The Effect of Increased Temperature and Coral Acclimation of *Sinularia dura*

Z S Juhi and K A Rabbani

Department of Environmental Science, School of Environmental Science and Management, Independent University, Bangladesh
E-mail: rabbani@iub.edu.bd

**Abstract.** Coral reefs are one of the most vulnerable ecosystems in the world. With evidence of recent and notable mass coral bleaching at the Great Barrier Reef, it is imperative that coral species and their response to increased temperatures be studied in order to identify coral acclimation and the “winners” and “losers” of climate change. *Sinularia dura* is a common coral species in South Asian and Southeast Asian water. This study has shown that even a 1 to 2 degrees centigrade increase in temperature can have huge effect on the health of *Sinularia Dura* which has implications to the status of coral reefs due to increased sea temperatures caused by climate change.

1. **Introduction**

Coral reefs are some of the most diverse and vulnerable ecosystems in the world. With ongoing climate change and ocean acidification, coral bleaching events are estimated to effect 90% of corals by 2060 if current emissions continue [1]. Coral bleaching occurs when environmental conditions disrupt the symbiosis, leading the degeneration and/or expulsion of its endosymbiotic algae (Zooxanthellae) from the coral host [2]. With time, as changes in environmental factors pose a challenge to their continued existence, corals can sometimes take major defensive or adaptive actions to ensure their survival [3]. Studies have shown that corals can recover rapidly following a dramatic decline and recoveries of coral cover have been documented at several locations all over the world [4]. Corals withstand heat stress via a number of mechanisms including acquiring thermally resistant symbionts, increasing physiological mechanisms by producing oxidative enzymes or by producing photo-protective compounds [5-9]. There are several biochemical methods of determining coral health and simply counting zooxanthellae density is an established method to monitor the health of corals [10-12]. Though there have been some studies looking at coral health and their relationship to increased temperature, few have been done on common South Asian corals [13].

Corals are a large economical assets for their fishing grounds and tourism in South East Asia and South Asia [14, 15]. It is important to identify species of corals in this region that are susceptible to climate change, and differentiate others to those that are more tolerant to increased temperatures. This study has thus been conducted on the coral species *Sinularia Dura*, also commonly known as cabbage coral. One of the most tolerant species of corals in South East Asia, we have tried to identify the rate of adaptability of this coral to stable sustained increase in water temperature while keeping all other parameters constant. The last part of this paper also attempted to record the recovery of this coral following exposure to elevated temperature to document the recovery this coral. This paper wanted to examine coral acclimation and how a specific hardy species of coral is going to respond to increase in temperature due to climate change.

2. **Methodology**
2.1. Coral Selection and Collection
All experiments were conducted on cultured soft coral *Sinularia Dura*, commonly known as cabbage leather coral which originates in the warmer water areas of the Indian Ocean. The selection of this specific type of coral has been subjected upon its high tolerance level of water parameters. As well as its higher capability to adapt to sudden changes has made it a highly strong competitor as a coral test subject. This coral was collected from a local aquaria during June 2016 measuring 11.5cm in diameter initially fragged onto a smaller live rock. The aquaria tank maintained a temperature of 25° C.

2.2. Tank Setup
The experiment was conducted at Independent University, Bangladesh during the periods of June to November, 2016. Before the arrival of the coral, a tank, dimensions of 24 in. X 13 in. X 13 in. (15 gallons) was set on cycle with SeaChem Marine Salt in water with a specific gravity of 1.021. The following specifications were acquired to mimic a healthy sea-like aquaria (Table 1).

| Table 1. Parameters setup for the tank |
| Parameter | Condition in tank | Typical ocean values |
|------------|-------------------|----------------------|
| Temperature | 24.5-28 °C | 25-30 °C |
| Salinity | 35 ppt | 34-36 ppt |
| pH | 8.1-8.3 | 8.0-8.5 |

Temperature changes were recorded with an analogue temperature recorder along with a HACH sensION 156 pH/Conductivity meter for salinity and pH recordings. A liverock was added to the aquaria as an effective bio filter and act as an initial bio-media to form an ideal ecosystem. Additionally, a hang on back power filter with sponge was added for filtration purposes and a small submersible utility pump is added for proper aeration to add flow and circulation for the coral, to form sea like currents.

2.3. Lighting
Three 54W T5 fluorescent lights were added to the coral aquaculture of Red, Blue and White. A light cycle between 10-12 hours per day controlled with a timer was also made to mimic natural photoperiods.

2.4. Zooxanthellae Calculation Procedure
A 2.5 cm sized piece from the coral was cut from its tip and put onto a micro-centrifuge tube using 30μl aquarium water with a micropipette. The Zooxanthellae cell density was calculated using the formula:

\[
\text{Total Cells/ml} = \text{Average # cells in each square} \times \text{dilution factor} \times 10^4.
\]

A haemocytometer, is used to count the density zooxanthellae cells. It is a slide with grids that can be seen under the microscope for making counting small cells easier and usually used for counting blood samples. 10 μl of the sample was carefully loaded onto the haemocytometer and the slides seen under the microscope. 4 squares from the chamber was counted and recorded with a total of 16 grids in each. The number of zooxanthellae cells was counted in each grid.

3. Results and Discussion
By nature, the coral *Sinularia dura* has a tendency to shed their waxy coating from time to time in order to remove detritus buildup, during which time they will appear to shrink up. This is a natural “cleansing process” that most mushroom corals go through. The polyps of the coral tend to close up in these situations, making the coral seem almost weak, and ash in color. Different water conditions in the wild, or in aquarium tanks will determine how often this coral retracts. Upon visual inspection of 3 months, it was deduced that this coral would shed its coating and retract once every month. During that period, the number of Zooxanthellae on average goes through a cycle as well. However, this is a
natural occurrence and does not reflect on the overall health of the coral as they open back up within a few days to a weeks’ time. A submersible water heater, was introduced into the aquaria and set at 25° C. During a period of 1-2 days, the temperature was increased by 1 degrees and maintained constant. A sample from the coral was taken to conduct an immediate Zooxanthellae density count using above mentioned procedures. Over the next one month, this gradual increase in temperature was done and recorded. However, at the final increase of 29.5 °C, the heater was taken off after assessing the corals threshold point. The coral was then left to retreat back to its normal temperatures in order to assess any recovery rates.  

*Simularia dura* Zooxanthellae cell density count

The cell density count period was conducted for a period of 28 days starting from 16th October 2016, until the 13th November, 2016. A total of 10 counts were conducted. The temperature increase in the tanks are also shown in the table below (Table 2). The count decreased with increasing temperature indicating that the health of corals decreased with increasing temperature.

**Table 2.** Zooxanthellae count of the experiment during the study

| Tank temperature | Zooxanthellae density count | Zooxanthellae under microscope |
|------------------|-----------------------------|-------------------------------|
| 25° C            | 12.75 cells/ml              |                               |
| 26° C            | 13.75 cells/ml              |                               |
| 27° C            | 13.75 cells/ml              |                               |
Upon visual and physical examination of the coral to 29.5°C, it was seen that the coral had almost bleached by 80% its patches of its fleshy mass disintegrated. The heater was then removed. By the very next day, the coral had completely disintegrated (Rapid Tissue Necrosis) into the tank with no solid mass left. Given the characteristic of “Hardy” coral, the *Sinularia dura* was objected for a partial recovery since the window of exposure to increased temperature was small.

4. **Conclusion**

Currently, our ocean average temperatures have reached at 27.6 degrees Celsius. At certain tropical area’s the current ocean temperature at coral infused locations have currently reached 33.9°C / 93°F. It is sad that up until the recent mass bleaching of the Great Barrier Reef in Australia, bleaching of coral reefs did not gain mass attention or advertising. Over the last 30-40 years 80% of coral in the Caribbean have been destroyed and 50% in Indonesia and the Pacific. Bleaching associated with the 1982 -1983 El-Nino killed over 95% of coral in the Galapagos Islands and the 1997-1998 El-Nino alone wiped out 16% of all coral on the planet. Globally about 19% of coral is dying out each year (NOAA). The experiment’s purpose was mainly to understand a hardy coral species’ capability to acclimate/adapt to rapid temperature rises. Although in the end, we may hopefully not be too late. It is quite well known that bleaching signs that do not result in a long-term loss of reef viability. In fact, if proper conditions were to return, coral reefs have a slight chance of recovery. But the process if slow. Yet now, it is not irreversible and we still have a small window of saving left.

5. **References**
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