Temporal and environmental influences on the early establishment and maintenance of coral-*Symbiodinium* symbioses

Thesis submitted by

David Abrego

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ABSTRACT

Understanding mechanisms underlying the formation and maintenance of coral-*Symbiodinium* symbioses as well as factors affecting the integrity of these symbioses is critical to predicting how coral holobionts might change in response to warming oceans predicted by climate change. Research reported in this thesis aims to enhance current knowledge of coral-*Symbiodinium* symbioses by: (1) examining temporal variation in *Symbiodinium* uptake by coral juveniles, (2) exploring the role of parental effects and ontogenetic stage in determining *Symbiodinium* associations, (3) assessing the impact of environmental parameters in the establishment of symbioses, and (4) evaluating whether some host-symbiont combinations are more resilient to environmental stress than others.

I found that newly settled juveniles of the corals *Acropora millepora* and *A. tenuis* do not necessarily take up the *Symbiodinium* type present in parental colonies, and that a potentially opportunist type D *Symbiodinium* quickly dominates symbioses in juveniles of both species at three sites in the central Great Barrier Reef. I also found that adult patterns of association may not become established for up to 2.5-3.5 years, suggesting a delay in the expression of symbiont specificity. In *A. tenuis,* continuing changes in *Symbiodinium* communities over the first 3.5 years are interpreted as fine-tuning of specificity mechanisms leading to establishment of the homologous algal symbiont characteristic of adult populations. Algal endosymbioses were much more stable over the same time period in juveniles of *A. millepora,* although further research is required to distinguish between absence of specificity and delayed expression of specificity. Changes in *Symbiodinium* communities in *A. tenuis* juveniles are not linked to the onset of reproductive maturity but may be linked to changes in micro-environmental conditions (possibly light intensity or access to nutrients) associated with growth of the colony.

Field studies investigating the role of environmental parameters in the establishment of symbioses revealed that light has little effect on the type of *Symbiodinium* initially acquired by both *A. millepora* and *A. tenuis*. This result was confirmed by experimental manipulations in aquaria where equal amounts of *Symbiodinium* types C1 and D were offered to newly settled juveniles maintained in two light levels by three temperature treatments. In contrast, I found that temperature has a significant effect on algal symbioses by affecting the type of *Symbiodinium* acquired by both coral species and by slowing and potentially stopping *Symbiodinium* uptake and the onset of symbioses at elevated temperatures. Type D *Symbiodinium* was found in larger proportions in juveniles at elevated temperatures (30 and 31°C), providing further evidence of the infective and potentially opportunistic nature of this *Symbiodinium* type. The benefits of type D to the host require further investigation as these juveniles had low levels of infection and it is unclear if their survival would depend on other mechanisms, such as a shift towards heterotrophy.

Comparisons of the resilience of corals hosting type C1 or D *Symbiodinium* to environmental stress indicate that *A. tenuis* juveniles have lower metabolic costs and enhanced physiological tolerance when hosting type C1 *Symbiodinium*. In other studies, the same D-type has been shown to confer higher thermal tolerance than both C2 in adults and C1 in juveniles of the closely related coral *A. millepora*. My results challenge speculations that associations with type D are universally most robust to thermal stress and highlight a potential role of host factors in determining the physiological performance of the holobiont. They also show that although the heat tolerance of corals may be contingent on the *Symbiodinium* strain *in hospite*, their response to heat and light stress is determined by species-specific interactions between both partners in the association.

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