INSIDE JEB

Miraculous skin metamorphosis for beached amphibious fish

A mangrove rivulus (*Kryptolebias marmoratus*) in mid-air after pushing off with its tail. Photo credit: Brock and Sherri Fenton.

Taking those first steps on land after emerging from the primordial swamp required a lot more than simply changing the way the earliest pioneers moved and breathed. The ancient innovators must also have sealed their skins to prevent water loss in the relatively dry surroundings. They may even have repurposed their external layer to absorb oxygen when their gills collapsed. Modern amphibious mangrove rivulus (*Kryptolebias marmoratus*) probably reprise this epic transformation each time they flip in the fin prints of their ancestors on land. So how do these modern-day descendants of the earliest land colonists pull off the feat each time they emerge? An international team of researchers from China, Canada, Germany and the USA, led by Andrew Whitehead from the University of California Davis (UCD), USA, and Patricia Wright from the University of Guelph, Canada, investigated the skin of beached mangrove rivulus to find out how the extraordinary creatures carry off this miraculous metamorphosis.

As mangrove rivulus thrive on the eastern shore of America, from Florida to Brazil, the team decided to compare the skins of a population from Honduras, which makes its home in brackish mangrove swamps, with another population that frequents freshwater ponds in Belize. The intrepid creatures routinely make their homes above the waterline, so Tessa Blanchard, from the University of Guelph, Canada, made sure that the fish were comfortably ensconced in individual moist containers for 1, 6, 24, 72 and 168 h before collecting portions of their skin. Scott Kelly, from York University, Canada, then scrutinised the samples and the team was amazed to see dramatic changes – even within an hour of leaving the water. The fish restructured the gaps between the skin cells that solvents, ions and other compounds usually pass through to make the skin more robust, and Kelly saw large numbers of blood vessels near the surface of the beached fish's skin, which pick up oxygen from the air and transport it quickly to the cells that balance the salts in the fish's bodies.

Yunwei Dong, from Ocean University of China, also analysed the gene expression patterns in the fish's skin during a sabbatical in the Whitehead lab, and discovered that the animals reduced the expression of genes that control the amount of collagen in their skin, which could help them to absorb oxygen and water, in addition to allowing them to get around on land more easily. The beached fish also altered the expression of genes that help them to absorb oxygen and maintain their delicate internal salt balance. Meanwhile, the skins of the high and dry fish began producing a group of proteins, Rhesus proteins, which are essential for disposing of toxic ammonia – the fish equivalent of urea waste produced by humans – which they usually eject through the gills in water. In addition, the team noticed that the fish increased the gene expression of aquaporins – specialised channel proteins to absorb water from their surroundings – to prevent themselves from drying out. Meanwhile, at the University of Münster, Germany, Angela Noll and Juergen Schmitz compared the genes of the mangrove rivulus with those of non-amphibious fish, and found that several of the key genes that allow the amphibious fish to emerge from water have changed significantly, underlining their importance for life on land.

'When *K. marmoratus* transitions from water to air, the skin quickly alters its barrier and exchange functions to delicately balance these dual purposes on land', says Whitehead, who is keen to understand the genetic mutations that could explain why some mangrove rivulus populations adjust better to life on land than others.

10.1242/jeb.242173

Dong, Y.-W., Blanchard, T. S., Noll, A., Vasquez, P., Schmitz, J., Kelly, S. P., Wright, P. and Whitehead, A. (2021). Genomic and physiological mechanisms underlying skin plasticity during water to air transition in an amphibious fish. *J. Exp. Biol.* **224**, jeb235515. doi:10.1242/jeb.235515

Kathryn Knight
kathryn.knight@biologists.com