Warming Determines Predation

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Project
» Temperature Regulation of Top-Down Control in a Pacific Upwelling System (Galapagos 2021)

Contributors	Affiliation	Role
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Abstract
We tested the effect of temperature on predation in rocky reefs in the Galapagos. Using mesocosms experiments, we measured feeding rates on three whelk species (Vasula melones, Hexaplex princeps, and Tribulus planospira) and one starfish species (Heliaster cumingi) across a gradient of temperatures. Our results showed that temperatures play an important role in determining feeding rates across the four experimental species, confirming predictions by metabolic scaling theory.

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Coverage

Location: San Cristóbal, Galápagos Archipelago

Methods & Sampling

Sampling Description

Organisms were collected from two locations on San Cristóbal, the easternmost island of the Galápagos Archipelago. *Vasula melones*, *Heliaster cumingi*, and *Tribulus planospira* were collected in Tijeretas (-0°53'18.0", -89°36'28.0"), a small bay on the southwest side of San Cristóbal.

H. cummingi were collected, and the experiment was conducted in July 2021. *V. melones*, and *T. planospira* were collected and experiments were conducted in July 2023. *Hexaplex princeps* was collected from La Barcaza (-0° 46' 41.7", -89° 31' 06.9"), a small islet located off the island's northwest coast, during morning periods during June 2021.

Experimental Methods

In the predation experiment, *Tribulus*, *Hexaplex*, and *Heliaster* were fed barnacles (*Megabalanus peninsularis*), while *Vasula* were fed small herbivorous snails (*Columbella haemastoma* and *Engina pyrostoma*). Although the largest *Vasula* typically consume barnacles, those used in the experiment were smaller and thus fed the smaller prey. Barnacles were collected at an 8 m depth from La Barcaza and intertidally at Kicker Rock (0° 46' 41.7" S, 89° 31' 06.9" W). The herbivorous snails used as prey were collected from Tijeretas.

We measured predator feeding rates inside 16 L glass aquaria during May, June, and July of 2021 and 2023. Throughout the predation experiments, individuals were exposed to 12 hours of both light and darkness. Experimental temperatures were maintained with a thermostat control system (Inkbird ITC-308 Digital Temperature Controller 2-Stage Outlet Thermostat Heating and Cooling). Once the temperature inside a given aquarium deviated by ± 0.3°C from the desired experimental temperature, the system activated a centralized chiller (AquaEuroUSA Max Chill-1/13 HP Chiller) or an individual submersible heater (Tetra HT30 Submersible Aquarium Heater & Electronic Thermostat, one per aquarium), respectively, to bring the temperature back to the experimental temperature

The selection of experimental temperatures varied among predators based on field observations and pilot studies, which indicated that some species could not tolerate higher temperatures. Due to space and other resource limitations in the laboratory, all temperature incubations and experiments across the four predator species were conducted asynchronously.

For the predation experiments with *Tribulus*, *Hexaplex*, and *Heliaster*, barnacle prey were epoxied (Z SPAR Splash Zone 2-Part Epoxy Compound) to small stones and placed in the aquaria. For the *Vasula* treatment, five herbivorous snails were added to each aquarium. Predation was monitored daily by checking for the presence of consumed prey, and any consumed prey was replaced within 24 hours. Additionally, we took note of the predator's position in the aquarium, and we used this to estimate a proxy of movement rate (number of position changes in the aquaria per day). To assess the effect of temperature on prey mortality, one control aquarium was included for each temperature incubation, where prey were exposed to the same conditions as the experimental trials but without predators. No significant effect of temperature on prey mortality was observed; no prey died in the control aquarium at any temperature.

Data Processing Description

Observations of prey consumed and movement were used to estimate feeding and movement rates. To achieve this, the authors divided the number of prey eaten and position changes in the aquarium by the duration of the experiment in days.

BCO-DMO Processing Description

* Within the primary data file, the first column name was corrected from "2" to "Species."
* "CollectionTime" values were converted from %b-%y (e.g., Jul-23) format to %Y-%m (e.g., 2023-07).
* Latitude and longitude values were split into separate columns from the original * Coordinates" column. These values were also converted from degrees, minutes, seconds to decimal degrees, and rounded to 6 decimal points.

Problem Description

No problems or issues associated with this dataset have been reported by the dataset authors.

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Parameters

Parameters for this dataset have not yet been identified

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Project Information

Temperature Regulation of Top-Down Control in a Pacific Upwelling System (Galapagos 2021)

Coverage: Galapagos Islands

NSF Award Abstract:
Nearly all the animals that inhabit the ocean are "cold-blooded" or ectothermic, meaning their body temperatures match the temperature of the ocean around them. This has important consequences for their physiology and more broadly for the way marine ecosystems function. When ectotherms warm up, their metabolism increases; meaning they breathe more rapidly, and eat more just to stay alive. This is bad news for prey since a warm predator is a hungry predator. But warming also enables prey species to crawl or swim away more quickly when being hunted. Thus, everything speeds up in warm water. Energy flows more quickly from the sun to seaweeds (via photosynthesis), to the herbivores, then on up to the large predators at the top of the food chain. The research team is testing these ideas in the Galápagos Islands to determine how temperature influences marine ecosystems. Ongoing work in this iconic natural laboratory is helping marine ecologists understand the role of temperature and how this and other ecosystems could function in the future as climate change warms the ocean. Other broader impacts of the project include student training and on-site outreach to tourists and the local community about ocean warming and some of the lesser-known species that inhabit the Galápagos.

The broad goal of this project is to understand the effect that temperature has on patterns and processes in upwelling systems. Specifically, the team is measuring the temperature-dependence of herbivory and carnivory in rocky subtidal habitats of the Galápagos. They are performing field experiments to measure the relative and interactive effects of temperature, herbivory, and nutrient flux on the productivity and standing biomass of benthic macroalgae. Additionally, they are using in situ predation assays across spatial and temporal temperature gradients and mesocosm experiments to determine the relationship between ocean temperature and predation intensity for predator-prey pairings including whelk–barnacle, sea star–urchin, and fish–squid.

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
NSF Division of Ocean Sciences (NSF OCE)	OCE-2128592

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