TECHNOLOGY OF MOLLUSC CULTURE

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INTRODUCTION

THE molluscs are an important group of shellfish and are exploited along the Indian coasts. Their meat is used as food; the shell is an important raw material in lime based industries and also in making curios. In temperature countries culture of molluscs such as oysters, clams, mussels scallops and abalones is widely practised to augment production. In India, technologies for farming several species of molluscs have been developed during the past two decades, mainly due to the efforts at the Central Marine Fisheries Research Institute (CMFRI).

IMPORTANCE OF MOLLUSCS IN AQUACULTURE

In 1992, out of 13,921,338 t of world aquaculture production, molluscs accounted for 3,500,719 t (value 3.7 billion US $) forming 18.1% (FAO 1994). Among the molluscs, mussels formed 31.0%; oysters 27.2% clams and cockles 21.9%; scallops 15.7%; and other molluscs 4.2%. Although FAO estimated the aquaculture production of molluscs from India during 1992 at 2500 t, their cultivation on commercial lines is yet to take off in India.

The bivalve molluscs feed on phytoplankton and detritus. They are efficient convertors of primary production into food suitable for human consumption and give high production per unit area. Fertilisers and feeds are not used during the grow-out in open coastal waters.

Recently the setback to shrimp culture particularly in Andhra Pradesh due to adverse environmental impact and the outbreak of disease, has generated considerable interest to look for alternate candidate species, such as bivalves, for aquaculture.

Attention is also focussed to utilise the filter-feeding bivalve molluscs such as clams, oysters and mussels for the purification of the waster water of the shrimp culture ponds.

TECHNOLOGIES FOR FARMING MOLLUSCS

The technologies for pearl oyster farming and pearl culture, edible oyster culture, clam culture and mussel culture have been developed at CMFRI and are here briefly described. Detailed information is given by James and Narasimham (1993).

Pearl oyster farming and pearl culture :

In our country six species of pearl oysters occur and *Pinctada fucata* and *P. margaritifera* are of commercial value in pearl production. The former occurs in considerable numbers in the Gulf of Mannar and Gulf of Kutch and the latter is confined to the Andaman and Nicobar group of islands. General accounts on saltwater pearl culture in India are given by Alagarswami (1987 and 1991) and James and Narasimham (1994).

The technology for the hatchery production of seed for both the species was developed by Alagarswami *et al* (1983; 1989). Ripe pearl oysters are held in groups of 25 in the conditioning room in seawater at about 25°C and fed with mixed micro-algae grown in outdoor tanks. Spawning is induced by slowly raising the water temperature to about 33°C. The larvae are fed with live *Isochrysis galbana* and the spat with live mixed algae cultures. Spat settlement occurs in about 20 days and they grow to 3 mm size in 2 months from spawning.

For mother oyster culture the spat are grown in box-type cages of 40 × 40 × 10 cm covered with an inner 2 mm mesh velon screen and an outer 10 mm nylon fish net for protection against crabs and predatory fishes. As the oysters grow, the inner velon screen net is dispensed with and the cages are covered with nylone fish net of appropriate mesh size. The cages are suspended from racks erected in 1-2.5 m water or from rafts moored in 5 m depth in sheltered open coastal waters. The cages and the oysters are periodically cleaned to remove foulers and predators. Hatchery produced *P. fucata*, grown in the Tuticorin Harbour farm of CMFRI have attained 47.0, 64.5 and 75.0 mm at the end of 1 - 3 years respectively. The survival of both implanted and mother oysters in the grow-out of 10 - 12 months is about 80%.

P. fucata of 45 mm and above and in inactive/resting reproductive phase are used in pearl production. The oysters are narcotised with menthol and a wooden plug is inserted in between the valves. The ventural mantle of a donor oyster is cut into 2 to 3 mm long and 2 mm broad pieces for grafting. Mild solutions of eosin, mercurochrome or azumin in seawater are used in graft tissue preparation. A passage is cut through the gonad of the narcotised oyster upto the selected spot, the mantle piece is inserted through the passage followed by the shell bead nucleus so that the latter is in contact with the former. After nucleus implantation the oysters are kept under observation for 2 - 3 days in FRP tanks having mild flow of seawater. They are placed in box-type cages and transferred to the farm. The farming techniques are broadly the same both for mother oyster culture and post-operative culture except that additional care is taken on the implanted oysters. A technician can implant more than 100 oysters per day and 3-7 mm nuclei are used in *P. fucata*. In Indian waters the pearl grows fast and reaches marketable size in 3 - 4 months with 2-3 mm nuclei and 15 - 18 months with 6-7 mm nuclei. Multiple nucleus implantations are also done in the same oyster. In a recent study conducted by CMFRI at Valinokkam, Tamil Nadu, a total of 9414 pearl oysters implanted with 3-5 mm nuclei showed 22.4% mortality during one year post-operative culture. On harvest, out of the remaining oysters, 25.3% of them yielded pearls (A.C.C. Victor, personal communication).

The production cost of 1000 pearl oyster spat is estimated as Rs. 54 and that of mother oysters Rs. 1200. For pearl production, on an investment of Rs. 10 lakhs, net profit is envisaged at 26.5% (James and Narasimham, 1993).

Edible oyster culture : Oyster is among the most widely cultured species. As early as the first century B.C. the Romans developed simple methods of collecting oyster seed and growing them for food. Oyster farming is widely practised in temperatrue countries. To meet the growing demand for animal protein several tropical countries are developing oyster culture on commercial lines.

Of the six species of oysters found in Indian waters, *Crassostrea madrasensis* and *C. gryphoides* are suitable for culture. The former is widely distributed along the Indian coast while the latter occurs along the Karnataka, Goa and Maharashtra coasts. Technology of farming *C. madrasensis* has been developed at CMFRI and the details are given by Nayar and Mahadevan (1987) and Rao *et al* (1992).

The hatchery technology for seed production of *C. madrasensis* has been developed by Nayar *et al* (1984) and is essentially the same as described for the pearl oyster. Spawning is induced by thermal stimulation and the larvae are set as spat in 15-20 days. Pretreated oyster shells are laid as spat collectors in the larval rearing tanks as the larvae pass off the eyed stage. The larvae are set as spat on these shells. Also cultchless spat (free spat) are produced by placing 0.5 mm shell grit on polythene sheet, spread on the bottom and sides of the larval rearing tank. Nursery rearing and farming are carried out in open coastal waters such as bays.

There are several types of oyster culture which are broadly classified as 'on bottom' and 'off-bottom' methods. The on-bottom culture, also known as seabed culture, has not been experimented in India. Production by this method is low at 5 - 5.7 t shell-on/ha/year in U.S.A. and France. The off-bottom method also called suspended culture, is widely practised and has several advantages such as : it is independent of the type of substratum; relatively rapid growth; good meat yield; three dimensional utilisation of culture area; and predation is minimum. In the Tuticorin bay CMFRI has developed three types of off-bottom oyster farming, namely; rack and ren (string method); rack and tray; and stake culture. In the rack and ren method, oyster spat collected on shell strings are suspended from racks erected in shallow waters (depth 1 — 2.5 m) and the production is at 80 t shell-on/ha/year. In the rack and tray method cultchless oyster seed are stocked in box-type cages of 90 × 25 × 10 cm and placed on racks. The production is 120 t shell-on/ha/year. By this method the oysters generally attain uniform shape as they are not attached and are preferred for eating raw on half shell; also, price realisation is high. In the stake method a stake is driven into the substratum and the nails on the upper portion hold oyster shells with attached spat. By this method the production is estimated at 20 t shell-on/ha/year. The oysters are harvested when the meat yield is high at 9-10% of the shell-on weight.

Oysters, mussels, clams and scallops accumulate several pathogenic organisms in their body. By depuration, the bacterial load is brought down to permissible levels. The oysters are placed in cleaning tanks under a flow of filtered seawater for 24 hours followed by one hour immersion in 3 ppm chlorinated seawater.

It is indicated that in a 0.4 h oyster farm, on an investment of Rs. 83000, the net profit at the end of 1st year (one crop) is Rs. 22,500 (James and Narasimham, 1993).

Mussel culture : Two species of mussels, namely the green mussel *Perna viridis* and the brown mussel *P. indica* are cultivable. The former is widely distributed and the latter has restricted distribution along the southwest coast. Kerala State is called the 'mussel fishery zone' of the country and extensive beds of both the mussels occur in this State. Detailed information on the technology of mussel farming is given by Nayar *et al.* (1980).

The basic technology for the green mussel seed production has been developed by Sreenivasan *et al.* (1988) and for brown mussel seed by Appukuttan *et al.* (1988) and the techniques are the same as adopted for pearl oyster. Spatfall occurs from 20th day onwards.

On-bottom mussel culture is extensively followed in the Netherlands but has not been attempted in India. The raft culture method has been widely experimented at several locations with highly encouraging results. Rafts made of teakwood or bamboo poles measuring 5 × 5 m to 8 × 8 m size have been used. In the green mussel culture, seed of 20 - 30 mm in length are seeded on 5-8 m long ropes at the rate of 500 - 700 g seed/metre length of rope and suspended from rafts moored in 7-10 m water in the open sea during fair weather season. The studies conducted by CMFRI and other agencies at Ratnagiri, Goa, Karwar, Calicut and Madras gave production of 4.4 to 12.3 kg shell-on/m rope/4-6 months. Based on the studies at Calicut it is estimated that a 6-m rope yields 61.8 kg and a raft of 8 × 8 m size holding 100 seeded ropes yields 6.18 t of shell-on mussels in 5 months. In the case of brown mussel the production is 10-15 kg shell-on/m rope/7 months and with the seeded portion of rope being 5 m, a raft of 6 × 6 m holding 50 ropes gives 3.75 t shell-on mussels in 7 months. Meat forms 30 to 40% of shell-on weight.

In the raft culture of the green mussel it is estimated that on an investment of Rs. 2.1 lakhs the net returns are placed at Rs. 70,000 (James and Narasimham, 1993).

Clam culture : Among the exploited bivalve resources of India, clams are by far the most widely distributed and abundant. Important cultivable species are : *Anadara granosa, Paphia malabarica, Meretrix meretrix, M. casta, Katelysia opima, Villorita cyprinoides* and *Tridacna* sp. The figures released by MPEDA reveal that 769 t of frozen clam meat valued at Rs. 2.28 crores was exported from the country during 1993-94.

Viable hatchery technology for the production of the seed of *A. granosa, M. meretrix, M. casta* and *P. malabarica* has been developed at CMFRI (Muthiah *et al.* 1992; Narasimham *et al.* 1988; Sreenivasan and Rao, 1991) and the techniques are the same as followed for other bivalves. Spat settlement takes place between 7th and 16th day after spawning for different clam species studied. The spat attain 2-3 mm length in 2 months in the hatchery and are transferred to the field for nursery rearing. Nursery rearing is carried either in open water bodies such as bays or in ponds. Clams are cultured on the bottom and this method is substrate specific. Clam farms are located in estuaries and bays, close to the shore. Pen enclosures to prevent the movement of clams away from the stocked area and net cover for protection against predators such as crabs are also used in clam culture. In the blood clam (*A. granosa*) cultured in the Kakinada bay, seed clams of 5.53 to 7.08 g stocked at 140 to 175/m^2 have attained 25.53 to 32.9 g at harvest. Production rates of 39.0 to 41.6 t shell-on/ha/5-6 months are obtained (Narasimham 1980, 1983, 1988). The meat forms 15-20% of shell-on weight.

The blood clam is extensively cultured in China, Japan, Malaysia and Thailand. In Thailand it is grown along with shrimp in shrimp culture ponds (Saraya, 1982). In Taiwan, after the setback to shrimp culture due to disease, several shrimp culture ponds are used for farming the clam *Meretrix lusoria* (Chew, 1994). It is known that a change in the species mix helps to tide over the devastation of the stock due to disease. Similar practice can be adopted by shrimp farmers. The venerid clam, *P. malabarica* may also be considered for culture in the shrimp ponds as this species is much sought after in the overseas markets. This species accounts for the bulk of 769 t frozen clam meat (value Rs. 2.28 crores) exported during 1993-1994 from the country.

It is indicated that in clam culture on an investment of Rs. 19 lakhs, net profit works out to Rs. 5-lakhs (James and Narasimham, 1993).

General Considerations

Although complete package of technologies for the cultivation of several species of molluscs have been developed in the country they are yet to be commercialised for several reasons. The foremost is the stagnant demand and low market value. Unless the demand picks up the need to augment production through culture does not arise. Vigorous extension drive, coupled with product development for both local consumption and export market are needed. As farming of molluscs is altogether a new concept, initial hesitancy on the part of entrepreneurs is understandable. Availability of venture capital and soft loans are needed to develop mollusc culture. Conflict of interest in the usage of water bodies for mollusc culture and other activities such as traditional fishing, navigation etc. are bound to arise. The solution lies in demarcation of the areas for different users. It is necessary to enact legislature which permits leasing of public water bodies to entrepreneurs taking up mollusc culture. The information given in this paper on the economics of culture of various molluscs is indicative of the profitability and is based on the data collected during the operation of R & D projects at CMFRI. However, it is imperative that large-scale demonstration projects for various farming systems for the cultivation of molluscs are organised so that generation of sound data base becomes available to farmers/entrepreneurs venturing into mollusc culture.

References

Alagarswami, K. (Ed.) 1987. Pearl culture. *Bull. Cent. Mar. Fish. Res. Inst.* **39** : 136 pp.

——— 1991. *Production of cultured pearls.* Indian Council of Agricultural Research, New Delhi. 112 pp.

———, S. Dharmaraj, T. S. Velayudhan, A. Chellam, A. C. C. Victor and A. D. Gandhi. 1983. Larval rearing and production of spat of pearl oyster *Pinctada fucata* (Gould). *Aquaculture,* **34** : 287-301.

———, ———, A. Chellam and T. S. Velayudhan. 1989. Larval and juvenile rearing of black-lip pearl oyster *Pinctada margaritifera* (Linnaeus). *Aquaculture,* **76** : 43-56.

Appukuttan, K. K., Mathew Joseph and K. T. Thomas, 1988. Larval rearing and spat production of the brown mussel *Perna indica* at Vizhinjam. *Bull. Cent. Mar. Fish. Res. Inst.,* **42**; pt. **2** : 337-343.

Chew, 1994. Shellfish culture in Taiwan. *Aquaculture Magazine.* **20** (2) : 69-75.

Fao, 1994. Aquaculture production. Circular No. 815, 216 pp.

James P. S. B. R. and K. A. Narasimham. 1993. *Handbook on Aquafarming - Molluscs.* Marine Products Export Development Authority of India, Cochin. 87 pp.

——— and ——— 1994. Saltwater pearl fisheries and pearl culture in India — An update. *Aquaculture Magazine.* **20**(4) : 41-49.

Muthiah, P., K. A. Narasimham, C. P. Gopinathan and D. Sundararajan. 1992. Larval rearing, spat production and juvenile growth of the blood clam, *Anadara granosa* (Linnaeus). *J. mar. biol. Ass. India,* **34** (1 & 2) : 138-143.

NARASIMHAM, K. A. 1980. Culture of the blood clam at Kakinada. *Mar. Fish. Infor. Ser., T & E. Ser.*, **23** : 7-9.

——— 1983. Experimental culture of the blood clam *Anadara granosa* (Linnaeus) in Kakinada Bay. *Proc. Symp. Coast. Aqua.*, Part II : 551-556. Marine Biological Association of India, Cochin, India.

——— 1988. Aspects of blood clam *Anadara granosa* (Linnaeus) culture in Kakinada Bay. *Bull. Cent. Mar. Fish. Res. Inst.* **42** (2) : 313-317.

———, P. MUTHIAH, C. P. GOPINATHAN AND A. D. GANDHI. 1988. Larval rearing and spat production of the great clam, *Meretrix meretrix* (Linnaeus). *Indian J. Fish.* **35** (2) : 107-112.

NAYAR, K. N., S. MAHADEVAN, K. ALAGARSWAMI AND P. T. MEENAKSHISUNDARAM (Eds.). 1980. Mussel farming - Progress and Prospects. *Cent. Mar. Fish. Res. Inst. Bulletin* No. 29 : 56 pp.

———, M. E. RAJAPANDIAN, A. D. GANDHI AND C. P. GOPINATHAN. 1984. Larval rearing and production of spat of the oyster *Crassostrea madrasensis* (Preston) in an experimental hatchery. *Indian J. Fish.*, **31** (2) : 233-243.

———, AND S. MAHADEVAN (Eds). 1987. Oyster culture — Status and Prospects. *Cent. Mar. Fish. Res. Inst. Bulletin* No. **38** : 78 pp.

RAO, K. S., M. E. RAJAPANDIAN, P. MUTHIAH, R. PALANISWAMY, K. RAMADOSS AND C. P. GOPINATHAN. 1992. *The Indian edible oyster — Technology of seed production and farming :* 23 pp. Central Marine Fisheries Research Institute, Cochin.

SARAYA, A. 1982. Thailand - Country paper. In. *Bivalve culture in Asia and the Pacific* (Eds : F. B. Davy and M. Graham) I. D. R. C. 200 e : 73-78. Proceedings of a workshop held in Singapore 16-19 February, 1982, Ottawa, Canada.

SREENIVASAN, P. V., K. SATYANARAYANA RAO, P. POOVANNAN AND R. THANGAVELU. 1988. Growth of larvae and spat of the green mussel *Perna viridis* (Linnaeus) in hatchery. *Mar. Fish. Infor. Serv.*, T & E Ser., No. **79** : 23-26.

——— AND ——— 1991. Spawning, larval development and spat settlement of the clam, *Meretrix casta* (Chemnitz); in the laboratory. *Indian J. Fish.*, **38**(1) : 1-8.