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Production of mother oysters of *Pinctada fucata* (Gould) by manipulation of stocking density

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ABSTRACT

Marine pearl culture is a multifaceted technique involving three different kind of works namely i) seed production, ii) farming and mother oyster development and iii) nucleation and pearl production. To make the technique more viable and economically feasible it is imperative to make critical analysis of the various technicalities involved in the culture strategy. Hence a commercial level scheme on marine pearl culture in the inshore waters of Gulf of Mannar (GOM) was taken up during 1998-2004 at Mandapam Regional Centre of Central Marine Fisheries Research Institute (CMFRI). Critical analysis of the data revealed that a definite upgradation of pearl culture technology is required in many components coupled with policy decisions by the State Government. The present paper focuses on a single major problem of production of mother oysters for nucleation and pearl production on a continuous and commercial scale of operation. The culture method, appropriate farm management, stock density, growth and survival, culling and their effect on the production of mother oyster suitable for nucleation are presented in the paper.

Introduction

Marine pearl culture is one of the viable proven technologies developed by CMFRI in 1973 consisting three major components, ie, hatchery seed production, spat rearing and mother oyster production and nucleus implantation and farming for pearl production. The viability of the technology has been tested through a field demonstration at Valinokkam Bay in 1992 involving local fishermen. The technique of producing marine pearls from the Indian pearl oyster, *Pinctada fucata* (Gould) has been tried both by governmental and private entrepreneurs like Southern Petrochemical Industries Corporation (SPIC) in collaboration with TNFDC and Orki enterprises, Mandapam on a commercial scale. Consultancy programmes on pearl culture with NCC Blue water, Andhra Pradesh, Balaji Biotech. Ltd., Nellore, A.P. and Gem Holiday Resorts Ltd., Madras were also taken up. The programmes however, were not continued for longer period for the reasons best known to them.

Recently, CMFRI executed pearl culture with the collaboration of M.S.

Swaminathan Research Foundation (MSSRF), Chennai, as a Societal programme by the local fisher folk at Pamban through cooperative society. During the years 1998-2004 marine pearl culture on commercial scale was taken up at Mandapam Regional Centre of Central Marine Fisheries Research Institute (CMFRI) in the inshore waters of Gulf of Mannar (GOM) and the technical viability was established once again. However, during the course of execution of the project, the researchers also encountered several technical problems of which the steady and continuous production of mother oysters was greatly felt for implantation purposes.

This paper attempts to highlight the effect of stocking density on growth in size and weight, culling period, survival rate and relative percentage production of mother oyster for continuous supply under commercial scale pearl production within a relatively shorter period.

Materials and methods

Culture system and environment

The present study was conducted from December 2000 to October 2001, on a farm size of about 1000 sqm area with rack and rafts and fully stocked with over a few lakhs of pearl oysters of assorted size to test the growth, survival and relative percentage production of mother oyster suitable for nucleation under optimum commercial farming conditions. The rearing was done in box type cages in a raft culture system. The depth range of the culture site was 3-4 m. Growth and survival data were collected once in a month from representative cages in duplicate. The prevailing environmental condition such as seawater temperature, dissolved oxygen content, pH and salinity were recorded once in a fortnight adopting standard analytical methods.

Spat/adult oyster rearing method

The young spats (ave. 3.5mm DVM) produced from the Institute's hatchery were selected for the study. They were transferred to the commercial farm and reared in specific sized culture bags (100 x 60cm) made of 1.0 mm mesh velon netting for the first one month and later with 3-5 mm mesh velon netting and covered with 10mm mesh fishing net till they grew to more than 15mm size. Subsequently they were reared in conventional box type cages (40x40x10cm) knitted with appropriate mesh sizes (10mm) for the rest of the period.

Stocking density

The effect of stocking density of spat on growth in size and weight, on survival rate and relative production was carried out in two phases.

(i) Uniform sized spats (Ave.3.5mm) were collected from the hatchery and stocked in densities of 1000, 2500 and 5000 nos of spats/cage. They were reared in box type cages with appropriate netting for a period of six months (ii) After that, the oysters above 30mm/5g were selected and reared at the densities of 125, 250 and 500 nos of oysters/cage for a further period of 5 months till the oysters grow to required size and weight for the purpose of nucleus implantation.

Farm management and data collection

Periodical examination of the spats was done once in 10 days and once in a month for the adult oysters. Physical cleaning of foulers was done by a blunt knife and with a jet of water. Predators were removed by hand. Data on growth in size, weight and survival were collected once in a month by measuring 10% of the total number of spats stocked

in each category. The data were pooled and the mean values are presented.

Results

Culture environment

The culture environment (GOM) was shallow open coast and had a depth ranging from 3-4 m. The bottom was sandy and rocky patches with growth of seaweeds. The prevailing environmental parameters were recorded and given in Table. 1. In general there were not much fluctuations in any of the parameters observed and especially the seawater salinity did not show any considerable change indicating less dilution even in monsoon period. pH remained almost stable. The dissolved oxygen content fluctuated very narrowly. The difference between mean air and surface seawater temperature was only 2 ºC.

Mean size/weight increase and survival of juvenile pearl oyster

The spats stocked with a mean initial size of 3.5 mm at the stocking density of 5000nos/bag had grown to 7.9; 12.8; 17.6; 20.0; 23.6 and 25.1 mm; in 2500 nos/bag, it had grown to 8.2; 12.5; 18.5; 23.1; 25.9 and 29.0 mm and in 1000nos /bag the oyster had grown to 8.9; 14.5; 21.6; 28.4; 32.6 and 36.0 mm in 6 months period of culture (Fig. 1). Analysis of this data showed that the initial growth rate of spats up to 3rd month was higher in lower densities, ranging from 4.4 to 4.9; 4.3 to 6.0 and 5.4 to 7.1mm per month in the respective densities of 5000, 2500 and 1000 nos./ cage. The growth was observed to decline during the successive three months ranging from 1.5 to 3.6; 2.8 to 4.6 and 3.4 to 6.8 mm in respective stocking densities. The size increase was observed to be high ranging from 3.4 to 7.1 mm during six months of culture in the stocking density of 1000 nos/bag when compared to the other two stocking densities. The mean monthly growth rate

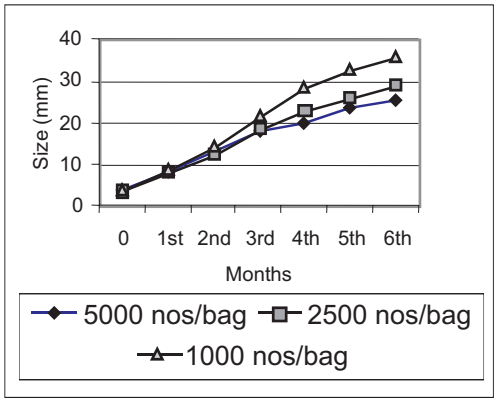

Fig.1.Mean size increase in juvenile *Pinctada fucata* in different stocking densities

was 3.6, 4.3 and 5.4 mm for the respective stocking densities.

Similarly, spats having the mean initial weight of 0.03g at transplanting had grown to 2.69, 3.5 and 5.9 g in respective stocking densities at the end

TABLE 1. *Environmental parameters at the culture site at Mandapam Camp (GOM) during December 2000 to October 2001*

Parameters	Minimum	Maximum	Average
Air temperature ºC	26.5	32.9	31.8
Seawater temperature ºC	25.6	32.4	30.0
Seawater salinity (ppt)	31.0	35.7	33.8
pH	8.1	8.6	8.5
Dissolved oxygen (ml/l)	4.3	5.6	5.0

of 6 months of culture (Fig. 2). The mean weight gain was high in the stocking density of 1000nos when compared to other stocking densities. The mean monthly weight gain obtained in this density was 0.978g.

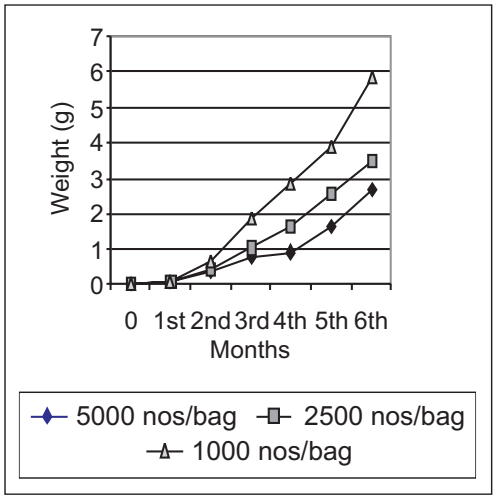

Fig.2. Mean weight increase in juvenile *P. fucata* in different stocking densities

The stocked juveniles showed varied level of survival rates in the different stocking densities. A maximum survival of 81.3 % was observed in 1000 nos/bag category and it was 63.1% and 54.3% in 2,500 and 5000 stocking densities respectively (Fig. 3).

Mean size/weight increase and survival in the adult pearl oyster

The adult oysters had grown from an initial mean size of 30.0mm to 33.0, 35.8, 38.3, 40.3 and 42.3 mm size in the cages stocked with a density of 500 nos/cage; to 34.0, 38.0, 41.2, 44.2 and 46.6mm in 250 nos/cage and 34.5, 39.1, 43.1, 46.4 and 49.4 mm in 125 nos/cage at the end of 5 months of culture period showing a mean monthly growth of 2.5, 3.3 and 3.9 mm within the period in the respective stocking densities (Fig. 4).

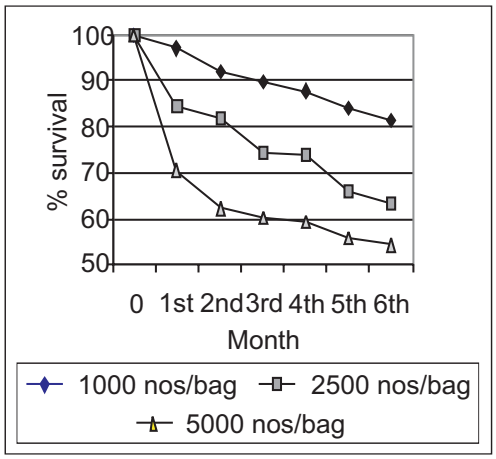

Fig.3. Mean survival % of juvenile *P.fucata* under different stocking densities

Similarly the oysters stocked with a mean weight of 5.0 g had grown to 7.6; 9.2 and 12.8 g at the end of 5 months culture for the respective stocking densities. The mean monthly weight gain in different groups of oysters was 0.52, 0.84 and 1.56g. (Fig. 5)

A maximum survival of 84.2 % was recorded in the cages stocked with a density of 125 nos / cage and it was 63.1% and 54.3% in other densities (Fig. 6).

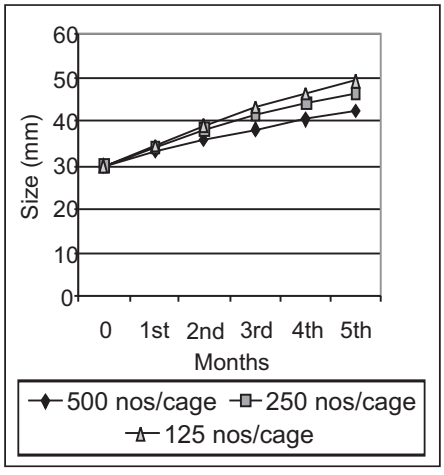

Fig.4. Mean size increase in adult *P. fucata* under different stocking densities

Relative percentage production of suitable sized oysters

A pearl oyster with a size of above 40 mm and a weight of 12 g was considered as suitable size for 3 to 4 + mm shell bead nucleus implantation and

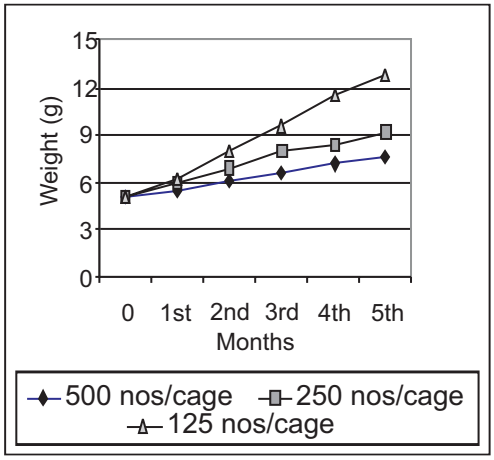

Fig.5. Mean weight increase in adult *P. fucata* under different stocking densities

tested for pearl production. The composition of such oyster group was found to be high (82.1%) in cages stocked with 125 oysters when compared to other

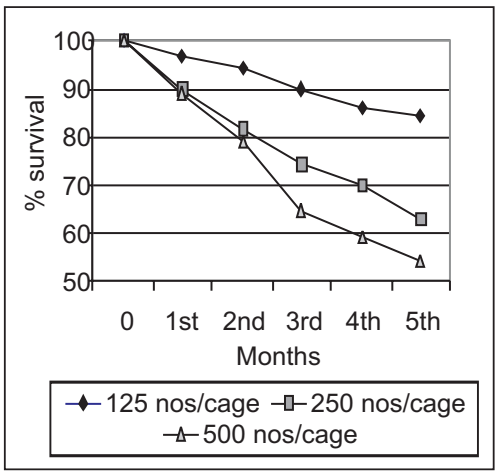

Fig.6. Mean survival % of adult *Pinctada fucata* under different stocking densities

densities where the implantable sized oysters constituted only 21.4% and 7.4% respectively (Fig. 7).

From the above data the production potential of a 5 x 6 m raft holding 100 cages under commercial scale operation was calculated and presented in Table.2

Discussion

Pearl culture has been carried out on experimental basis and entrepreneurial levels at various places. A detailed review of progress and problems

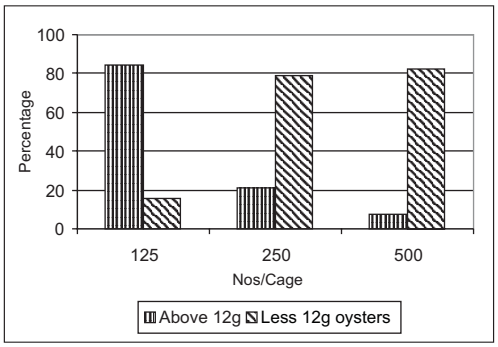

Fig.7. Relative % production of suitable sized oysters for nucleation at different densities

of pearl culture in India was by Alagarsami, 1983; Victor given *et al.*, 2000 a.

Even though bays having deep and calm waters with moderate currents to bring in food and flush the droppings from the farm are rare along the coast of mainland of India, the Gulf of Mannar to some extent offers a compromise with regard availability of oysters and workable farming conditions. The environmental parameters of the present study area were almost comparable with the farm at Veppalodai situated in Gulf of Mannar where high quality cultured pearls were produced from shallow open coastal areas (Victor, 1983).

Even though the amount of foulers

TABLE.2. *Production potential of a standard raft (5x6 m/100 cages) under commercial scale operation*

Density/cage	% Survival (Nos)	% production of implantable sized oysters	Production potential (Nos)
125	84.2 (10,525)	82.1	8,641
250	63.1 (15,775)	21.4	3,371
500	54.3 (27,150)	7.4	2,009

and borers were not quantified in the present study, Alagarsami and Chellam (1976) reported that fouling and boring organisms had some effect on the growth and survival of *Pinctada fucata* as observed in the farm reared oysters at Veppalodai, Gulf of Mannar. Similarly, fouling and boring on the cultured oysters were noticed all along the present study. Most common form of foulers and borers were barnacles *Balanus amphitrite*, simple and compound ascidians, *Ascidia* spp., and *Diplosoma* sp. and bryozoans, *Membranipora* sp. Apart from this polychaete borers *Polydora* sp were observed on the cultured oysters resulting in considerable mortality. Fouling by barnacles and oysters reduces the growth of the pearl oyster due to the combined effects of reduced food availability and increased competition (Mohamed, 1976).

Chellam, (1978,1988) has observed the growth increment and other shell attributes of *P. fucata* for farm grown oysters of higher size group (30-40 & 50-60mm) and stated that smaller sized groups exhibited continuous growth and the bigger sized group showed retarded growth. Jeyabaskaran *et al.*, (1983) reported a faster growth of 4.7mm/month during initial months of rearing of *Pinctada fucata* (average size -25.0mm) under farm conditions at Tuticorin. The spats were reared in 60x45x9cm cages in the stocking density of 400/cage. Appukuttan (1987) has studied the spat fall and recorded the growth of *Pinctada fucata* in Vizhinjam Bay as 1.5mm/month for the large sized spats stocked at density of 100nos/cage. He also reported that younger stages grow faster (3.9mm/month). Recently, Victor *et al.* (2000b) reported the growth of 6.3mm/month from Gulf of Mannar waters when spats of size 7.2mm stocked at a density of 1500/cage.

The first phase of culture for 6 months period indicated a maximum average growth rate of 5.4 mm/month in the stocking density of 1000 nos/bag, which is comparable to the results obtained for spats reared at density of 1500/cage by Victor *et al.* (2000 b & c) in spite of the farm size being much larger and fully stocked with few lakhs of assorted sized oysters in the present experiment. Abdussamad *et al.*, 1998 also obtained similar growth/weight rates for *Pinctada fucata* reared at Kakinada Bay waters in low stocking. Subsequent culling and culture of these oysters for another 5 months yielded a maximum average growth of 3.9 mm/month in lower stocking densities of 125nos/cage. Hence it is possible to produce oysters of operatable size of above 40mm from the mean initial stock size of 3.5mm within a total period of 11 months by manipulating stocking density and culling.

Similarly, the maximum mean monthly weight gain (0.975g) obtained in the juvenile oyster rearing was noticed in the lowest stocking density of 1000 nos/cage. Subsequent culture of these oysters at a stocking density of 125nos/cage for

next 5 months yielded a weight gain of 1.3g/month. The weight gain in the latter phase of culture is considered to be critical in mother oyster production for the purpose of nucleation. As regard to the survival during the culture, maximum percentage survival of 81.3 & 84.2 % was noticed in the lowest stocking densities of 1000nos/bag and 125 nos./ cage at the respective stages.

The results of present study is in conformity with many others concerning the relationship between growth and stocking density in shellfish culture, where the possible conclusion is decline in growth rate as the stocking density increased (Hadley and Manzi, 1984; Parsons and Dadswell, 1992; Holliday, 1993).

Water flow and food availability are the two important factors that influence growth of bivalves (Wilson, 1987; Brown and Hartwick, 1988). An increase in stocking density invariably reduces the water exchange and food availability in cages. Fouling also plays a major role in reducing water flow inside the cages. This could explain the reduced growth of pearl oysters in increased densities in the present study also. Taylor *et.al.* (1997) attributed the gregarious behaviour exhibited by *Pincatda maxima* to the reduced growth in higher stocking densities. Gervis and Sims (1992) also reported localized overcrowding due to space limitations in the cage as a cause for slow growth rate in juvenile pearl oysters *Pinctada fucata*. In the present study also in higher densities more number of individuals (upto 38) were found attached together as group. This gregarious behaviour of *Pinctada fucata* might have affected the growth at higher densities.

It is evident from the results obtained in this experiment that a planned transplant and rearing of hatchery produced seed, culling and restocking after at a particular period (6th month) helps in producing the desired size/weight gained mother oysters within a total culture period of 11 months for 3 to 4 + mm shell bead nucleation and pearl production.

The relative proportion of suitable sized mother oysters was also found to be much higher (82.1%) in lower stocking density of 125 nos./cage category when compared with the other stocking densities tested (21.4% & 7.4%), where the oysters gained only size but not weight suitable for nucleation. Even though Alagarsami and Dharmaraj (1984) suggested that 20g sized oysters are ideal for implanting nucleus in *P.fucata*, with 4 mm nucleus, in the present study oysters at a size of 12g was found suitable for implanting 3 &4 mm nucleus.

From the above results, it could be concluded that for a commercial scale pearl culture operation, a stocking density of 1000 nos/bag up to a size of 30 mm and a weight of about 5g and culling after 6 months and subsequent restocking and culture at 125 nos /cage for another 5 months would be appropriate for obtaining regular supply of mother oysters of required size, weight (above 45mm & 12g) and numbers (above 82%) for nucleation and pearl production.

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