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Deoxygenated toadfish turn up gill serotonin degradation to catch breath

A gulf toadfish sheltering in a tube in a tank in the laboratory. Photo credit: John Sebastiani.

Serotonin is probably most famed for its mood-altering role in the human brain. Yet, long before people began taking serotonin reuptake inhibitors to treat depression, the versatile neurotransmitter was known to cause blood vessels to constrict, which could be a problem for fish when oxygen levels in water plummet naturally. 'Toadfish slow their heart rate, lower their blood pressure and breathe deeper when oxygen drops. These responses help maximize their oxygen absorption and usage', says John Sebastiani from the University of Miami, USA. Knowing that the levels of serotonin in the blood are tightly maintained by a delicate balance between tissue absorption and destruction and excretion, Sebastiani, Allyson Sabatelli and Danielle McDonald, also from the University of Miami, decided to investigate how Gulf toadfish (*Opsanus beta*) manage serotonin levels in their blood when their oxygen supply drops a little.

'Toadfish are lazy and like to settle on the bottom, so it's pretty common for them to be accidentally caught in shrimping boat nets', says Sebastiani, explaining that fishermen just throw them back. 'As long as we have buckets of seawater and an air pump, we can collect the fish and safely transport them back to campus', he adds. After returning to the lab, the team reduced the oxygen in the fish's water from 100% to 50% – which isn't too extreme for the fish – for 2 min, 40 min and 24 h respectively, before collecting samples of the fish's brains, gills, liver, kidneys and heart, as well as their bile and urine to monitor their ability to absorb serotonin and break it down.

Checking the amount of serotonin circulating in the fish's blood, the team found that levels in the fish that experienced 40 min of lower oxygen had fallen by 34%, while the fish that had spent a whole day in reduced oxygen experienced a 54% drop. However, when the researchers checked which tissues were absorbing and destroying serotonin, they were surprised that the heart had reduced how much serotonin it was breaking down – potentially supplying the gills with more of the blood vessel constricting neurotransmitter, instead of removing it from the blood to dilate the gill blood vessels and allow them to absorb more oxygen from the depleted water. But the researchers had recorded that serotonin levels in the blood declined, so which other tissue was removing the neurotransmitter from the fish's blood?

Next, the team measured serotonin breakdown in the gill when the fish experienced periods of reduced oxygen, and the level increased threefold. 'These results suggest that serotonin clearance is upregulated during hypoxia and likely driven, in part, by mechanisms within the gill', says Sebastiani.

In addition, when measuring the quantity of serotonin being excreted in the bile produced by the liver, the researchers discovered that the neurotransmitter levels almost doubled after they replaced the fish's well-oxygenated water with poorly oxygenated water for 40 min. As well as breaking the neurotransmitter down, the fish also excrete it. However, the team points out that serotonin production in the liver, which is a major source of the neurotransmitter, could reduce when the fish experience a fall in oxygen, and they are curious to find out more about how serotonin impacts the fish's heart function when their oxygen supply dwindles.

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