Why overfishing leads to smaller cod

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Overfishing, hunting and intensive agriculture and forestry can sometimes contribute to plants and animals becoming endangered. New research from Lund University in Sweden and University of Toronto can now show why this leads to entire populations becoming smaller in size, as well as reproducing earlier. The study is published in the journal

PNAS.

Researchers from Lund and Toronto are behind the study conducted on five different species of damselflies. They have studied how different environmental factors affect when and at what size the damselflies begin to reproduce. In the study, the researchers also shed light on how overfishing off the coast of Newfoundland has had direct consequences for the reproduction size and age of cod, which is similar to what they have found in damselflies.

"Overfishing has resulted in the cod now reproducing earlier and at a smaller size, something it has been forced to do to survive. If it had not evolved in this way, it might have completely disappeared from the waters off southeastern Canada," says Viktor Nilsson-Örtman, a researcher at Lund University.

The classic explanation for the smaller reproductive size is that it is a direct consequence of a higher mortality rate due to overfishing. But that might not be the case, according to Viktor Nilsson-Örtman and his colleague Locke Rowe at the University of Toronto. In support of their thesis, the two researchers point out that the cod should then have returned to a larger reproductive size when the overfishing stopped. However, that has not happened.

Instead, they point to another explanation. Overfishing off Newfoundland may have led to a rapid, evolutionary change in the species' threshold size (the smallest size at which an organism can begin to reproduce). The smaller threshold size was maintained when overfishing ceased. Evolution has thus made a permanent change, and the cod have continued to reproduce earlier and at a smaller size.

"Our results show that future fishing quotas may need to be changed so that species avoid developing smaller threshold sizes only to get stuck

there," says Viktor Nilsson-Örtman.

The theory of threshold sizes was put forth over 40 years ago and applies to all living organisms, but has remained a theory until now.

The unique aspect of the current study is that the researchers prove that threshold sizes exist in reality and that they control how organisms react to various environmental factors, such as access to food. The study also shows that threshold sizes can change via evolution.

"It is important to understand that both animals and plants that we use for our food supply can undergo evolutionary changes in size if they are exploited too harshly. Cod stocks outside Newfoundland are one example, but this could apply to crops that are harvested at frequent intervals or huntable game," concludes Viktor Nilsson-Örtman.

More information: Viktor Nilsson-Örtman et al. The evolution of developmental thresholds and reaction norms for age and size at maturity, *Proceedings of the National Academy of Sciences* (2021). DOI: 10.1073/pnas.2017185118

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