Researchers solve puzzle of water-to-land transition of vertebrates

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Protopterus aethiopicus at Suma aquarium. Credit: harum.koh, CC2.0

The water-to-land transition is a leap in the history of vertebrate evolution and one of the most important scientific issues in vertebrate evolution. Previous studies have shown that vertebrate landing occurred

in bony fishes.

A team led by Kunming Institute of Zoology of the Chinese Academy of Sciences, collaborating with domestic and overseas researchers, has unraveled the mystery of water-to-land transition of vertebrates by investigating the genomes of African lungfish, bichir, paddlefish, bowfin and alligator gar. They reported the findings in two studies, both published in *Cell*.

The five species analyzed by the researchers belong to the two major groups (lobe- and ray-finned fishes) of extant bony fishes. Lungfishes are the closest extant relatives of tetrapods and harbor the largest genome sizes (40Gb), which is more than 10 times the size of human genome.

The researchers found that the functional elements related to limb flexibility might have originate from cartilaginous fishes, and were conserved in lobe- and ray-finned bony fishes but were completely lost in the teleosts. Primitive lungs might also have originated from the common ancestor of bony fishes although and then lungs were replaced by the swim bladder in most ray-finned fishes.

Adding lungfish into the analysis, the researchers proposed that the evolution of water-to-land transition of vertebrates might have taken place in three crucial steps of genetic innovation.

The first step was that the common ancestors of bony fishes already had an initial air-breathing ability and relative molecular basis. The second step was an increase in air breathing capacity through the appearance of more respiratory-related genes and functional elements of sarcopterygians. The third step might have resulted from further genetic innovations like more genes and functional elements, providing the last critical basis for the water-to-land transition.

Additionally, the researchers found that the functions related to limb movement also gradually evolved. The humerus is a proximal basal element of the sarcopterygian forelimb, which evolved from the metapterygium in basal ray-finned fish, the radius might have originate from the ancestors of lungfish and tetrapods, and the pentadactyl limb eventually appeared in tetrapods.

In addition, they showed that the water-to-land transition also accompanied with the co-evolution of circulatory system, brain, and locomotion system.

The findings of these studies are important to understand the evolution mechanism and process of vertebrates from water to land.

More information: Kun Wang et al. African lungfish genome sheds light on the vertebrate water-to-land transition, *Cell* (2021). DOI: 10.1016/j.cell.2021.01.047

Xupeng Bi et al. Tracing the genetic footprints of vertebrate landing in non-teleost ray-finned fishes, *Cell* (2021). DOI: 10.1016/j.cell.2021.01.046

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