How fish got onto land, and stayed there

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A group of Pacific leaping blennies out of the water on the foreshores of the island Guam. Credit: Terry Ord

Research on blennies, a family of fish that have repeatedly left the sea for land, suggests that being a 'jack of all trades' allows species to make the dramatic transition onto land but adapting into a 'master of one'

allows them to stay there. The findings are published in the British Ecological Society journal *Functional Ecology*.

Researchers from University of New South Wales and the University of Minnesota pooled data on hundreds of species of blennies, a diverse family of fish where some are aquatic and others have left the water completely. They found that a flexible diet and behavior were likely to be instrumental in the transition to land.

However, once out of the water, restrictions on the type of food available triggered major evolutionary changes, particularly to their teeth, as land dwelling blennies have become specialists in scraping algae and detritus from rocks.

Dr. Terry Ord, lead author of the research, said: "The implications of our findings are that having a broad diet or being behaviorally flexible can help you move into a new habitat. But once there, this flexibility becomes eroded by natural selection. This presumably means those highly specialized species are less likely to be able to make further transitions, or cope with abrupt environment changes in their existing habitat."

The scenario of fish colonizing land has obvious parallels with the origin of all land vertebrates. "Fossils can give us important insights into how that transition might have unfolded, and the types of evolutionary adaptations it required or produced. But having a contemporary example of fish making similar ecological transitions can also help us understand the general challenges that are faced by fish out of the water" said Dr. Ord.

Blennies are a remarkable family of fish with different species occupying strikingly different environments. Some are aquatic. Others spend time in and out of the water in the intertidal zone, an extreme

environment with fluctuating water levels and pools that can rapidly change in temperature and oxygen levels.

Some species of blenny are terrestrial and spend almost their entire lives out of the water in the splash zone and must keep moist in order to breathe through their skin and gills. Despite these challenges, blennies have been incredibly successful in repeatedly making these dramatic transitions.

Because of this diversity, different blenny fish species represent clearly defined stages of the invasion process between two completely different environments. This makes them a unique group of animals to study.

Dr. Ord explained the origin of the study with his co-author Dr. Peter Hundt: "We both had extensive data collected on many different species of blenny from across the world. Peter had detailed information on diet and teeth morphology, while I had lots of data on behavior and frequency of different species emerging from water for brief or extended periods on land.

"We threw a set of complex evolutionary statistical models at this combined data and we were able to reveal the sequence of events that likely allowed aquatic marine fishes to ultimately evolve into fishes that could leave water and then colonize land. Our study also showed how those species on land adaptively changed to better suit the specialized diet needed to survive on land."

The authors caution that although the observational data suggests a flexible diet and behavior allows a transition to new environments to occur, it cannot confirm causality. "Ideally we would perform some type of experimental investigation to try to establish casualty. What this experimental study might be is hard to imagine at this stage, but we're working on it." Said Dr. Ord.

The authors are also looking to further investigate how the invasion of land has impacted other aspects of blenny fish behavior, ecology and bodies. "Terrestrial blennies are really agile out of water, and I suspect they've adapted their body shape to allow them to hop about the rocks so freely. Which in turn implies they might not be able to go back to the water" said Dr. Ord, "It would also be exciting to know how their sensory systems might have adapted out of the water as well, given vision and smell would probably work quite differently in these environments."

More information: *Functional Ecology* (2020). besjournals.onlinelibrary.wile … 1111/1365-2435.13600

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