SCIENCE & TECHNOLOGY

Environment influences coral's resilience to acidification

Ocean acidification is an effect of climate change that threatens the health of coral. A new study examines how coral samples from the Great Barrier Reef fare in acidic conditions.

Postdoc Kristen Brown diving in the reef to obtain samples

Postdoctoral researcher Kristen Brown (above) collected coral samples from a reef slope to see how they fared in acidic conditions. (Image: Courtesy of Kristen Brown)

Overreliance on fossil fuels has led to a buildup of greenhouse gasses like carbon dioxide (CO_2) in the atmosphere. But CO_2 doesn't only stay in the air; it also dissolves into the ocean, where it decreases the pH of the water and leads to ocean acidification. Corals are especially vulnerable to damage from ocean acidification, and rising CO_2 levels jeopardize the future of coral reefs globally. However, a new study from researchers at the University of Pennsylvania (https://www.upenn.edu/) and Australia's University of Queensland (https://www.uq.edu.au/), reports certain corals may do better than others at withstanding ocean acidification.

The study was published in *Proceedings of the Royal Society B* (https://doi.org/10.1098/rspb.2022.0941). Using samples from the Great Barrier Reef, the researchers studied how coral from environments with greater CO_2 variability respond to increasing acidification.

Ocean acidification threatens coral because it breaks down the rocky, calcified skeletons that give coral its distinctive structure, says Katie Barott (https://www.bio.upenn.edu/people/katie-barott), an assistant professor of biology (https://www.bio.upenn.edu/) in Penn's School of Arts & Sciences (https://www.sas.upenn.edu/) and senior author on the study. When water CO_2 levels surge, corals can no longer grow or maintain their skeletons.

While ocean acidification is a consequence of climate change, there are also regular fluctuations in water pH that occur regardless of greenhouse gas emission levels. These fluctuations are driven by respiration from the coral and photosynthesis from the coral's symbiotic algae.

Coral is an animal, meaning that it "breathes" out CO_2 as part of its cellular metabolism. And when sunlight penetrates the water, the photosynthetic algae that live inside coral consume that CO_2 to produce energy for themselves. Because photosynthesis requires sunlight, water CO_2 levels—and therefore water pH—ebb and flow over the course of the day.

To see how this natural variability in daily pH levels affects coral, researchers studied samples of the same coral species, *Pocillopora damicornis*, from two different locations. In the first location, the coral grew in a reef flat, a shallow lagoon in the middle of the reef. There, CO_2 levels plummet during the day as the coral's symbiotic algae photosynthesize, and CO_2 builds up at night as the sunlight wanes. Low water flow between the reef flat and the surrounding ocean also causes greater variability in CO_2 levels because the built-up CO_2 stays in the reef flat rather than being washed away.

The second sampling location was a reef slope, where the edge of the coral reef dropped off into the ocean. In this location, less sunlight and more water flow meant CO_2 levels remained stable throughout the day.

To see how coral from each environment responded when placed in a new setting, the researchers took coral samples from the reef flat and the reef slope, then cut them in half. One half was placed into a tank that simulated a reef flat, while the other half was placed in a tank that simulated a reef slope. During the course of eight weeks, the researchers monitored how the coral grew in response to the two different environments.

Coral samples float in a row of experimental tanks that simulate the acidity of the reef environment.

Researchers monitored coral samples in treatment tanks that simulated environments with stable or variable acidity.

In the ocean, coral from the reef flat normally grows long, wide branches, whereas coral from the reef slope normally grows dense, consolidated branches. But after eight weeks in the treatment tanks, the researchers started to "see shifts in how they were calcifying," says Barott.

The researchers found that the surface area of the coral's skeletons—a metric of how long the branches grew—changed in response to their new environments. This means that in the tanks that simulated the reef flat, parts of the coral skeleton began to grow longer, and in the tanks that simulated the reef slope parts of the coral skeleton began to grow shorter.

However, many other features of the coral's growth and calcification stayed true to its original environment. These results suggest that, while coral can partially adapt to new changes in environmental acidity, its behavior is still constrained by its native environment.

The researchers also wanted to understand coral responses to extreme changes in water acidity at the cellular level. Using a toothbrush to scrape off fragments of the coral, Barott and colleagues isolated single cells of the *Pocillopora damicornis* and exposed them to highly acidic levels of CO_2. Using fluorescent dyes to track the cellular pH, the researchers observed the cells for an hour to see if they could restore their natural pH levels.

While coral cells from both the reef slope and the reef flat were generally able to withstand the stress of acidification, cells from the reef flat were better able to stabilize their pH levels. "We found that corals from environments with extreme CO_2 fluctuations were better able to regulate their cellular chemistry when faced with acidification stress," says Kristen Brown (https://www.bio.upenn.edu/people/kristen-brown), a postdoctoral researcher in Barott's lab and the lead author on the study.

The researchers believe that the reef flat coral's exposure to natural pH variability primed it to endure more extreme acidification. "Those cells are dealing with these sorts of big pH disturbances every day," says Barott. "So, they must have some toolkit to deal with that."

Barott and her team are still figuring out what exactly that toolkit is. In the next phase of their research, they'll begin to explore which specific proteins and genes underlie the reef flat coral's resilience against acidification.

The lab also plans to test how heat stress, another threat to coral, compounds stress from acidification. So far, their research has shown that coral may not be as adept at bouncing back from heat stress as it is from acidification.

The researchers hope that ultimately they can uncover how coral adapts to environmental stressors like acidification and utilize those adaptations to mitigate damage from climate change. "There are already corals out there that can deal with these types of stressors," says Barott. "So, we're trying to figure out what makes those corals special. How do they adapt, or adjust, or acclimate to those extreme conditions? And then, how can we harness that basic biology to help corals survive into the future?"

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Barott and Brown's coauthors on the study were the University of Queensland's Matheus A. Mello-Athayde, Eugenia M. Sampayo, Aaron Chai, and Sophie Dove.

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