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Cave fish born without a cave

Exciting scientific development at the University of Konstanz: After thousands of years underground, Europe's first cave fish produce their first offspring outside of a cave system

Following the recent discovery of the first European cave fish in Southern Germany, researchers at the University of Konstanz are successful in providing this fish with the suitable conditions to spawn offspring outside of their natural habitat. The fish ecologist PD Dr Jasminca Behrmann-Godel and her team member Myriam Schmid are happy to report that they are now nurturing and studying the next generation of cave fish at the university's Limnological Institute.

The European cave fish is the northernmost of its kind in the world and is thought to have diverged from surface populations after the end of the last glacial period around 20,000 years ago. This loach belongs to the genus *Barbatula* and was discovered in a cave that is part of an underground karst water system north of Konstanz. A few of these fish have now found a new home at the University of Konstanz. Meanwhile, additional cave fish specimens were recently discovered in another part of the cave system.

"The only cave fish to exist outside of a cave are being cared for at our research institute. The fact that we were able to create an environment for these fish to not only survive, but to also successfully breed outside of their natural underground habitat is extraordinary", says Behrmann-Godel, the lead author of the study that announced the discovery of the cave fish in 2017.

Joachim Kreiselmaier – cave diver and member of the "Freunde der Aachöhle" association that is dedicated to the exploration and protection of the Aach cave and the interconnected karst water system – was the first to discover the fish during a challenging five hour dive in 2015. Thanks to his continued exploration of the cave system, Behrmann-Godel and her colleague Myriam Schmid were able to bring at least two male and two female adult fish together this year. Considering the general lack of scientific knowledge regarding the breeding behaviour of these cave fish, both did not have very high expectations for these loaches to produce offspring in an artificial setting.

"We provided our adult cave fish at the Limnological Institute various substrates on which they could lay their eggs. We provided them with access to sand, large pebbles and a basin with small stones. We even installed a basin filled with fine gravel covered by a lattice to keep the adults from eating the eggs. But exactly where the cave fish actually prefer to lay their eggs remains a mystery," explains Behrmann-Godel.

For Myriam Schmid, the little hatchlings were a real surprise. She looks after the cave fish at the Limnological Institute and she was the first to discover the approximately 1.5 centimetre long baby cave fish this past June, around two months after their presumed spawning period. "Even though

we checked the aquarium on a daily basis, we did not immediately see the babies. The fact remains, however, that we now have four young cave fish to nurture and learn from!”

The need for offspring and future research

“We were also the first to successfully breed the cave loach’s surface relatives: The stone loach from Danube and Radolfzeller Aach rivers. And we now have stable laboratory populations”, exclaims Behrmann-Godel. She is convinced that they will be able to do the same for the cave fish in the near future – with up to 30 to 50 adult animals that reproduce on a regular basis. Joachim Kreiselmaier thinks that it’s important to breed stable cave fish at the Limnological Institute: “In this way, we can limit the number of fish we bring back from the caves for research purposes”.

While the current research focus is on studying the cave fish’s genome and carrying out comparative genomic studies with other species, Behrmann-Godel and her colleagues also look forward to carrying out controlled and comparative laboratory studies with their cave and stone loach populations. Their goal is to find out which typical cave fish traits – such as reduced eye size, reduced pigmentation, or enlarged nostrils – are based on phenotypic plasticities and which result from genetic changes. “Future crossbreeding trials with both loach groups will also require stable lab populations”, explains Behrmann-Godel.

Further research on cave fish behaviour and distribution

To learn more about the behaviour of the cave fish, Behrmann-Godel is currently collaborating with Dr Jolle Jolles, a behavioural ecologist in the research field of Collective Behaviour at both the University of Konstanz and the Max Planck Institute of Ornithology in Radolfzell, Germany. The researchers are utilising, among other things, high-resolution video technology with infrared light to film the fish in the dark. The team intends to investigate the behaviour of individual cave fish in detail as well as how their group behaviour may differ from that of the surface populations.

In the future, the fish ecologist from Konstanz also hopes to learn more about how these cave fish managed to survive in their natural cave environment for thousands of years and how it behaves in total darkness: “How do these fish know when it is time to breed? How do they find their partners or nourishment, and what food chains and microorganisms exist in the caves? Are there maybe other caves with cave fish populations or related species waiting to be discovered?”

Due to a late-breaking discovery, Behrmann-Godel’s last question can now be (partially) answered: On 18 August 2018, cave diver Bogdan Grygoruk – also a member of the “Freunde der Aachhöhle” association – reported that he found further specimens of the same cave fish in an upstream area of the Danube-Aach underground karst water system, which is separated from the original discovery site by a deep depression (doline or sinkhole). This new discovery confirms Behrmann-Godel’s hypothesis that the cave fish inhabit other parts of the approximately 250 square kilometre large underwater system: “As a result of this new cave fish sighting, we have further evidence to support our assumption that the European cave fish is dispersed over a wide area and that the corresponding population size of the cave fish is very large.”

Facts:

- Researchers at the University of Konstanz are successful in providing adult specimens of the first European cave fish with the suitable conditions to produce offspring outside of their natural cave habitat.
- The fish ecologist PD Dr Jasminca Behrmann-Godel and her colleague Myriam Schmid are happy to report that they are now nurturing and studying four young cave fish at the university's Limnological Institute.
- Stable cave and stone loach populations are being bred to facilitate future controlled and comparative laboratory research and to limit the extraction of fish from the caves.
- Larger fish populations are also necessary for swarm behaviour studies in collaboration with scientists from the Collective Behaviour research area at the University of Konstanz.
- A recent second cave fish discovery in a different area of the Danube-Aach underground karst water system confirms Dr Behrmann-Godel's hypothesis that the cave fish is dispersed over a wider area and that its population size is potentially very large.

Note to editors:

You can download a photo and a video here:

https://cms.uni-konstanz.de/fileadmin/pi/files/2018/Bilder/Hoehlenfisch/Hoehlenfisch_ganz_ohne_Hoehle.jpg

Caption: First cave fish offspring at the University of Konstanz.

Photo: University of Konstanz

<https://youtu.be/22LShl3bcC0>

Caption:

Young cave fish, born in June 2018 at the Limnological Institute of the University of Konstanz, swim with adult animals in the aquarium.

Video: PD Dr Jasminca Behrmann-Godel

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