Results of an experiment on post-settlement survival for Porites corals in Palau

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Project
» Collaborative Research: How do selection, plasticity, and dispersal interact to determine coral success in warmer and more variable environments? (Palau coral selection plasticity dispersal)

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Abstract
The early life-history stages of marine invertebrates, including corals, are subject to high mortality. Numerous environmental and biological factors serve as bottlenecks, restricting recruitment and connectivity of populations. We conducted a lab experiment to determine the influence of temperature and light on post-settlement mortality of massive Porites corals in April 2023. Adult massive Porites corals were collected from six sites in Palau immediately prior to their spawning season. Collected corals were held in individual plastic containers (4.2 L; 17 x 13 x 19 cm) in ambient unfiltered flow-through seawater tanks at the Palau International Coral Reef Center (PICRC). Three days post fertilization, larvae were settled on glass microscope slides with crushed crustose coralline algae used as a settlement cue. Slides were randomly distributed among two temperature treatments (30° C, 33° C) and two light levels (ambient, high) in a 2-way crossed design. Immediately after settlement and every two days throughout the experiment, slides were photographed individually using a Nikon D850 camera with a macro lens. Living settlers were counted in each image to track settler survival over time. Temperature and light level in each treatment were logged using Hobo pendants (Onset, Wareham, USA).

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Coverage

Location: Palau
Spatial Extent: **Lat**:0 **Lon**:0

Methods & Sampling

Adult massive *Porites* corals were collected from six sites in Palau immediately prior to their spawning season in

April 2023 . Corals were either whole colonies or fragments of large colonies removed with a hammer and chisel (15 – 30 cm diameter). Collected corals were held in individual plastic containers (4.2 L; 17 x 13 x 19 cm) in ambient unfiltered flow-through seawater tanks at the Palau International Coral Reef Center (PICRC). At sunset, water levels in flow-through tanks were lowered to ~15 cm so that each colony was isolated in its individual container, maintaining gametes separate until fertilization. Sperm was collected directly from male colonies using a large plastic pipette during release, and eggs were collected by pipette or by scooping from the surface with a clean petri dish. One hour after fertilization began, embryos underwent a series of dilutions with 5 µm filtered seawater (FSW) and gently split into multiple containers filled with 5 µm FSW to dilute any remaining sperm and prevent polyspermy. We pooled gametes from 4 males and one female. Three days post fertilization, larvae were settled on glass microscope slides with crushed crustose coralline algae used as a settlement cue (CCA, multiple types combined). There were 22.8 ± 1.4 individuals per slide (mean ± SE). Slides were randomly distributed among two temperature treatments (30° C, 33° C) and two light levels (ambient, high) in a 2-way crossed design. Each treatment consisted of one water tank (50 x 37 x 30 cm) (n=18 sides per treatment) with constantly-circulating FSW (5 µm). Partial water changes (~30%) were conducted every two days. Water temperature was controlled using aquarium heaters, and light levels were held constant using 165W LED aquarium lights (ARKNOAH) suspended over each tank (12:12 light:dark cycle). Glass slides with attached settlers were placed in plastic trays in a horizontal orientation with the most densely-populated side of the slide facing up. Slides were elevated off the bottom of the tank ~10 cm by a PVC rack. Temperature and light level in each treatment were logged using Hobo pendants (Onset, Wareham, USA). Immediately after settlement and every two days throughout the experiment, slides were photographed individually using a Nikon D850 camera with a macro lens. Living settlers were counted in each image to track settler survival over time.

In order to determine carryover effects of delayed settlement for massive *Porites*, a subset of larvae from the post-settlement mortality experiment was held in FSW (0.5 µm) for an additional 8 days (i.e., until 11 dpf) before being presented with a substrate to settle on or any settlement cues. Partial water changes (~50%) were conducted every two days to prevent formation of a biofilm, which can induce settlement. These delayed-settlement larvae were allowed to settle on glass slides as described above, resulting in 70.3 ± 13.8 settlers per slide. Slides were distributed between 30° C and 33° C temperature treatments, both with ambient light, such that an approximately equal number of settlers were in each treatment (n=5 slides per treatment). Images were recorded as described above. Images of settlers on each of 5 randomly-selected slides from the control treatment (30° C, ambient light) for both prompt (4 dpf) and delayed-settlement individuals (12 dpf) were used to quantify size at settlement. Selected individuals were settled apart from any other individual, so that the size was not influenced by crowding. The slide width was used a size reference, and settler diameter was measured using the straight-line tool in ImageJ.

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Parameters

Parameters for this dataset have not yet been identified

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Project Information

Collaborative Research: How do selection, plasticity, and dispersal interact to determine coral success in warmer and more variable environments? (Palau coral selection plasticity dispersal)

Coverage: Palauan coral reefs

NSF Award Abstract:
Coral reefs host thousands of marine species, help protect coastlines from storm damage, generate tourism, and house fish used for human consumption. However, corals are vulnerable to increasing water temperatures, which can lead to coral death. One way for reefs to survive in warming oceans is for corals that are well-suited to warmer waters to repopulate reefs that have less temperature-tolerant individuals. For this strategy to succeed, however, the more temperature-tolerant corals need to be able to disperse to and survive in these different environments. This project takes advantage of reef systems in the Pacific nation of Palau that naturally experience a wide range in temperatures across short geographic distances. Using cutting-edge ecological and genomic techniques, the team of investigators is directly testing whether young corals from

Palau's warmest reefs can successfully be carried by ocean currents to Palau's currently cooler reefs and subsequently survive and thrive in these habitats. Given the relevance of this research for the local ecology, the team is disseminating results to the Palauan government through a written report in conjunction with Palauan scientists who are interning with the team, and to the Palauan people through public presentations. As part of this work, the investigators are maintaining a blog and are organizing a music-lecture series combining dance, music, and science to promote awareness of the coral reef crisis across English and Spanish-speaking communities in the US. Results from this project are informing restoration and conservation practices of the Coral Conservation Consortium as well as other efforts worldwide.

A major question in evolutionary biology is how plasticity and adaptation interact to influence survival under novel environments. Understanding these processes is increasingly important as rising temperatures associated with climate change influence species globally. For marine organisms with pelagic larval phases, including reef-building corals, the post-settlement period constitutes a critical bottleneck for adaptation and plasticity, with the added complexity that the conditions experienced and time spent as larvae can incur carryover effects. This project leverages reefs in Palau that span a steep environmental gradient to study how environmental variation drives selection and plasticity and to examine if dispersal between reefs limits success across habitats due to carryover effects. The investigators are testing the overarching hypothesis that corals from warmer and more variable environments are adapted to warmer temperatures and exhibit increased plasticity, but that dispersal between reefs incurs a fitness cost. The team integrates field and molecular techniques to: 1) investigate the degree of selection occurring on warmer and more variable reefs, 2) test whether corals transplanted to more variable environments improve their thermal tolerance through developmental plasticity, and 3) examine whether delays in metamorphosis required for dispersal across reefs comes at a fitness cost due to carryover effects.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
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