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Can Evolution Beat Climate Change?

The purple sea urchin may be able to evolve to cope with ocean acidification, but that does not mean other species will be able to mimic the trick

By David Biello | Monday, April 15, 2013 | 5 comments

FAST EVOLUTION: New research suggests that the purple sea urchin may be able to evolve to cope with the ocean acidification brought on by climate change.
Image: Kirt L. Onthank

The oceanic pincushion known as the purple sea urchin relies on its many spines and pincers for protection and food. An inability to form its spiny shell would devastate the species, which thrives on rocky shores off North America's west coast. Unfortunately for the purple sea urchin, higher carbon dioxide levels in the atmosphere as a result of human fossil-fuel burning presage a more acidic ocean that might make it harder to form such shells.

But new research suggests that the purple sea urchin may have the genetic reserves to combat this insidious threat. A study published in *Proceedings of the National Academy of Sciences* on April 8 found that exposing purple sea urchins to the kinds of acidified ocean conditions possible in the future unleashed genetic changes that may help the animal survive. The researchers showed that although the exterior of sea urchin larvae changed very little, their genetics adapted to high CO_2 environmental conditions in a single life span.

Shifting environmental conditions have always played an outsize role in driving evolution. A climate change from cold to hot transforms everything an organism needs to survive and thrive, so each animal, plant, microbe and fungus species must adapt or die—as happened during the transition out of the most recent ice age. So the question isn't if the current bout of human-induced climate change will drive evolution, but how—and maybe when?

In the case of the purple sea urchin exposing urchin larvae to current and projected levels of ocean acidification—and then sampling their genes at set dates of development—revealed a population undergoing genetic changes under more acidic conditions. Simply put, those larvae with versions of genes better adapted to high CO_2 conditions became more common. "In a sense, it is the beginning of evolution," explains biologist Melissa Pespeni of Indiana University Bloomington, who lead the experiment. "Only the individuals with the 'right' gene copies would be able to pass their genes on to the next generation."

The genes in question code for proteins involved in processes like extracting shell-building minerals from seawater or fat metabolism. The larvae exposed to today's conditions showed none of the changes seen in those exposed to higher CO_2 conditions. And the effect grew over time—some selection could be detected after one day, but an even more prominent shift was apparent by the seventh day of development.

Previous studies have suggested that such purple sea urchins—and other shell-forming organisms—would struggle to grow and develop as the ocean grew more acidic, results that the new study ascribes to differing lab conditions, particularly how densely the urchin larvae are packed. Although purple sea urchins like to cluster close together, testing larvae under these conditions may have exacerbated the impact of ocean acidification.

Of course, purple sea urchins are unlikely to face stress only from ocean acidification; other threats include overfishing for urchin roe. This research suggests that the key to any evolved response to ocean acidification is having enough diversity in the population to allow natural forces to pick and choose what survives and thrives. Plus, "we don't know if there are negative side effects of such rapid evolutionary change," Pespeni notes. The genes lost as a result of selection to cope with high acidity could prove to play an important role in anything from avoiding predators to immune system responses.

Regardless, such evolution does not have to be slow, as this sea urchin work shows. Research in soil mites published on April 8 in *Ecology Letters* reaffirms that point, finding that laboratory-induced natural selection—in this case for shorter maturation time—can work in as little as 15 generations.

Then again, the purple sea urchin may be uniquely prepared to face a future of increased acidity. The upwelling ocean environment where it lives periodically fluctuates between high- and low-CO_2 seawater conditions anyway. That means the population may have retained the genetic capacity to deal with high CO_2—Pespeni notes they have more genetic variability than most other organisms, a genetic reservoir that may serve the urchins well as they face the effects of climate change.

That also suggests other organisms at sea and on land without that history of exposure will not share the same genetic resilience—as well as often lacking the purple sea urchins' large population sizes. "Right now, it's really unclear what sorts of species are likely to be able to evolve their way out of trouble," says ecologist Dov Sax of Brown University, who was not involved in this research. "It's a giant question that needs to be resolved and feeds into the issue of who is most at risk of extinction from climate change."