UNIVERSITÉ DE GENÈVE

PRESS RELEASE

Geneva | March 24th, 2021

Scaled, armoured or naked: how does the skin of fish evolve?

Researchers at the UNIGE have traced the family tree of ray-finned fish in order to reconstruct the evolution of the protective structures of their skin.

Usually scaled, the skin of fish can also be naked or made up of bony plates that form an armour, sometimes even covered with teeth. But how has this skin evolved over the ages? To answer this question, researchers at the University of Geneva (UNIGE), Switzerland, have reconstructed the evolution of the protective skin structures in fish, going back to the common ancestor of ray-finned fish, more than 420 million years ago. They found that only fish that had lost their scales were able to develop a bony armour, and that the protective state of their skin influenced their choice of open water or sea floor habitats. This study, published in the journal *Evolution Letters*, provides a new explanation for the incredible diversity of this lineage of fish, which includes more than 25,000 species.

Ray-finned fish, such as catfish or goldfish, constitute the most diverse lineage of vertebrates on Earth, with no less than 25 000 species, i.e. half of the planet's vertebrates. "Far from being limited to scales, these fish species can also have completely naked skin or a bony armour, sometimes covered with teeth, as is the case with certain catfish", notes Juan Montoya, a researcher in the Department of Genetics and Evolution at the UNIGE Faculty of Science. But how did the protective structure of the skin evolve in these fish?

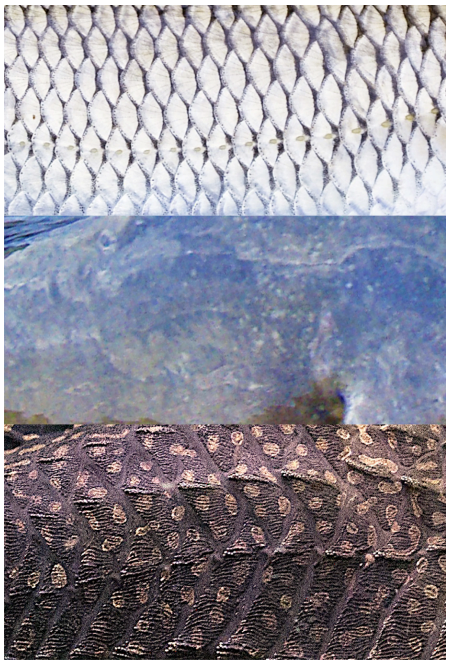
A family tree that goes back 420 million years

The researchers used an evolutionary tree of fish that lists 11,600 species. "In order to reconstruct the ancestral characteristics of the species, we worked in parallel with a second tree of 304 species, which precisely establishes the links of relationship", explains Alexandre Lemopoulos, a researcher in the Department of Genetics and Evolution at the Faculty of Science of the UNIGE. They asked themselves two questions: What type of protection do the fish have on their skin? And do they live in the open water or on the seabed?

Using mathematical models, they reconstructed the most likely ancestral state and, as they went up the family tree, they reconstructed the transitions between the three skin types and observed whether these had conditioned their habitat. "We were able to go back to the first ancestor of ray-finned fish, more than 420 million years ago, who had scales", enthuses Juan Montoya.

Only naked fish can develop armour

By analysing the transitional stages, the Geneva researchers found several lineages of fish that lost their scales, but at different positions in the tree. "There is therefore no temporal coincidence in this evolution", emphasises Alexandre Lemopoulos. Moreover, once a lineage of fish has lost its scales, it cannot find them again. "On the other hand, some of these naked fish subsequently developed bony plates cove-



Scaled skin of a chub (*Squalius cephalus*), naked skin of a catfish (*Ictalurus punctatus*) and skin with bony armour of an armoured catfish (*Pterygoplichthys multiradiatus*).

High resolution pictures

ring part or all of their body, forming a solid armour", points out Juan Montoya. "We now need to discover the underlying genetic mechanism, which probably no longer allows a return to the scale stage, but makes it possible to build a compensatory external skeleton." Thus, only naked fish were able to build up this armour. "It does not seem possible to go directly from a scaly skin to a cuirassed skin, nor to have a mixture of these two structures", he says.

Skin conditions the place of residence

The researchers also observed that the change in skin condition conditioned the place of habitation. "Several species of fish that have lost their scales have left the open waters in which they lived for the seabed, certainly finding an advantage in this new environment", explains Alexandre Lemopoulos. This is a pre-adaptation: the fish lose their scales, change environment and find advantages. As this sequence was repeated independently in several groups of fish, the researchers deduce that a skin without scales offers a real advantage for living on the bottom. "It should be noted that once a lineage of fish establishes itself on the seabed, it no longer returns to the open water, even if it subsequently develops a bony armour", he continues.

Two hypotheses seem to explain this 'move': respiration and immune defence. "Fish breathe through their gills, but also through their skin. Bare skin improves gas exchange in poorly oxygenated water by increasing the respiratory surface", suggests Alexandre Lemopoulos. Furthermore, recent studies have shown that the immune defence against viruses and bacteria, which are very present in the seabed, was more effective when the skin had no scales.

It is therefore thanks to the evolution of the protective structures of the skin that several families of fish have migrated to the seabed and opened up new ecological niches, colonising more and more different environments, whether in fresh or salt water. "This has contributed to the establishment of this enormous diversity, which makes ray-finned fish the largest group of vertebrates on the planet", concludes Juan Montoya.

contact

Juan Montoya
Lecturer
Department of Genetics and Evolution
Faculty of science
+41 22 379 67 86
Juan.Montoya@unige.ch

DOI: 10.1002/evl3.219

UNIVERSITÉ DE GENÈVE
Communication Department
24 rue du Général-Dufour
CH-1211 Geneva 4

Tel. +41 22 379 77 17

media@unige.ch
www.unige.ch