Fossil killifish: New findings reveal unforeseen diversity

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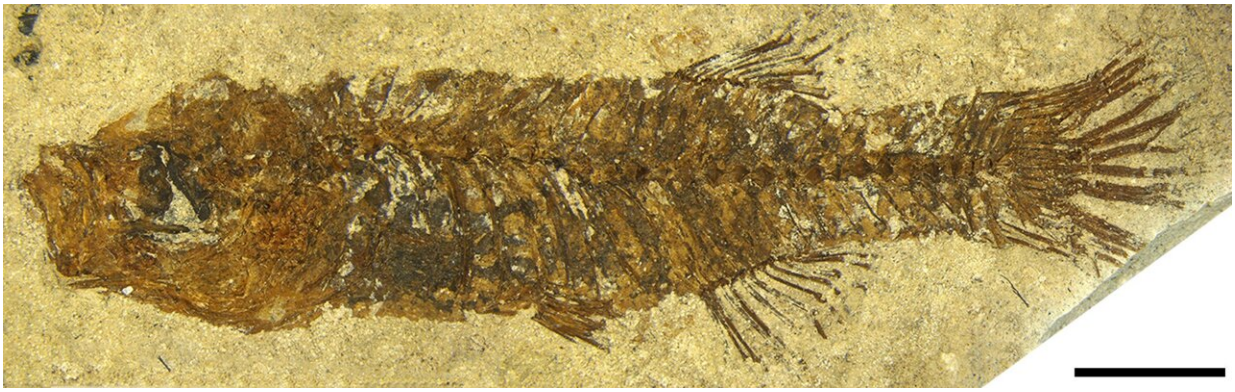


Fossil skeleton of Wilsonilebias langhianus, one of the newly discovered species. Credit: Andrea Herbert Mainero

Killifish, or egg-laying toothcarps, are known for their ecological adaptability and species diversity. Two families of killifish exist in Europe today: the highly species-rich Aphaniidae and the relatively species-poor Valenciidae, which has just three species. How these differences in species diversity originated is one of the questions that the group of Professor Bettina Reichenbacher investigates.

With an international team, the LMU paleontologists have now demonstrated through their study of fossil killifish that the Valenciidae were once much richer in species. Moreover, they have discovered possible causes for their disappearance.

The paper is published in the *Journal of Systematic Palaeontology*.

The researchers analyzed fossil killifish from a new site in the Dinaric Alps in Bosnia and Herzegovina. In this region, where fossil killifish were previously almost unknown, a freshwater lake existed for around 250,000 years during the Middle Miocene, roughly 14.8 million years ago. This lake offered an ideal habitat for the 3–4 cm large fish. In total, the research team managed to excavate the skeletons of 179 fish, 94 of which even had preserved otoliths in their skulls.

"It's extremely rare to find skeletons with preserved otoliths; these fossils are key discoveries," says Reichenbacher.

Two new fossil genera

By studying the typical shape of otoliths, scientists can determine the species. Meanwhile, the skeletal features allow them, for example, to reconstruct the family relationships of the fish. The researchers were able to assign the new discoveries from Bosnia and Herzegovina to the family Valenciidae and identify two new fossil genera: Miovalencia and Wilsonilebias, both of which were represented with two species. Three of these species were previously unknown, while the fourth was already identified from earlier otolith finds but not recognized as Valenciidae.

Recovery of the fossils at the new site in Bosnia and Herzegovina. Credit: Davit Vasilyan, Jurassica Museum, Porrentruy, Schweiz

To the surprise of the researchers, moreover, the skeleton of Wilsonilebias had a specialized structure supporting the anal fin. This suggests that Wilsonilebias reproduced through internal fertilization, as

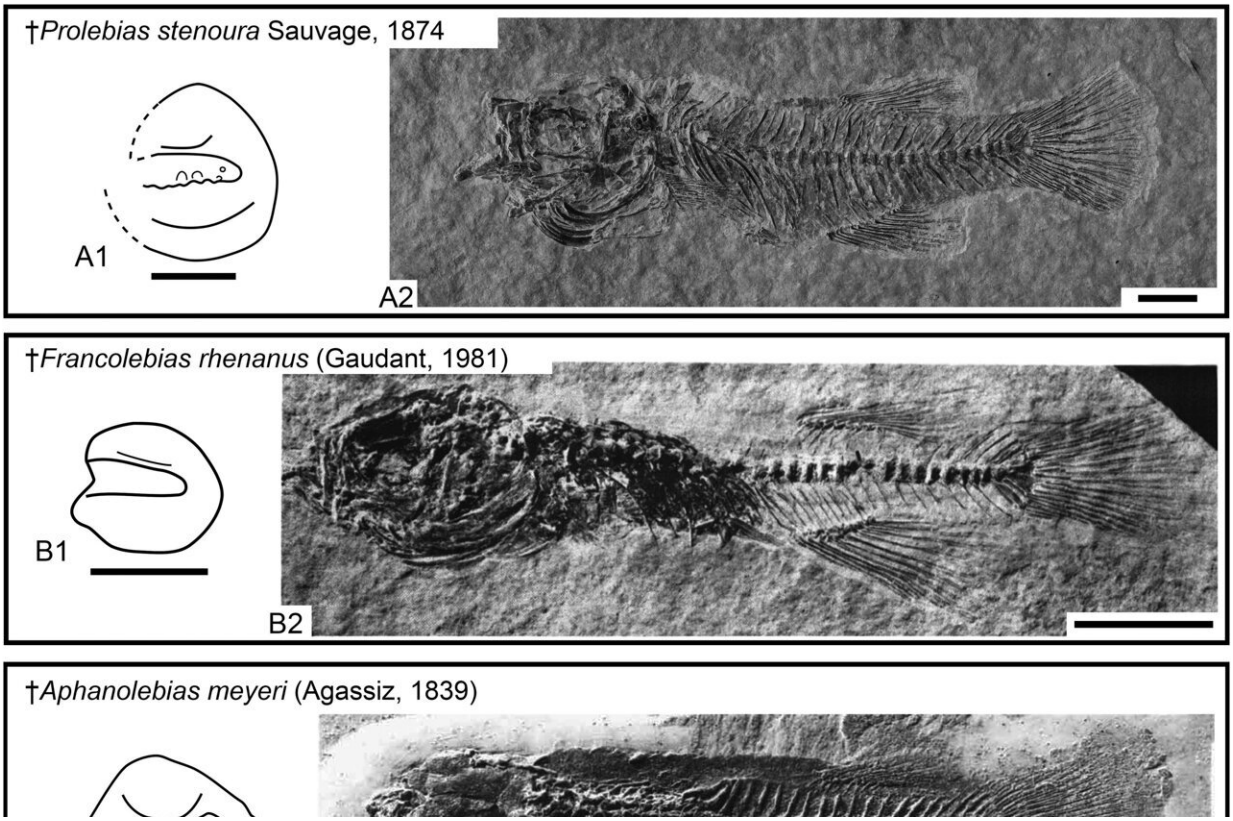
today's 'live-bearing' toothcarps do.

"Yet this does not necessarily mean that Wilsonilebias gave birth to live young, as some fish today lay eggs even after fertilization has occurred internally," says Reichenbacher.

"Nevertheless, our results show that some Valenciidae used different reproduction methods in the past as compared to their current descendants, which reproduce exclusively by means of external fertilization. It may even have been one of the secrets of their success at that time."

Four killifish species in a single lake would seem to be quite a lot. Andrea Herbert Mainero, doctoral student and lead author of the study, hypothesizes that the species divided up their habitat and thus their food sources. The two Wilsonilebias species probably lived in deeper water, where they may have fed on plankton. The rounded otoliths of Wilsonilebias support this conjecture, as many fish species that live in deeper water today are characterized by rounded otoliths.

By contrast, the two species of Miovalencia might have lived in shallow areas near the shore, where they would have benefited from a rich array of algae and ground-dwelling microorganisms.



Otoliths and skeletons of previously described fossil species of the Valenciidae. Credit: *Journal of Systematic Palaeontology* (2024).DOI: 10.1080/14772019.2024.2412539

Relics of a greater diversity

Furthermore, the discoveries demonstrate that there were 6 genera and 17 species of Valenciidae in the Miocene, whereas just one genus with three species is extant today. Some 14.8 million years ago, at the end of the so-called Middle Miocene Climatic Optimum, the climate was mainly warm and humid, such that there were sufficient lakes, large and small, for killifish to develop. In the further course of the Miocene, the climate became drier and many of these lakes disappeared.

"We conjecture that Valenciidae couldn't adapt to this climatic change, with a consequent decline in diversity," says Herbert Mainero.

"As such, the three species today are relics of a once much greater diversity," adds Reichenbacher.

The new research findings offer valuable insights into the historical development of Eurasian fauna and highlight the importance of protecting the three extant Valencia species, of which one is endangered and the two others are threatened with extinction.

More information: Andrea Herbert Mainero et al, Two new genera of killifish (Cyprinodontiformes) from the Middle Miocene of the Bugojno Basin, Bosnia and Herzegovina: insights into the lost diversity of Valenciidae, *Journal of Systematic Palaeontology* (2024). DOI: 10.1080/14772019.2024.2412539

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