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Feeding and ingestion rates in different size groups of pearl oyster *Pinctada fucata* (Gould) spat

Preetha Panikkar[1], R. Paulraj and D. Kandasami

[1]*Central Inland Fisheries Research Institute, Hessarghatta Lake Post, Bangalore-560 089, India*
Central Marine Fisheries Research Institute, Cochin – 682 018, India

Abstract

Optimum feed requirement and ingestion rate of pearl oyster *Pinctada fucata* spat of three different size groups were studied. The spat were fed *Chaetoceros* sp. at different concentrations to study the feeding rate. Spat in the size group 5-9 mm had the maximum growth when fed at a concentration of 3 lakh cells ml^{-1} $spat^{-1}$ day^{-1}. Spat in the size range 10-14 mm and 15-19mm showed the maximum growth at a feed concentration of 6 lakh cells and 9 lakh cells respectively. The growth rate was found to be higher in smaller group with lower concentration of feed whereas growth increment was higher in larger group at a higher concentration. The ingestion rates were found to be directly related to the size of the spat. Larger the spat, more is the rate of ingestion hr^{-1}. The results of this study could be taken advantage of in the hatchery and onshore culture systems for maintaining optimum algal densities for raising oyster spat.

Key words: Feeding and ingestion rates in pearl oyster.

Introduction

Pearl oysters belonging to the genus *Pinctada* are found to be the most suitable for pearl production. The Central Marine Fisheries Research Institute has developed technologies for open sea culture and hatchery production of seed of the pearl oyster *Pinctada fucata*. As the oyster is a filter feeder an adequate supply of the preferred live feed must be ensured to sustain maximum growth and survival. Feed is an important constituent in hatchery and culture operations. Feeding rate in the larvae of the pearl oyster *P. fucata* was estimated by Krishnan (1987) but there are no well documented reports on the feeding rate of the spat other than the work of Numaguchi (1999) on *Pinctada fucata martensii*. Optimum feeding rate has to be estimated to avoid feed wastage and to sustain an efficient growth. The estimation of ingestion rates of pearl oyster spat is important from the view of feeding studies and also as an indicator of the animal's reaction to it's environment. Although spat are better at withstanding unfavourable conditions, than are the larvae, they are more sensitive compared to the adult stages and their successful culture requires care. The present investigation was thus taken up to determine the optimum feeding rate and ingestion rate of pearl oyster spat of different size groups.

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Material and methods

Feeding rate

Pearl oyster spat of three different size groups viz. A (5-9mm), B (10-14mm) and C (15-19mm) were segregated and stocked in 2 l plastic beakers at the rate of 10 spat l^{-1} of filtered seawater. Each set of the experiment was run with four replicates for each treatment. At the beginning of each experiment, groups of 20 spat were randomly selected from the experimental population, weighed and introduced to each beaker. Initial individual live weight of the spat was determined at the beginning of the experiment. They were fed daily with *Chaetoceros* sp. Living diatom cells were cultured under continuous light and harvested during late exponential phase. Based on the results of the earlier experiments, the feed concentrations were adjusted for different size groups.

Group A was fed at cell concentrations of 1,2,3 and 4 lakh cells ml^{-1} $spat^{-1}$ day^{-1}. Groups B and C were fed at 6,9,12 and 15 lakh cells ml^{-1} $spat^{-1}$ day^{-1}. The experimental set up was covered with a black cloth to prevent multiplication of cells within the beakers. Growth increment in terms of wet weight was recorded every 10 days. The duration of the experiment was 60 days. At the end of the experiment the percentage survival was determined specific growth rate (SGR) was calculated as

$$SGR = \frac{100(\ln Wt - \ln Wo)}{t}$$

where W_t is the mean final wet weight, W_o is the mean initial wet weight and t is the duration of the experiment in days.

Ingestion rate

Ingestion rate refers to the number of diatom cells removed from the suspension by the oysters (Baker and Mann, 1994). An experiment was conducted to estimate the 'ingestion rate' of pearl oyster spat of different size groups. The experiment was carried out in 2 l plastic beakers at a stocking density of 10 spat $beaker^{-1}$. The spat used were of three different size groups, viz., size A (5-9 mm), B (10-14 mm) and C (15-19 mm). A control set was maintained without spat to account for the multiplication of cells. Seven replicates were established for each treatment and the control. The entire experimental beakers were covered with a black cloth to prevent multiplication of diatom cells. The spat were fed with *Chaetoceros* sp. Initial cell counts were taken immediately upon the addition of feed in the beakers. Three cell counts were made for each sample. Cell counts were taken at 2,4 and 6 hrs after the initiation of the experiment. Ingestion rates were calculated (Sprung, 1984) as shown below.

$$F = \frac{V}{N} \cdot \frac{\ln Co - \ln Ct}{T}$$

$$A = \frac{\ln Co^* - \ln Ct^*}{T}$$

$$I = FC$$

where, F= filtration rate (ml h^{-1} $individual^{-1}$), N= number of oysters in the beaker, V= average volume of beaker during clearance measurements, C_o= initial cell concentration (cells ml^{-1}), C_t= final cell concentration (cells ml^{-1}), C_o^* and C_t^* = initial and final cell concentrations in control beakers (cells ml^{-1}), T = time over which clearance rate was measured (2h), C= mean cell concentration during ingestion rate measurements (cells ml^{-1}), A = changes in control beakers and I = ingestion rate (cells ml^{-1} individuals^{-1}). The data on feeding rate and ingestion rate were subjected to one way analysis of variance.

Results

Mean survival was greater than 80% in all the cultures. Growth rates of pearl oyster spat at different feeding levels showed that larger size needs higher concentration of feed. The average wet weight gain was found to be the highest (146.9 %) in the smallest size group (5-9 mm) when fed at a concentration of 3 lakh cells ml^{-1} spat^{-1} day^{-1}.

Lower and higher concentrations resulted in lesser growth increment (Table 1). Spat of size range 10-14mm registered a wet weight gain of 36.3 % at a feed concentration of 6 lakh cells ml^{-1} spat^{-1} day^{-1} (Table 2). Higher concentrations produced a comparatively lesser growth rate. Growth increment was highest (20.0%) in the group 15-19 mm when fed at a rate of 9 lakh cells ml^{-1} spat^{-1} day^{-1} (Table 3).

Specific growth rates (SGR) calculated for different size groups are shown in Figures 1 and 2. SGR recorded was the maximum for the smallest size group. One way analysis of variance conducted to test the influence of size group on different feeding rates indicated the effect to be highly significant (P>0.01). The mean gain in weight of spat at different feeding rates differed significantly among the size groups.

Filtration rates were calculated from the filtration values for different size

Table 1. *Weight gain in pearl oyster spat (5-9mm) at different feeding rates.*

Feed conc. (X10^5 cells/ ml/spat/d	Mean weight (g)	Mean Final weight (g)	Av. Wt. gain(g)	Av. Wt. gain(%)
1	0.0850	0.175	0.0900	105.9
2	0.0742	0.182	0.1048	145.5
3	0.0814	0.201	0.1196	146.9
4	0.0794	0.154	0.0746	93.9

Table 2. *Weight gain in pearl oyster spat (10-14mm) at different feeding rates.*

Feed conc. (X10^5 cells/ ml/spat/d	Mean weight (g)	Mean Final weight (g)	Av. Wt. gain(g)	Av. Wt. gain(%)
6	0.1723	0.234	0.0626	36.3
9	0.1896	0.2234	0.0338	17.8
12	0.1942	0.1993	0.0051	2.6
15	0.1844	0.1881	0.0037	2.0

Table 3. *Weight gain in pearl oyster spat (15-19mm) at* different feeding rates

Feed conc. (X10^5 cells/ ml/spat/d	Mean weight (g)	Mean Final weight (g)	Av. Wt. gain(g)	Av. Wt. gain(%)
6	0.3406	0.3690	0.0284	8.34
9	0.3388	0.4066	0.0678	20.0
12	0.3462	0.4024	0.0562	16.2
15	0.3315	0.3752	0.0437	13.8

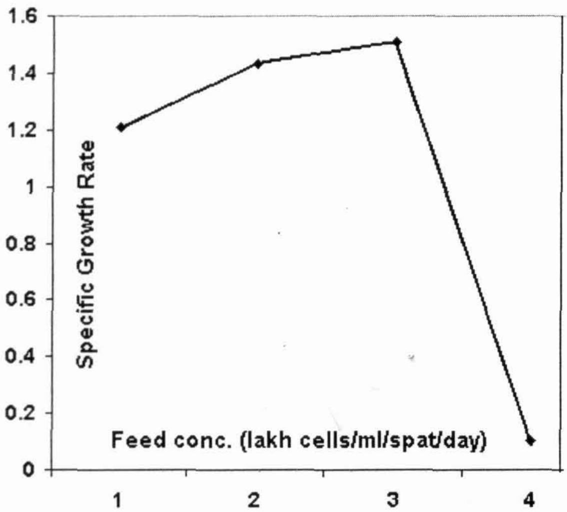

Fig.1. *Growth rate in pearl oyster spat (5-9 mm)*

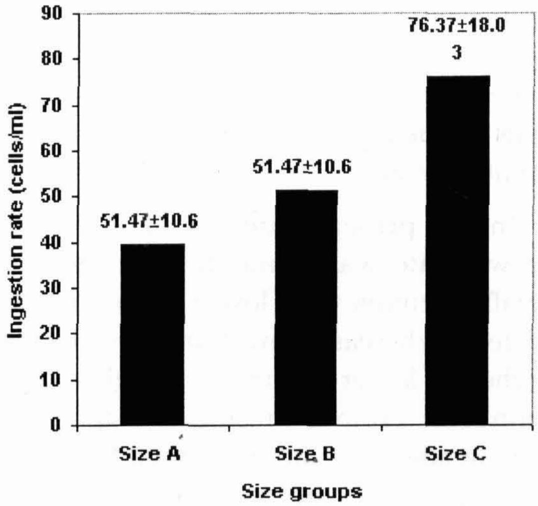

Fig.3. *Ingestion rate in pearl oyster spat*

groups and the ingestion rates were calculated from the filtration values. Size A recorded 34.96 ± 10.6, size B 51.47 ± 10.6 and C showed the maximum ingestion rate of 76.37 ± 18.03 cells h^{-1} $individual^{-1}$ (Fig. 3). One way analysis of variance conducted to test the effects of size groups on ingestion rate showed that F value was highly significant at $P > 0.01$ and the ingestion rates differed significantly for different size groups. Filtration rates and ingestion rates were higher in larger size groups.

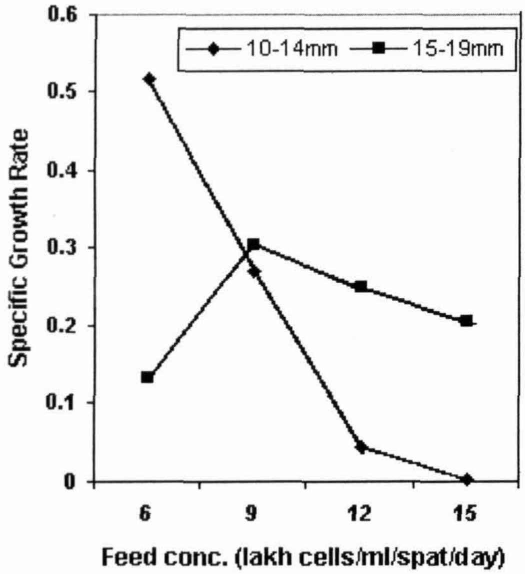

Fig.2. *Growth rate in pearl oyster spat*

Discussion

Growth rates can assist in evaluating the feeding response of the spat and in estimating the optimum feed requirement by various size groups at different algal densities. Numaguchi (1999) reported a sigmoidal relationship between algal concentration and growth rate of *P. martensii* spat when fed *Pavlova lutheri.*

Since the experimental set up was covered with black cloth, the multiplication of algal cells was arrested as direct sunlight was prevented during the present study. Walne (1970) has reported that direct sunlight is harmful to oyster spat and oysters *Ostrea edulis* kept in dark grew faster than those exposed to the sun.

Walne (1970) has also mentioned that open feeding animals will quickly close at the passage of a shadow and if this happens frequently it is possible that it would eventually affect the growth rate.

In the present study with *P. fucata*, growth rate was found to be higher in smaller groups with lower concentration of feed whereas growth increment was higher in larger groups at a higher concentration. From the results it is apparent that an adequate supply of food has to be present in water, but too much is harmful as too little as comparable with the works of Walne (1974). An attempt to provide excess food can be deleterious. The results further suggest the need to test each new algal food at different concentrations to optimize diet density, which sustains maximum growth.

The spat to some extent compensates reduction of food by increasing the filtration rate. This is a common phenomenon observed with filter feeding animals and thus an insufficient food supply is exhausted as rapidly as an adequate supply, but energy has to be expended to obtain food resulting in reduced growth rate.

The rates of filtration and ingestion are directly related to the size of the spat. Larger the spat, more is the rate of ingestion hr^{-1}. The results of the present study are comparable with those of Gerdes (1983) on *Crassostrea gigas;* Mooney *et al.* (1999) on *Mytilus edulis* and *M. trossulus.* The amount of food available to the suspension feeding lamellibranchs is determined by the rate at which the surrounding water is transported through the gills (Joergensen, 1960). The reduced requirement associated with smaller body mass and decreasing maintenance requirement result from greater efficiencies with which smaller bivalves utilize the absorbed ration for maintenance metabolism. Greater maintenance efficiency in smaller animals also explains why maximum net growth efficiency is a decreasing function of body size (Thompson and Bayne, 1974; Widdows, 1978).

Onshore pearl culture is less risky and highly lucrative compared to open sea pearl culture (Rao and Devaraj, 1996). It provides the opportunity to combine all key factors together at the optimum level through good planning and management, thus making the onshore pearl culture highly successful. Most of the bivalves are known to tolerate wide ranges in salinity, turbidity and temperature if they are well fed to compensate the stress on account of significant deviations from normal environmental conditions. Thus the feed seems to be a key factor in determining the growth of these bivalves. The results of this investigation could be taken advantage of in onshore tank systems by maintaining the algal density at optimum levels for the different size groups of pearl oyster spat.

References

Baker, S. M. and R. Mann. 1994. Feeding ability during settlement and metamorphosis in the oyster *Crassostrea virginica* (Gmelin, 1791) and the effects of hypoxia on post settlement ingestion rates. *J. Exp. Mar. Biol. Ecol.*, **181**: 239-253.

Gerdes, D. 1983. The Pacific oyster *Crassostrea gigas*. Part I. Feeding behaviour of larvae and adults. *Aquaculture,* **31** : 195-219.

Joergensen, C. B. 1970. Efficiency of particle retention and rate of water transport in undisturbed lamellibranches. *J. du. Cons.,* **26** (1) : 94-116.

Krishnan A. 1987. Studies on the larval nutrition in the pearl oyster *Pinctada fucata* (Gould). *Ph. D. Thesis.* Cochin University, India.250pp.

Mooney, M., G. J Parsons. and C. Courturier. 1999. A comparison of feeding physiology in different sizes of cultured and wild *Mytilus edulis* and *M. trossulus. J. Shellfish. Res.,* **18** (1): 300pp.

Numaguchi, K. 1999. Effective feeding concentration of the microalga *Pavlova lutheri* for the growth of early spat of the pearl oyster *Pinctada fucata martensii. J. Wld. Aquacult. Soc.,* **30** (2): 290-292.

Sprung, M. 1984. Physiological energetics of mussel larvae (*Mytilus edulis*) II. Food uptake. *Mar. Ecol. Prog. Ser.,* **17**, 295-305.

Rao, G. S. amd M. Devaraj. 1996. Prospects of large scale onshore marine pearl culture along the Indian coasts. *Mar. Fish. Infor. Serv., T & E Ser.,* No. **143**: 1-7.

Thompson R. J. and B.L. Bayne. 1974. Some relationships between growth, metabolism and food in the mussel *Mytilus edulis. Mar. Biol.,* **27**: 317-326.

Walne, P.R. 1970. Studies on the food value of nineteen genera of algae to juvenile bivalves of the genera *Ostrea, Crassostrea, Mercenaria* and *Mytilus. Fish. Invest. Min. Agric. Fish Food (GB) Ser. II,* **25**: 62pp.

———— 1974. Culture of bivalve mollusks. *Fishing News (Books) Ltd.,* Surrey, 173pp.

Widdows, J. 1978. Combined effects of body size, food concentration and season on the physiology of *Mytilus edulis . J. Mar. Biol. Assoc. U. K.* **58**: 109-124.