Microbiome Manipulation: Using Beneficial Microorganisms of Coral (BMCs) to Increase Disease Resilience

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Populations of the Caribbean staghorn coral have markedly declined since the 1980s due primarily to infectious diseases. We have identified a strong linkage between disease susceptibility in this coral species with high abundance of a known bacterial parasite in the genus *Aquarickettsia*. In contrast, naturally disease-resistant staghorn genotypes harbor a more diverse microbiome. We hypothesized that the microbiome of these staghorn genotypes contains potential beneficial microorganisms for corals (BMCs) that may confer some of the observed disease resistance. Additionally, we hypothesized that the rapid, significant loss of the parasite *Aquarickettsia* through experimentally-induced bleaching would allow for the introduction of beneficial bacterial taxa to fill the niche left open by the loss of this parasite. To date, we have isolated and characterized over 186 bacterial isolates from disease-resistant staghorn genotypes and found that 72 show beneficial properties against a known coral pathogen, *Serratia marcescens*. We further screened and tested these potential BMCs using the coral model *Aiptasia* (sensu *Exaiptasia diaphana*). Individual BMC cocktails were validated in Aiptasia to ensure non-virulence and beneficial properties against the coral pathogen. To manipulate the existing microbiome of disease-susceptible staghorn genotypes, we investigated two methods to reduce populations of *Aquarickettsia*: thermal- and menthol-induced bleaching. After significant loss of *Aquarickettsia* through these methods, we tested different approaches to introduce beneficial bacterial taxa. We found that adding the BMC cocktail to the coral food was the best inoculant. The microbiomes pre- and post-inoculation of the BMCs were analyzed by 16S rRNA sequencing. Our results represent the first microbiome replacement study in *Acropora cervicornis* and pave the way for continued trials of microbiome replacement with a greater number of coral genotypes, species, and life stages. The use of coral food as the inoculant of the BMCs is a scalable method and the ability to use BMCs to replace a known bacterial parasite will almost certainly improve disease outcomes and will be transformative for coral restoration efforts.