Team reports new evidence that microbial algae in Caribbean came from the Pacific; could do long-term damage

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Underwater look at Nikko Bay, Palau, where many coral associate with *S. trenchii*, a stress-tolerant zooxanthellae alga. Credit: Allison Lewis

University of Delaware's Daniel "Tye" Pettay reports new evidence that

Symbiodinium trenchii (*S. trenchii*), a stress-tolerant zooxanthellae alga found in coral communities across the Greater Caribbean, is actually an introduced species from the Indio-Pacific Ocean.

The findings appeared in the June 1 online issue of the prestigious journal *Proceedings of the National Academy of Science* (*PNAS*) in an article entitled, "Microbial invasion of the Caribbean by an Indo-Pacific coral 'zooxanthella.'"

Coral reefs are an important ecosystem for marine plants and animals. More than 25 percent of marine species spend a portion of their life on a coral reef, despite the fact that coral reefs cover merely one-tenth of a percent of the world's oceans.

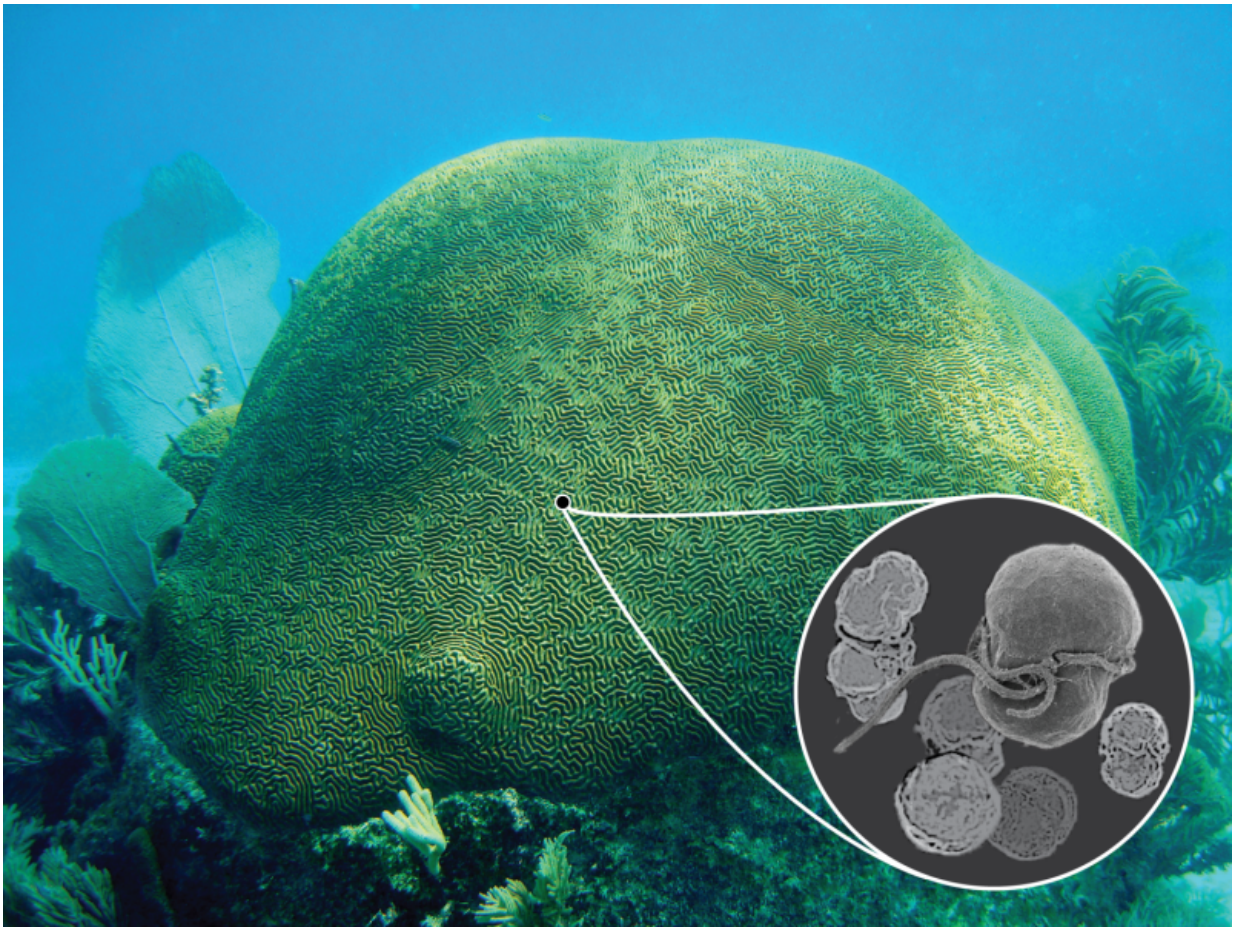
Corals form symbiotic relationships with single-celled algae that live in their tissues. The coral provides the algae with a protected environment in which to grow and the compounds necessary for photosynthesis. In return, the algae provide organic nutrients necessary for the coral to survive, grow and produce calcium carbonate skeletons that form the structures of coral reefs.

Environmental stressors due to climate change, particularly rising seawater temperatures, can disrupt this symbiotic relationship causing the coral to expel their algae and turn white. When this phenomenon—known as coral bleaching—occurs, the coral lose the valuable nutrients provided by their algae and begin to starve. If they remain bleached for prolonged periods of time, the coral will die.

As a result, researchers have focused on identifying stress tolerant algal symbionts that may allow reef coral to better cope with future temperature increases. *S. trenchii* is the predominant one in the Caribbean and was originally thought of as a "coral reef savior" because it made corals more thermally tolerant.

Pettay's studies, however, reveal that while this microscopic algal species helps certain Caribbean corals tolerate elevated temperatures, it can cause previously unknown negative effects on coral health. Pettay and his colleagues discovered that Caribbean coral colonies that associate with *S. trenchii* grew 50 percent more slowly than colonies that harbored native algal species.

"The real concern over slower growth is that reef formation may not keep pace with the natural destructive processes in the environment, and, in turn, could negatively impact the diverse marine species that rely on the habitat these reefs provide," said Pettay, a post-doctoral researcher in the School of Marine Science and Policy, which is housed in UD's College of Earth, Ocean, and Environment, and the paper's lead author.



Colony of the symmetrical brain coral, *Pseudodiploria strigosa*, that is a common reef-building coral in the Caribbean. When under stress, these animals may harbor a species of mutualistic microbe, which was recently discovered to be introduced from the Indo-Pacific. This microscopic symbiont, a dinoflagellate, increases the stress tolerance of native corals, but may significantly reduce the animal's rate of calcification, thus diminishing their role as reef builders. Credit: Robin T. Smith, Science Under Sail; Sung Yeon Lee and Hae Jin Jeong, Seoul National University

In addition to habitat loss, smaller reefs, or their complete loss, would diminish their role in coastal protection from storm surge and hurricanes in some areas, Pettay said.

It turns out that Caribbean *S. trenchii* not only impact growth, but that this population contains very little genetic diversity and is highly inbred. In contrast, *S. trenchii* in the Indian and Pacific oceans contains more genetic diversity on a single reef, the size of a soccer or football field, than in the entire Caribbean Sea. These findings, along with the fact that the Caribbean population is closely related to those in the Indo-Pacific, led the researchers to conclude that *S. trenchii* is not natural to the Caribbean, but recently introduced, potentially via the ballast water of cargo ships coming through the Panama Canal.

Taken together, these discoveries raise new questions about the stability and adaptability of Caribbean reefs in the future.

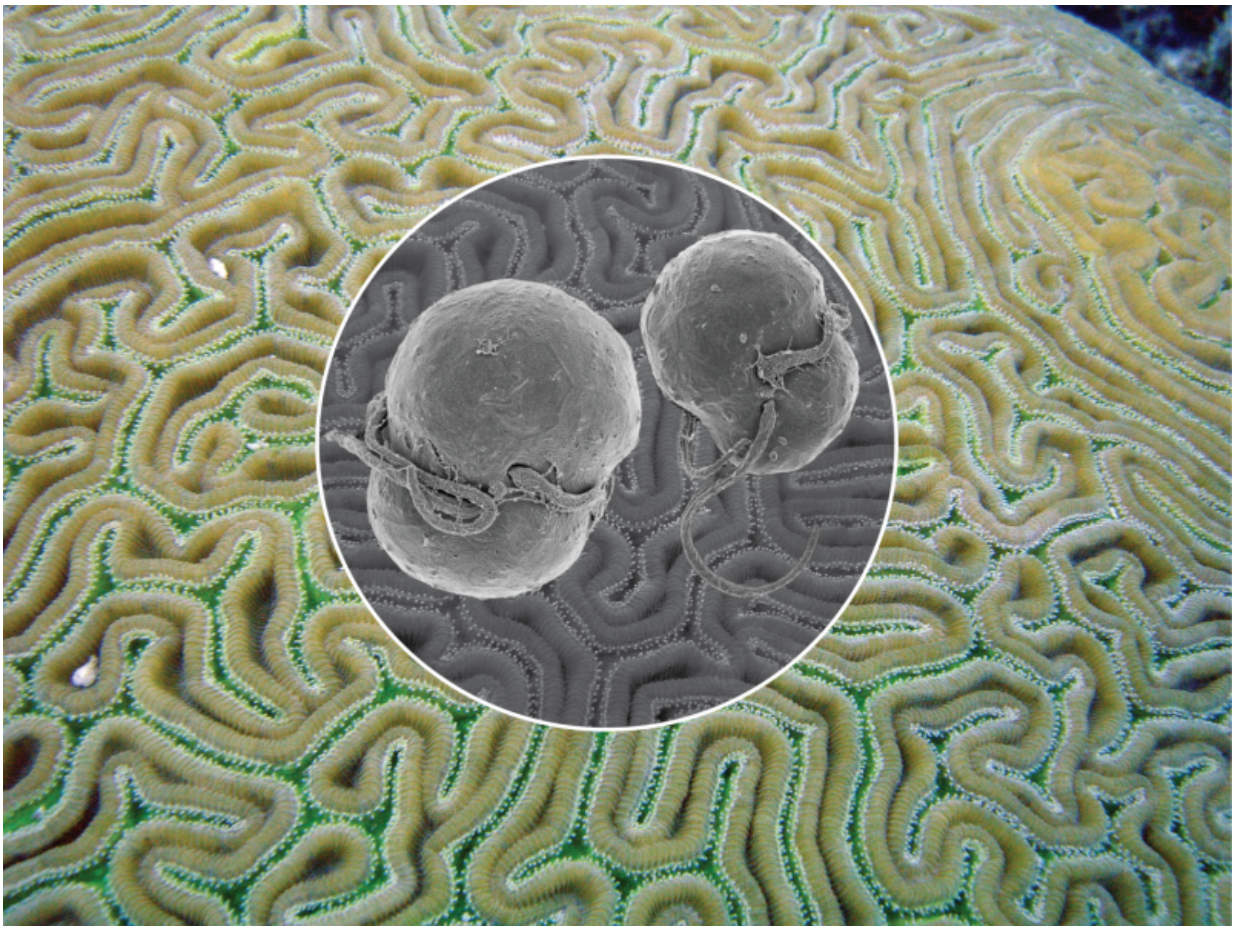
Physiologically stressed reef corals lose their symbionts and appear bleached. The invasive symbiont, *Symbiodinium trenchii* is quick to populate these animals after cessation of thermal stress. Credit: Dustin Kemp, University of Georgia

An uncertain future

However it arrived in the Caribbean, *S. trenchii* is there to stay and may be increasing in prevalence. Previous research by some of the coauthors show that *S. trenchii* exhibits opportunistic behavior and can out-compete other symbionts during times of stress; activities that may occur more frequently in the future.

During a bleaching event in the southern Caribbean in 2005, for example, the scientists witnessed *S. trenchii* moving into corals as seawater temperatures began to rise and coral bleaching occurred.

Many people are aware of the negative effects introduced plants and animals, such as zebra mussels, gypsy moths, kudzu or the seaweed Caulerpa, can impart on native ecosystems. However, single-celled microorganisms can have similar consequences, and the effects of *S. trenchii* on coral growth speak to this possibility.



Diploria labyrinthiformis is a common reef-building coral in the Caribbean. When under stress, these animals may harbor a species of mutualistic microbe, that was recently discovered to be introduced from the Indo-Pacific. The

symboint increases the stress tolerance of native corals, but may significantly reduce the animal's rate of calcification, thus diminishing their role as reef builders . Credit: Robin T. Smith, Science Under Sail; Sung Yeon Lee and Hae Jin Jeong, Seoul National University

For the past two years, Pettay, his co-authors and Mark Warner, professor in the School of Marine Science and Policy and Pettay's post-doctoral advisor, have conducted temperature experiments on coral naturally associating with *S. trenchii* in Palau, in the Pacific Ocean. They are comparing these results to southern Caribbean coral, in Curaçao, where *S. trenchii* was introduced.

According to Pettay, only time will tell whether the introduction of *S. trenchii* in the Greater Caribbean will lead to major changes in coral reef functioning, and if the short-term benefit of stress tolerance will be negated by the long-term effects of reduced growth.

"The magnitude of these negative effects on Caribbean coral reefs is unknown at this time," he said.

More information: Microbial invasion of the Caribbean by an Indo-Pacific coral zooxanthella, www.pnas.org/cgi/doi/10.1073/pnas.1502283112

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