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Antarctic bald notothens use spleen scuba tank to keep down blood viscosity

A bald notothen (*Pagothenia borchgrevinki*). Photo credit: Michael Axelsson.

Trapped in the frigid currents surrounding Antarctica with body temperatures that virtually never exceed 0°C, icefish and rockcod live at temperatures that would freeze most species solid. To survive, the fish pack their body fluids with antifreeze proteins to ensure that they remain liquid. However, pumping protein-packed thick blood around the body is hard work for the heart and some fish have taken drastic measures to overcome the pressure. For example, icefish have entirely done away with red blood cells to thin the blood and reduce viscosity. But Michael Axelsson, Jeroen Brijs and Albin Gräns from the University of Gothenburg and the Swedish University of Agricultural Sciences wondered whether the spleen could hold the key to the survival of another Antarctic species, bald notothens (*Pagothenia borchgrevinki*). Explaining that the spleen usually stores red blood cells ready for use during exertion – the organ has even been referred to as the Weddell seal's natural scuba tank – Brijs and colleagues wondered whether bald notothens depend on their spleens to store red blood cells and reduce blood viscosity in readiness for a workout?

After travelling south to the McMurdo Research Station in Antarctica, Axelsson, Gräns and their colleagues Malin Rosengren and Fredrik Jutfelt went fishing through the sea ice for the hardy creatures. 'Encountering the frosty wastelands of Antarctica was a very memorable experience, despite the extremely low temperatures and imminent risk of getting caught in a snow-storm', says Gräns. Then the team set about finding how many red blood cells were circulating in the fish's blood when the animals were swimming hard or when they were digesting dinner, which is another energetic process for cold-blooded creatures.

Dividing the fish into four groups, the team fed one group before chasing them around the tank for 10 min, while the second set of fed fish had a rest. Meanwhile, the third group had a 10 min workout on an empty stomach while the hungry fourth group rested. The scientists then took blood samples and discovered that fish that were simply digesting a meal had more than doubled the quantity of red blood cells in their circulation, while the unfed fish that had been chased around the tank had more than tripled their red blood cell count. The spleen seemed to be helping out the fish when they were exerting themselves by boosting their red blood cell supply. But what would this increase mean for the fish in practice? Would the additional red blood cells supply more oxygen to fuel their exertions and how would their hearts cope with the raised blood viscosity?

The team recorded how much oxygen the fish consumed while they were exercising and then operated on other fish to tie off their spleens – to prevent them from releasing red blood cells – to find out how well they fared during exertion. The fish that could no longer use blood cells from their spleens increased their metabolic rate by ∼70%, but the fish that still had use of their spleen scuba tanks raised their metabolic rate by an impressive ∼150%. However, the blood pressure of the exercising fish rose by 12% and their hearts were working 30% harder, thanks to the additional circulating red blood cells. 'There is a considerable energetic and physiological cost associated with transporting the highly viscous blood', says Gräns.

Bald notothens are able to capitalise on their ability to hold red blood cells in reserve, ready for an additional burst of energy, without incurring the costs of pumping viscous blood around the body continually. Brijs says, 'This strategy is most likely advantageous for bald notothens when hunting their prey or escaping their predators'.

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