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MUSSEL CULTURE IN INDIA—CONSTRAINTS AND PROSPECTS

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Europe has been the centre of commercial mussel farming in the world and production has been nearly stagnating over the past decade in the major mussel producing countries—Spain, the Netherlands, France and Italy, due to common problems of high cost of production through advanced technologies, limitations of growing grounds and the price structure not being commensurate with cost of production. It is believed that any substantial increase in world production of mussels can come about only through expansion of mussel culture programmes in the developing countries, including India.

Due to several limitations, natural production of mussels in India cannot be increased more than 2-3 times the present sustenance level. The technology of mussel culture which has been developed at the Central Marine Fisheries Research Institute has shown the high production potential and field extension programmes have already been taken up. In the paper, the constraints for expansion of mussel culture into the level of a small industry have been identified.

The need for research thrusts for improving the technology and increasing production rate has been highlighted. Areas which need such efforts are seed production, transplantation of mussels, studies on ecology and physiology of mussels, experiments on mixed farming, improvements in the culture system specific to our coastal conditions, pollution and disease problems and post-harvest technology. Legal aspects relating to lease of water areas and navigational problems have been touched upon.

The immediate need is for a perspective planning for the development of mussel culture as an industry with the full realisation of its potential. Governmental support and assistance from public financing institutions with an element of risk coverage in the initial stages would help the establishment and growth of the industry.

INTRODUCTION

The world mussel production has been stagnant around 400,000 tonnes over the last decade despite the realisation that mussel culture has the highest potential for production as compared to the culture of any other organisms—fin-fishes, crustaceans or other molluscs. This has been mainly due to the fact that mussel farming as a business has concentrated only in Europe, particularly in four countries—Spain, the Netherlands, Italy and France, and developments elsewhere have not been significant to any degree as to contribute perceptibly to the world production. Certain common factors have affected the growth of mussel culture in Europe. They

are limitations of growing grounds, increasing labour costs and farming risks, pollution problems and prices not being commensurate with increasing production costs as a result of introduction of mechanisation, technological innovations and material sophistication. This situation is likely to continue until there is a price tilt in favour of cultured mussel.

While there is a long history of exploitation and farming of mussels in Europe, recognition of its importance has been slow to develop elsewhere in the world. In the Far East, where mussel had been considered a pest, there has been an awakening and the Philippines, Thailand and more recently, Singapore have taken up small ventures of mussel culture. New Zealand, Australia, South Africa and South America are some of the other regions where experimental work as well as production-oriented programmes have been initiated in the recent years. The two major aquaculture countries—Japan and U.S.A.—do not show any interest in mussel culture due largely to consumers' non-favour.

It would therefore appear that any substantial increase in world production of mussels can come about only through expansion of the current development programmes in the non-traditional regions such as the South, South East and Far East Asia, South America, South Africa, Australia and New Zealand. The commonest advantages of Asian mussel culture would be its tropical waters where the mussel attains harvestable size within 5-6 months as against 2-2½ years in some parts of Europe and the cheap labour. The problems likewise common, would be making mussel acceptable as food for the large population and holding the price structure remunerative to the mussel farmer and within the reach of the poor who are in need of protein food most for improving nutritional standards.

Davies (1970, *Proc. Symp. Mollusca*, 3 : 873-884[1]), based on map reading, estimated a million and a quarter acres of creeks and gulfs between Karachi, Ceylon and the Ganges and projected that, at a yield of a ton per acre, this area, if cultivable, would produce a million and a quarter tonnes of mussels, enough to give 20 million people day's protein ration once a week throughout the year. This projection for India, although might appear speculative, is indicative of the scale of probable production if an all-out effort were to be made to realise this potential.

In India we have built up the primary infrastructure, that is the technology of mussel culture, which has been good enough to attract some governmental investment and interest of fishermen. Extention and expansion would depend on fixing developmental priorities and aiding the process carefully through integrated measures of production and marketing.

Natural Production of Mussels

Jones and Alagarswami (1973, *Proc. Symp. liv. Res. Seas India*, 641-647, Spl. Publ. CMFRI[2]) made a preliminary estimate of the natural production of mussels (exploited) at 823.4 tonnes and also believed that an estimate of 1000 tonnes as the total marine mussel landings of India will not be wide of the actual figures. Since the above estimate was made there has been some increase in the landings, particularly in the mussel zones of Calicut-Tellicherry and Vizhinjam-Colachal-Muttom.

The natural distribution of mussels along the Indian coast is patchy. While dense settlement of the green mussel *Perna viridis* is seen along the Malabar Coast (Cannanore-Calicut), it is scattered/scanty in other areas including the Andaman Islands. New settlements of green mussel on the submerged parts of sea wall and groynes between Quilon and Narakkal along the Kerala coast have been seen in recent years, but the resource is very limited. The brown mussel *Perna indica* is restricted to the south-west coast (Quilon-Cape Comorin) and is not reported from elsewhere. Thus the mussel beds are very much restricted and there does not appear to be much scope for increasing production from these areas by the traditional fishing methods beyond 2 or 3 times the present level even if the effort were to be increased. The only alternative for stepping up production is through adopting culture techniques.

Status of Mussel Culture in India

The Central Marine Fisheries Research Institute has carried out pioneering researches on mussel culture in India. Starting its work at Vizhinjam on the brown mussel *Perna indica* in the early seventies, the Institute has developed the techniques of floating raft culture in the Vizhinjam Bay (*CMFRI Spl. Publn.* 2, 1978[3]). Since 1978 experiments on open-sea mussel culture have been conducted outside the bay (*Mar. Fish. Infor. Serv. T & E Ser.*, No. 16, 1980, CMFRI[4]). The relative merits of mussel farming in the bay and open-sea have been identified. While growth of mussel is faster in the open sea, maintenance of rafts during the south-west monsoon has been found to be a major problem in taking advantage of this factor.

Experiments on the culture of the green mussel *P. viridis* were initiated at Calicut in 1975 and have

provided valuable data and an insight into the problems of open-sea culture. The production has been high in suspended culture and indications are that it could be as high as in the Galician Bays of Spain, the leading mussel culture centre of the world, if farm management could be improved upon. The south-west monsoon forces the harvest to be taken in April/May, the seeding being done in November/December, and the mussel attains marketable size within these five months.

At Kovalam near Madras, culture of green mussel in floating rafts faces the problem of rough sea conditions including periodic cyclones. An experiment on the French-style pole culture has proved a failure as the poles could not withstand the strong currents and cyclone. Submerged raft culture has been tried with partial success in 1979 and the system is under improvement. Along this coast also *P. viridis* attains marketable size within 5-6 months.

The production rate in suspended rope culture of mussels has been 10-15 kg per metre length of rope in 5 to 6 months and length of individual ropes has ranged from 5-7 m according to the depth of the experimental farm. This compares very favourably with about 25 kg ($\frac{1}{2}$ cwt) of mussel yield in a 10 ft. long rope within 16 to 18 months of settlement in a Scottish loach (Mason, 1969, *World Fishing*, 18(4) 22-24[5]).

In the open-sea culture the distance of the mussel farm has been 0.5-1.0 km off Kovalam and about 3 km off Calicut.

The seed grounds for collection of seed for the experimental farms have been identified and transportation methods have been evolved. So far wild stocks of seed have largely been used in farming and seed obtained on untwisted nylon ropes in the farm itself has also been used to a limited extent at Vizhinjam. Spat settlement and commencement of culture operations in the farm do not coincide both at Calicut (south-west coast) and Kovalam (Madras coast). At the latter centre, where green mussel was transplanted, suspension of a breeding stock from the raft results in good spatfall on the 'Mangalore type' baked tile cultch. Apparently the circulation pattern in the inshore waters off Kovalam appears conducive to the growth of the larvae and settlement of spat in the same area without drifting away from the area of spawning.

Based on the results obtained over the years, extension programmes on mussel culture have been initiated with the involvement of the scientists in the work. An Operational Research Project for the blending of culture of mussels with the traditional capture fisheries of the fishermen has been taken up at Kovalam.

The Lab-to-Land programme on mussel culture, where the technology is transferred to fishermen, functions at Calicut (S.W. coast) and Karikattukuppam, a fishing village adjacent to Kovalam (Madras coast). A pilot project on brown mussel culture is in operation at Vizhinjam by the Department of Fisheries of Government of Kerala.

Some work has been done on development of mussel products acceptable to consumer's at the Central Institute of Fisheries Technology, Cochin, under an Inter-Institutional Project with the Central Marine Fisheries Research Institute. The former (CIFT) has also carried out extension programmes on mussel products.

Development Constraints in Mussel Culture

Despite the fact, that the technology of mussel culture has been developed and some demonstrations have been conducted through extension programmes, there has been no large-scale adoption of the technology so far for increasing production. The constraints faced in developing mussel farming as an industry can be summed up as follows :

(*a*) Mariculture as a whole is a new venture for the country and therefore there is some hesitation on investments for any work in the sea.

(*b*) Acceptance of mussel as food is very low and is restricted to a few pockets in the coastal areas. The present wild production more or less meets the demands of this limited consumer sector. There is an urgent need for enlarging acceptability through a well-organised nutrition programme.

(*c*) The seafood processing industry has not taken any serious note of the export potential and efforts have so far been lacking for exploring export markets for the Indian mussel.

(*d*) The present selling price of wild mussels is related only to the labour costs as no capital investments, barring that on the canoe, are involved. Mussel farming, by the raft method, involves some capital expenditure and maintenance costs and, therefore, any venture would presuppose realisation of higher prices for cultured mussels than for the wild. Unless demand increases considerably either for internal consumption or for exports it would be difficult to get a favourable price structure for cultured mussels.

The above constraints are the foremost stalling the development of a mussel culture industry in the country

and these are areas for governmental consideration for taking appropriate measures. There are good reasons for providing this support as mussel culture would increase production of animal protein to meet the needs of the fast growing population, create employment opportunities and earn foreign exchange through production of high priced commodities. This would also lead more meaningfully towards diversification in our fisheries and socio-economic improvements in the small-scale fisheries sector.

Research Thrusts

Although the basic technology for mussel culture has been developed, there are several aspects which need research efforts for improving the technology and increasing production.

(a) Seed production

One of the major constraints a mussel culture industry would face is the shortage of seed supply for the farms. Availability of mussel seed in the wild is severely restricted to a few rocky patches and this cannot meet the demands. It would be necessary to identify strategic sites for collection of mussel seed through suspension of spat collectors which could act as the seed farms. The groynes laid along some parts of the Kerala coast as an anti-erosion measure have proved to be good collectors of the plantigrades of green mussel (Nair *et al.*, 1975, *Indian J. Fish.*, **22** : 236-242[6]). As mentioned earlier, suspension of breeding stock from the raft at Kovalam has resulted in good spatfall on several occasions. These are indicative of the types of experimental work needed to be carried out for locating sites for seed farms and developing appropriate methods for attracting the spat to settle. The Forest Research Institute at Dehra Dun has, over the years, carried out extensive work on marine fouling organisms by laying panels at different centres and at different depths and it would be worthwhile sifting the records for data on mussel 'fouling' to get an indication of the areas where further intensive efforts could be spent.

Another aspect of seed production is the development of hatcheries. There has been very little attention in the world for developing hatcheries for mussels although oyster, calm and abalone hatcheries have been developed on a commercial scale. The mussel industry of Europe has not faced any crisis of seed shortage due to abundant natural supply. Unless low-cost natural seed farms could be developed as envisaged, it would be imperative to go in for hatchery technology for production of mussel seed.

(b) Transplantation

Strategies for transplantation of spat or seed mussel to areas of poor spatfall but high phytoplankton productivity and thus conducive for culture will have to be developed for large-scale development programmes in mussel culture.

(c) Ecology and physiology of mussels

Information on the biology of the green and brown mussels is scanty and is limited to growth studies and spawning periodicity. Some work has been done on larval development. There is need for intensive researches on reproductive biology, larval history, spatfall, larval and adult nutrition, diseases and parasites and mortality, physiological studies on biochemical composition, metabolsim, osmotic adaptations, neurosecretory control of reproduction, tolerance limits to salinity and temperature changes, suspended materials and feeding efficiency, reactions to photic changes and other stimuli, byssus secretion and locomotory capability of mussel from spat onwards. Knowledge on these aspects can be utilised in improving various aspects of mussel culture.

(d) Mixed farming

It has been suggested that multispecies aquaculture systems would be more efficient and productive than single species systems for oysters, clams and mussels (Tenore, K.R., J. C. Goldman and J. P. Clarner, 1973. *J. exp. mar. Biol. Ecol.* **12** : 157-165[7]). In this context, the food chain dynamics, especially ecological efficiency of mussels, need detailed studies. The utilization of the same mussel rafts simultaneously for cage culture of fin-fish and lobsters should be considered. Part of the mussels collected in the process of thinning the ropes could also be used as feed for these organisms.

(e) Culture ecosystem

Another important aspect for research is the mussel culture environment. There is need for a survey of the coastal areas and identification of suitable sites for mussel culture with reference to coastal configuration, sea and wind conditions, land drainage, physico-chemical factors and pollution susceptibility. The productivity of the sites should be studied in greater detail to understand the potential of biomass production.

Silting would be a major problem in large-scale mussel culture as the entire water column is used for production. Besides accumulation of suspended matter, the faecal discharge of the massive population in the farm will in itself amount to a considerable suspension load and might act as a source of pollution.

These factors would bring about a change in the ecosystem itself and their effect on the efficiency of filtration of mussel which is also the mechanism of its feeding should be understood. These studies would help in determining the carrying capacity of a given water body, including the number of rafts to be used in a given area.

The growth potential of mussel in different ecosystems—estuaries, bays and open sea—needs investigation. Biofouling and boring are two major aspects affecting the production of a farm ; the former is a serious problem in post-harvest treatment. Economical and effective control measures should be developed. Predation by fish and lobsters has already been observed in the mussel farm and this could be a major factor affecting production.

(f) Pollution and disease problems

Molluscs are well known for their uptake and retention of pollutants. They are also usually a source of bacterial and virus diseases. Faecal pollution is known to affect mussels, both in the farm as well as in natural beds.

Could the green or brown mussel be used as an indicator of pollution, particularly the accumulation of toxic heavy metals from the sea water ? Little is known about the accrual of cadmium, zinc, copper, mercury and other heavy metals in the tissues of mussels, their storage and excretion. The kinetics of this need study to understand better the mechanisms of immobilisation and detoxication of metals, if any, in mussels. Tolerance levels should be fixed and regulations formulated and enforced, and depuration techniques adopted so that only clean mussel meat is passed on to the consumers.

Paralytic shell-fish poison in mussel flesh has been reported in Britain and some other countries due to outbursts of certain species of dinoflagellates which are taken by the mussels. Continuous monitoring of mussel farms will be necessary to prevent such outbreaks. In our waters, the effects of noxious blooms of dinoflagellates such as *Hornellia marina* and other organisms need special study, as destructive blooms occur along the south-west coast periodically. Sale of mussels during such periods may have to be stopped.

(g) Genetics

In mussel culture, genetics may play an important role though not in the immediate future. This may be in developing viable strains with desirable meat quality or delayed maturation so that better growth conversion is obtained or in producing strains resistant to diseases.

(h) Post-harvest technology

Post-harvest technology has an important role in developing products both for the export market and for internal consumption. The first task would be to develop suitable low-cost process for depuration. Processes such as chlorination, ozonation or ultraviolet light treatment are used for purification of oysters in other countries. The one which would be within the reach of a common mussel farmer and effective at the same time should be developed.

The technology of suspended culture is basically dependent on the byssal attachment of mussels to the ropes and shells. In this process the mussels develop a strong byssus the removal of which is a laborious task after harvest. Suitable technique should be developed for simple mechanical removal of byssus without injuring the body tissue.

It has been found that the mussels in the farm exhibit a pronounced reproductive phase within the five-month period of culture and the gonads acquire a strong brick-red colour. Consumer acceptance may be affected by the colour of the gonad. The culture technology as well as post-harvest technology should devote attention to this aspect.

Some work has been done on processing and product development of mussels. An intensified effort is necessary in this direction taking into account market demands, acceptability and purchasing power of the consumers. Elsewhere Mussel Protein Concentrates has been developed for the European consumers.

(i) Farming technology

The farming technology itself needs innovations. Raft culture as practised today has severe limitations for our open-sea conditions. Buoyancy, stability and mooring of rafts are the three aspects which need improvement with regard to durability and in terms of reduction of costs. The entire system of raft culture should be improved to suit the open coastal conditions and to withstand the monsoon so that year-round culture with two harvests becomes possible. At present farming is done only half the year and the rafts are beached in the unfavourable season. Submerged rafts are under trial and, if successful, would form a solution. Buffering the wave action with automobile tyres, flexible rafts, and long-line culture are some of the aspects for experimentation. The system of farming must be made less tiresome for the people who work on it. Thus there has to be a detailed reconsideration of all aspects of the farming system for evolving a suitable technology

for open-sea mussel culture. Marine farm engineering has to come into play in this development.

Legal Aspects

For farming of any organism either on land or in water, ownership or lease right with protection against encroachment is a pre-requisite. In all the countries where mariculture is in vogue, there is a system of leasing of public water areas to individuals or groups so that the farming activities are carried out without interference. India is just entering into mariculture and it is time that aspects of leasing of water areas are considered in detail and regulations formulated.

Development of mariculture in the coastal areas might often come in conflict with the traditional coastal fisheries in regard to areas of operation, right of navigational passage, possible change in resource structure and damage to fishing or culture equipment. In anticipation of such problems, suitable measures should be worked out for a healthy growth of both the capture and culture fisheries sectors.

Ship navigation is another important aspect and mariculture activities should not infringe on navigational requirements.

Prospects of Mussel Culture

It has been well recognised that the marine living resources should be increasingly exploited to meet the protein requirements of the people. In terms of production potential, mussel is one of the best resources of the sea and quantitatively it surpasses the production rates of any currently cultivated animal on land or in the sea. To this must be added the fast growth rate of mussels in our waters. It is therefore only judicious that this advantage is converted into practical application. The present annual marine fish production of India is around 1.4 million tonnes. This could be substantially augmented if mussel culture is taken up on a large scale. Besides meeting part of protein requirements of the people of the country, it offers scope for foreign exchange earnings, employment potential in the coastal areas and in putting the presently under-utilised areas into better production. There is also scope for blending of mussel farming with the traditional vocation of the marine fishermen community for providing an additional occupation with income potential.

The immediate need is for a perspective planning for the development of mussel culture as an industry with the full realisation of its potential. The constraints—technological, developmental and extension needs—have been indicated earlier in the paper. These aspects should form a part of the integrated approach. Governmental support and assistance from public financing institutions with an element of risk coverage in the initial stages would help the establishment and growth of the industry. Mussel culture should, at least to begin with, be viewed as a social necessity with a bias on nutritional improvement of the people. Later the industry would be governed by the usual norms of demand and supply.