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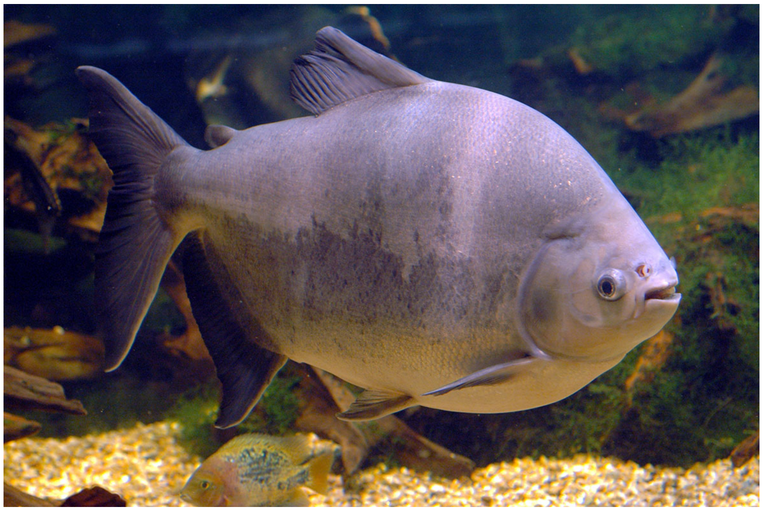
Fish maintain tissue pH despite CO_2 blast



Tambaqui (*Colossoma macropomum*), Leipzig Zoo, Germany. Photo credit: Tino Straus, GNU Free Documentation License, Version 1.2 or any later version published by the Free Software Foundation.

Even though lake and river CO_2 levels never near the fizzy heights found inside a can of soda, CO_2 can vary drastically between bodies of water, even within a matter of meters. 'For example, CO_2 levels in tropical environments may be as high as 8 kPa, which is 27 times higher than the average global freshwater level of 0.3 kPa', says Ryan Shartau from the University of British Columbia, Canada. Sudden blasts of CO_2 can send the physiology of fish haywire, swiftly driving down the pH of their blood before they topple over and asphyxiate. Although most fish are able to rebalance their blood pH swiftly enough to maintain their equilibrium when CO_2 shifts are mild, a select few seem to be able to deal with potentially fatal build-ups of CO_2 by stabilising the pH within tissues, regardless of the pH of their circulating blood. 'Prior to 2008, only three fish species, marbled swamp eel, armoured catfish and white sturgeon, were known to maintain a stable pH of their tissues during high CO_2', says Shartau. However, he and his thesis advisor, Colin Brauner, wondered how unique these extraordinary fish are, so they tested how white sturgeon, which deal well with high CO_2, and rainbow trout, which do not, coped as they increased the CO_2 in the fishes' water.

Raising the CO_2 concentration at rates ranging from 1 up to 4 kPa h^{-1}, Shartau found that the white sturgeon fared far better than the rainbow trout. The sturgeon only toppled over at 22 kPa CO_2 compared with the rainbow trout, which lost their balance at 5.5 kPa CO_2. Then Shartau set his sights on more exotic fish from waters that can experience naturally high pulses of CO_2. Visiting Dane Crossley's lab at the University of North Texas, he and Zac Kohl caught spotted gar and channel catfish from nearby lakes and rivers, and settled them into the lab before increasing the CO_2 levels in their water to 1.5, 3 or 6 kPa CO_2 for 3 h. Then the pressure was on to measure the pH of the fish's blood and to collect specimens of the fish's heart, muscle, liver and brain without the internal pH altering. 'We rapidly collected the tissues, wrapped them in aluminium foil and flash-froze them in liquid nitrogen to stop metabolic activity', says Shartau. However, he recalls underestimating how much time it would take to process all of the tissues. 'I was seriously short on time, so I worked solid around the clock, with only a short break for Thanksgiving dinner at Dane's, before going back in the lab and finishing an hour before I headed to the airport', he laughs.

Over the next 4 years, Shartau visited Adalberto Val at the Brazilian National Institute for Research of the Amazon and Peter Allen at Mississippi State University, USA, to check out the responses of fish ranging from American paddlefish and alligator gar to matrinxã and the most resilient of them all, tambaqui. When the team finally compared the pH values of the fishes' tissues against those of their blood, they were astonished. Although the fish blood pH values fell dramatically as the CO_2 level increased, their tissue pH remained stable and some even raised the pH of the heart. 'We were surprised by the number of fish species able to maintain a stable pH inside their tissues during those high CO_2 exposures', says Shartau, adding, 'Going into this study, we were concerned we might not find any'. He and Brauner are now keen to find out exactly how fish pull off this feat and whether aquatic invertebrates are also capable of defending themselves from a blast of CO_2.

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