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Development of Mussels *Perna perna* (*Linnaeus*, 1758) (Mollusca-Bivalvia) in Culture in South Brazilian

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ABSTRACT

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In order to determine the potential of the *Perna perna* mussel in culture in the south of Brazil, two experiments had been realized in "Armação do Itapocoroy" bay, center-north coast of the state of Santa Catarina, employing methods and materials used in commercial scale cultures. *Several biological and physic-chemical variables were analyzed.* For environmental characterization the following variables were evaluated: transparency, temperature, salinity, dissolved oxygen, seston and basic nutrients. *The salt, temperature and oxygen are ideal for this species. The seston presented a great variation, with a high organic concentration*. Growth curve was determined with a mean increment of 0,55cm/month; the *gain of weight* (fattening) curve *was obtained* with a mean addition of 2,57g/month; the maximum biological production was reached after 6,7 months of culture; and the survival tax was 79,2%. The biggest eatable material was detected in mussels possessing with 6 to 7 cm of length in the end of spring. In practical terms, is the recommended harvesting period, bringing consequently greater profit for the producer.

ADDITIONAL INDEX WORDS: *Mussel, culture*, *Perna perna.*

INTRODUCTION

The mussel culture is developed in an intensive system of semi-integral monoculture, that does not demand investments with larviculture and feeding as in other mariculture techniques, what allows the development of this activity to be carried out in diverse regions of the globe, according to social and environmental characteristics (MORALES, 1983).

MANSON (1976) and ANDRéU (1976) determined that performance of the mussel culture in hang ropes is higher than that of any type of culture an income for surface unit superior to any another type of culture carried through in natural environment. This is due to the utilization of areas with high productivity, excellent tax of alimentary conversion rate and low production cost.

The mussel culture occupies a place of prominence in the worldwide mariculture, with a production of 1.688.855 tons of mussels in the year of 1998. Although Brazilian production still does not possess a significant production of this scale. However, its production grew geometrically in the last decade, becoming the greater producer of Latin-America with a harvest of 12.500 tons in 2.000, having the state of Santa Catarina as the greater national producer, with a crop of 11,359 tons in year of 2.000 (MALACULTURA BRASILEIRA, 2001).

In order to verify the potential of an area for the mussel culture, it is basic to determine the growth rate, because, in addition to its economic advantage, a fast growth rate implies mussels with better looking shells and high condition index (BAIRD, 1996). The object of this study was to analyze a region in order to implement the cultivation os *P. perna* mussels. The analyses comprised the evaluation of the environmental variables, the determination of the growth rate, the measurement of the condition index and survival rate of a cultivation, using commercial techniques and materials.

MATERIALS AND METHODS

The study site was located in Enseada da Armação do Itapocoroy (26º58'S and 48º35'W), in the central-northern coastal region of Santa Catarina State, Brazil. In this bay, the cultivation site was 5m deep and was characterized by sandy-muddy sediments, and protected from the south winds, the strongest, and exposed to the less intense north winds.

In order to obtain the biological data in this commercial cultivation context the research periods were adapted to the species' biological synchronism. Hence, this work began in December 1991 (austral summer) when the species' longest recruiting period occurs and ended in November when the organisms reach their reproduction peak.

During this one-year period the cultivation site water was collected bimonthly for the analysis of its seston, dissolved oxygen (by Winkler's method), salinity (by Harvey's method) and macronutrients (with a spectrophotometer). The variations in temperature and transparency were recorded fortnightly by using a thermometer and a Secchi disc, respectively.

In order to analyze the total seston and determine the organic from the inorganic matter, a given volume of water was filtered with a pre-weighed Whatman filter number 4, and the resulting material was dried in an oven at 4ºC until its weight became constant. Afterwards, in order to eliminate the organic matter, the sample was calcined in a muffler for one hour at 45ºC and weighted again, thus obtaining its total, organic and inorganic seston.

The young mussels were collected in the natural environment, above the rocky shore in the intertidal layer, near the place of the experiment.

Five-hundred young mussels, known as seeds, were used for the cultivation nets had been used, each with 2,5 the 3,5 cm of total length and they were collectively weight so as to estimate the initial average individual weight.

The organisms had been distributed in a homogeneous way, in a tubular net of cotton mesh with 1 meter of length, a diameter of 10 cm approximately and a mesh opening of 0,5 cm between-knots. This cotton net was placed inside of a tubular nylon net with 3 cm between-knots. The nets were labeled and moored by one of the extremities in a floating structure called "long-line", 30 cm apart from each other.

Two types of experiments were simultaneously developed in the period of 12 months:

Experiment 1 or Bimonthly - two nets had been immersed in December of 1991 and removed after two months, when both were substituted by others. This routine was followed until the end of the experiment in November of 1992, with total duration time of 12 months.

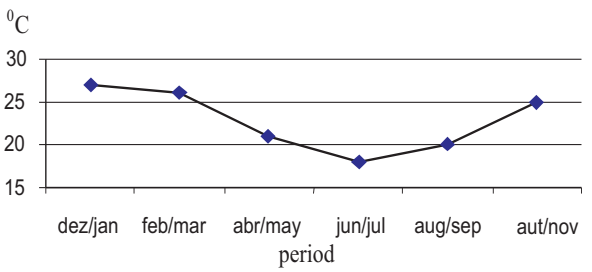

Figure 1. Average bimonthly values for water temperature during the experimental period.

Experiment 2 or Continuous - twelve nets had been immersed in March. Two were removed every two months until it reached the commercial size (7 cm).

Every net removed from each experiment was manually processed, the mussels were counted to calculate the survival and 300 individuals of each experiment were randomly chosen and measured according to biometric characteristics of this species.

Survival was defined as the percentage of mussel fixed in the nets after the period of immersion in relation to the initial number, without taking into consideration the reason of the disappearance.

Since the young mussels or seeds were collected from the same place and supposedly of the same recruitment, it was possible to establish the theoretical curve of growth using the equation of "Von Bertalanffy".

To evaluate the increase of weight or fattening and to determine the point of maximum tangency of the curve, which corresponds to the age of culmination of biological production (ending of the maturity and the beginning of senility) the mathematical model proposed by HOSOKAWA (1986) was used.

RESULTS

The temperature of the surface water varied as the seasonal standard, in 9ºC, with a maximum of 27ºC in January and a minimum of 18ºC in July (Figure 1).

The water transparency was characterized by an intense variation of the values, even in short time periods, presenting an annual average of 2,4 m, being the lower and higher values in the winter and summer, respectively.

Seston also had an accented variation, presenting the lower value in the summer being 2,32g/l, and a highest of 109,33g/l in the winter, with the annual mean was 35,53g/l. It was composed of 50,2% in organic mater and 49,9% of organic matter, on the average.

There is no significant continental freshwater discharge near the experiment site, despite the proximity of the Itajaí-Açu River, which discharges about 10 km far from the bay. Thus, the salinity remained in the amplitude expected, the mean value was 30,49º/$_{00}$, with a highest of 32,99º/$_{00}$ and a lowest of 26,71º/$_{00}$.

The dissolved oxygen presented little variation, as well as the macronutrients (N, P, NO_2 e NO_3) with exception of nitrate, with relatively high mean value of 3,36 g at. NO_3/l (Table 1).

The result of growth in the Experiment 1 showed different

Table 1. *Values of the environmental variables in "Armação do Itapocoroy" bay, SC, Br, during experimental period.*

Variables	Max.	Min.	Mean
Oxigen (mg. l^{-1})	8,99	8,54	8,70
Ammonia (g at. (N/l)	2,23	0,15	0,87
Phosphate (g at. P/l).	0,45	0,15	0,27
Nitrite (g at. NO_2/l)	0,16	0,01	0,10
Nitrate (g. at.NO_3/l)	9,39	0,39	3,36

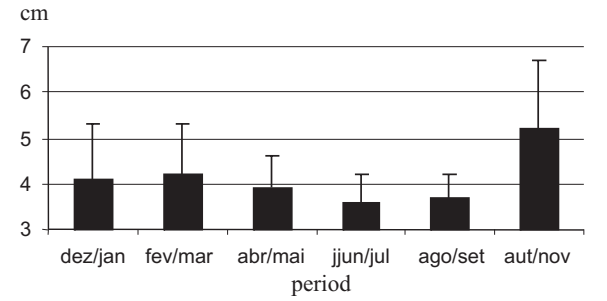

Figure 2. Average length and standard deviation of the *P.perna* mussel cultivated in experiment 1.

values throughout the year, means that in this period of two months there was an addition of 2,2 cm bimonthly from the seeds of 3 cm mean length with accented growth in the spring, mainly in the period of October to November, reaching 5,2 cm in average (Figure 2).

Another period of significant growth occurred in the February to March, reaching 4,2 cm with a mean addition of 1,9 cm, followed by December to January, with 4,1 cm, increasing 1,1 cm and then winter months of June to July. The mussels had the lowest rate of mean growth from august to September, increasing only 0,6% from the initial size.

Experiment 2 (Figure 3), showed that the growth was continuous throughout the eight months of immersion, reaching 7,7 cm, with a mean growth of 0,58 cm/month.

The "Von Bertalanffy's" equation, with the respective theoretical curve of growth related to time is presented in Figure 4.

The weight variation of the mussels in Experiment 1 (Figure 5) may also indicate the assimilation of these organisms. In the October to November they had reached 6,9 g in average, with addition or production of 3,7g from the initial weight of 3,2g; contrasting with the previous period, August to September, when the lowest fattening, values was obtaining, adding just 1,1g from the initial mean weight of 3,5g.

The average weight increase of mussels in experiment 2 was 2,57 g/month, reaching a mean of 23,8 g after eight months of culture, which means they had increased 20,6 g from the initial weight of 3,3g (Figure 6).

Through the observation of the maximum tangency point of the fattening curve it was possible to identify the maximum biological production after 6,7 months of cultivation (Figure 7).

DISCUSSIONS

The spatial distance between population of natural environment and cultured mussels differs in the growth rate, being this a consequence of the transference of benthic species to be cultivated in the pelagic zone, where feeding conditions are excellent and a mild environment (REDHOSE, 1984).

This culture was carried out under ideal conditions, with few nets and in the first meter of the water column, being the great variation of the transparency an indicative of sea currents action

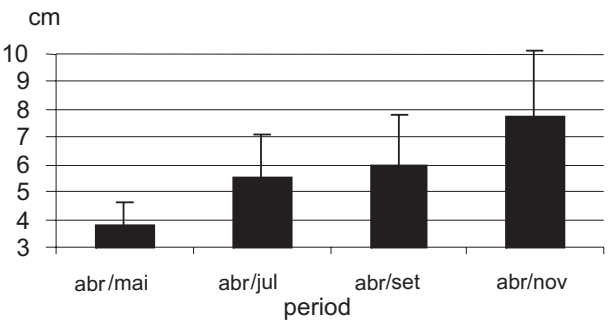

Figure 3. Average length and standard deviation of the *P.perna* mussel cultivated in experiment 2.

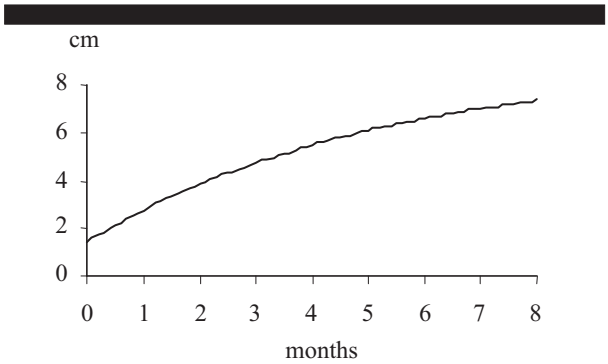

Figure 4. Growth curve of *P.perna* mussel cultivated in Armação do Itapocoroy Bay, SC-Brazil, according to the cumulative experiment 2.

in the place, with greater growth observed on the ropes directly exposed to these currents (ROSENBERG and LOO, 1983; PINEDÁ and AGUADO, 1980).

Food availability is a primordial factor for development (CHONCHENCHEB *et al*., 1980; PINEDÁ and AGUADO, 1980; REDHOUSE,1984; FERNANDES,1981).The greatest food availability occur in the spring due to the increase of phytoplankton biomass (ROSENBERG, 1983). In addition, assimilation differ according to the type of the food, when it has more organic matter, the growth is higher (FERNANDEZ, 1981).

Although, there is an contradiction on alimentary preference of *P. perna*, there are advantages in feeding on phytoplankton as compared relation to a detritivore diet (SALAYA , 1973).

The high indices of organic matter registered in seston within the cultured area, if compared with the 12% found in the largest producing area in Holland (Sea of Waldden), indicate abundant food availability that propitiates the fast growth.

The experiments results indicate that mussels *P. perna* near to domestic effluent discharges had greater growth due higher offer of organic substance (FERNANDEZ, 1981). Albeit fundamental, a high rate of organic matter may be harmful when it is originated from domestic sewage. Due to lacking sanitary infrastructure in Brazil's coastal cities, aggravated by the influx of tourist in the summer months.

The enrichment of the local water promoted by nitrate may be beneficial in terms of primary production, therefore increasing food avaibility. Nevertheless, if this rate is too high, it is possible the development excessive of bacteria, unwanted sanitary consequences can take place.

Commercially, *P. perna* mussel seeds have 1 to 4cm length, favoring 3 cm seeds due to its capability of generate gametes (FERNANDEZ, 1981). In both experiments the growth rate was continuous during the whole year, being lower in the winter, from June to July and August to September, and higher in the spring, mainly from October to November, and a higher condition index or gonad repletion was also detected in this last period.

In this experiment the relation between weight and the size of the organisms during its development was similar to that observed by other authors (FERNANDEZ, 1981; CHATTERZSI, 1980).

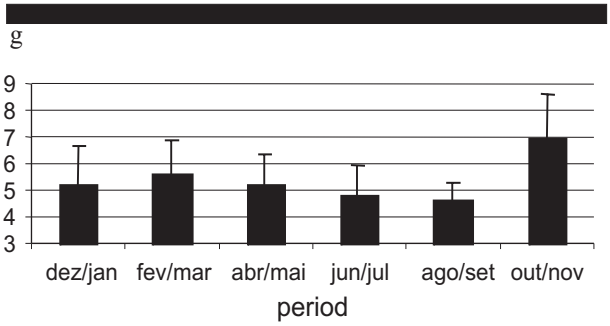

Figure 5. Average weight and standard deviation of the *P.perna* mussel cultivated in "Armação do Itapocoroy" bay, SC-Br, according to experiment 1.

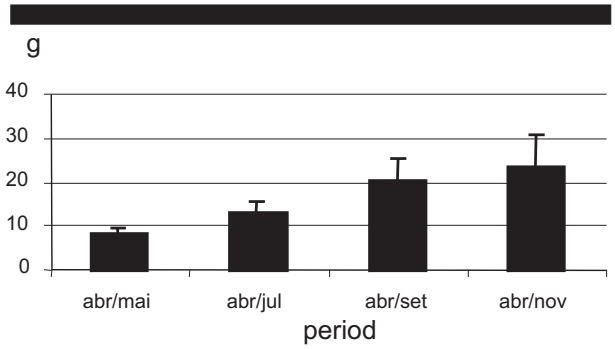

Figure 6. Weight increased and standard deviation of the P. perna mussel cultivated in Armação do Itapocoroy Bay, according to the cumulative experiment 2.

The development of bivalves is based on its size due to the error caused by inter-valvar water in the total weight of the each individual.

Observing weight development through the polynomial, three biological phases can be identified (youth, maturity and senility) for the mussels cultivated in "Armação do Itapocoroy" bay, getting maximum biological production at 6,7 months of culture, when the curve tends to stabilize due to an decreased increment speed presented in this locality and age.

The fattening curve, after getting a maximum biological production at 6,5 months of culture, did not presented the accelerated rhythm of development, because assimilation increase with age, as more energy is needed to maintain the metabolism (WILBUR, 1964; ROSENBERG, 1983).

Determination of maximum biological production is fundamental in experiments of this objective, because in spite of fact the larger mussels have a higher market price (BAIRD, 1966) and a long permanence of mussels in order to get individuals of larger dimension it's not an advantage because the mortality rate, parasitism and the epibionthics increases and decreases the growth rate due an reduction of the alimentary efficiency related to age (WILBUR, 1964).

The age of maximum biological production determined was similar to the results gotten when the protheic level of soft parts of the animal in relation to its size was analyzed (MAGALHÃES, 1985).

Temperature is certainly a basic factor influencing the release of gametes in the mussels (ROJAS, 1971; KENT, 1979; MORALES, 1983; WALNE, 1964; BAYNE, 1972; BAIRD, 1966).

In this experiments developed with *P. perna* in semitropical region, the results of the condition index values had occurred in the spring. Similar results had been observed in the works developed with the species *M. edulis* in temperate region (BAIRD, 1966; MASON, 1976; ANDRÉU, 1976).

However, *P. perna* is a tropical species, where the seasonal variation are not very marked and has a small variation of temperature, this is not the only element influencing the sexual cycle (UMIJI, 1958 and LUNETTA, 1968).

It was observed that at extreme values of temperature, the lowest values of the condition index were detected, suggesting

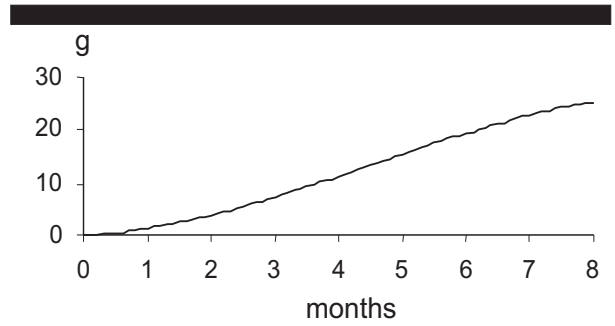

Figure 7. Fattening curve of the *P.perna* mussel cultivated in Armação do Itapocoroy Bay, SC-Br, according to the experiment 2.

that this variable does influence the species, but may be not directly, since temperature also intervenes with food availability and filtration rhythm.

The biggest eatable material was detected in mussels possessing with 6 to 7 cm of length in the end of spring. This, in practical terms, is the recommended harvesting period, bringing consequently greater profit for the producer.

Growth methods aimed at the commercial size measure are usual, however the attainment of a commercial size is complex, diverging according to cultural and economic characteristics.

The mortality of 21% by the end of experiment 2 is coherent with expected patterns for the culture of this species (PEREZ, 1979). It is basically due to the action of the excessive weight and volume of mussels in the nets (CHONCHENCHOB *et al*., 1980; PEREZ, 1977 ; MATTSSON and LINDÉN, 1983).

However, these authors also determined that the storm action contributes significantly on the mortality of these organisms, this fact was not observed in this culture, since in the winter months and mainly in the spring, mortality was low as a consequence of adverse environment conditions promoted by storm surges.

Experiment 2, which kept mussels immersed for a longer period, suffering environmental actions, presented divergent results from those of experiment 1, indicating the cold months (April to September) as responsible for higher loss of individuals, occurring a mortality of 10% during all the sampling period.

The analysis of the examination of the dead mussel shells, that remained in the nets, many presented the edge of the posterior region broken, mainly the young individuals, an this is the action of the predatory crabs (UROSA, 1972). This result suggests too, that mortality from predators' action is higher on small sized individuals (seeds) (SEED, 1976; FERNANDEZ, 1981).

Despite the model of culture used, with floats and hung nets, which protects mussels from great part of it is natural intertidal benthonic predators, as crustaceans and gastropods like *Thais haemastoma*, they remained vulnerable to the actions of pelagic and nektonic predators as fish and birds.

Despite the cumulative characteristic of mortality and the loss of young individuals possibly brings economic losses, what influences the reduction of the biomass is the loss of large mussels, since small individuals contribute little for the total of the biomass (DARE and DAVIS, 1975).

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