DRAFT Fertilizer impacts on damselfish behavior in Mo'orea

Website: https://www.bco-dmo.org/dataset/949539
Data Type: experimental, Other Field Results
Version: 1
Version Date: 2025-01-23

Project
» Positive Effects of Coral Biodiversity on Coral Performance: Patterns, Processes, and Dynamics (Coral Biodiversity)

Contributors	Affiliation	Role
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Abstract
Data examining the effects of fertilizer addition on damselfish behavior from a before-after control impact (BACI) experiment conducted in Moorea, French Polynesia in order to understand the effects of nutrient pulse events on fish herbivory and agonism. The effects of treatments on behavior were assessed by video recording each territory with a GoPro Hero7 black for 20–30 min immediately before applying treatments (“Day 0”) and 14 days post-treatment (“Day 14”). We assessed: 1) grazing by damselfish in their own territories, 2) grazing by roving herbivores in damselfish territories, 3) aggression towards conspecifics, and 4) aggression towards heterospecifics in each video. Data were collected and analyzed by Noam T Altman-Kurosaki of the Georgia Institute of Technology.

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Coverage

Location: Moorea, French Polynesia (17°28'41.9"S 149°50'21.3"W), depth < 3m
Spatial Extent: **Lat**:-17.478306 **Lon**:-149.83925
Temporal Extent: 2021-06-13 - 2021-07-07

Dataset Description

This dataset is part of a larger study of the coral reef ecosystem in Mo’orea, French Polynesia that examines mechanisms governing interactions between damselfish, corals, and turf algae. The different analyses from the broader study are listed here, with links to these associated data in the 'Related Datasets' section below.

Analyses undertaken include:

- Fertilizer impacts on damselfish behavior (***this dataset of Damselfish behavior video***)
- Fertilizer impacts on biomass plus isotopic composition of algal turfs (*Damselfish turf biomass dataset*

950508)
- Fertilizer impacts on coral predation and herbivory (*Corallivory dataset 9xxxxxx, Herbivory dataset 9xxxxx)*
- Impacts of fertilizer and caging on coral and algal growth (*Coral growth dataset 9xxxxx, Algal overgrowth dataset 9xxxxxx)*
- Coral-turf allelopathy (*Turf extracts PAM dataset 949219, Coral-algal contact dataset 9xxxxxx)*
- Species composition of turf gardens (*dataset 949552 + supplemental for Coral Reefs paper)*

Methods & Sampling

This dataset presents results examining the effects of fertilizer addition on damselfish behavior from a before-after control impact (BACI) experiment. We identified 15 spatially blocked pairs of *Stegastes nigricans (*damselfish) territories and into one randomly determined territory of each pair we attached a nylon mesh pouch filled with 50 grams of Osmocote slow-release fertilizer (14:14:14 NPK) directly to the substrate using u-nails. In the other plot of that pair, we attached a nylon pouch filled with 50 grams of sediment collected nearby as a physical control. All territories were at a depth of < 3 m. Pairs were ~20 meters from each other, with blocked pairs separated by > 20 meters. We measured territory size following Blanchette et al. (2019) by measuring the length, width, and height of the territory. The number and size (to the nearest centimeter) of all damselfish within each territory were estimated visually.

The treatments' effects on behavior were assessed by video recording each territory for 20–30 minutes immediately before applying treatments (“Day 0”) and 14 days post-treatment (“Day 14”). Small video-cameras (Go-Pro Hero 7 Black) were mounted on dive weights that could be placed unobtrusively on nearby substrates. We ignored the first 5 minutes of each video to minimize the impact of camera placement on behavioral observations. Because damselfish tend to chase other herbivores from their territories, we assessed: 1) grazing by damselfish in their own territories, 2) grazing by roving herbivores in damselfish territories, 3) aggression towards conspecifics, and 4) aggression towards heterospecifics in each video. Behaviors were quantified for all resident damselfish that were visible for at least 50% of the video for each territory (i.e. not concealed in crevices or behind reef structure) and all behaviors (i.e. the number of bites or chases made by an individual fish) were standardized by the length of time that any damselfish was visible and the area of the territory at the timepoint a video was taken (i.e., Day 0 or Day 14). All behaviors were compared using generalized linear mixed effects models (GLMER) with timepoint, treatment, and their interaction as fixed effects, as is standard in BACI designs. Territory ID was nested within spatial blocking as a random effect to account for pseudoreplication from both observing multiple fish within a territory and observing the same territory over two timepoints. Within factor pairwise comparisons were conducted using the emmeans package in R (Lenth, 2023). Preliminary data visualization suggested that behavior data could be zero-inflated or overdispersed, so all behaviors were modeled using i) a Poisson family, ii) a Poisson family with a zero-inflated intercept, and iii) a negative binomial. Model assumptions for all families were assessed using DHARMa (Hartig 2022), and models were compared using the Second-order Akaike’s Information Criterion (AICc) using the MuMIn package in R (Bartoń 2024). The top model that satisfied model assumptions was then used for each behavior. Damselfish bite rate data were overdispersed, so were modeled using a negative binomial distribution. Bite rates from non-damselfish herbivores and heterospecific chase rates were both zero-inflated, so were modeled as a zero-inflated Poisson regression. Conspecific chases were modeled using a standard Poisson regression.

Changes in traits of damselfish turfs and biomass were assessed by collecting six samples of turf that were about two centimeters square (~2 cm2) using a hammer and chisel from each damselfish territory both pre- and 14 days post-treatment. Weights, ash-free dry weights, and isotopic compositions were determined to assess and describe the turf biomass. Full details can be found in BCO-DMO dataset 950508 "Damselfish Turf Biomass". (See Related Datasets section below).

Data Processing Description

Behaviors were manually counted by viewing each video several times.

All behaviors were compared using generalized linear mixed effects models (GLMER) with timepoint, treatment, and their interaction as fixed effects, as is standard in BACI designs.

R packages emmeans, Dharma, and MuMIn were used for analysis

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Related Publications

Blanchette, A., Ely, T., Zeko, A., Sura, S. A., Turba, R., & Fong, P. (2019). Damselfish Stegastes nigricans increase algal growth within their territories on shallow coral reefs via enhanced nutrient supplies. Journal of Experimental Marine Biology and Ecology, 513, 21–26. https://doi.org/10.1016/j.jembe.2019.02.001
Methods

Hartig, F. (2016). DHARMa: Residual Diagnostics for Hierarchical (Multi-Level / Mixed) Regression Models [Dataset]. In CRAN: Contributed Packages. The R Foundation. https://doi.org/10.32614/cran.package.dharma
Software

Lenth, R. (2023). emmeans: Estimated Marginal Means, aka Least-Squares Means. R package version 1.8.5, https://CRAN.R-project.org/package=emmeans.
Software

MuMIn, Barton, K. (2018). multi-model inference. R package version 1.15. 6. 2016. https://CRAN.R-project.org/package=MuMIn
Software

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Related Datasets

IsSupplementedBy

Altman-Kurosaki, N. T., Hay, M. E. (2025) **[DRAFT] The biomass of turf samples in damselfish territory before and after treatment with fertilizer in Mo'orea, French Polynesia from June to July 2025.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-02-04 http://lod.bco-dmo.org/id/dataset/950508 [view at BCO-DMO]

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	Micromass Optima interfaced to an elemental analyzer
Generic Instrument Name	Continuous Flow Interface for Mass Spectrometers
Dataset-specific Description	Samples were analyzed with continuous-flow isotope ratio mass spectrometry using a Micromass Optima interfaced to a CE Elantech NA2500 elemental analyzer.
Generic Instrument Description	A Continuous Flow Interface connects solid and liquid sample preparation devices to instruments that measure isotopic composition. It allows the introduction of the sample and also reference and carrier gases. Examples: Finnigan MATConFlo II, ThermoScientific ConFlo IV, and Picarro Caddy. Note: This is NOT an analyzer

Dataset-specific Instrument Name	CE Elantech NA2500 elemental analyzer
Generic Instrument Name	Elemental Analyzer
Dataset-specific Description	Samples were analyzed with continuous-flow isotope ratio mass spectrometry using a Micromass Optima interfaced to a CE Elantech NA2500 elemental analyzer.
Generic Instrument Description	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.

Dataset-specific Instrument Name	Micromass Optima
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Samples were analyzed with continuous-flow isotope ratio mass spectrometry using a Micromass Optima interfaced to a CE Elantech NA2500 elemental analyzer.
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

Dataset-specific Instrument Name	Go-Pro Hero 7 Black
Generic Instrument Name	Underwater Camera
Dataset-specific Description	Small video-cameras (Go-Pro Hero 7 Black) were use to assess damselfish behavior in each territory.
Generic Instrument Description	All types of photographic equipment that may be deployed underwater including stills, video, film and digital systems.

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Project Information

Positive Effects of Coral Biodiversity on Coral Performance: Patterns, Processes, and Dynamics (Coral Biodiversity)

Coverage: Moorea, French Polynesia, South Pacific Ocean (17º32’S 149º50’W)

NSF Award Abstract:
Coral reefs are extremely diverse, supply critical ecosystem services, and are collapsing at an alarming rate, with 80% coral loss in the Caribbean and >50% in the Pacific in recent decades. Previous studies emphasized negative interactions (competition, predation) as structuring reef systems, but positive interactions in such species-rich systems could be of equal importance in maintaining ecosystem function. If foundation species like corals depend on positive interactions, then their fitness may decline with the loss of surrounding species, creating a biodiversity meltdown where loss of one coral causes losses of others. This project conducts

manipulative field experiments to understand the role of coral biodiversity in facilitating coral growth, survival, resilience, and retention of these foundation species and the critical ecosystem services they provide in shallow tropical seas. This project is committed to: 1) Educating and exciting influential business and civic leaders about conservation and restoration of coastal marine systems before these systems lose ecological function and value. This will involve influential Rotary clubs within North Georgia/Atlanta (the major economic engine of the southeastern US) as an initial focus. 2) Using the Research News and Institute Communications Office at Georgia Tech and well-developed contacts with science writers to produce popular press pieces on important ocean ecology discoveries emerging from these studies. (3) Organizing a public workshop of internationally prominent scientists focused on Maintaining Marine Biodiversity as a Strategy to Sustain Ecosystem Services and Coastal Cultures and Economies. A previous effort like this, organized by the investigators, attracted about 200 attendees and was webcast to numerous high schools in Georgia and to foreign investigators in less developed countries that could not attend. Speakers also conducted in-person video interviews with local high school classes. Due to that success, this model will be repeated. 4) Working with an association of educators and cultural leaders in French Polynesia to produce electronic format presentations on our work and on reef conservation that are appropriate for use by both teachers and leaders within Polynesian culture.

Ecologists have excelled at demonstrating the importance of direct (often negative) interactions among species pairs. However, when these interactions occur in a complex context among thousands of other species in the field, the sum of the many, poorly-known, indirect interactions can counterbalance, or even reverse, the better-known direct interactions, generating diffuse mutualisms instead of agonistic outcomes. In a proof-of-concept initial experiment, coral growth and survivorship were greater in coral polycultures than monocultures, especially during early stages of community development. Processes generating this outcome are unclear but understanding these is of critical importance as diversity and function of reefs decline and as humans need to predict and adapt to changing environments. This interdisciplinary investigation merges expertise in experimental field ecology, chemical ecology, and the ecology of microbiomes to investigate the functional role of biodiversity in coral reef ecosystems. Experiments use a novel coral transplantation method and field manipulations to assess: 1) whether greater coral species diversity enhances coral community performance, as well as growth and survivorship of individual corals, 2) whether greater genotypic diversity enhances coral performance within a species, 3) whether greater diversity of seaweed competitors further suppresses corals and enhances seaweed performance, and 4) the processes driving the patterns documented above, including the roles of disease, intraspecific versus interspecific competition, predators, mutualists, and differential access to, or use of, resources. The research investigates the relationship between biodiversity and ecosystem function across dimensions of coral taxonomic diversity, from species to genotypes, and creates a series of experiments elucidating general principles underlying ecosystem dynamics. Filling these knowledge gaps advances our fundamental understanding of how biodiversity influences ecosystem function at multiple scales and provides insight into the processes promoting coral coexistence in these species-rich ecosystems. Findings will have practical implications for coral management and restoration and may improve predictions regarding coral reef resilience and recovery in the face of changing climate.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1947522

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