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# The Effect of Temperature on the Growth of Two Pest Seaweeds in Fiji

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**Abstract**

Macroalgal blooms are becoming problematic worldwide which is further exacerbated by climate change. This study looks at the effects of temperature on the growth of two pest macroalgae from Fiji, *Sargassum polycystum* and *Gracilaria edulis*, under laboratory conditions. The two algal species were subjected separately to different temperature regimes (28°C, 30°C, 32°C and 34°C). Results showed a significant difference in the Specific Growth Rate (SGR) of *G. edulis* between the four temperatures with optimal growth at 28-30°C. The SGR of *S. polycystum* could not be determined for experimental reasons due to biomass loss. The optimal temperature for rhizoidal length (RL) of *G. edulis* was 32-34°C, while for *S. polycystum* RL was 28°C.

**Keywords**
Climate Change
Growth
Macroalgae
Temperature

## 1. INTRODUCTION

The current climate of the ocean varies and it is the interaction between the ocean and the atmosphere that drives the Pacific climate through interchanging heat, water and wind (Dessler, 2012). There are many components such as wind and water that drive the ocean and atmospheric circulation but one of the most important components is the Sea Surface Temperature (SST, IPCC, 2013; Harley et al. 2012). Climate change has caused a ripple effect by affecting not only the lives of the people of the earth but the entire ecological functioning and processes of the marine environment and organisms (Harley et al. 2012). The rate at which humans are contributing to the greenhouse gases suggest that by 2100, the temperature of the earth would have risen by four degrees Celsius (IPCC, 2013).The anthropogenic activities of humans, such as emission of carbon dioxide from factories into the atmosphere, have caused many problems, of which one is macroalgal abundance (Mosley & Aalbersberg, 2003; Mosley & Aalbergsberg, 2005; Hoey & Bellwood, 2010). Macroalgae, better known as seaweeds, have many important uses in the marine environment. They serve as food for herbivores. Temperature is one of the factors governing the growth of macroalgae and changing temperatures is an essential component of the marine environment (Goodwin et al. 2013; Kailasam & Sivakami, 2004; Raikar et al.2001; Wienckel & Dieck, 1989). The geographical distribution of macroalgae can be attributed to the water-temperature that could be tolerated (Breeman, 1988; Lobban &Harrison, 1997; Sarojini et al. 2013). In addition, macroalgae of the same species could have different tolerance to temperature thus have different geographical boundaries based on those temperature tolerance regime (Breeman, 1988; McLachlan & Bird, 1984). According to Breeman (1988) high and low temperature ranges avert the microthallus growth which is the most resilient part in the life history of macroalgae. Moreover, species of different genera may prefer different temperatures for optimal growth due to geographical isolation (Mojumdar, 1979; Wienckel & Dieck, 1989).

Increasing temperature have been known to cause a shift from coral dominated ecosystems to macroalgal dominated ecosystems (Fong et al. 2006). The marine environment is based upon a complex system that works well with a series of factors such as salinity, irradiance, pH with nutrients and SST being among the most important factors (Lia et al. 2004; Williams et al. 2013). Increase in temperature can also cause an occurrence of pest species. Pest species are fast growing and cause problems such and anoxia of some marine organisms. They are fast growing and thus become resilient to the harsh environment thereby displacing the native species. In this study, the effect of temperature on the growth of two pest seaweed species in Fiji (*Gracilaria edulis* and *Sargassum polycystum*) was investigated under controlled laboratory conditions to understand better the effects of anthropogenic activities on island coastal marine ecosystems.

## 2. MATERIALS AND METHODS

Sampling for *S. polycystum* and *G. edulis* was done on Makuluva Island in Fiji. The samples were collected from the wild using the quadrat method using a 0.25 m×0.25 m quadrat which was randomly placed in the inter-tidal region. The samples collected were then cleaned by wiping off substrates and particles. Afterwards these samples were placed in dark polyethylene bags containing sterile seawater to prevent any further metabolism of the seaweeds. Following this, the samples were transferred to a tank to be treated for 1 week to allow the samples to use up the remaining nutrients present in the tissues with LED lamps at 114 µmoles/m$^2$/s allowing for 12 hours light and 12 hours dark inside the laboratory (Raikar et al. 2001). There were four tanks where conditions such as light irradiance, salinity and dissolved oxygen were kept constant, while temperatures varied. The control tank was at 28℃ while the remaining three tanks were set at 30℃, 32℃ and 34℃ since the temperature of the planet is expected to increase by four degrees by 2100 (IPCC, 2013). The water in the tanks was changed every three days. Specific Growth Rate (SGR) was determined by taking the biomass on the top pan balance and the Rhizoidal Length (RL) was measured using the measuring tape.

## 3. RESULTS

*Gracilaria edulis* had an optimal growth at 28-30°C where the SGR at 30°C was 0.79 %/day± 0.39 as seen in **Fig. 1**. The large standard error at 28°C seems to be due to thallus loss. The RL of *G. edulis* was optimal at 32-34°C while that for *S. polycystum* was optimal at 28°C as depicted in **Fig. 2**. The SGR of *S. polycystum* could not be ascertained because of thallus loss after 5 days of culture. **Table 1** shows the summary of the mean and standard error of the RL of the two macroalgae.

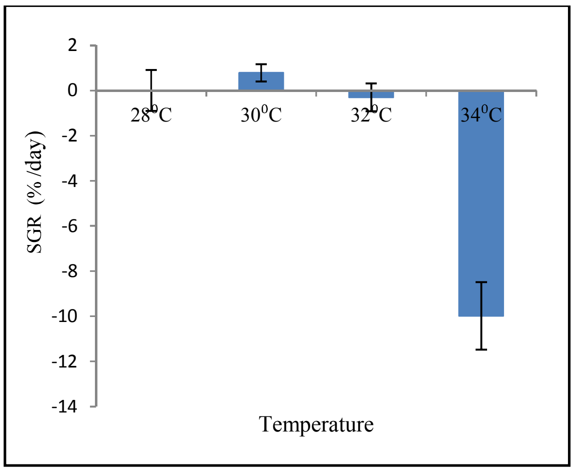


**Fig. 1 Specific Growth Rate (SGR) for Gracilaria edulis at various temperatures**

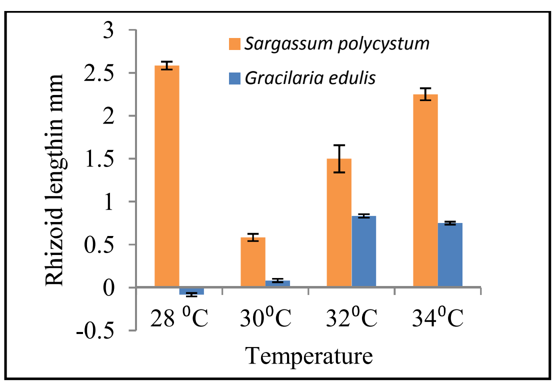


**Fig. 2 Rhizoidal Lengths (RL) of *Sargassum polycystum* and *Gracilaria edulis* at various temperatures**

**Table 1 Summary for the mean and standard error in Rhizoidal Length (RL) of *Gracilaria edulis* and *Sargassum polycystum* at various temperatures**

| Macroalgae | Temperature (℃) | Mean ± SE |
|---|---|---|
| *Gracilaria edulis* | 28 | -0.00833±0.019299605 |
| | 30 | 0.008333±0.0193 |
| | 32 | 0.083333±0.020719 |
| | 34 | 0.075±0.017944 |
| *Sargassum polycystum* | 28 | 0.258333±0.045156853 |
| | 30 | 0.058333±0.041667 |
| | 32 | 0.15±0.158353 |
| | 34 | 0.225±0.069767 |

## DISCUSSION

Previous studies have been conducted on the effects of temperature and nutrients on macroalgae but not much has been done in the Pacific Ocean on pest species such as *G. edulis* and *S. polycystum*. The SGR for *G. edulis* was greater (0.79 % /day± 0.39) at the optimal temperature of 28-30℃. Raikar et al (2001) showed that *G. edulis* from India and *G. lichenoides* from Malaysia also have a high daily growth rate at 30℃. *Gracilaria* spp. from tropical regions are found to be growing well at 28℃ (Raikar et al. 2001; Edding et al. 1987). The sea water temperature at Makaluva Island was 29.9℃.The experimental results concur with the environmental temperatures at which *G. edulis* grows optimally. It must be noted that macroalgae will grow naturally in the environment in which they are adapted to and temperatures above or below their optimal temperature range would deter thallus growth (Annigeri, 1979; Mojumdar, 1979; Toh, 1996). *Sargassum polycystum* reduced its thallus biomass at these temperatures (Kokubu et al., 2015). Therefore, for *S. polycystum* the RL was measured instead of the SGR and was found to be optimal at 28℃. This is attributed to the biochemical reactions within the tissues which double in rate for every 10℃ increase; however, the enzymatic activities have optimal temperature at which they perform after which they denature (Lobban & Harrison, 1997). This could also be one of the reasons why the optimal temperature of *G. edulis* SGR was 28-30℃ in this study.

Recent studies show that due to dark respiration increasing with temperature, *Sargassum* spp. can survive between the ranges of 8-36 ℃ which could account for the intact rhizoid at 34℃ (Iyer et al. 2004; Raikar et al. 2001). For *G. edulis* the RL was optimal at 32-34℃ because of its ability to tolerate high temperature (Iyer et al. 2004; Raikar et al. 2001). For good growth a myriad of conditions is required. The combined effects of the environmental parameters are essential for the proper growth of seaweeds (Boustany et al. 2015; Kokubu et al. 2015; Williams et al. 2013). According to Lobban & Wynne (1981), the floristic communities of the marine environment have been altered due to thermal and industrial/domestic pollution.

*Sargassum polycystum* and *G. edulis* are both invasive pest species that thrive from changes in the environment. Fluctuations in the oceanic temperature have long been a contributing factor to changes in the marine ecology (Meek et al. 2012; Nian-Zhia et al. 2015). Macroalgal communities are becoming dominant due to increasing temperature (Wernberg et al. 2012). Increasing temperature have been known to cause a shift from coral dominated ecosystems to macroalgal dominated ones (Fong et al. 2006). Furthermore, Cook et al. (2001) showed that coral degradation due to increasing temperature results in increased abundance of opportunistic macroalgae. According to Raikar et al. (2001), when the optimal temperature is 30℃ then the species can make a transition from growing in temperate region to tropical region. In this study, *S. polycystum* and *G. edulis* were investigated because they are opportunistic and resilient to increasing temperature. Harsh environmental conditions result in less herbivores in the marine environment and without them to regulate the macroalgal population, macroalgal abundance can become a problem. Abundance also causes a coral phase shift to macroalgal dominance. Coupled with unsustainable management of sewage, macroalgal abundance becomes a nuisance (Mosley & Aalberberg, 2005; Fong et al. 1998). Different types of seaweeds behave differently. In this study, *G. edulis* is a red seaweed while *S. polycystum* is a brown seaweed, thus their mechanisms for adaptation to harsh environment could be diffrent (Lobban& Wynne, 1981).

Seasonality is one of the factors that governs the growth of macroalgae and is difficult to mimic in a laboratory. Changes in the seasonal cycle can result in phenologic changes in the seaweed. *Sargassum* spp. occurs mostly in warm temperate regions (Kantachumpoo et al. 2013). *Sargassum polycystum* and *G. edulis* were present on Makaluva waters from October to December 2015; however, in March 2016, their abundance decreased which was attributed to Cyclone Winston that occurred in February 2016. Another visit in May 2016 showed that both macroalgae were abundant again, suggesting that *S. polycystum* and *G. edulis* occur annually. *Sargassum polycytsum* undergoes an annual reproduction cycle; however, changes in the environmental conditions can cause a bimodal cycle in order to adapt to environmental stress (Akira & Masafumi, 1999; Chopin & Floc'h, 1987). *Gracilaria* spp. grows well in spring and starts decreasing from June to October (Givernaud et al. 1999). One of the seasonal changes in the environment is El Niño Southern Oscillation. For this study, it is plausible that not just temperature plays an important role but a multitude of factors such as seasonality and ocean circulation.

This research was conducted in laboratory conditions; so, it is not possible to say if this would have happened in nature, as there are other factors that constantly affect the growth of macroalgae. In addition macroalgae behave differently in their natural environment when compared to culturing in the laboratory. The results of this study could form the basis for further research in macroalgal growth in-situ and extend the knowledge on *S. polycystum* and *G. edulis* biology.

## CONCLUSION

Based on the effect of temperature on the growth of *S. polycystum* and *G. edulis*, we conclude that an increase in temperature of up to an optimal level ranging between 28 and 32℃ can result in favorable growth of seaweed biomass and rhizoidal length. Increase in temperature is projected to increase by 2℃ if carbon dioxide emission is not reduced. Coupled with other effects of increased in temperature, seaweed abundance could be an issue especially when they are pest species which replace native species.

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