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INSIDE JEB

Nocturnal reef residents have deep-sea-like eyes

A crimson soldierfish (*Myripristis murdjan*) in a coral crevice. Photo credit: Justin Marshall.

Swirling with colour, coral reefs teem with vivid life during daylight. But at night, a different crew emerges from the nooks and crannies. 'The visual systems of teleost fish usually match their habitats and lifestyles', says Fanny de Busserolles from The University of Queensland (UQ), Australia, explaining that there has been a lot of interest in the vision of the gaudy creatures that populate reefs by day. However, less was known about the vision of their nocturnal cohabitants. 'I am particularly interested in visual adaptations and capabilities in dim light', says de Busserolles, who is intrigued by the vision of deep-sea fish. So, when she arrived in subtropical Brisbane to work with Justin Marshall at UQ, the chance to investigate some of the nocturnal creatures residing on the Great Barrier Reef was too good to pass up.

'Holocentrids [squirrelfish and soldierfish] were the ideal family for our study due to their connection to the deep-sea environment', says de Busserolles, explaining that the fish are linked to her love of the depths; 'the entire family is thought to have originated in deeper water before most of its representatives migrated up to the reef', she says. Fishing in the sea around Lizard Island, Australia, with UQ colleagues Fabio Cortesi, Sara Stieb, Martin Luehrmann and Marshall, de Busserolles collected four species of soldierfish and five different squirrelfish. 'They were pretty hard to catch during the day because they are very shy and tend to hide in holes, caves and crevices', de Busserolles recalls.

Looking at the overall structure of the eyes back in Brisbane, de Busserolles could see that they were large, to collect as much light as possible in the dim conditions. And, when Cortesi extracted the RNA from each retina to find out which light-sensitive genes the fish were expressing, he found that all of the fish expressed one rod opsin – which they produced in high levels in their light-sensitive rod cells. In addition, the fish expressed some colour-sensitive cone opsin genes, but at much lower levels than the rod opsin, with the soldierfish expressing two cone opsins while the squirrelfish expressed three cone opsins. Luehrmann also simulated which shades the colour-sensitive cone opsins detect and it turned out that they pick up shades of green and blue. In addition, Sara Stieb revealed two types of cone in the fishes' retinas: cones expressing the blue opsin, with a second type expressing one or two green opsin genes. 'These findings indicate that holocentrids may be able to see colours during the day', says de Busserolles.

However, when she and Lily Fogg (also from UQ), painstakingly investigated the distribution of photoreceptor cells in the fishes' retinas, it was apparent that their eyes are also extremely well prepared for dim nocturnal conditions. Instead of carrying a single layer of photoreceptors at the back of the eye, the fish's retinas comprised stacks of rod cells layered one on top of another, with up to 17 rod cell layers in the eyes of crimson soldierfish (*Myripristis murdjan*). Explaining that these 'multibank' retinas are mostly found in deep-sea species, de Busserolles says, 'We do not know what the function of this adaptation is, but possible hypotheses are that they may enhance the sensitivity of the eye and/or they may provide some kind of colour vision in dim light conditions'.

So, soldierfish and squirrelfish are well prepared for their nocturnal life on the Great Barrier Reef and de Busserolles and her colleagues are keen to find out just how good the fish's colour vision is, especially in the dimmest conditions.

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de Busserolles, F., Cortesi, F., Fogg, L., Stieb, S. M., Luehrmann, M, and Marshall, N. J. (2021). The visual ecology of Holocentridae, a nocturnal coral reef fish family with a deep-sea-like multibank retina. *J. Exp. Biol.* **224**, jeb233098. doi:10.1242/233098

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