Cold Stress-induced Oxidative Stress in Corals

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Introduction:

Coral bleaching, characterized by the loss of symbiotic algae from corals, is primarily associated with elevated water temperatures, known as hot stress induced bleaching. However, cold water can also induce coral bleaching, impacting various physiological processes (Higuchi et al., 2015). Extensive research has focused on the mechanisms of coral bleaching under heat stress, highlighting the association between oxidative stress and subsequent bleaching events (DeSalvo et al., 2008). On the other hand, cold stress bleaching has been less studied compared to heat stress bleaching, resulting in a limited understanding of the mechanisms and impacts involved (Higuchi et al., 2015). Similar stress responses are observed in higher plants under cold stress to those reported for coral bleaching under hot stress, including disrupted photosynthesis and oxidative stress (Wang et al., 2017). The accumulation of reactive oxygen species (ROS) can cause damage to cellular components. These parallels between corals and higher plants suggest a common underlying mechanism for cold stress induced bleaching. The purpose of this study is to investigate whether oxidative stress occurs during cold-induced coral bleaching.

Lipid peroxidation (LPO) and total antioxidant capacity (TAC) assays were used to quantify oxidative stress in cold-stressed corals. Trial experiments confirmed reliable and reproducible quantification of LPO and TAC in the coral host.

Material & Methods:

A total of 12 microcolonies of *P. heronensis* were randomly selected. The microcolonies were then divided into two conditions: control condition(n=6) and cold stress(n=6), and then incubated for 48 hours.

In the control condition, the temperature was kept constant at 20° C throughout the entire 48-hour duration. In the cold stress group, the temperature was initially maintained at 20° C for 24 hours. Using chilling circulators, the temperature was gradually lowered from 20° C to 15° C over a span of 5 hours, with a decrease of 1° C per hour. The temperature was then maintained at a constant 15° C for an additional 24 hours.

Following the experimental period, a dark adaptation of 30 minutes was conducted on the microcolonies to measure the fluorescence (Fv/Fm). The physiological and biochemical performances of both the coral host and symbionts were measured.

Results:

Photosynthetic efficiency, lipid peroxidation levels, and total antioxidant capacity showed a significant difference between cold stress and control conditions ($p = 0.0032$, $p = 0.03016$, $p = 0.04179$, respectively). However, no significant results were observed for protein biomass, zooxanthellae density.

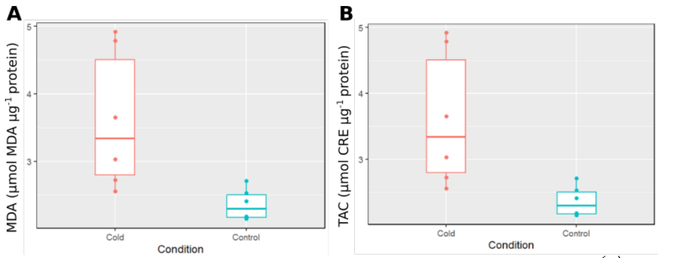

Figure 1: Lipid peroxidation levels as shown as MDA concentrations (A) and total antioxidant capacity (B) of corals exposed to short term cold stress.

Discussion:

Reduced photosystem efficiency is commonly observed in both hot stress-induced bleaching (Hoegh-Guldberg, 1999) and cold stress-induced bleaching (Roth et al., 2012).. The significant difference in total antioxidant capacity indicates compromised antioxidant enzyme generation, such as superoxide dismutase (Higuchi et al., 2015). This limited capacity contributed to ROS accumulation and increased lipid peroxidation levels, indicating oxidative damage. This imbalance in reactive oxygen species (ROS) production and scavenging, resulting in oxidative stress and cellular damage, aligns with findings for higher plants under cold stress (Hasanuzzaman et al., 2020). Overall, impaired PSII function under cold stress reduced photosynthesis, increased ROS, and compromised antioxidant defences, leading to oxidative damage. This shows that mechanisms of cold stress induced bleaching are similar to those under hot stress for hermatypic corals.

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