tetrapods to leave behind their aquatic ways and become true landlubbers. After that initial landfall, another 80 million years went by before tetrapods developed jaws adapted for terrestrial feeding, according to Philip Anderson, an evolutionary paleobiologist at the University of Massachusetts, Amherst, who presented a survey of fossils from this time period at the meeting.

Those early tetrapods must have had a hard time figuring out how to swallow terrestrial food, if another study presented at the meeting is any guide. That work described the great lengths that some modern fish must go to catch and eat prey out of water. "That's something that paleontologists have not thought about too much," says Alice Gibb, a functional morphologist at Northern Arizona University in Flagstaff. The combination of paleontology and functional morphology evidence shows "that the switch [to eating on land] was awfully hard," concludes Richard Blob, an evolutionary biomechanist at Clemson University in South Carolina.

Vertebrates were among the last animals to crawl onto land. Which locomotor changes enabled this move "is pretty well resolved," says Michael Coates, a vertebrate paleontologist at the University of Chicago in Illinois. But understanding what and how the first four-legged vertebrates ate "is somewhat in its infancy," says Miriam Ashley-Ross, a functional morphologist at Wake Forest University in Winston-Salem, North Carolina.

Some researchers have argued that the first tetrapods were quick to exploit land-based food; others are not sure whether these animals were "surf" or "turf" eaters. Anderson began to wonder about the transition to terrestrial diets 2 years ago, after an initial survey of fossils confirmed that the lower jaws of early tetrapods were very fishlike. He and his colleagues have now extended that work, in all measuring jaws from 97 genera dating from the Devonian 416 million years ago through the early Permian, 295 million years ago. The fossils included classic early tetrapods such as *Acanthostega* and *Tiktaalik*, some closely related fish, ancestral amphibians, and some later evolving reptilelike and mammal-like species. Early tetrapods had elongated jaws, like those in their fish ancestors. But about 80 million years into their evolution, shorter, deeper jaws appeared, Anderson found. These stronger jaws would have been better able to munch on vegetation, he notes.

Early on in tetrapod evolution, "big changes are going on elsewhere in anatomy and the jaws lurch into changing later on," Coates says. During that period, the researchers suggest, these animals may have made brief forays onto land but hunted in the water.

With fishlike mouths, early tetrapods would have faced a difficult task eating on land. Underwater, fish usually rely on suction to draw food into their mouths and swallow. To generate enough inward force in less dense air, a fish—or early tetrapod—would have to expand its mouth 28 times faster, Sam Van Wassenbergh, a biomechanist at the University of Ghent in Belgium, reported at the meeting. And even then, because air is so much less viscous, the air flow might not be enough to draw in prey. Moreover, most fish mouths face forward to grab food items suspended straight ahead in water, not food laying below on the ground.

Many modern terrestrial tetrapods have solved their swallowing problem by having tongues do the job. But Van Wassenbergh started thinking about how early tetrapods might have dined on land after he studied the eel catfish, which lives in the muddy swamps of tropical Africa. It has a tiny head and a long body with no paired fins. When he filmed this fish in 2006, he determined that the secret to its success to capturing insects on land was arching the front end of its body to position the mouth directly over the prey. Once the food is captured, the catfish quickly slips back into the water; only there, where it can take in water to wash down the prey, can it swallow, Van Wassenbergh said.

More recently, he has turned to mudskippers, 15-centimeter-long fish commonly found in the mud in mangrove swamps. In contrast to the eel catfish, the mudskipper has big paired fins and doesn't have to go back into the water with each mouthful of prey.

Mudskippers solve the swallowing problem by carrying water with them, Van Wassenbergh reported. His studies revealed that these fish fill their mouths with water before emerging onto land. They scoot along with their fins, then bend their head down to grab the food. As they do this, they compress the sides of the mouth, moving the water forward and, sometimes, forcing water out as they grab the prey. Instantly, the fish sucks the water back in. That mouthful of water enables them to swallow and keep hunting.

Fossils rarely preserve evidence of the muscles and cartilage connecting bones, and the dearth of such soft tissue data makes it difficult to know how exactly early tetrapods could maneuver their jaws or swallow. But although these animals lacked the complex mouths of mudskippers, Van Wassenbergh "showed that it is possible for something to come up on land and still use the fish suction system," Anderson says. That's certainly food for thought for those trying to reconstruct the life of early tetrapods.

CREDIT: JULIUS T. CSOTONYI

Published by AAAS