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INSIDE JEB

Caiman red blood cells carry bicarbonate, not blood plasma

A submerged broad-snouted caiman (*Caiman latirostris*). Photo credit: Naim Bautista.

Lurking at the bottom of a river in wait for a passing meal, crocodiles spend less time submerged than you might imagine. ‘The durations of voluntary dives appear relatively short, 10–15 min’, say Naim Bautista and Christian Damsgaard, from Aarhus University, Denmark, explaining that the reptiles are probably able to sustain their sluggish metabolism using only the oxygen they carry down, rather than by switching to anaerobic metabolism when their oxygen stores dwindle. The team also knew that the oxygen-carrying protein, haemoglobin, found in the reptiles’ red blood cells has an exceptional ability. In addition to transporting oxygen and the waste CO_2 that is generated by metabolism, the protein is capable of holding onto a derivative of CO_2, bicarbonate, which is usually transported out of the red blood cells of vertebrates and carried in the blood plasma. Yet no one had ever checked whether the predatory reptiles capitalise on this capacity during a dive. Does the unusual haemoglobin hold onto bicarbonate anions while the reptiles are submerged, or is the protein’s ability to bind bicarbonate just a novelty discovered by scientists almost 50 years earlier? Bautista, Damsgaard, Angela Fago and Tobias Wang decided to check.

The team chose to work with some of the more diminutive members of the crocodile family – spectacled and broad-snouted caimans – rather than their heftier cousins. After gently submerging the animals for ∼20 min periods to get them used to diving in the lab, Bautista and Damsgaard prepared to collect a series of blood samples over the course of a 32 min dive, once the animals were relaxed. ‘Running the diving protocol was hard. We depended on a full set of haematological parameters measured in three blood samples within 30 min to calculate the distribution of bicarbonate across the red blood cell membrane during diving. This required a lot of preparation and coordination before and during the experiments’, says Bautista. Then, he and Damsgaard measured the oxygen concentration in the blood and red blood cells, the CO_2 levels, the pH, and the concentration of free bicarbonate in the plasma and the red blood cells, to determine where the anion was accumulating.

Impressively, the amount of bicarbonate bound to the haemoglobin in the reptiles’ red blood cells rose as the oxygen they were carrying fell. Instead of ejecting bicarbonate into the blood plasma, the caimans were holding onto it in their red blood cells. But why have these reptiles evolved this ability when other creatures haven’t bothered?

Although the team admits that they are not certain, they suggest that it may help the caimans to maintain a stable red blood cell pH, which would fall if the basic bicarbonate was released into the plasma. Alternatively, the accumulation of bicarbonate in the red blood cells could help them to deliver oxygen to tissues to maintain aerobic metabolism as the submerged animals’ oxygen stores decline. It is also possible that the ability to mop up bicarbonate released into the blood when an animal digests a meal and to store it in red blood cells could combat the dramatic increase in blood pH that would otherwise occur, which could impair oxygen delivery to other tissues while submerged on a river bed. Whatever the reason, Bautista, Damsgaard and colleagues have confirmed that the reptiles genuinely capitalise on the bicarbonate carrying capacity of their unconventional haemoglobin when they settle down for a session of sunken dinner spotting.

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Kathryn Knight
kathryn.knight@biologists.com

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