

Growth and Survival of *Pinctada margaritifera* Mother of Pearl Oyster Co-cultured with *Kappaphycus alvarezii* Seaweeds

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Abstract

This study investigated the effect of co-culturing *Pinctada margaritifera* pearl oysters with *Kappaphycus alvarezii* on the biomass of fouling organisms on pearl oysters. The experiment also investigated the effect of reduced fouling due to co-culture on the growth rate of *Pinctada margaritifera* pearl oysters. The experiment had a treatment and control. Both treatment and control had 5 panel nets with 21 oysters. The result indicated that co-cultured oysters had significantly higher growth rates than the monoculture oysters. The results also showed that the co-cultured *Pinctada margaritifera* oysters had less fouling organisms attached to it when compared to monoculture oysters.

Keywords: *Pinctada margaritifera*; *Kappaphycus alvarezii*; Mother of Pearl Oysters (MOP); Co-culture; Growth rate

Introduction

Culture of pearl oyster

Culturing any single species at any intensity in any water type is known as monoculture [1]. In the Pacific, pearl oysters are often monoculture on structures comprising a strong main line, which is held in place and a float using anchors and buoys respectively [2]. The oysters are placed in; chaplets, pocket panels, lantern baskets or spat collectors, and hang on the main line [2]. This method is preferred as the entire farm structures are in the water column so the farm is sheltered during rough weather. Moreover, the material costs less and if the need arises, lines can be relocated [2].

Culture of seaweeds

Kappaphycus alvarezii is a micro-algae that comes in colors such as red, brown, yellowish and green [3]. It occurs in reef zones of Indo-Pacific, China, Japan, Southeast Asia and east Africa regions to Guam [4]. *Kappaphycus alvarezii* seaweed is of commercial importance for the extraction of carrageenan [5]. Carrageenan, sulfated polysaccharide, is major cell wall component of *Kappaphycus alvarezii* [6]. Carrageenan is utilized as a; thickener, emulsifier, stabilizer and gelling agent, by the food, pharmaceutical, textile and cosmetics industry [7]. *Kappaphycus alvarezii* seaweeds are cultured in the ocean using a floating bamboo method, mangrove stakes and net method, and bottom monoline method [8]. In all methods, seaweed seedlings are tied using a string to lines (rope or fishing line) which are stretched in a row and staked at each end [8]. This method of seaweed farming has been recognized to be economical, easy to construct, manage and maintain [8].

Co-culturing

It has been proven that co-culturing pearl oysters with red algae helps as the presence of algae has positive effects on pearl oyster

growth [9] and the quality of produced pearls [10]. The seaweed, *Kappaphycus alvarezii* is edible seaweed consumed in different forms by people in many countries [11]. Marine algae have the ability to produce chemically active metabolites for protection against other fouling organisms [12]. The active metabolites has antibacterial, anti-algal, anti-macro fouling and antifungal properties, which are not only effective in preventing biofouling but have other likely uses, e.g. in therapeutics [12]. Therefore, the overall productivity can be improved by co-culturing oyster with green algae so that the farmers are able to reduce the problem of biofouling.

Research Methodology

Study site

The study was conducted using the existing long lines of pearl *Pinctada margaritifera* farm known as Valili Pearl Farms in Savusavu Bay, Vanua Levu, Fiji.

Spat collection and selection

Oyster spats used for this experiment were collected from Savusavu Bay using Accordion-style spat collectors. The spats between 40 mm and 55 mm DVM size were selected for this experiment as this was the most abundant size of spats available from the 20 mm to 70 mm range.

Collection of seaweed seedlings

The seaweed seedlings were obtained from the Yaroi youth seaweed farm. The seaweed farm is also located in Savusavu bay. The seaweed was harvested, packed and transported to the study site in a fiber boat. Approximately 100-gram (initial weight) seaweed seedlings were selected from the harvested seaweeds.

Panel net and experiment setup

After 21 spats were chosen, they were cleaned using a hand brush and placed into pocket panel nets. There was 1 treatment with 5 replicates including a control. Each panel net had a total of 105 spats. For the treatment, 8 seedlings of 100 g *Kappaphycus alvarezii* seaweed

were tied onto the panel nets with the spats. The control did not have any seaweed tied onto panel nets with spats. The panel nets were placed on the long line adjacent to each other in the sea.

Taking dry weight of fouling organisms

After 6 months of culture, fouling organisms were removed from 10 random oysters from each replicate. The fouling organisms were packed into zip lock plastic bags and brought to laboratory where they were dried for 24 hours at 50°C in ovens. The dried samples were weighed to 4 decimal points in an analytical balance in milligrams.

Growth measurements and water parameters

Dorso-ventral measurement (DVM) also referred to as dorso-ventral height (DVH) was used for the measurement of growth of pearl oysters [13]. The water parameters were measured using YSI 6920 data logger. YSI 6920 was programmed and left suspended at the experiment site where it recorded water parameters. Salinity, depth, temperature and pH were retrieved from the equipment during sampling.

Recording and analysis

The raw growth data of a treatment and a control of *Pinctada margaritifera* were tested for normality using Shapiro-Wilk test [14]. Data that were normally distributed was analyzed using one-way ANOVA to examine the variability in growth of the oysters over time. The entire tests were performed using SPSS version 22 statistical package.

Results

Growth rate of pearl oysters

Pinctada margaritifera mother of pearl oyster showed the highest growth (Table 1) when co-cultured with *Kappaphycus alvarezii* in Savusavu Bay. The monocultured oysters showed slightly lower growth than the co-cultured oysters.

Frequency of cleaning	DVM (mm)
Monocultured	9.85 ± 0.5
Co-cultured	10.71 ± 0.5

Table 1: Final means (± S.E.) dorso-ventral measurement (DVM) for *Pinctada margaritifera* for co-cultured treatment and monocultured control from January 2012 through to June 2012.

Growth rate of pearl oysters within co-cultured treatment

There was a difference in average growth of oysters within the co-cultured treatment. The oysters from panel net 2 and 3 had the highest growth. There was a slow growth of oysters in panel 4 and 5. Oysters from panel net 1 showed the lowest growth (Figure 1).

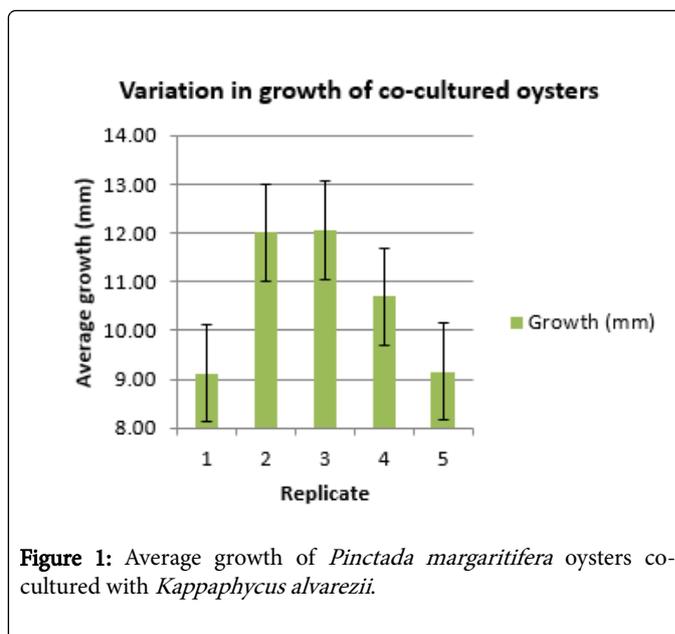


Figure 1: Average growth of *Pinctada margaritifera* oysters co-cultured with *Kappaphycus alvarezii*.

Growth rate of pearl oysters within monocultured treatment

There was a difference in average growth of oysters within the monocultured treatment. The oysters from panel net 1 and 5 had the highest growth. There was a slow growth of oysters in Panels 2 and 4. Oysters from panel net 3 showed the lowest growth (Figure 2).

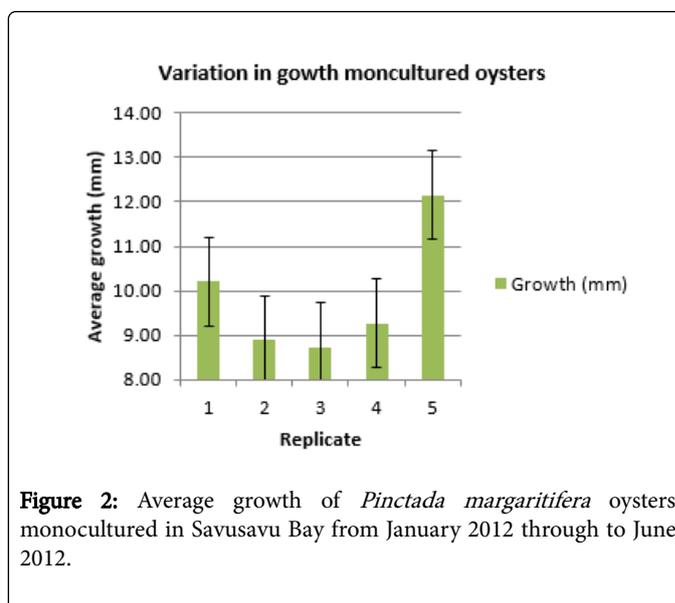
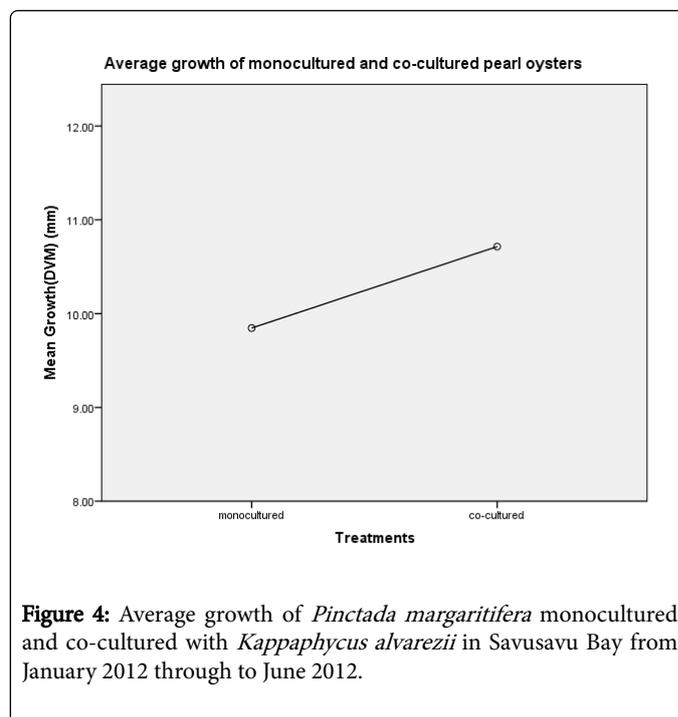
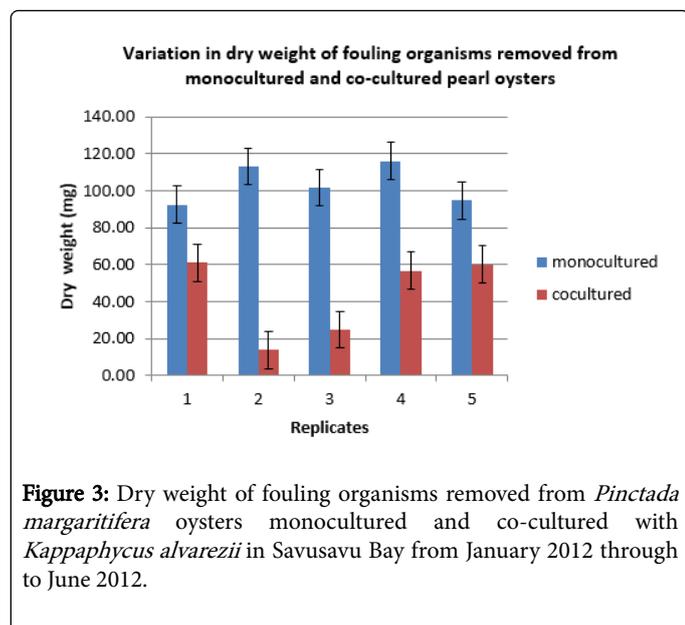


Figure 2: Average growth of *Pinctada margaritifera* oysters monocultured in Savusavu Bay from January 2012 through to June 2012.

Dry weight of fouling organisms

There was vast difference in the dry weight of fouling organisms between the monocultured pearl oysters and co-cultured pearl oysters. Dry weight of fouling organisms was lower in oysters that were co-cultured. All 5 replicates showed lower dry weight in co-cultured when compared with monocultured oysters (Figure 3).



Water parameters

The water parameters were retrieved from YSI 6920 which measured depth, pH, salinity, temperature from January 2012 through to June 2012 at frequency of every hour.

Statistical analysis

The normality test showed that the growth data for monocultured and co-cultured *Pinctada margaritifera* were normally distributed hence a parametric test was run. One way ANOVA test for the *Pinctada margaritifera* mean growth revealed that there were significant differences between the monocultured and co-cultured oysters, $F(1,207) = 5.987, p = 0.015$ in Savusavu bay between the months of January, 2012 and June, 2012.

Discussion

Co-culturing *Pinctada margaritifera* MOP oysters with *Kappaphycus alvarezii* seaweed had positive effects on the growth rate of oysters. Results showed that the co-cultured oysters had significantly higher growth while the monocultured oysters had lower growth. In China, *Pinctada martensi* was co-cultured with *Kappaphycus alvarezii* [9], and similar results were obtained where the oyster had better growth when co-cultured compared to monocultured oysters. The integration of seaweed with animal culture has been previously tested in Taiwan and China [9]. The co-culture system was based on the concept that algae takes up carbon dioxide and uses up metabolic waste from surrounding water releasing oxygen thus creating a favorable environment for animal growth [15]. A study by Wei (1990) showed that the integration of seaweed with animals favored higher growth for animals such as shrimp, mussel and crabs.

The present study showed that the presence of algae in co-culture system had reduced biofouling on *Pinctada margaritifera* MOP oysters when compared to the monoculture system. Figure 4 showed that all replicates in the co-culture treatment had lower fouling biomass than the monoculture treatment.

A reduction in fouling was observed and this may have enhanced *Pinctada margaritifera* growth in the co-culture system. Over the period of 6 months the mean growth (DVM) of the monocultured oysters was 9.85 ± 0.5 mm when compared to co-cultured oysters with significantly higher mean growth (DVM) of 10.71 ± 0.5 mm. The results showed that the co-culture system reduced the amount of fouling organisms settling on the oyster which positively affected the growth. The common biofouling organisms that were observed were barnacles, other oyster species, Crassostrea species, ascidian species and polychaete worms.

Marine algae release chemically active metabolites in their surrounding waters as protective measure against settling organisms [12]. Active metabolites or biogenic compounds such as halogenated furanones or fimbrolides have anti-bacterial, anti-algal, anti-macrofouling and antifungal properties [10]. Co-culturing pearl oysters with seaweeds improves quality of pearls and the pearl retention rate. Oysters co-cultured with red algae produced premium quality pearl when compared with monocultured oysters [10].

Water parameters	Minimum	Maximum	Mean	Standard deviation
Depth	4.06	6.45	5.66	0.68825
pH	6.67	8.18	7.59	0.54586
Salinity	29.2	35.16	33.73	1.77011
Temperature	25.75	29.58	28.04	1.35339

Table 2: Average water quality parameters (Depth, pH, salinity, and temperature) retrieved from the YSI 6920 data logger placed at the experiment site in Savusavu Bay, Fiji.

In this study, the major water parameters salinity and temperature results (Table 2) indicated that the environmental conditions in which

Pinctada margaritifera oysters were cultured were near to optimum ranges. Temperature ranged from 25.8- 29.6°C and salinity ranged from 29.2-35.1 ppt although the maximum salinity went beyond that of the optimum. Optimum functioning temperature for *Pinctada margaritifera* species is 26-29°C [16,17]. Although marine oysters can tolerate wide salinity ranges from 40 -50 ppt, the optimum salinity range is 28-30 ppt [18].

Conclusion

Under the environment conditions experienced during the current study and the same degree of handling, *Pinctada margaritifera* MOP oysters had a significant difference in growth when they were subjected to monoculture and co-culture systems. This study showed that for the best survival and growth, *Pinctada margaritifera* MOP oysters can be co-cultured with *Kappaphycus alvarezii*. Co-culture reduces fouling and has the potential to enhance growth of *Pinctada margaritifera* MOP oysters.

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