Vertebrate jaw design locked 400 million years ago

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A sample of lower jaw diversity from 400 million years ago which includes from top to bottom: a giant 8-meter apex predator, a lungfish with a duck-like snout, a reef-dwelling representative of a totally extinct group of vertebrates, a fish-like relative of land animals, and a shark-like cousin of bony fishes. Jaws are not to scale and all are oriented so their front end is to the left. Credit: Simon Powell

More than 99 per cent of modern vertebrates (animals with a backbone, including humans) have jaws, yet 420 million years ago, jawless,

toothless armour-plated fishes dominated the seas, lakes, and rivers. There were no vertebrates yet on land and the recently evolved jawed fishes were minor players in this alien world, some sporting unusual jaw shapes and structures that bear little physical resemblance to modern animals.

The researchers, led by Dr Philip Anderson of Bristol's School of Earth Sciences, applied concepts from physics and engineering to unravel the potential feeding functions of these unusual, early vertebrate jaw designs, and compared this data to patterns of diversity in both jawed and jawless fishes. While it has long been assumed that jawed fishes were better adapted, and therefore directly out-competed and replaced their jawless neighbours during this tumultuous time, this assertion has never been tested.

Dr Anderson said: "Surprisingly, our results indicate that long-held assumptions concerning the replacement of jawless fishes by newly evolved jawed forms are likely wrong. The variety of feeding mechanisms in early jawed animals appears to have had little to no affect on the diversity of jawless fishes, which shared ecological space with the jawed fishes for at least 30 million years before beginning to notably decline. When the jawless fishes do decline, we see no indication that their jawed cousins took up new functional roles, calling into question old ideas of ecological replacement.

"Furthermore, jawed vertebrates achieved a stable diversity in their feeding apparatus early in their evolution, and maintained this diversity in the face of major environmental changes during the Devonian period. Previous studies have suggested that the rise of major jawed vertebrate ecological diversity is tied to a documented oxygenation event 400 million years ago, but our results place the first burst of diversification of jawed vertebrates well before that.

"The groups which comprise the majority of modern fish diversity (ray-finned fishes), as well as our own fish ancestors (early tetrapods), are restricted to only a few types of jaws and feeding ecologies, while bizarre, extinct groups (such as placoderms and a surprising number of extinct lungfishes) show a wide range of feeding ecologies that at the time dominated the jawed vertebrate world. It is interesting to speculate what modern jawed vertebrates might have looked like if these diverse groups hadn't been severely diminished (extinct in the case of the placoderms) after the Devonian."

The research group hopes that these new methods for assessing the variation in functional systems (such as feeding apparatus), will be applied to the study of other extinct groups during times of dramatic transitions, such as mass extinctions and evolutionary radiations.

More information: 'Initial radiation of jaws demonstrated stability despite faunal and environmental change' by Philip S. L. Anderson, Matt Friedman, Martin D. Brazeau, Emily J. Rayfield, *Nature* (2011).

Provided by University of Bristol

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