UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE & ATMOSPHERIC SCIENCE

The effect of the initial proportion of *Durusdinium trenchii* on photochemical efficiency and the rate of decline in symbiont to host ratio during heat stress

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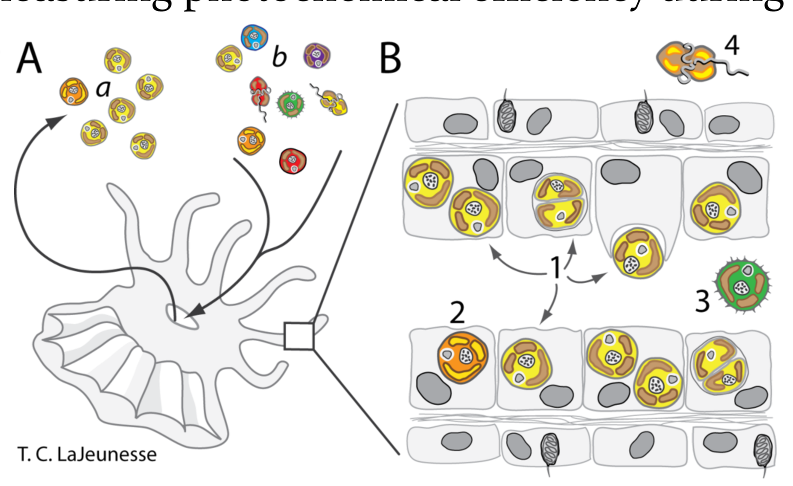
Introduction

- Rising sea temperatures has led to more frequent, severe and large-scale coral bleaching events. [4]
- Bleaching is the breakdown in the symbiosis between the coral host and its symbiotic algae that resides in the corals' gastrodermis.[6]
- Some symbionts in the genus *Durusdinium* are thermotolerant and increase the bleaching resistance of their hosts by 1-2°C, compared to other symbiont genera, such as *Breviolum* and *Cladocopium*.[2,9]
- It has been proposed that reef symbiont communities can shift their symbiont composition to bring forth "background" heat resilient following a heat stress.[1,3]
- The focus of this experiment is to determine whether higher initial proportions of *D. trenchii* leads to less severe bleaching by determining symbiont to host cell ratio and measuring photochemical efficiency during heat stress.



Methods

- A total of 60 replicate cores from 10 colonies of each of the three species, *Montastraea cavernosa*, *Orbicella faveolata*, and *Siderastrea siderea* were collected.
- They were collected from Emerald Reef, Miami-Dade County, Florida in the spring and fall of 2019.
- Their symbiont communities were analyzed to assess the initial proportions of *D. trenchii*.
- They were exposed to 32°C for 25 days for heat stress.
- Bleaching response was measured as declines in symbiont to host cell ratio using quantitative PCR and photochemical efficiency with chlorophyll fluorometry.

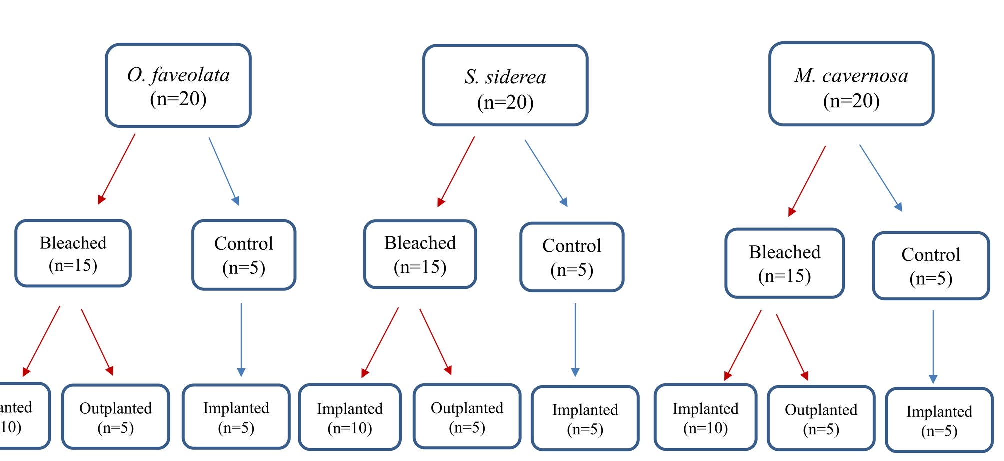


Figure 1. Experiment overview for spring and fall collection

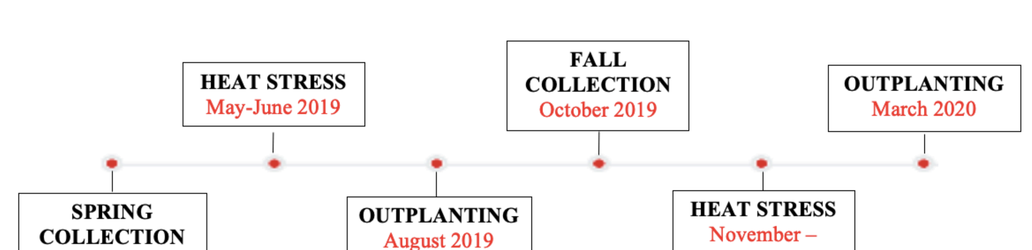


Figure 2. Timeline for spring and fall collection, heat stress, and outplanting

Results

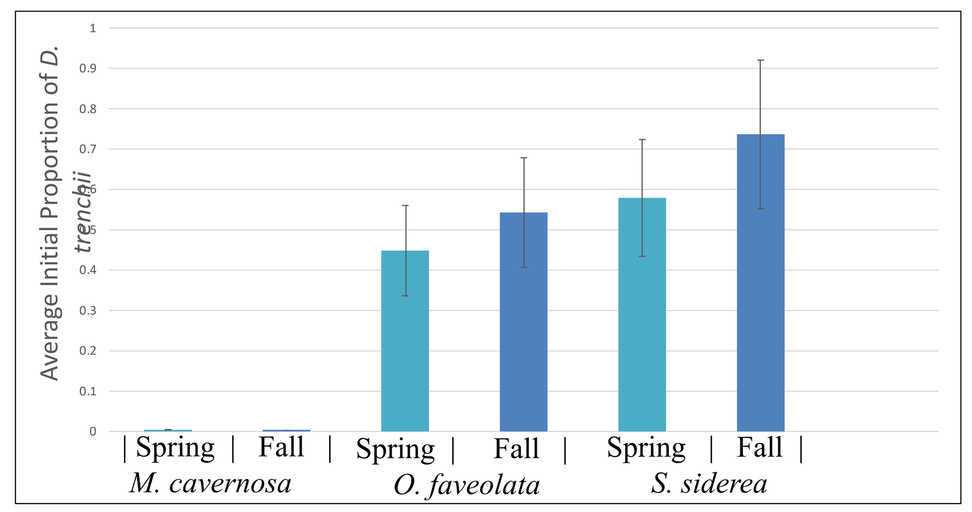


Figure 3. Average mean values for the initial proportion of D. trenchii in fall and spring collections for three species

- Based on non-parametric Kruskal-Wallis test, there was no statistical difference in the initial proportions of *D. trenchii* within species distinguished by timepoints, spring and fall ($p=0.3688$).
- An ANOVA showed a statistical difference between *Montastraea cavernosa* and *Orbicella faveolata or Siderastrea siderea* ($p<0.05$) but not a statistical difference between *Orbicella faveolata* and *Siderastrea siderea* ($p=0.1214$).
- There was no interaction between species and timepoint ($p=0.7641$).

Symbiont to Host Ratio and DHW

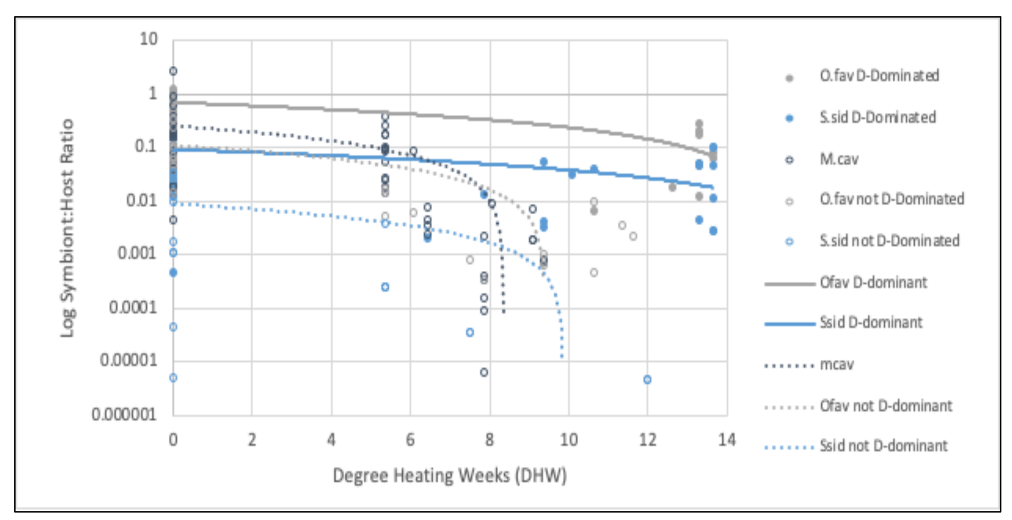


Figure 4. Symbiont to host ratio over DHW for D-dominant and not D-dominant species

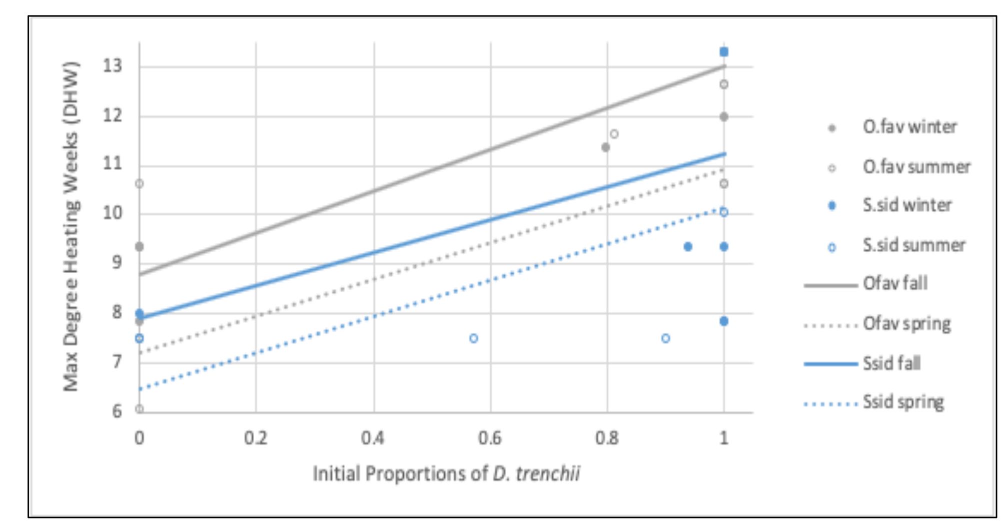
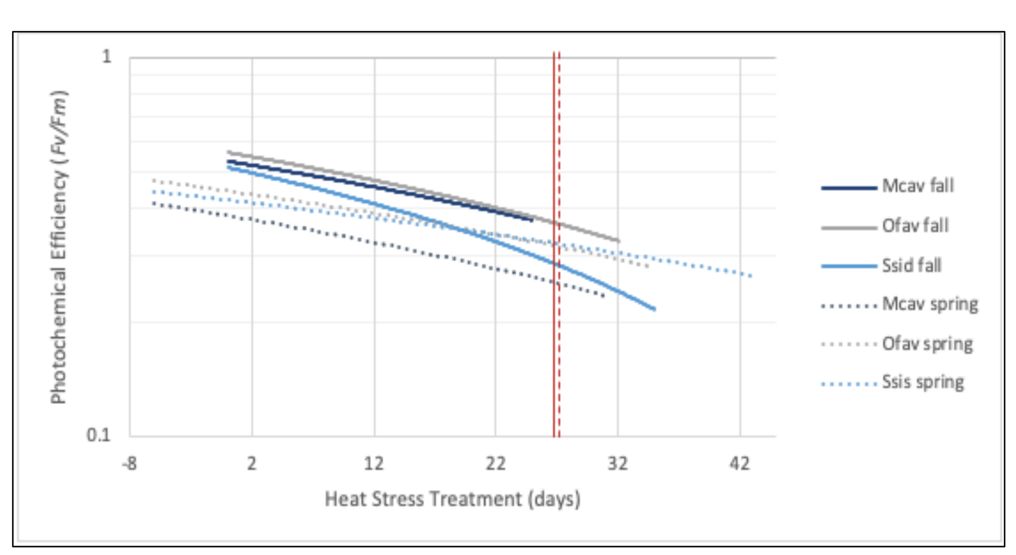


Figure 5. Relationship between initial proportions of D.trenchii and maximum DHW for spring and fall

- A linear model and ANOVA showed a significant effect of DHW on overall Log of symbiont to host ratio (LogS:H).
- Initial dominance of *Durusdinium* had greatest effect on DHW ($p=0.021497$), compared to dominance of *Breviolum* or *Cladocopium.*
- Pairwise comparisons showed greatest statistical difference between *Cladocopium* and *Durusdinium* and less difference between *Breviolum* and *Durusdinium.*

- A non-parametric Kruskal-Wallis test showed the initial proportions of *D. trenchii* significantly affected whether corals were able to reach higher DHWs ($p<0.001$).
- The rate of increase between initial proportions of *D. trenchii* and maximum DHW did not differ between timepoints ($p=0.98$).
- There was a significant difference in maximum DHW reached by each timepoint but not based on initial proportions ($p<0.01$).

Photochemical Efficiency



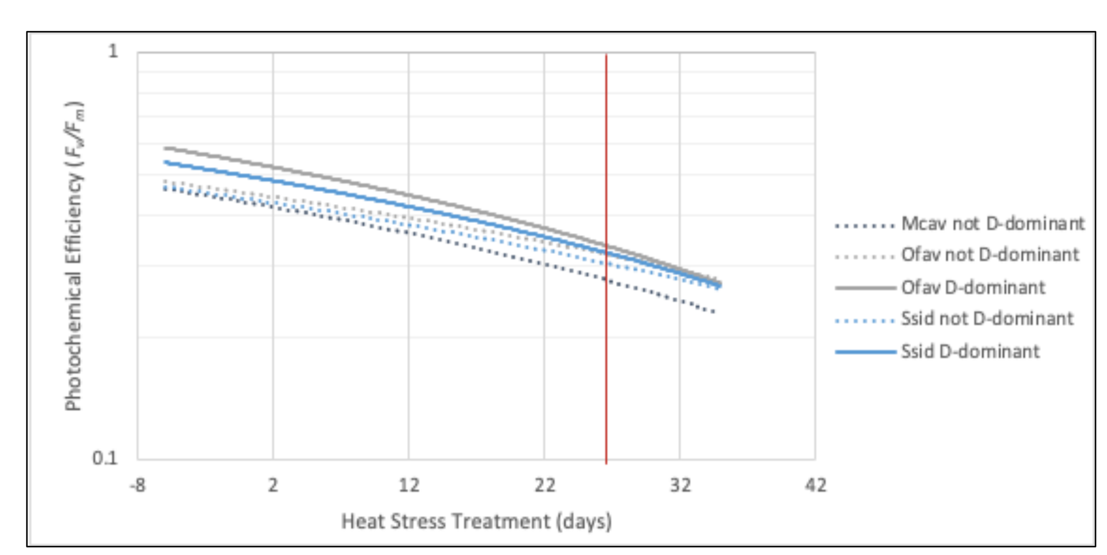


Figure 6 and 7. Photochemical efficiency (F_v/F_m) during heat stress for spring and fall (left) and D-dominant and not D-dominant (right). The solid and dotted red lines represent a temperature increase during treatment from 32°C to 33°C

- Photochemical efficiency declined in corals as the number of days of heat stress increased, indicating bleaching over time.
- The fall corals and the corals initially dominated by *Durusdinium* started out with a higher photochemical efficiency compared to their counterparts.
- As the heat stress experiment carried on, there was not much of a difference in trend between the spring and fall corals nor between the corals dominated by *Durusdinium* and corals not dominated by *Durusdinium*.

Discussion

- A difference in *D. trenchii* between spring and fall collections was hypothesized, due to exposure to summer maximum, but likely no difference detected since there was not a record of bleaching in Florida during summer 2019.
- A slower decline in Log(S:H) by corals dominated by *Durusdinium* may indicate an enhanced tolerance to heat stress.[8]
- Initial proportions of *D. trenchii* had an overall effect on time it took to reach bleaching threshold, indicating that even trace amounts of *D. trenchii* can provide a better bleaching response.[11]
- Lack of a significant difference in trendlines for declines in F_v/F_m may have been a result of increasing temperatures from 32°C to 33°C, as previous studies have showed similar declines in *Cladocopium* and *Durusdinium* at 33°C.[10]
- Overall, declines in photochemical efficiency of PSII is a result of the accumulation of damage due to the quenching capacity of photochemistry and photo-protective pathways being exceeded by excitation energy.[7]
- In conclusion, higher initial proportions of *D. trenchii*, induced by elevated temperatures, may result in an enhanced bleaching response for *Orbicella faveolata and Siderastera siderea.*
- The benefits and trade-offs recognized by *Durusdinium* indicate the need for researching the long-term implications of corals hosting the heat-tolerant clade. [5]

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References

[1] Bay, L. K., Doyle, J., Logan, M., & Berkelmans, R. (2016). Recovery from bleaching is mediated by threshold densities of background thermo-tolerant symbiont types in a reef-building coral. *Royal Society Open Science*, *3*(6). 160322

[2] Berkelmans, R., & van Oppen, M. J. H. (2006). The role of zooxanthellae in the thermal tolerance of corals: A "nugget of hope" for coral reefs in an era of climate change. *Proceedings. Biological Sciences*, *273*(1599), 2305–2312.

[3] Cunning, R., Silverstein, R. N., & Baker, A. C. (2018). Symbiont shuffling linked to differential photochemical dynamics of Symbiodinium in three Caribbean reef corals. *Coral Reefs*, *37*(1), 145–152.

[4] Hofmann, M., Mathesius, S., Kriegler, E., Vuuren, D. P. van, & Schellnhuber, H. J. (2019). Strong time dependence of ocean acidification mitigation by atmospheric carbon dioxide removal. *Nature Communications*, *10*(1), 1–10.

[5] Morikawa, M. K., & Palumbi, S. R. (2019). Using naturally occurring climate resilient corals to construct bleaching-resistant nurseries. *Proceedings of the National Academy of Sciences*, *116*(21), 10586–10591.

[6] Muller-Parker, G., D'Elia, C., & Cook, C. (2015). *Interactions Between Corals and Their Symbiotic Algae* (pp. 99–116).

[7] Roth, M. S. (2014). The engine of the reef: Photobiology of the coral–algal symbiosis. *Frontiers in Microbiology*, *5*.

[8] Scheufen, T., Iglesias-Prieto, R., & Enríquez, S. (2017a). Changes in the Number of Symbionts and Symbiodinium Cell Pigmentation Modulate Differentially Coral Light Absorption and Photosynthetic Performance. *Frontiers in Marine Science*, *4*.

[9] Silverstein, R. N., Cunning, R., & Baker, A. C. (2015). Change in algal symbiont communities after bleaching, not prior heat exposure, increases heat tolerance of reef corals. *Global Change Biology*, *21*(1), 236–249.

[10] Silverstein, R. N., Cunning, R., & Baker, A. C. (2017). Tenacious D: Symbiodinium in clade D remain in reef corals at both high and low temperature extremes despite impairment. *The Journal of Experimental Biology*, *220*(Pt 7), 1192–1196.

[11] Stat, M., & Gates, R. D. (2011). *Clade D Symbiodinium in Scleractinian Corals: A "Nugget" of Hope, a Selfish Opportunist, an Ominous Sign, or All of the Above?* [Review Article]. Journal of Marine Biology; Hindawi.