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Influence of stocking density and culture management on growth and mortality of the mangrove native oyster *Crassostrea* sp. in southern Brazil

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Resumo

Efeito da variação da densidade de estocagem e manejo sobre o crescimento e a mortalidade da ostra nativa de mangue *Crassostrea* sp. no Sul do Brasil. O presente estudo analisa o crescimento e sobrevivência de sementes da ostra-do-mangue *Crassostrea* sp., produzidas artificialmente, sob diferentes tratamentos de manejo (lavação) de cultivo e densidades de estocagem. Foram testadas duas variações de lavação, a cada sete ou 14 dias, e duas densidades iniciais de estocagem, 1.000 e 2.000 sementes por bandeja, com subseqüentes densidades proporcionais pós-repicagem, durante 5 meses de cultivo em Florianópolis-SC. Observou-se um excelente desempenho em todos os tratamentos, com destaque para melhor crescimento (9,9 mm/mês) no tratamento de maior densidade e maior periodicidade de lavação, atingindo altura final de 60mm, com crescimento alométrico das valvas. As taxas de mortalidade foram baixas (7,5%), reafirmando a vocação da região e da espécie nativa ao cultivo com sementes produzidas em laboratório.

Unitermos: cultivo de ostras, ostras de mangue, *Crassostrea* sp., manejo, densidade.

Abstract

This study analyzed the growth and survival of the mangrove native oyster *Crassostrea* sp. in the initial stages of culture (nursery and intermediate culture) submitted to different treatments of stocking density and cleaning management for 5 months, in Florianópolis/SC, southern Brazil. Treatments consisted of two cleaning managements (every 7 or 14 days) and two initial stocking densities (1,000 and 2,000 seeds per tray). After every thinning, densities were kept proportional per area, according to oyster growth. All treatments showed excellent results, but the best growth rate (9.9mm per month) was observed in the treatment with high stocking density and long cleaning interval, with a final height of 60mm and allometric shell growth. A low mortality rate (7.5%) suggests good conditions of the area and of the native oyster for the grow-out of hatchery-reared spats.

Key words: oyster culture, mangrove oysters, *Crassostrea* sp., management, density.

Introduction

Oyster culture in southern Brazil has been a successful activity in Santa Catarina State for the last ten years with the Japanese oyster *Crassostrea gigas*. Currently, the state is the main Brazilian oyster producer, with one million dozens of oysters harvested in 2000 (Barardi and Santos, 2001) and more than 2,500 metric tons in 2004 (Neto, 2005). However, due to culture constraints caused by the fact that *C. gigas* is an exotic species from temperate regions, studies on the indigenous mangrove oyster, *Crassostrea* sp. have increased.

The mangrove oyster is typical of tropical zones and occurs mainly on the aerial roots of the red mangrove *Rhizophora mangle*, or on intertidal rocky shores (Nascimento, 1982). Nevertheless, there is some controversy about the genus in Brazil. Pereira et al. (1988) and Nascimento (1991) agree that *C. brasiliana* is distinct from *C. rhizophorae*, because the former is larger and is always found in subtidal mangrove channels, whereas the latter is smaller and occurs in intertidal zones. Rios (1994) considered *C. brasiliana* to be a synonym of *C. rhizophorae*. Ignacio et al. (2000) found through allozyme electrophoresis that sympatric populations from both species of Crassostrea were different enough to be considered distinct species and that *C. rhizophorae* populations collected from distant locations were very similar. Although there are many mangrove oyster cultures starting up in Brazil, it is still not clear whether one or two species of oysters are being cultured. Recently, a study on the molecular genetics of the oysters confirmed that there are two species of native *Crassostrea*: *C. brasiliana*, usually associated with shore-mud bottom beds and *C. rhizophorae*, strongly associated with mangroves (Lazoski, 2004). Thus, the term *Crassostrea* sp. is used in the present study to indicate the mangrove oyster.

A successful oyster culture depends greatly on the adaptation of management practices to local characteristics. In other words, specific methodology used for one specific species in a specific location can promote better results and enhance productivity.

The correct management of spat stocking densities guarantees good oyster growth and promotes the development of the oyster culture process as a whole. The effect of stocking density has been investigated in many species of oysters (Taylor et al., 1997a).

Another important factor affecting oyster growth associated with correct management practices is the rate of predation and pathogen infestation. The correct control of fouling organisms, infestations and predators in oyster culture by cleaning management strongly contributes to higher production (Taylor et al., 1997b).

Optimal stocking density in commercial aquaculture is determined by site-specific physicochemical factors (horizontal seston flux), biological factors (species-specific filtration rate), and economic factors such as gear and labor costs (Rheault and Rice, 1996). Lower stocking densities will eventually result in less competition and faster growth rates, but this increase comes at the expense of more investment in gear, more laboratory work, and a higher lease requirement (Rheault and Rice, 1995). Due to difficulties in collecting and identifying spats from natural stocks in Santa Catarina State, hatchery-reared spats are transferred to producers to enhance production. However, information is still scarce on the best management practices for oyster culture, which include cleaning, thinning, sorting or grading, pest control and predator protection. Therefore, this study aimed at assessing the management practices adopted for *Crassostrea* sp. spats by oyster farmers in Santa Catarina State-SC (Brazil). For such, the usual seed stocking density and cleaning management methodology for tropical oyster species in Brazil were adopted.

Materials and Methods

Ten mm high *Crassostrea* sp. hatchery-reared spats were selected, following the methodology by Galtsoff (1964). Oysters were grown for 5 months in raft culture at Sambaqui Beach, Florianópolis, SC – Brazil (Figure 1), with temperatures from 20 to 26^{o}C and salinity between 30 and 32‰. Oyster development was evaluated based on shell growth and total volume of the animals in the lanternet tray and survival during that period.

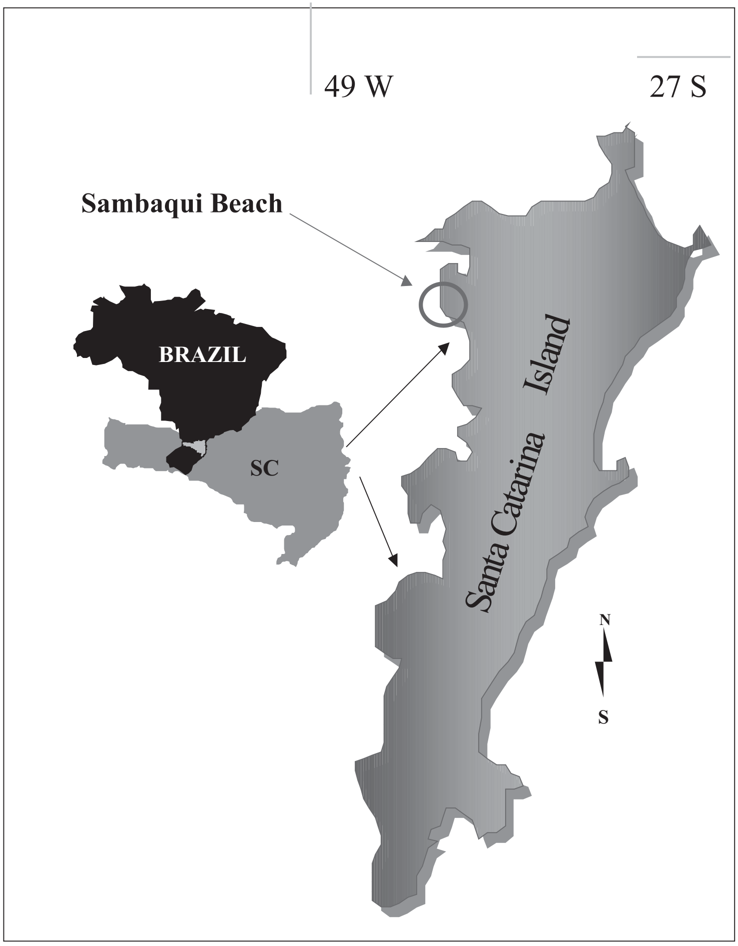

FIGURE 1: Location of the culture site at Sambaqui Beach, Florianópolis Is., SC, Brazil.

Two initial stocking densities of 1,000 and 2,000 seeds per lanternet tray (400mm in diameter) were adopted as low and high densities, respectively, and cultured suspended from rafts. In addition, two frequencies of cleaning (every 7 or 14 days) were adopted for both densities (Table 1). Each treatment had three replicates.

Data were analyzed by analysis of variance (ANOVA) and linear regression, and Tukey's comparison of means when necessary. Probabilities of 0.05 or less were considered statistically significant.

TABLE 1: Description of the four treatments used in the experiment.

Treatment	Description
D1M1	Low Density, 1000 seeds / short cleaning interval, 7 days.
D2M1	High Density, 2000 seeds / short cleaning interval, 7 days.
D1M2	Low Density, 1000 seeds / long cleaning interval, 14 days.
D2M2	High Density, 2000 seeds / long cleaning interval, 14 days.

Results

The best growth in height was observed in the treatment with high stocking density and long cleaning interval (D2M2) (Table 2; Figure 2).

TABLE 2: Mean final height (mm) per treatment.

Treatment	Final height (mm)	
D2M2	58.83	a
D1M2	55.84	b
D2M1	54.16	b
D1M1	49.81	c

Different letters indicate statistical significance ($p<0.05$).

Crassostrea sp. hatchery-reared spats showed very good results regarding growth and survival when transferred to grow-out sites. In addition, growth was very strong in the first month, reaching approximately three times the initial size (Figure 2 and Table 3).

For the treatment with the best growth (D2M2), mortality was low even during winter, in the first month of culture, when it was 7.5% (Table 4).

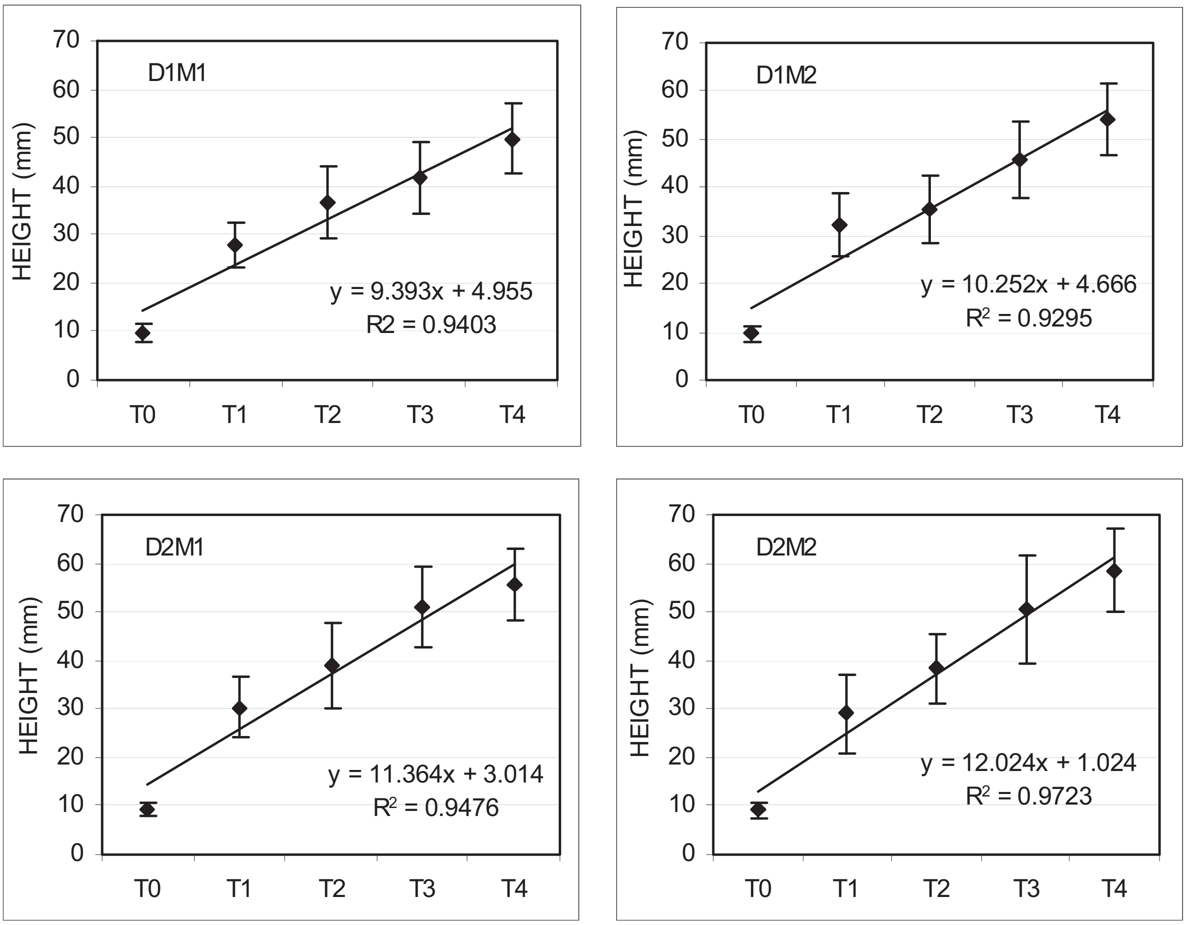

FIGURE 2: Linear regression of growth in height under the different treatments.

TABLE 3: Height and volumetric growth rates per month, for the different treatments.

Months	Growth in Height (mm)		Volumetric Growth (Liters)	
	Low density	High density	Low density	High density
1-2	3.28 ± 0.15	3.18 ± 0.23	10.31 ± 0.52	7.16 ± 0.70
2-3	1.25 ± 0.07	1.26 ± 0.07	3.23 ± 0.03	3.51 ± 0.03
3-4	1.31 ± 0.05	1.33 ± 0.02	1.94 ± 0.16	2.21 ± 0.13
4-5	1.11 ± 0.05	1.11 ± 0.05	1.94 ± 0.07	1.89 ± 0.49

Values are means ± standard deviation.

TABLE 4: Month mortality (%) per treatment.

Months	Mortality (%)			
	D1M1	D2M1	D1M2	D2M2
1-2	3.50 ± 0.012	9.10 ± 0.035	2.10 ± 0.009	7.50 ± 0.010
2-3	5.95 ± 0.013	5.60 ± 0.004	15.07 ± 0.048	5.08 ± 0.025
3-4	5.01 ± 1.200	1.98 ± 0.426	12.00 ± 0.001	1.26 ± 0.005
4-5	0.00 ± 0.000	0.00 ± 0.000	2.00 ± 0.014	0.41 ± 0.003

Values are means ± standard deviation.

Discussion

Best *Crassostrea* sp. oyster growth was observed under treatment D2M2, with high density and long cleaning interval, showing a final height of 60mm after 5 months. A growth rate of 9.9mm/month under that treatment was higher than the 2.5mm/month found by Guzenski (1996), who also cultured *C. rhizophorae* hatchery-reared spats on Sambaqui Beach, but with different culture structures and management.

The growth rate found in this study is similar to that obtained in other countries, such as Cuba, where Vélez (1991) reported growth of up to 50mm and 70-80mm for *C. rhizophorae* during 5-6 months of cultivation using intertidal and subtidal rafts, respectively. Littlewood (1988) in Jamaica and Hernandez et al. (1998) in Venezuela also obtained oysters with more than 50mm in six months, in salinities around 35ppt.

The results from this study are higher than those found in other studies with *C. rhizophorae* spats collected from natural sources in Bahia (0.64mm/month) by Santos (1978) and with *Crassostrea brasiliana* on the Brazilian southeast coast using different methods of culture (Pereira et al., 1988; Pereira and Soares, 1996).

In other estuaries, such as the Itapessoca river estuary in Pernambuco State, *C. rhizophorae* reached 46mm after one year of cultivation (Nascimento et al., 1980). Ramos et al. (1986) reported that *C. rhizophorae* had grown to only 40mm in height after one year in Baía de Todos os Santos, Bahia state, and they found it difficult to compare their data with other studies.

Smaller *C. rhizophorae* oyster size at Cururuca river estuary, Maranhão state, in high salinity waters was described in a report by SUDAM (1983). Vilanova and Fonteles-Filho (1989) also verified that oysters from

Ceará river estuary were smaller than in other areas with lower salinity, and they indicated salinity as the primary cause of the reduced growth. Pereira et al. (1988) reported that the best growth and survival rates for *C. rhizophorae* were found in low salinities.

Further to salinity, higher mortality in May in the present study could also be attributed to the high number of predators, mainly flatworms such as Stylochophana divae and carnivorous gastropods such as *Cymatium parthenopeum*, which were more frequent in that month. According to Vélez (1991) and Hernandez et al. (1998) in Venezuela, *C. parthenopeum* is the most serious potential predator of oysters. In a study with *C. brasiliana.*

The decrease in wet and dry meat weight in March is probably related to reproduction, coinciding with the spawning peak, as observed by Vélez (1991). Vilanova and Fonteles Filho (1989) also observed a greater number of young oysters in drier months, when salinity was higher.

The low mortality rates found in the present study demonstrate that the raft-suspended culture system (Montoya, 1988) is feasible at Sambaqui Beach, since it is an estuarine beach with phytoplankton-rich waters. Such chlorophyll a availability promoted oyster growth in the treatment with high stocking density, showing that even in the subtropical zone, a tropical oyster such as *Crassostrea* sp., can be cultured commercially with hatchery-reared spats, adopting the culture management reported in the present study.

In conclusion, the management treatment is very important to the grow-out of native mangrove oysters. In conditions of salinity between 30 and 32‰, hatchery-reared spats of native mangrove oyster showed low mortality and the best growth rate (9.9mm per month, with a final height of 60 mm after 5 months) was observed in the treatment with high stocking density and long interval of water pressure cleaning interval. These results are compatible with the use of these oysters in production systems in southern Brazil.

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