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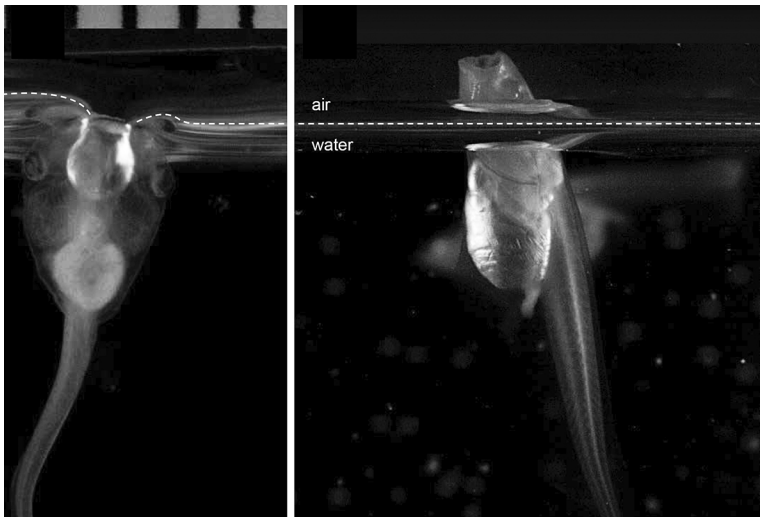
INSIDE JEB

Size is key for surface-breaking tadpoles



A young *Xenopus laevis* tadpole (left) slurps the water's surface into its mouth and an older, larger tadpole (right) breaks the surface.

At our size, it can be hard to appreciate just how difficult it is to burst through the surface of the water, but for recently hatched African clawed frog tadpoles (*Xenopus laevis*), the surface tension is simply too tough to break, even to breathe. Instead of breaching the top of the water, the youngsters swim up and simply slurp the surface into their mouths, creating a bubble which they can then inhale. Only once the youngsters reach the age of ∼24 days post-fertilisation (dpf) do they become capable of bursting through the surface to inhale air. But even then, these tadpoles continue sucking in bubbles, so why bother erupting through the surface? Or are they breaching the glassy barrier to supplement their oxygen supply as they begin to require more oxygen than can be provided by their watery surroundings? Intrigued, Jackson Phillips, Amanda Hewes and Kurt Schwenk, all from the University of Connecticut, USA, filmed the youngsters from before they began surfacing until they were on the verge of metamorphosing into amphibious adults 2 months later.

'Our videos were truly a labour of love', says Phillips, who used banks of lights positioned at the perfect angle to see through the transparent tadpoles, eventually collecting ∼100 h of movies as the tadpoles and almost fully developed frogs visited the surface. Sure enough, the youngsters began visiting the surface around 5 dpf, when they were ∼3 mm long, sucking in a bubble of air before closing the mouth, breaking free of the water–air interface and then forcing some of the air into their tiny developing lungs by depressing the floor of the mouth.

However, when the tadpoles were ∼10 mm long (∼24 dpf) – around the age when they begin requiring more oxygen than the water can provide and may need to supplement with additional oxygen from the air – they began bursting through the surface to gulp down a mouthful of air and inflate the lungs. Over the following weeks, Phillips and Schwenk filmed the developing youngsters as they switched almost exclusively to breaching the surface as their limbs developed, although they still slurped bubbles from the surface on occasions. And, as the tadpoles developed their finally recognisable frog shape, they began swimming more powerfully with their legs to the surface to burst through.

Yet, when Phillips and Hewes scrutinised the tadpole's developing lungs, they did not find a significant blood supply within the organs until the youngsters had developed forelimbs and hindlimbs (∼50 dpf), long after they began breaking through the surface to gulp mouthfuls of air. Given the lung's poor blood supply, the African clawed frog tadpoles were unlikely to be gulping air into the lungs to breathe oxygen. However, Phillips points out that these tadpoles were kept in well-oxygenated water and may not have required the additional oxygen supply provided by the lungs, delaying the lungs' development, in contrast to tadpoles in ponds that naturally experience low oxygen, which may force the youngsters to develop a robust lung blood supply earlier to compensate for the lack of oxygen in the water.

So, it seems that the transition from bubble sucking to breaching the surface is probably a consequence of the animals growing larger, rather than their need for oxygen, and Phillips has teamed up with co-author Molly Womack (Utah State University, USA) to find out how lunged and lungless species of tadpole cope when oxygen in their aquatic homes becomes scarce.

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Phillips, J. R., Hewes, A. E., Womack, M. C. and Schwenk, K. (2022). The mechanics of air-breathing in African clawed frog tadpoles, *Xenopus laevis* (Anura: Pipidae). *J. Exp. Biol.* **225**, jeb243102. doi:10.1242/jeb.243102

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