Marine Fisheries Research and Management

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2000

52 Pearl culture

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ABSTRACT

Pearl culture gives the highest gross income for unit area among aquaculture systems. The techniques developed by CMFRI to suit Indian condition have attracted the entrepreneurs to enter into the venture of pearl culture. The rate of return works out to more than 50%. The recent line of research on the onshore pearl oyster farming and pearl culture, can easily revolutionize the concept and this can be profitably taken up in the east and west coasts of India where prawn farming was successfully conducted. In this paper the cost of seed production and economics of pearl production is dealt with. The possibilities of taking up production of seed of desired qualities through selective breeding, manipulation of conditions in the onshore tanks culture are counted as priorities. Black pearl production and farming and pearl culture in the natural beds are the other priorities.

Introduction

The molluscs, the univalved gastropods and the two valved bivalves, with a nacreous layer, are capable of producing pearls. But in nature, very few species produce pearls which are of gem quality. The important group of marine molluscs which produce natural pearls, is the pearl oysters. Among the commercial species which have been exploited for the natural pearls and later for culture pearl production are *Pinctada fucata, P. maxima* and *P. margaritifera*. The other bivalve, which produces pearls, is the wing-shell *Pteria penquin*. The only important gastropod used for pearl production is the abalone, *Haliotis discus*.

The CMFRI had initiated the experimental pearl production in 1972 and the first Indian spherical cultured pearl was produced in July 1973 (Alagarswami, 1974). The technology on seafarming of pearl oysters, cultured pearl production etc. were standardised after repeated experiments (Chellam *et al.*, 1987, Alagarswami, 1987). Based on the technology, a private farm had come up for commercial production of pearls in the year 1982.

The CMFRI again in the year 1982 had succeeded in the production of seed by hatchery method (Alagarswami *et al.*, 1983). Now the technologies of pearl oyster seed production, farming and pearl production are proven ones. By employing these technologies, the seed of pearl oysters can be produced in the hatchery under controlled condition and they can be raised to the size suitable for implantation in the inshore farms and pearls can be produced. In furtherence of this achievement, the seed of the black-lip pearl oyster, *Pinctada margaritifera* were also produced in the hatchery in the year 1987 (Alagarswami *et al.*, 1989).

The development of the hatchery technology had made it possible not to depend solely on the oysters from the natural beds for cultured production. Survey of the beds since 1975 had shown that they receive very irregular spatfall and in some seasons very meagre (Alagarswami *et al.*, 1987).

The recent attempt to raise the mother oysters in onshore tanks by feeding them suitably with live plankters, is giving encouraging results. The CMFRI is in the process of consolidating the technology of using onshore tanks for farming of pearl oyster and cultured pearl production.

Indian pearl oyster resource

The Indian pearl oyster, *Pinctada fucata* is restricted to the Gulf of Kutch in the northwest coast, Vizhinjam on the southwest coast, Gulf of Mannar in the south east coast of the Indian subcontinent. In the Gulf of Kutch, the oyster beds are situated in the intertidal zone at a distance of 1-5 km from the coast line. The density of population is very sparse and the recent survey shows the population to range from 1-6 oysters per hectare (Pandya, 1974).

In the Gulf of Mannar, the oysters are found attached to the submarine plateau of inshore areas at a depth of 10-20 m. More than 70 such beds exist here, extending from Pamban in the north and Manapad in the south. The pearl fisheries was in existence in the central part of the beds and record shows 27 pearl fisheries in a period of 165 years from 1796 to 1961. The recent survey of the beds during 1975 to 1986 shows that the beds receive irregular spat fall during different seasons and that they had never attained the fishable size. Heavy to very heavy mortality had occurred to the spat/oysters and no particular reason could be attributed for this (Alagarswami *et al.*, 1988).

After the development of a hatchery technology in 1982 to produce seed of

pearl oysters by the CMFRI (Alagarswami *et al.*, 1983) all of the departmental requirements for R&D on pearl culture and the requirement of some of the state/ agencies/universities have been met from this. Through the facilities available at present, one million seed can be produced in one run.

Farming methods

Spat, mother oysters and nucleated oysters are farmed by raft and rack methods, the former is employed when the water depth exceepds 5m and the latter when the depth is less than 5m. Culture of oysters from raft is one of the suitable farming methods in sheltered bays. A raft of the size 6m X 5m constructed with teak poles are floated with 4 bouys of 200 litre capacity, can hold about 100 culture cages.

In the rack culture method, teak poles are driven into the seabottom at equal intervals of 1 m and horizontal poles are tied with coir ropes above the sea water level. Culture cages are suspended from the horizontal poles. The rack can be extended as per the requirment.

Large concrete tanks of 75-100 tons of water holding capacity are used for onshore pearl oyster farming. The spat/mother oysters/nucleated oysters cultured in these tanks should be fed with cultures of phytoplankters.

Different culture methods like long-line culture and on bottom culture can also be employed according to the condition of the sea and sea bottom.

Eventhough different types of farming methods are followed elsewhere in the world, unit raft system is found to be the most suited one for the Indian coast especially Gulf of Mannar (Chellam *et al.*, 1987).

Juveniles of oysters are reared in net cages made of synthetic fabric of velon screen (mesh size: 1 - 10 mm) till they reach a size of 20 mm. The mother oysters are reared in box cages with mesh of 10 - 15 mm. In the initial period of 1 - 2 months, the nucleated oysters are reared in box cages having a mesh of 1mm base. This is to recover the nucleus in case of rejection.

Techniques of culture pearl production

In nature, the entry of core particle inside the body tissue of an oyster and the irritation caused by it is responsible for the formation of a natural pearl. The same technique is manipulated by man in the process of cultured pearl production. Here,

the core material is a well polished spherical shell bread nucleus. In order to facilitate the formation of a good quality pearl, a pallial mantle piece taken from a donor oyster is introduced along with the nucleus inside the gonad of the oyster (Alagarswami, 1987). Various steps involved in cultured production such as conditioning of oysters for surgery, graft tissue preparation, nucleus implantation, post operative care etc are given in detail by Victor *et al.*, 1994. The quality of a cultured pearl can be improved by refinements in operation techniques and also in rearing the nucleated oysters (Alagarswami, 1987).

Seed production

The production of the seed of pearl oyster *Pinctada fucata* by hatchery method is perfected by CMFRI in the year 1982 and since then millions of seed were produced and used for farming, pearl production and sea-ranching experiments. Detailed accounts on experimental and mass production of seed of *P. fucata* and *P. margaritifera* in the hatchery are given by Alagarswami *et al.* (1983, 1987, 1989).

Status of pearl culture / production in the world

The global production of marine pearls is about 78 tons, valued at US $ 1042 million (Fassler, 1994). Japan still holds the monopoly in the production of sea pearls. They have done this by maintaining the state-of-the-art and following the Mikimoto's Dictum of not sharing this with others. Country-wise production of pearls indicated that Japan ranked first with a production of 63375 Kg in 1993 worth US $ 900 million. French Polynesia increased production from 407 Kg in 1987, worth US $ 20 million to 2094 Kg in 1993 worth US $ 77 million. Indonesia has produced 1008 Kg. Australia has produced 892 Kg worth US $ 100 million. Philippines harvested 450 Kg worth US $ 3.3 million. Cook Islands produced 150 Kg valued at US $ 4.5 million. Indian production of cultured pearls is very meagre and yet to enter in the world trade.

Seed production and economics

A sophisticated pearl oyster hatchery system was established at the Research Centre of CMFRI, Tuticorin in 1981 and seed of pearl oysters was produced since then. The development of pearl oyster hatchery and the mass production of pearl oyster seed, had since then, led to the development of hatcheries for the production of seed of edible oysters, mussels, clams and gastropods.

This system contains the facilities like filtered seawater supply, air supply,

microalgal culture, brood stock maintenance and conditioning, induced spawning, larval rearing, and spat settling.

Different types of parameters were taken into account while standardizing a package of techniques for the production of the seed of pearl oyster. Larval concentration, schedule of feeding, colour of the larval rearing & spat settling tanks, aeration, favourable seasons etc. are a few to mention here. Not less then 10% of larvae had successfully settled as spat. Research is in progress to reduce the time of settlement to less than three weeks.

The experimental production of spat in the hatchery during 1981-94 is given below.

Year	No. of spat set.	Year	No. of spat set.
1981	12,8471	1988	77,2900
1982	51,7521	1989	35,2460
1983	24,6162	1990	31,3800
1984	67,8142	1991	20,7670
1985	4,09,0200	1992	21,2050
1986	3,05,1630	1993	63,4710
1987	54,8600	1994	34,2676

A four months period from May to August is considered to be unfavourable for spat production at Tuticorin. This is because of high saline water, heavy dust fall, warmer landward wind and occasional spurt in the appearance of ciliates in the culture water; these factors are singly or in combination responsible for the larval mortality.

The settled spat are allowed to grow in the hatchery tank itself for about 60 days. They are fed with mixed algae, cultured in the open tanks, having *Chaetoceros* as the main food. The feeding rate is 50,000 cells/spat/day and this ration is increased as the spat grows. An average size of 3 mm is attained within a period of 60 days by then they are ready for transplantation to the site of culture. Through the nursery

rearing of spat, a minimum of 50% survival is obtained.

The cost of a seed of pearl oyster of the size 3mm is worked out based on the facilities available in the shellfish hatchery at Tuticorin. A minimum quantity of 5 million spat per annum can be produced when five runs of spat production is carried out. The cost is worked out under the following main heads:

I	Capital cost:	
A.	Buildings	: Rs. 2,26,750
B.	Tanks	: Rs. 2,42,500
C.	Major equipments	: Rs. 2,53,500
II	Recurring expenditure	: Rs. 3,49,210
		10,71,960
Total seed production (3mm)		50,000,000
Cost of a seed		Rs. 0.214

Pearl production and economics

The seed of 3mm and above are transported to the farm and reared in special type of net cages. The seed are carefully monitored and as they grow, the netting has to be changed till they reach a size of 25-30 mm in about 6 months. The growth of the farm-reared oysters is worked out to be 47mm and 8.3g in the first year, 64.5mm and 31.6g in the second year and 75.0 mm and 45.4g in the third year (Chellam, 1987). The cumulative mortality of the seed is found to be 50% in the first month, 20% in the second month, 10% in the third month 5% in the sixth month and 5% upto the fifteenth month. For the nucleus implantation purpose, an oyster with a size of about 45-55 mm with a weight of 15-20g is found to tolerate the stress of operation and the nucleus load is accepted because the flesh of the animal and the shell cavity is sufficient to accommodate the nucleus. This size is obtained in a period of 12-15 month of farm rearing.

The rate of growth of nacre depends on the size of the nucleus and the size of oyster. The length of culture period to produce a pearl of acceptance in the Indian condition is found to be 3-4 months for nuclei of 2-3mm diameter and 15-18 months for nuclei of 5-6mm diameter. In oyster of size 40-50mm, on a 3mm nucleus, the nacre growth was 0.141mm per quarter, while it was 0.213mm in oysters of the size 50-60mm. On nuclei of 4mm the nacre growth was 0.150mm per quarter in oysters of 40-50mm and 0.163mm in oysters of 50-60mm. The nacre growth was 0.168mm per quarter when oysters of 60-70mm were implanted with 5mm nuclei.

Alagarswami (1975) observed growth of nacre in *P. fucata* pearls at Veppalodai as follows :

Nucleus diameter(mm)	Thickness of nacre (mm)	Duration of culture
3.00	0.32	191 days
4.00	0.31	161 days
5.80	0.26	159 days

The implanted oyster may die in the culture farm due to a variety of reasons, like the infection of the wounds inflicted at the time of implantation of the nucleus. Biofouling, shell boring and pollution may also cause mortality. Under normal condition an annual mortality rate of 10-12% of the nucleated oysters can be expected.

Nucleus ejection, non-formation of pearl-sac due to defective surgery and incorrect orientation of the graft may also lower the rate of production of pearls. This may range 10-15% in the normal case. These defects can be improved with the professional expertise and practice. In Indian experiments, a gross production of about 62.8% in single implantation and 68.3% in multiple implantation with reference to the number of nuclei used was grade A (37.6%), grade B (37.6%) and grade C (24.8%) (Alagarswami, 1987).

A field evaluation of the economics of pearl culture was worked out recently based on the study conducted at Valinokkam in which raft culture was employed. The rate of return worked out to 56.7% (Victor, *et al.*, 1995). Detailed account of the expenditure and return for a crop is given below:

Expenditure :

a)	Cost of a raft	:	Rs.13,000
b)	Cost of rearing cages	:	Rs.10,000
c)	Cost of 10,355 oysters @ Rs.1,40 per oyster	:	Rs. 14,500
d)	Cost of shell bead nuclei @ Rs.100 per unit number (for 9,414 oysters)	:	Rs. 9,500
e)	Cost of instruments, glasswares plastic wares, chemicals etc	:	Rs. 5,000
f)	Cost of labour	:	Rs. 3,000

Pearl production:

Gross pearl production (25.3%)	:	1849
Production of A,B grade pearls (83.6%)	:	1546

Revenue:

Sale of pearls (138.28G) : 1296 Nos	:	Rs.73,133
Distribution to fishermen in due labour charges	:	Rs.12,500
		Rs.85,633

Experimental onshore pearl oyster farming

The experiments taken up in the recent months to rear the juveniles, culture the mother oyster and nucleated oysters for pearl production, have given encouraging results. Culture of oysters in large onshore cement tanks having filtered/semifiltered seawater and feeding them artificially with live phytoplankters cultured in the open, has been taken up at Mandapam, Madras, Kakinada and Visakhapatnam on experimental basis. As far as the growth of juveniles and mother oyster are concerned, the progress was very good. A satisfactory result on production of cultured pearls was obtained in the first experiment at Kakinada. In other places, the results are awaited. Onshore pearl culture system, if developed and standardized will have greater advantage over the nearshore farming system on the following lines.

Faster growth and fattening can be achieved by providing suitable food, (natural and artificial) and thus the duration can be shortened in mother oyster culture. Due

to the supply of filtered / semifiltered seawater, unwanted materials and organisms can be prevented from entering into the culture system. Labour on the oyster maintenance will be at the minimum level. Manipulation of factors conducive to obtain faster pearl growth and deposition of desired colour of nacre is possible when a package of programmes is developed on onshore pearl culture system.

Future research priorities and conclusion

Pearl oyster farming in terms of value is one of the world's leading aquaculture industries. The world production of marine pearls accounted for 78 tons worth approximately US $ 1042 million; whereas Indian import of cultured pearls is worth US $ 10 million per annum.

Pearl culture is a lucrative field which promise high potential for import substitution and export promoton. With the expansion and development of pearl culture activities, there is good scope for exporting marine pearls from India besides reducing imports.

Species: *Pinctada fucata* is the major species on which major work has been done in India. Besides this, India is proud to have the resources of the black-lip pearl oyster *Pinctada margaritifera* in Andaman & Nicobar Island. This spices is known for the production of fine steel and black pearls under culture. Specific technology for *P.margaritifera* has to be developed for the production of this high value black pearls. Spat collection from the natural beds will have to be attempted adopting standard methods already available in other areas such as Sudan and French Polynesia.

Options for organisational set up: Pearl culture is a composite industry with different components. These include spat production, mother oyster culture, pearl processing and marketing. Each is a field of specialisation requiring separate technology, skill and equipment. Put together it becomes a composite industry raising the capital, man power and technology requirements to a higher level. The advantage will be that a composite enterprise can mobilise resources, manage problems with competence and have greater control over situations.

Pearl farmer's co-operative: In this background, young fishermen with aptitude for pearl culture may form themselves into a pearl farmer's co-operative society with financial support from the co-operative sector. The society will look after both input supply and output management. The activities under input supply include facilitation of leasing of sea area and shore facility, supply of oysters, supply of farm materials, supply of nuclei, arrangement for security and arrangement for training of the

members. The output management cell will purchase the pearls produced by the members, attend to sorting, grading, processing and marketing of pearls.

Privatisation: Pearl oysters are monopoly of Tamil Nadu Government and hence private entrepreneurs are not allowed to take oysters from the pearl oyster beds. The present Government is favouring the policy of privatisation to develop pearl culture in a big way. A country like India with enormous man power and plenty of resources is still not able to emerge as one of the major pearl producing countries in the world. When we look into the history of pearl industries in other countries, we find that they have achieved their best because of the number of firms established by different entrepreneurs. Hence the idea of privatisation is good as big companies, or individuals can come forward and they will look after their industry in a very good manner as profit will be the main aim of any business.

Earning of foreign exchange: Pearl has a good demand in the international market. With technology available and environmental condition conducive for the production of cultured pearls, the reason for not producing bulk quantity of pearl should be discussed with scientists and administrators and urgent steps should be taken to increase production.

Thrust areas: The scientists of CMFRI during the last 25 years had achieved considerable success both in seed production and pearl production. However, there are several areas where much attention is needed. Some of the major priority area in pearl culture would be improvement of oyster quality through genetic studies, increase in pearl production, improvement of quality of cultured pearls through selective breeding and mantle tissue culture and identification and control of disease. On the hatchery front, the major thrust would be on the synchronus larval growth and spat settling, economic nursery rearing and improvement of seed production by genetic application.

In India there is ample scope for developing pearl culture industry in all coastal areas including shallow waters of different locations, especially in the Gulf of Mannar, Lakshadweep Islands and the Andaman and Nicobar Islands. Lack of awareness and information in this regard serves to some extent as the cause for the potential entrepreneurs not venturing into this field. There is good scope for privatisation as well as for large scale co-operative movement in this field.

Acknowledgement

The authors are indebted to Dr.M. Devaraj, Director, CMFRI, Cochin for identifying us to write this paper and to Dr.K.A. Narasimham, Head of Molluscan Fisheries Division, for offering valuable suggestions in improving the paper.

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