Coral photosynthetic efficiency (Pulse-Amplitude-Modulation, PAM) fluorometry from Acropora millepora corals exposed to seaweeds

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Data Type: experimental
Version: 0
Version Date: 2020-07-13

Project
» Killer Seaweeds: Allelopathy against Fijian Corals (Killer Seaweeds)

Contributors	Affiliation	Role
Hay, Mark	Georgia Institute of Technology (GA Tech)	Principal Investigator
Clements, Cody	Georgia Institute of Technology (GA Tech)	Co-Principal Investigator, Contact
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Coral photosynthetic efficiency (Pulse-Amplitude-Modulation, PAM) fluorometry from Acropora millepora corals exposed to seaweeds.

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Coverage

Spatial Extent: **Lat**:-18.2164722 **Lon**:177.7173056

Dataset Description

Coral photosynthetic efficiency (Pulse-Amplitude-Modulation, PAM) fluorometry from Acropora millepora corals exposed to seaweeds. See 'Master ID Sheet.xlsx' in Supplemental Files for the treatment descriptions.

These data are presented in Figure 1 of Clements et al, 2020.

Methods & Sampling

Methodology:

To create standardized units of coral, nine ~6-8 cm length branches of Acropora millepora were collected from twelve separate colonies (108 branches total) within Votua's MPA during October 2014 and individually epoxied (Emerkit) into the cut-off necks of inverted plastic bottles. These were then anchored on the reef by screwing them individually into an upturned bottle cap embedded within the substrate (see Video S1 at http://www.intres.com/articles/suppl/m586p011_supp/ for an example of this experimental method) and allowed to acclimate for ~1 month. Corals were then subjected to one of nine experimental treatments for 33 days: (1) direct contact with four thalli of Galaxaura rugosa (live seaweed), (2) close proximity (i.e. ~1.5cm away, no contact) to four thalli of Galaxaura, (3) direct contact with four Galaxaura mimics (microfiber dust cloth), (4) close proximity to four Galaxaura mimics, (5) direct contact with four Sargassum polycystum thalli (live seaweed), (6) close proximity to four Sargassum thalli, (7) direct contact with four Sargassum mimics (plastic aquarium plants), (8) close proximity to four Sargassum mimics, or (9) no seaweed or mimic exposure (control) (n = 9-13 per treatment).

Sampling and analytical procedures:

At 32 days, we used PAM fluorometry (Diving-PAM, Walz, Germany) to assess treatment effects on coral photosynthetic efficiency via measurements of photosystem II (PSII) quantum yield of zooxanthellae within each coral (i.e. effective quantum yield, ΦPSII). All readings were taken in situ on light-adapted corals between 0900-1400 h and were interspersed among treatments through time to prevent confounding treatment effects with time or changing light conditons. We took three readings haphazardly around each coral branch; these were averaged to obtain an “overall” photosynthetic efficiency value for each coral. We also measured a “worst-case” photosynthetic efficiency reading taken at the location that visually appeared most damaged on each coral. For each measure of photosynthetic efficiency, we separately compared ΦPSII values of control corals to those of corals in direct contact or close proximity with Galaxaura or its mimics or Sargassum or its mimics using linear mixed effect (LME) models in R (v. 3.6.1) (R Core Team 2016) with the package nlme (Pinheiro et al. 2017). Coral colony was used as a random factor in all analyses. Subsequent pairwise comparisons were performed using Tukey contrasts with the generalized linear hypothesis test (glht) in the R package multcomp (Hothorn et al. 2008).

Data Processing Description

BCO-DMO Processing Notes:
- data submitted in Excel file "Coral Photosynthetic Efficiency.xlsx" sheet "Sheet1" extracted to csv
- added conventional header with dataset name, PI name, version date
- modified parameter names to conform with BCO-DMO naming conventions
- rounded PAM_Overall values to integers

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Supplemental Files

File
Master list of sample id's, coral colony genotype, treatment, and treatment description filename: Master_ID_Sheet.xlsx (Microsoft Excel, 14.13 KB) MD5:62b3f2cb3afc25e8b36aae12af3261b2

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Related Publications

Clements, C. S., Burns, A. S., Stewart, F. J., & Hay, M. E. (2020). Seaweed-coral competition in the field: effects on coral growth, photosynthesis and microbiomes require direct contact. Proceedings of the Royal Society B: Biological Sciences, 287(1927), 20200366. doi:10.1098/rspb.2020.0366
Results

Hothorn, T., Bretz, F., & Westfall, P. (2008). Simultaneous Inference in General Parametric Models. Biometrical Journal, 50(3), 346–363. doi:10.1002/bimj.200810425
Methods

Pinheiro, J.D., Bates, D., DebRoy, S., Sarkar, D. and the R Core Team (2014) nlme: linear and nonlinear mixed effects models. R package version 3.1–131. http://CRAN.R-project.org package=nlme
Methods

R Core Team (2016) R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria. https://www.r-project.org
Software

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Parameters

Parameter	Description	Units
Sample_ID	The ID for each sample	unitless
Number	The sequential numbering order of samples in our data sheet (for organization purposes)	unitless
Treatment_ID	Treatment IDs are described in the file Master ID Sheet.xlsx	unitless
Colony	The colony that a sample was originally sourced from in the field for the experiment	unitless

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Instruments

Dataset-specific Instrument Name	PAM fluorometer (Diving-PAM, Walz, Germany)
Generic Instrument Name	Fluorometer
Dataset-specific Description	A chlorophyll fluorometer for studying photosynthesis in and under water.
Generic Instrument Description	A fluorometer or fluorimeter is a device used to measure parameters of fluorescence: its intensity and wavelength distribution of emission spectrum after excitation by a certain spectrum of light. The instrument is designed to measure the amount of stimulated electromagnetic radiation produced by pulses of electromagnetic radiation emitted into a water sample or in situ.

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Project Information

Killer Seaweeds: Allelopathy against Fijian Corals (Killer Seaweeds)

Coverage: Viti Levu, Fiji (18º13.049’S, 177º42.968’E)

Extracted from the NSF award abstract:

Coral reefs are in dramatic global decline, with reefs commonly converting from species-rich and topographically-complex communities dominated by corals to species- poor and topographically-simplified communities dominated by seaweeds. These phase-shifts result in fundamental loss of ecosystem function. Despite debate about whether coral-to-algal transitions are commonly a primary cause, or simply a consequence, of coral mortality, rigorous field investigation of seaweed-coral competition has received limited attention. There is limited information on how the outcome of seaweed-coral competition varies among species or the relative importance of different competitive mechanisms in facilitating seaweed dominance. In an effort to address this topic, the PI will conduct field experiments in the tropical South Pacific (Fiji) to determine the effects of seaweeds on corals when in direct contact, which seaweeds are most damaging to corals, the role allelopathic lipids that are transferred via contact in producing these effects, the identity and surface concentrations of these metabolites, and the dynamic nature of seaweed metabolite production and coral response following contact. The herbivorous fishes most responsible for controlling allelopathic seaweeds will be identified, the roles of seaweed metabolites in allelopathy vs herbivore deterrence will be studied, and the potential for better managing and conserving critical reef herbivores so as to slow or reverse conversion of coral reef to seaweed meadows will be examined.

Preliminary results indicate that seaweeds may commonly damage corals via lipid- soluble allelochemicals. Such chemically-mediated interactions could kill or damage adult corals and produce the suppression of coral fecundity and recruitment noted by previous investigators and could precipitate positive feedback mechanisms making reef recovery increasingly unlikely as seaweed abundance increases. Chemically-mediated seaweed-coral competition may play a critical role in the degradation of present-day coral reefs. Increasing information on which seaweeds are most aggressive to corals and which herbivores best limit these seaweeds may prove useful in better managing reefs to facilitate resilience and possible recovery despite threats of global-scale stresses. Fiji is well positioned to rapidly use findings from this project for better management of reef resources because it has already erected >260 MPAs, Fijian villagers have already bought-in to the value of MPAs, and the Fiji Locally-Managed Marine Area (FLMMA) Network is well organized to get information to villagers in a culturally sensitive and useful manner.

The broader impacts of this project are far reaching. The project provides training opportunities for 2-2.5 Ph.D students and 1 undergraduate student each year in the interdisciplinary areas of marine ecology, marine conservation, and marine chemical ecology. Findings from this project will be immediately integrated into classes at Ga Tech and made available throughout Fiji via a foundation and web site that have already set-up to support marine conservation efforts in Fiji and marine education efforts both within Fiji and internationally. Business and community leaders from Atlanta (via Rotary International Service efforts) have been recruited to help organize and fund community service and outreach projects in Fiji -- several of which are likely to involve marine conservation and education based in part on these efforts there. Media outlets (National Geographic, NPR, Animal Planet, Audubon Magazine, etc.) and local Rotary clubs will be used to better disseminate these discoveries to the public.

PUBLICATIONS PRODUCED AS A RESULT OF THIS RESEARCH

Rasher DB, Stout EP, Engel S, Kubanek J, and ME Hay. "Macroalgal terpenes function as allelopathic agents against reef corals", Proceedings of the National Academy of Sciences, v. 108, 2011, p. 17726.

Beattie AJ, ME Hay, B Magnusson, R de Nys, J Smeathers, JFV Vincent. "Ecology and bioprospecting," Austral Ecology, v.36, 2011, p. 341.

Rasher DB and ME Hay. "Seaweed allelopathy degrades the resilience and function of coral reefs," Communicative and Integrative Biology, v.3, 2010.

Hay ME, Rasher DB. "Corals in crisis," The Scientist, v.24, 2010, p. 42.

Hay ME and DB Rasher. "Coral reefs in crisis: reversing the biotic death spiral," Faculty 1000 Biology Reports 2010, v.2, 2010.

Rasher DB and ME Hay. "Chemically rich seaweeds poison corals when not controlled by herbivores", Proceedings of the National Academy of Sciences, v.107, 2010, p. 9683.

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Funding

Funding Source	Award
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