Tilapia farming: Dwarfism is a response to overcrowding stress

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Nile tilapia. Credit: Germano Roberto Schüür, Wikimedia Commons

Tilapia living in crowded aquaculture ponds or small freshwater reservoirs adapt so well to these stressful environments that they stop growing and reproduce at a smaller size than their stress-free counterparts.

A new study by researchers at the University of Kelaniya in Sri Lanka

and the University of British Columbia in Canada, explains that while most fishes die when stressed, tilapia survive in rough environments by stunting and carrying on with their lives in dwarf form.

"Tilapia and other fish in the Cichlidae family do not spawn 'earlier' than other fishes, as it is commonly believed," Upali S. Amarasinghe, lead author of the study and professor at the University of Kelaniya, said. "Rather, they are uncommonly tolerant of stressful environmental conditions which, however, elevate their oxygen demand."

As happens with other fishes, when tilapia's metabolism accelerates, it needs more oxygen to sustain its body functions. But as a result of the interaction between an increased metabolism and a growing body, gills reach a point where they cannot supply enough oxygen for a larger body, so the fish either dies or just stops growing.

"Gill surface area grows in two dimensions, that is, length and width, but they cannot keep up with bodies that grow in three dimensions—length, width and depth," said Daniel Pauly, co-author of the study and principal investigator of the Sea Around Us initiative at UBC's Institute for the Oceans and Fisheries. "As fish get bigger, their gills provide less oxygen per unit of body weight. Thus, to stay alive in stressful conditions that increase their oxygen demand, fish have to remain smaller. This theme is further developed in what I called the gill oxygen limitation theory."

The stress tilapia experience under suboptimal conditions adds to the stress they experience when the surface of their gills cannot scale with the increasing oxygen demand of their growing bodies. In consequence, the hormonal cascade that leads to maturation and spawning is triggered at smaller sizes than under optimal conditions.

But the spawning doesn't occur at a younger age, as the fish's growth process has already ended.

To reach this conclusion, the researchers analyzed the length at first maturity and maximum lengths in 41 populations of nine fish species such as tilapia and other cichlids found in lakes and aquaculture ponds across the world, from Brazil to Uganda, and from Egypt to Hong Kong.

When looking at the ratio between the maximum lengths these fishes can reach and their lengths when they reproduce for the first time, they found it was the same ratio previously identified in other freshwater and marine fishes.

"This ratio tells us that tilapia in stressful conditions don't spawn 'earlier," they just adjust their size downward, but their life cycle continues," Amarasinghe said.

"These findings will matter to fish farmers, notably in Asia, whose ponds are often full of wildly reproducing, small tilapia for which there is no market," Pauly said.

More information: Amarasinghe US and Pauly D (2021) The Relationship Between Size at Maturity and Maximum Size in Cichlid Populations Corroborates the Gill-Oxygen Limitation Theory (GOLT). *Asian Fisheries Science* 34: 14-22 doi.org/10.33997/j.afs.2021.34.1.002

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