

Devonian Tetrapod Humerus

By Jeffrey K. Parrott

Today's Science On File, July 2004

A new fossil find has lent evolutionary significance to a common (and sometimes unpleasant) activity: the push-up. It suggests that the ability of early fish to assume an underwater stance similar to doing a push-up was a key step in the evolution of limbs, which allowed later animals to clamber onto dry land.

The evolution of land-dwelling, four-legged tetrapods from fish is a milestone in evolutionary history. The term "tetrapod" refers to any vertebrate, or backboned animal, with four limbs (the word comes from Greek *tetra-* "four" + *-pod* "foot"). The first tetrapod species emerged between 355 and 410 million years ago during the Devonian Period of the Paleozoic Era. Many diverse species subsequently evolved from these early four-legged creatures. Modern tetrapods include amphibians, reptiles, birds and mammals (so humans are tetrapods too).

Scientists have long wondered how the transition from fish to tetrapod took place. More specifically, scientists would like to understand how limbs evolved from fins. Did limbs evolve specifically to allow "terrestrial locomotion," or movement on dry land? If not, what adaptive functions did fins have that could have led to the development of limbs? What were the intermediate stages between fish and tetrapods, between fins and limbs? "The transition wasn't all or nothing," explains Ted Daeschler, a member of the team that uncovered the new fossil, in *National Geographic*. "It's not that some animals were thrown on land. There were certainly other functions intermediate."

The fossil, discovered in Pennsylvania, has yielded novel evidence about these important questions. Paleontologists Neil H. Shubin and Michael I. Coates of the University of Chicago, and their colleague Daeschler, a vertebrate zoologist at the Academy of Natural Sciences in Philadelphia, described their find in the April 2, 2004 issue of the journal *Science*. Their new fossil suggests that early fish used their fins to remain stationary in shallow moving water, and that this function--not the need to move on land--was the basis for the evolutionary development of tetrapod limbs.

The fossil that Shubin and his colleagues discovered is a humerus bone from a Devonian species of tetrapod. (The humerus is the bone that connects a tetrapod's body to its forelimb. In humans, the humerus is the upper arm bone, between the shoulder and the elbow.) The research team is not sure whether the fossil comes from an entirely new tetrapod, or if it comes from a known species at a different stage of development. "So rather than throw another name on this thing," Daeschler said, "we're saying that it is an early tetrapod humerus." The fossil, which the team refers to as ANSP 21350 in their *Science* article, is the oldest limb bone ever found.

ANSP 21350 reveals much about the creature that once possessed it. The bone's shape indicates that it was attached to large pectoral muscles. The limb jutted out at a right

angle to the animal's body, rather than facing the back of the body like a fish's fins. Thus, the animal would have had quite strong limbs, but a very restricted range of movement. "The animal's arm was permanently flexed in a sprawling posture, like a crocodile's," Shubin told the New York Times. The scientists do not think that the creature would have been able to walk. Rather, it most likely used its limbs to prop itself up in shallow moving water, in a motion very much like a push-up. By "station holding" in this way, the animal would have been able to wait comfortably for prey to drift by in the stream current. It probably also used its limbs to move along the bottom. "Think of a shallow stream choked with plants, not of an open sea," Shubin said to National Geographic. "At some level, these shallow streams approach a more terrestrial environment in the ways that animals would move around."

ANSP 21350 has characteristic features of both fish and tetrapod humeri, meaning that it comes from an intermediate stage, somewhere between fins used exclusively for swimming and limbs used exclusively for walking on land. Therefore, scientists believe that this tetrapod's fish ancestors must have already been using their fins for station holding in moving water. Such a motion, very much like later tetrapod push-ups, would have helped fish to feed and move in shallow, plant-filled streams and similar environments. As Daeschler explains, "When fish used their fins to prop themselves up on the bottom...it was a very useful invention at the time." Station holding by fish led to the evolutionary development of limbs, which were better adapted than fins to performing this function in an aquatic environment. This occurred long before tetrapods began using their limbs to walk on dry land.

The tetrapod humerus fossil ANSP 21350 was unearthed in the Catskill Mountains of north-central Pennsylvania, after bedrock was cut away during road construction to reveal an ancient streambed. Two previously unknown tetrapod species, *Hynierpeton basseti* and *Densignathus rowei*, were discovered along with other plant and animal fossils at the site, indicating that a great diversity of life forms once co-existed in this Devonian stream. Scientists plan to continue excavating in this region of Pennsylvania and elsewhere in North America. The research team writes in their Science report that they expect to find fossilized track marks left by tetrapods as they moved along the muddy bottoms of their stream habitats. This would give support to their claim that limbs evolved for station holding and movement in shallow aquatic environments rather than specifically for terrestrial locomotion. Such discoveries should provide welcome details about the evolutionary transition from fish fins to tetrapod limbs, a change of such importance that we cannot imagine life on Earth without it.

Further Reading

"From Fins to Fingers." Jennifer A. Clack. Science, April 2, 2004, page 57.

"The Early Evolution of the Tetrapod Humerus." Neil H. Shubin, et al. Science, April 2, 2004, page 90.

Internet Resources

"Devonian Times" (www.mdgekko.com/devonian/index.html) A 'newspaper' about the Devonian Period, featuring pictures and descriptions of early tetrapods, and excavations in the Red Hills region of Pennsylvania.

"The Missing Link" (www.pbs.org/wgbh/nova/link/) A companion website to the PBS program "The Missing Link". Contains information about the evolution of tetrapods and other early life forms, and interviews with paleontologists.

"Introduction to the Tetrapoda"
(www.ucmp.berkeley.edu/vertebrates/tetrapods/tetraintro.html) All about tetrapods, then and now.

Keywords for electronic searches:

tetrapod, Devonian, humerus, evolution, ANSP 21350