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INSIDE JEB

How extraordinary periwinkles withstand extreme heat

Echinolittorina malaccana on the rocky shore line. Photo credit: Yun-wei Dong

Life might seem to be less eventful for the tenacious creatures that carve out life on the rocky sea shore once the tide has receded, but looks can be deceptive. Once the tide has gone on sunny days, many molluscs are at risk of baking in the sun. But the heat holds little fear for one species making a living on the southern coast of China. 'The rocky intertidal periwinkle snail, *Echinolittorina malaccana*, is one of the most heat-tolerant eukaryotes, with an upper lethal thermal temperature of near 55°C', says Yun-wei Dong from Ocean University of China. So how do these masters of heat deal with wilting conditions? And how hot does it really get once the surf has departed? Intrigued by the molluscs' robust reputation, Dong, with colleagues from Xiamen University and his own institution, set about finding out just how hot knobbly periwinkles get.

First, Dong secured iButton thermometers alongside the hardy snails on their rocky shore homes for 3 months during the summer in 2014 and was impressed to see that the average temperature generally hovered around 32°C. However, the temperatures did creep much higher from time to time and on one occasion even exceeded an extraordinary 53°C. But what effect did these high temperatures have on the mini molluscs' beating hearts?

Warming the snails gradually from 25°C, the team discovered that the heat really set the periwinkles' hearts racing, first hitting a high of ∼42 beats min^{-1} at 37°C before reaching a second high of ∼67 beats min^{-1} at 52°C, after which they began to fail. 'According to the heart beat curve of *E. malaccana*, metabolic depression occurs from ∼37°C to ∼45°C', says Dong, adding that this reduction in metabolic rate helps the snails to survive at intermediate temperatures.

The team then tracked the compounds produced in the snails' bodies as a result of their metabolism and realised that the hardy molluscs switched from running their metabolism on oxygen at lower temperatures to other sources of energy for anaerobic metabolism at temperatures above 37°C. 'High temperature and hypoxia [low oxygen] commonly co-occur in intertidal molluscs', says Dong, explaining that shifting to anaerobic metabolism as the temperature soars allows the periwinkles to continue meeting their energy demands as their oxygen supplies dwindle.

In addition, the team noticed that the snails produced a range of compounds that protect them from the damaging effects of heat. They included molecules that mop up toxic forms of oxygen – reactive oxygen species – that are produced by stress, modified lipids that improve the stability of cell membranes at high temperatures and a range of small molecules that protect proteins from damage. 'This thermophilic species thus can deploy a wide array of adaptive strategies to acclimatise to extremely high temperatures', says Dong.

Having revealed the physiological mechanisms that underpin the periwinkle's extraordinary resilience, Dong and his team are eager to discover how the modest mollusc's genome has adapted to permit them to endure such extreme temperatures. But he is also concerned about their future. 'We will apply these physiological traits in a species distribution model for predicating species biogeographic pattern in the context of climate change', says Dong.

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