How fishes conquered the ocean

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Scientists at the University of Bergen, Norway have deduced how bony fishes conquered the oceans by duplicating their yolk-producing genes and filling their eggs with the water of life – the degradation of yolk proteins from one of the duplicated genes causes the eggs to fill with vital water and float.

This is the major solution realized by extant marine teleosts that showed an unprecedented radiation during the late Cretaceous and early Paleogene Periods. The work is a unique hypothesis that integrates the cellular and molecular physiology of teleost reproduction with their evolutionary and environmental history.

"The oceans have not always been filled with fishes as nowadays" says researcher Dr. Roderick Nigel Finn at the Department of Biology, University of Bergen, Norway. "To the contrary", Dr Finn says, "the fossil record shows that the ancestors of the bony fishes (teleosts) inhabited fresh water environments for at least 150 million years before they entered the oceans".

"Apparently, it was not until the Eocene epoch (about 55 million years ago) that an unparalleled and rapid burst of thousands of new marine teleost species took place as evidenced by their sudden appearance in the fossil records of marine sediments. The basis for this successful radiation is unexplained and has intrigued biologists for many years", says Dr. Finn and adds, "Our paper in PLoS ONE relates to the molecular solutions evolved among the teleost ancestors and provides a compelling hypothesis of when, how and why the teleosts succeeded in

the oceanic environment. It is common knowledge that water is essential for life," continues Dr. Finn, "so it seems a surprising paradox that fishes that live in water should have a problem acquiring it. Yet it was this paradox that provided the trail of clues for us to follow".

"The physiological problems of reverting from a fresh water environment to the saline seawater is demanding for the water balance of fishes", says professor Hans Jørgen Fyhn, a colleague of Dr. Finn, and adds, "This is especially so for their newly spawned eggs since they lack the adult organs and mechanisms responsible for coping with these problems. For years we studied various aspects of the physiological adaptations of the fish egg to the marine environment. It is most satisfying that Dr. Finn has been able to tie the threads together in molecular and evolutionary terms with their impressive, comparative sequence alignment study of the involved yolk genes and proteins as published in *PLoS ONE*".

In the paper the authors (RN Finn & BA Kristoffersen) have used Bayesian analysis to examine the evolution of vertebrate yolk protein (vitellogenin) genes in relation to the "Three round hypothesis" of whole genome duplication among vertebrates, and the functional end points of the vitellogenin fractional degradation during the final stages of oogenesis, a period that prepares the egg for spawning and fertilization. They show that teleost vitellogenins have undergone a post-R3 lineage-specific gene duplication to form paralogous clusters that correlate to the pelagic and benthic character of the eggs.

The alteration in the function (neo-functionalization) of one of the duplicated genes (paralogues) allowed its yolk protein products to be broken down to free amino acids and thus drive hydration of the maturing eggs. The timing of these events matches the appearance of the vast numbers of marine acanthomorph teleosts in the fossil record. The authors propose that the neo-functionalization of duplicated vitellogenin

genes was a key event in the evolution and success of the acanthomorph teleosts in the oceanic environment.

"This study is an exciting part of our research focus in Developmental Biology of Fishes, and the work published in *PLoS ONE* is clearly a high point of these efforts" says professor Jarl Giske, head of the Department of Biology at the University of Bergen."It is stimulating to both students and staff at the department when our researchers are able to contribute to solving great evolutionary problems."

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