Investigating Coral Bleaching Mechanisms and Potential Biochemical Prevention/Rescue Measures

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Development of bleaching prevention and remediation measures based on coral nutrient supply pathways, Tokyo University
Bleaching phenomena elucidated from omics and microscale studies, Tsukuba University
Development of a bleaching model considering in vivo response and prediction of the effectiveness of bleaching prevention and remedial measures, Tokyo Institute of Technology

[Abstract]

Key Words: Global warming, Coral bleaching, Reactive oxygen species, Stable isotope ratios, Comprehensive genetic analysis, Ecosystem modeling.

This study focuses on the development of prevention and remedial measures for high temperature stress induced coral bleaching. The measures tested rely on the role of antioxidants, a reactive oxygen species (ROS) defense mechanism during bleaching, metal enrichment and coral nutritional status. The effect of supplementation in either metal enriched yeast or Artemia larvae as bleaching mitigation measures were tested. An increase in antioxidant enzyme activity of the coral host was observed after supplementation with metals enriched yeasts (Fe, Mn). Supplementation with Artemia larvae mitigated the coral zooxanthellae density decreased under high water temperature. Furthermore, supplementation with Fe-yeast and Artemia larvae enhanced the activity of antioxidant enzymes in zooxanthellae. Supplementation with Artemia larvae and Mn yeast resulted in a 1.6-fold higher survival rate compared to non-fed corals after 3 weeks of high water temperature treatment. These results indicate that supplementation in either metal enriched yeast or Artemia larvae could allow a higher survival rates of corals after a bleaching event, thereby providing a mitigation measure to bleaching induced by short high-temperature period.

To assess the role of the nutritional status in the mitigation of bleaching and increased survival rates following bleaching by supplementation we first developed indicators that reflect coral lipid stores, heterotrophic dependence, nitrogen nutrient sources, and trophic status with symbiotic algae. Using these indicators, we evaluated the nutritional status of corals when fed various diets and showed that corals assimilate Artemia larvae as a source of nutrients and store this additional input in the form of lipids. This showed that the nutritional status of corals was actually improved by feeding. Furthermore, the effects and mechanisms of action of various biochemical techniques proposed to prevent coral bleaching were reviewed and verified using model experimental systems.

Microsensing techniques, comprehensive gene expression analysis, and bacterial population analysis were used to verify the effectiveness of these techniques and to evaluate potential adverse effects. Corals fed Artemia larvae showed increased gene expression related to metabolism, such as organic matter and sugar metabolism, and the change in genes expression that occurred under high temperature stress were mitigated by supplementation. This result confirms the potential

of supplementation as a stress-relieving measure. Corals with higher expression of metabolism-related genes related to glutamate synthase and ammonium transport showed higher survival rates, while corals expressing genes related to cytotoxicity showed lower survival rates. The bacterium Endozoichomonas, an indicator of coral health, did not show any tendency to decrease in response to supplementation, and there was no increase in pathogenic microorganisms, indicating that supplementation does not cause changes in coral microbiome or the growth of harmful bacteria.

A bleaching model for the coral-zooxanthellae symbiosis was developed. This model can reasonably explain the physiological and biochemical parameters obtained experimentally during the selection and evaluation of these measures. Moreover, it can describe the response and recovery characteristics of corals in high temperature environments. This model was extended to a model that reproduces large-scale bleaching in a real marine area. Simulations showed that corals that were well nourished by food recovered in less than one-third of the time predicted for corals that were poorly nourished. The model supported the importance of maintaining good coral nutritional status in mitigating bleaching and recovering from bleaching.

[References]

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