Thermal performance of the temperate coral *Porites heronensis*: significance for its future distribution

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Introduction

A northward shift of hermatypic corals distribution due to the increase in seawater temperature under climate change has been observed in Japan, with further shift predicted in the future. However, the factors limiting the northern distribution of corals and how these affect their physiologies are not well understood.

Most hermatypic corals thrive in tropical or subtropical regions. The main factor limiting their distribution is considered to be the lowest annual seawater temperature. Therefore, it is important to study the physiological response to temperature change of hermatypic corals living in the vicinity of the northern distribution limit.

The present study investigates the thermal performance of a temperate hermatypic coral, *Porites heronensis* and its significance for its ecology and distribution under present and future sea surface temperature.

Materials & Methods

Colonies of *P. heronensis* were collected in the Nabeta Bay, Shimoda City, Shizuoka Prefecture in March and September 2015. Colonies were fractionated in small fragments and the exposed skeletons were covered with marine epoxy. The corals were allowed to recover and acclimate in a stock aquarium for at least one month with running natural seawater, a temperature of 19°C, and a 12h light cycle under metal halide lamp.

Six corals fragments per temperature treatment were randomly moved to an experimental aquarium (same conditions as the stock aquarium, except for the temperature). The seawater temperature was changed 1°C per day from 19°C to the different target temperatures (12, 15, 19, 23, 26, and 29°C). The corals were then incubated for 14 days under the target temperature.

On day 0, 7, and 14, seawater flow was stopped and metabolism (photosynthesis, respiration, and calcification) was measured through incubation. Photosystem II efficiency (Fv/Fm) and buoyancy weight were also measured on these days. On day 14, the corals were sacrificed, their tissues removed from the skeleton using an airjet, and homogenized. Chlorophyll *a* concentration, zooxanthellae density, host protein contents, and coral surface were measured. Daily growth was assessed using the increase in buoyancy weight during total incubation.

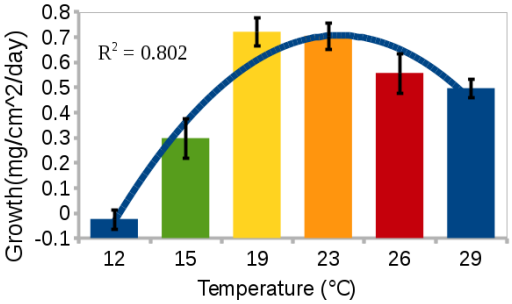
Significance of the variation of the measured parameters among the temperature treatments were assessed using ANOVA. If a significant difference was found, thermal performance curves for each parameters were determined by polynomial regression.

Results

On day 14, net photosynthesis rates, respiration rates, zooxanthellae densities and chlorophyll *a* concentrations were the highest under 19°C. The growth rates also reached a maximum at 19°C, with a slight decrease from 19 to 29°C, and a more drastic towards 12°C. The host tissue proteins contents had similar levels in all treatments.

All coral replicates in the 29°C treatment showed bleaching symptoms: decreased zooxanthellae density, decreased Fv/Fm and negative net photosynthesis rates on day 14. Under 12°C, corals severely bleached during the temperature adjustment period and died within the 14 days incubation.

The thermal performance curve obtained by polynomial regression of the growth rates at the different temperatures, showed a maximum around 21°C.



Discussion

The optimal temperature for the growth of the coral *P. heronensis* was showed to be around 21°C. This temperature is slightly higher than 19°C, the annual average sea surface temperature (SST) observed in Nabeta Bay.

The results obtained showed that the annual lowest SST in Nabeta Bay, 12°C, could limit the growth of *P. heronensis* with bleaching or even high mortality occurring during winter. This result highlights the important role of the annual lowest SST in limiting the northern distribution of corals.

Increased seawater temperature due to climate change could decrease bleaching occurrence and mortality during winter, resulting in an increase in the population of *P. heronensis* in Nabeta Bay. It could also allow a poleward shift of the northern limit of its distribution. The corals showed signs of bleaching at 29°C. The annual maximum temperature in Nabeta Bay being 26°C, a future increase of more than 3°C could lead to possible bleaching during summer even in high latitudes, such as Shimoda City.