

## INSIDE JEB

# Unpredictability is key for mussels' seashore resilience



California mussels (*Mytilus californianus*), courtesy of Dr Sophie McCoy, Florida State University. Photo credit: NOAA Photo Library, Public domain, via Wikimedia Commons (CC BY 2.0).

Scientists like their experiments to be well defined: tightly regulating temperature fluctuations, precisely positioning heat sources and painstakingly defining exposures. Conditions in the real world are rarely this meticulous. But just how much of an impact does the pure randomness of the natural world have on the creatures that inhabit some of the planet's most peripheral environments, such as mussels clinging to the seashore? Immersed in cool, refreshing water twice daily, these molluscs are left high and dry once the waves recede, in sometimes searing conditions, which can vary dramatically from one day to the next – some are overcast while others drenched in sun. So, how do these seaside residents cope with and prepare for the sheer unpredictability of their seashore homes? Sarah Nancollas and Anne Todgham from the University of California, Davis, USA, decided to put *Mytilus californianus* mussels through their paces in the lab, exposing the stalwart molluscs to reconstructions of genuine seashore conditions, to find out how well prepared the mussels are for extreme circumstances.

After gathering mussels from the seashore just north of the University of

California, Davis, Bodega Marine Laboratory, Bodega Bay, USA, Nancollas and Todgham rehomed the coastline residents in tanks that they could inundate twice a day with water, to simulate high tide, as well as turning on heat lamps to simulate the sun when the water level fell. Then, they recreated the conditions experienced by mussels over a 2-week period in late winter 2019, when the sea receded and the mussels experienced overcast and sunny days, with their top body temperatures ranging from 15 to 28°C. In addition, other mussels experienced relatively balmy conditions, as the researchers warmed them twice a day to a dependably constant 20°C, while others were exposed continually to air at 13°C – the same temperature as the water. Then, after 2 weeks, the duo tested the mussels' heart rates, to find out how resilient they were when temperatures climbed critically, how much glycogen they were carrying in preparation for deprivation when the tide went out and how well they would cope during low tide, when they could no longer breathe oxygen from the water and had to respire anaerobically until the simulated tide returned.

'Both air exposure and stochasticity [the randomness] of temperature change were important in determining thermal performance', says Nancollas, who discovered that the mussels that had experienced the natural wildly varying seashore temperature fluctuations had plentiful glycogen stores in place to survive low tide when their food supply vanishes. However, the cells of the hardy seaside residents were no better prepared to withstand sizzling temperatures than mussels that had experienced mild predictable warmth when their water level dropped each day, although their hearts were more resilient, continuing to beat at temperatures over 40°C when the hearts of mussels that had experienced predictable warmth failed. 'The mussels prioritise energy reserves to deal with unpredictable low tide conditions', says Nancollas. And it seemed that the metabolisms of the mussels living in the real-world simulation were more efficient than those of mussels living in the more artificial laboratory conditions, although the real-world simulation mussels grew more slowly, suggesting that they had less spare energy to invest in growth.

'Our results suggest that while thermal magnitude plays an important role in shaping physiological performances, other key elements of the intertidal environment complexity such as stochasticity, thermal variability and thermal history are also important considerations for determining how species will respond to climate warming', says Nancollas.

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**Nancollas, S. J. and Todgham, A. E.** (2022). The influence of stochastic temperature fluctuations in shaping the physiological performance of the California mussel, *Mytilus californianus*. *J. Exp. Biol.* **225**, jeb243729. doi:10.1242/jeb.243729.

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