Backswimmers use buoyancy aid like a gill

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Ever since he can remember, Karl Jones has been fascinated by the animals that live in streams. 'I grew up next to a river in the Adelaide Hills where I spent many hours catching the creatures that live there', he recalls; and one group of aquatic insects that caught his eye was the backswimmers. However, two members of the Family (*Anisops* and *Buenoa*) have an even more remarkable talent: they can swim at depths that other backswimmers can only reach fleetingly.

Explaining that the intrepid insects take down an air bubble that they use to regulate their buoyancy, Jones adds that other aquatic insects depend on air bubbles to extract oxygen from the water. However, it was believed that the surface area of the deep-diving backswimmers' bubble was too small to allow them to use the buoyancy aid as an ad hoc gill to supplement their oxygen supply: Roger Seymour and Jones decided to test this. They publish their discovery that the backswimmers can use their air bubbles to extract oxygen from the surrounding water to supplement their oxygen supply and extend dives in *Journal of Experimental Biology*.

As the insects consume oxygen from the bubble, a small amount of nitrogen diffuses out during a dive, reducing their buoyancy, and Seymour realised that he could alter the buoyancy changes by replacing the nitrogen in the bubble with other gases, such as helium—which is lost faster than nitrogen—and sulphur hexafluoride—which diffuses away more slowly. By filming the insects while they swam, Jones, Seymour, Edward Snelling and Amy Watson could see how the different gases affected the insects' buoyancy and dive durations.

Collecting *Anisops deanei* from a local pond, Jones built mini-dive chambers where he could monitor a pair of insects diving simultaneously, and filmed over 300 dives. Analysing the movies with Watson, Jones could see that the insects carrying helium-laced air bubbles had the shortest dives (1.5 min), while the sulphur hexafluoride-doped bubble allowed the insects to remain submerged for an impressive 3 min, compared with the 2 min dives clocked up by the insects diving with regular air. Gas was definitely being lost from the bubbles, suggesting that oxygen could also diffuse in from the surroundings.

The team also noticed that during the initial descent the insects had to swim hard to overcome the bubble's buoyancy. However, they became less buoyant as they consumed oxygen over the course of the dive until the volume of the bubble had shrunk enough for the insects to become slightly negatively buoyant. At this point, the insects began releasing oxygen stored by haemoglobin in the abdomen, stabilising the bubble's volume to maintain almost neutral buoyancy while they remained submerged. Next, the team built a computer simulation of gas loss from the bubble based on the buoyancy changes that they observed, and realised that the insects could extend their period of near-neutral buoyancy by extracting as much as 20% of the oxygen consumed during the dive from the water. Having confirmed that backswimmers use their dive bubbles as a gill, Jones is keen to find out whether the insects detect the oxygen level in the bubbles that they carry. Explaining that oxygen diffuses faster through helium than through sulphur hexafluoride, Jones was amazed to see that the helium insects only surfaced for 0.18 s to recharge the bubble, compared with the sulphur hexafluoride insects, which took 10 times longer, suggesting that the insects only put themselves at risk at the surface for as long as it takes to recharge the oxygen.

More information: Jones, K. K., Snelling, E. P., Watson, A. P. and Seymour, R. S. (2015). Gas exchange and dive characteristics of the free-swimming backswimmer Anisops deanei. *J. Exp. Biol*. 218, DOI: 10.1242/jeb.125047

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