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Is evolution predictable?

Julia Wandt Department of Communication and Marketing
University of Konstanz

Konstanz biologists prove parallel evolution in Nicaraguan crater lake

Suppose we could turn back time and start evolution from scratch: Would the same species that we know today form? In other words, is evolution repeating itself? Is the emergence of species and their evolutionary adaptation predictable? Biologists from the University of Konstanz now found clear evidence of a repetitive, so-called "parallel" evolution, at least in shorter periods of about 1,500 years. The research team around Konstanz evolutionary biologist Prof. Dr. med. Axel Meyer studied genetic and phenotypic changes of seven different cichlid species that colonized the same crater lakes in Nicaragua. The result: All seven fish species show parallel evolutionary adaptations to the common habitat. The focus of the study was the adaptation of the eye of the seven fish species to the light conditions of the crater lakes. The research results were published online on July 17, 2018 in the research magazine "Evolution Letters".

The seven species of fish originally came from the two large lakes of Nicaragua and colonized from there several smaller crater lakes. This is an ideal field of research for evolutionary biology: after all, the younger fish populations of the crater lakes can be compared with their counterparts from the older populations that have remained in the great lakes of Nicaragua.

In the eye of the perch
While the big lakes have murky water that lets little light through, the crater lakes are crystal clear. The species of fish that migrated to these crater lakes were therefore found in altered light conditions: "The light conditions are shifted from long-wave, reddish light to short-wave blue light," explains Andreas Härer, lead author of the study. "We predicted that the fish will change their visual sensitivity to shorter wavelengths - and that's exactly what we found," Härer says. In the evolutionary adaptations of the eye to the changed light conditions, the biologists found an outstanding "natural experiment" among the cichlids. After all, all seven species of fish examined, as different as they are,

Seven Opsins
"We determined all the genes that are active in the retina of the fish's eye. We then filtered out the opsins responsible for color vision, "explains Andreas Härer. An opsin is a protein of the visual pigment. Humans have only three different opsins, one for red, one for green, one for blue.

Cichlids, on the other hand, have seven different opsins and thus greater variety to perceive colors. "Typically, they also only use three of them, but if the light conditions change, they can use a different set of opsins," says Härer.

So how does the particular set of opsins the fish use shift due to the changing light conditions of the crater lake? "What opsine has changed in detail differs between the different species - but all changed in the same direction towards shorter wavelengths. On the net, the picture is consistent, "concludes Andreas Härer. Figuratively speaking, in their "evolutionary roadmap," the species use different routes in detail, but the goal is the same. Equal habitats have led to similar evolutionary adjustments of the eye in seven different fish species.

Forecasts for evolution
Whether evolution may repeat exactly when we rewind the time billions of years, can only be speculated. The Konstanz evolutionary biologists can show, however, that for shorter periods of several thousand years, we can well predict how species will repeat and adapt in a similar way to new environmental conditions. "We therefore have the opportunity to anticipate the changes that are to be expected. For example, in terms of climate change, studies such as ours allow us to provide more accurate predictions on how species will adapt, "Andreas Härer points out.

The research project is part of the ERC Advanced Grant "Comparative genomics of parallel evolution in repeated adaptive radiations" by Prof. Dr. med. Axel Meyer, which receives 2.5 million euros from the European Research Council (ERC).

Facts overview:

- Konstanz evolutionary biologists show parallel evolution of seven different cichlid species that have migrated to the same habitat.

- Original publication: Andreas Härer, Axel Meyer, Julián Torres-Dowdall: Convergent phenotypic evolution of the visual system via different molecular routes: How Neotropical cichlid fishes adapt to novel light environments. Evolution Letters. July 2018.
https://doi.org/10.1002/evl3.71

- Molecular biological analysis of the evolution of the eye of seven fish species as they adapt to new lighting conditions.

- Equal habitats have led to a similar evolutionary change of the eye in all seven fish species studied, an adaptation of opsins (proteins of the visual pigment) to shorter wavelengths.

- Research project as part of the ERC Advanced Grant "Comparative genomics of parallel evolution in repeated adaptive radiations" by Prof. Dr. med. Axel Meyer.

- Funded by the European Research Council (ERC) and the German Research Foundation (DFG).

Note to editors:
Photos can be downloaded below:

https: //cms.uni-konstanz.de/fileadmin/pi/fileserver/2018/Bilder/Buntbarsch_Evolu ...
Caption: Amphilophus citrinellus, one of the seven cichlid species studied.
Picture: Claudius Kratochwil

https: //cms.uni-konstanz.de/fileadmin/pi/fileserver/2018/Bilder/Buntbarsch_Evolu ...
Caption: From the Nicaraguan Sea (picture), the cichlid species colonized the smaller and clearer crater lakes.

https: //cms.uni-konstanz.de/fileadmin/pi/fileserver/2018/Bilder/Buntbarsch_Evolu ...
Caption : Crater Lake Xiloá in Nicaragua. The much clearer water led to evolutionary adaptations of the eye of the cichlid species.

Contact:
University of Konstanz
Communications and Marketing
Phone: + 49 7531 88-3603
E-Mail: kum@uni-konstanz.de

- uni.kn

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