Bivalve mariculture in India – progress in research and development

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Introduction

We are all aware that with an average growth rate of 6.9% per annum, aquaculture is the fastest growing food production sector in the world (FAO, 2009) and now accounts for nearly half of the global fish production. Given the projected population growth over the next two decades, it is estimated that at least an additional 40 million tonnes of aquatic food will be required by 2030 to maintain the current per capita consumption. Among the Asian countries, India ranks second in aquaculture and third in capture fisheries production and is one of the leading nations in marine products export. In mariculture, India has been a late starter in developing and commercializing technologies. I recall that in the nineteen eighties, as Director of CMFRI, I gave impetus to research programmes on culture of a number of marine species, such as, mussels, oysters, pearl oysters, sea cucumbers, seaweeds and the like which has now led to a fledging small-scale industry. Until then, mariculture was confined to traditional shrimp culture practices. During the nineteen eighties and nineties several comprehensive technologies, including hatchery techniques for production of seeds were developed for farming in coastal water bodies.

Traditionally, in India, bivalves have always been considered as subsistence food of the poor, save for pockets of high consumption like the Malabar and Goa coasts. In Malabar and Goa culinary preparations with bivalves go a long way back in history. But, taking into account the status of bivalves in international aquaculture production (a third of the total by weight) and trade, focus was placed on developing technologies for its farming and hatchery production of seeds. Through this focused attention, techniques for farming mussels, oysters and pearl oysters were developed by the CMFRI in the nineteen eighties, but they did not achieve commercial status until the mid-nineties. In the case of mussels and oysters due to concerted technology transfer efforts by CMFRI from the nineties, the combined production has crossed 20,000 tonnes making India one of the top-ten countries in Asia in bivalve mariculture production. In marine pearl culture too India has made significant achievements in developing a pearl production technology, besides a protocol for hatchery production of pearl spats. However, several issues hinder its development on a commercial scale. Let us examine in brief the progress in farming for each of these commodities.

Mussel farming

Although the technology for mussel farming has been demonstrated in several locations within Kerala State and in different maritime States, the diffusion of the technology was predominantly in northern districts of Kerala and now rapidly spreading to other southern districts as well. Several reasons, such as, fast growth of mussels because of favorable hydrological and geoclimatic conditions, availability of seed from nearby coastal areas, and availability of loans and subsidies from banks and development agencies have been identified as contributory factors for this development. Three types of farm ownerships are observed: individual, family, and ownerships by self-help groups (SHGs). The adoption curves are such that there were only a few adopters initially followed by an increasing rate of adoption in the subsequent years because of the demonstration effect. There is a deep-rooted ''risk aversion'' attitude widely prevalent among technology adopters. Age could not be significantly related to technology adoption, while education and occupation of the respondents significantly influenced the technology adoption process. The biggest outcome of mussel farming in Kerala was the empowerment of women with 87% of the SHG farms owned by women. The successful diffusion of mussel farming is the result of a combination of factors, chiefly, the availability of suitable water bodies; high rate of education; proximity of mussel markets and high degree of mussel consumption in the area; and a unique synergy between technology developers (CMFRI), promoters (State development agencies such as BFFDA and ADAK), and credit advancers (local cooperative banks). This development scenario can surely work as a role model for other states and developing nations where similar hydrological, social, and market environment exists.

The basic method of farming developed and promoted by CMFRI in India is by constructing trestles (called racks in India) and suspending the seeded ropes from the horizontal platform in shallow seas and estuaries, though in certain regions, seed mussels are just sown on the substrate (on-bottom) and farmed.

The annual production of farmed mussels has shown a gradual increase from 1997 and it was steep particularly from 2003. On-bottom farming, which is a custom of simply relaying of seed mussels with low inputs, contributed 19% to the production. In certain estuaries, where the depth is less than 1.5 m, the seeded ropes are not hung vertically; rather, they are tied horizontally parallel to estuary bottom. The value of the mussel produced is estimated at $US 12 million on the basis of farm-gate prices during the period 2009–2010. The total area utilized for trestle farming in 2005–2006 was estimated at 14.14 ha, and onbottom farming was done in 11.17 ha in the state mainly at Kozhikode and Malappuram districts. The average productivity for trestle method was estimated at 564.9 tonnes/ha, while for on-bottom method, it was 171.9 tonnes/ha. However, there were regional differences in productivity, with high values in Kasaragod and Ernakulam and comparatively low values in Kozhikode and Malappuram.

Credit constraints can be a problem for small aquaculture farms in developing countries and it can actually impede adoption. The subsidies provided by the government agencies served to attract villagers to the mussel farming technology, and these first-time adopters continued the farming activity even after cessation of the subsidy after the first year. Obviously, it is the profitability and creditworthiness of mussel farming technology that has driven the adoption process in Kerala. The rate of returns from mussel farming ranged from 190 to 350% and the capital recovery factor ranged from 1.7 to 3.3, depending on the location. As a spin-off, several small business enterprises which supply other inputs for farming have also been established; the economic value of which has been assessed as nearly a million dollars.

Refinements in mussel farming technology have been made by CMFRI to reduce capital costs (mainly on nylon ropes) by using alternate core materials and pre-stitched cotton net tubes. Seeding is one of the most critical activities in mussel farming. The process which is physically demanding (as farmers have to kneel and bend down to do it) is crucial to the success of farming as the uniform attachment of mussel seed around the rope is dependent on how well it is done. Now, to reduce the physical strain and to increase efficiency during this process, a semi-automated mussel seeder has been designed, developed and field tested. Both old and new farmers have adopted this technical advancement. The chief advantages of the seeder are reduction in time taken for seeding resulting in increased efficiency and lower labour costs and reduction in physical strain during the process. The time taken for manual stitching of 1m rope by the conventional method is 8 minutes whereas in the seeder the same can be accomplished in 2 minutes.

Another innovation to easily separate the mussels from the rope during harvest a semi-automated mussel declumping machine has also been developed. The machine had two separate units, a metal drum and a metallic circular fixed shield with a central opening with a diameter of 10mm fixed on a stand and a ramp for placing the harvested rope. One meter mussel rope could be de-clumped in two minutes. The chief advantages were that physical exertion during harvesting could be avoided and that it was more hygienic and efficient.

Oyster farming

Growth in commercial oyster farming in India has not been as phenomenal as that of mussels. Again the state of Kerala, particularly the southern districts, has taken the lead. Although, oysters form an integral part of the biota in intertidal areas all along the Indian coast, oyster fishing is mostly at a subsistence level catering to very restricted local markets, particularly in the states of Kerala, Maharashtra and Goa. The oyster farming technology developed by CMFRI in the nineteen seventies following the rack and ren and rack and tray methods could not be commercialized for more than 20 years due to lack of consumer demand. Again, it is the concerted technology transfer efforts by scientists of CMFRI that has led to a commercial practice. The technology adoption has been slow, mainly because of the difficulty in post harvest handling of oysters and the limited markets. Even among oyster consumers, the preference is for cooked meat, rather than whole and live, making heat shucking a necessity. Heat shucking is tedious in the case of oysters as compared to mussels, as they open their valves only on strong steaming. Besides, oyster processors invariably complain about cuts and bruises on their hands while shucking the oyster meat. So much so, many first-time oyster farmers in Ashtamudi, Kayamkulam and Vembanad Lakes of Kerala have switched to mussel farming. However, this trend is recently being reversed due to better market price and also the realization that oysters are more euryhaline than mussels, and hence more conducive for culture in an estuarine environment.

Women SHGs are in the forefront of oyster farming activities, with nearly 2000 families from central and south Kerala being involved. Production has touched nearly 2500 tonnes, and oyster farming has developed as a small-scale industry. Activities related to seed collection, seeding, heat shucking and marketing has led to economic empowerment of villagers especially women.

The development of hatchery technology for oyster seed production paved the way for the expansion of oyster culture into new cultivable areas where no natural stocks were available or natural spatfall was poor. Initially the set larvae (spat) on cultch were transported from hatchery to culture site. Now scientists of CMFRI have been able to develop a remote setting method by which eyed or pediveliger larvae are transported without water, in moist condition to distant places where they are set on the cultch material. The use of this technique has revolutionized oyster farming along the west coast of USA and is expected to make similar impact here too.

The CMFRI has recently taken up an ambitious R&D programme funded by the World Bank to speed up technology adoption in oyster farming in the states of Kerala, Goa and Maharashtra. Through a value-chain approach, it is planned to develop depuration units, value-added products units and an oyster hatchery along the west coast ensuring supply of spats through the remote setting technique. Of interest is the recent attention in live oyster consumption in high-end restaurants in metropolitan cities linked to the backwater tourism industry. Initial results indicate that the unit price of oysters can go up by as much as 10-times through this value-chain and can function as a means of attracting new farmers and increasing production.

Impact assessment of farming

Bivalve farming is not an entirely eco-friendly practice of aquaculture as previously thought. Several studies abroad and in India have shown that continued farming in one location leads to bio-deposition and change in benthic in-faunal community structure. Indian farmers are advised not to keep farm location in one place for more than 2 years. The ecological disaster which portends widespread farming of bivalves in semi-enclosed water bodies has also been addressed by scientists of CMFRI. The carrying capacities of some of the water bodies for bivalve farming have been determined and this information needs to become an essential input of the regulatory mechanisms. Farm structures and bivalves obstructs the free flow of water currents through the farm site thereby aiding sedimentation and organic enrichment but the short-term farming period during the impacts were not significant. However, short-term oyster/ mussel farming does not alter the sediment characteristics under the farm.

Mussel watch

Bivalves have been used as sentinel organisms for monitoring contaminants in the marine environment and mussel watch data has been used for assuring seafood safety. They are efficient bioaccumulators of heavy metals, polycyclic aromatic hydrocarbons and other organic compounds, and because they are sessile they may reflect local contaminant concentrations more accurately than mobile crustaceans and finfish species. A recent study indicates that coastal waters of Karnataka and Kerala are minimally contaminated with genotoxic and carcinogenic chemicals.

Bivalves- Organic by default

Organic farming is based on holistic production management systems which promote and enhance ecosystem health, including biodiversity, biological cycles and biological activity. Bivalve shellfish aquaculture meets each of these criteria, and in fact, is probably organic by default. Bivalve molluscs are not fed so there are no nutrients being added to the marine environment. They are biofilters which feed on phytoplankton which occurs naturally in the water. This biofiltering activity has the beneficial secondary effect of taking up nutrients and purifying the water column, thereby enhancing ecosystem health. Bivalves also create habitat for other marine creatures. As three-dimensional structures, bivalves are host to flora and fauna which make their homes in shellfish beds. These beds also provide cover and forage for fish during their juvenile out-migration stage, enhancing biodiversity, biological cycles and biological activities through the creation of critical habitat. With a view to meet the demands of the discerning customers, and also to enhance the value of the product (by as much as 30%), organic bivalve farming protocols and guidelines have been developed as part of the NPOP (National Programme on Organic Protocols) in India. The focus here has been on classification of bivalve growing water bodies following the regulations of the European Union (EU Directive 2006/113/EC). Currently Indian bivalves are not exported to Europe, as the produce does not meet the monitoring protocols set by the EU. Efforts to meet the regulations are being jointly addressed by the MPEDA, CMFRI, CIFT and EIC and it is expected that exports to the EU would be possible in a couple of years.

Pearl Farming

As a technology very close to my heart, considering that we are coaxing the oyster to produce one of the most bewitching of natural gems, I kept this for the last. The allure of the pearl, the most ancient and most precious of gems is timeless and universal for humans. The pearl has a history more ancient, more fascinating and more regal than any other gem and India has a wealth of marine pearl producing oysters: the Pinctada fucata distributed in the Gulf of Mannar, Palk Bay and Gulf of Kutch and the blacklip pearl oyster, P. margaritifera in the Andaman and Nicobar Islands. The technology for pearl production, based principally on the Japanese methodology of pearl production, was tried and developed successfully in the Indian pearl oysters mainly through the efforts of Dr. K. Alagarswami and his team of scientists from the CMFRI. Later, in the eighties, they went on to standardize the hatchery protocols for this species too.

Once again, this is a technology developed in the nineteen seventies, but unlike mussels and oysters, yet to become a full-fledged commercial practice in the country. I am glad to understand that through funding from the Ministry of Earth Sciences (MoES), the CMFRI is very seriously attempting to transfer the technology through women SHGs in coastal villages in the Gulf of Mannar, Kerala and Lakshadweep. The newly developed technique of mabe pearl production, which is relatively less skill-demanding, and with fast turnover rates (2 months), serves to attract farmers to pearl farming. The MoES is also funding a project on black pearl production in the Andaman and Nicobar Islands being executed by CMFRI. During the last 7 seven years, this project has been able to establish pearl farms and on-farm grow-out techniques; establish a black pearl hatchery and achieve success in production of pearl spat; develop and standardize mabe pearl production technique and develop technique for continuous mabe production without sacrificing oysters and conduct training programmes to shellcraft artisans and women fishers on mabe production. Black pearl production itself has not been achieved yet, but as I understand, a lot of effort is being put to achieve it. Indeed, the scenario in Indian pearl farming appears poised for a big leap forward and I look forward to seeing it during my lifetime.

Clam Farming

A number of clam species, mainly belonging to Veneridae, Arcidae and Corbuculidae family are fished from coastal waters of India, and annual estimates of catches are close to a 100,000 tonnes. Because of the high inter-annual variability of the resource, many fishers have resorted to re-laying of seed clams in water bodies close to their homesteads particularly in Kerala and Karnataka. Out of the total production nearly 10% is obtained through this semi-culture practice. Earlier, the CMFRI had brought out a culture technology package using pen enclosures for the blood clam Anadara granosa with a production potential of 40 t/ha/6 months, however, this has not reached commercial application yet. Currently, major attempts are being made to develop on-bottom and off-bottom clam farming techniques for the black clam (Villorita cyprinoides) and the short-neck clam (Paphia malabarica), which have reasonably good price structure locally and abroad.

On Gender and Bivalves

The development scenario scripted by bivalve farmers in Kerala shows that women were the major players with more than 4,000 women becoming owners of bivalve farms. Support from the government prompted women to form self-help groups. This led to group farming, which helped women overcome social inhibitions and prove their competence. The fact that women increased the farm area and intensity of farming shows that they became efficient aqua-planners and aqua-managers and it also proved that women are better carriers of development. Their prompt repayment of loans increased the faith of the bankers and the schemes of helping groups continued over the years. Women were therefore all-round players, right from planning to utilization of profit.

Application of Biotechnology

In oyster and mussel farming knowledge of the time of spatfall is very important for farmers to decide on the time for setting spat collectors. This is particularly important when the current farming practice is wholly dependent on natural spat as seed. Through a project funded by the DBT, the CMFRI has achieved preliminary success in developing a PCR based protocol for identification of mussel and oyster larvae from a cocktail mix of various holo and mero plankters (as found in a plankton collection). So far, bivalve farming has not been affected by any serious diseases. Very recently scientists from CMFRI were able to detect an OIE listed protozoan pathogen Perkinsus olseni in farmed and wild pearl oyster P. fucata from the Gulf of Mannar. A PCR kit for its detection was also developed. It is possibile that perkinsosis could be one of the major reasons for the decline of the P. fucata beds in the Gulf of Mannar over a period of time.

A recent advancement is the development of a neutraceutical from Indian green mussels, again by scientists of CMFRI, called GME (green mussel extract) which has been found to have definitive anti-arthritic properties mimicking the pain killer drug aspirin. This drug which is now undergoing field trials, is surely a means of value addition to mussels, and bound to improve incomes of mussel farmers.

Prospects for Future Development

It is quite clear from the fast pace of its development in the state of Kerala that bivalve farming can develop as a new sunrise mariculture industry in India. Unlike other aquaculture industries, it is not capital intensive and offers great scope for improving the incomes or the rural fishers as an alternate livelihood. But primarily, what has spurred its growth in Kerala is the considerable demand for the produce among the populace. Other bivalve consuming states like Karnataka, Goa and Maharashtra can also be targeted in the next phase of development. Policy makers and planners need to address the following for sustained development of this spanking industry.

Mussels & oysters

Promote bivalve farming, particularly mussels, in all maritime states using Kerala as a developmental model.

Since farming depends on seed availability from natural sources, development of methods to collect seeds from the wild is necessary.

Determine carrying capacity of backwaters/ estuaries for bivalve farming and restrict farming accordingly.

Make a prospective (5 years) plan to improve hygiene in farming areas using international guidelines as a criterion.

Conduct awareness campaigns for improving bivalve consumption in India

Pearl oysters

Demark areas for mariculture and create mariculture zones with adequate legal protection and articulate open-access water body leasing policies.

Promote SHGs to take up pearl farming in identified pearl mariculture zones

Undertake stock enhancement of blacklip pearl oysters in A&N Islands using the hatchery technology developed recently

Priority in research for production of large fucata pearls and black pearls

Processing and marketing

Encourage value added products (VAP) for bivalves to increase marketing possibilities (especially live oysters) and to make the farming practice more remunerative.

Research focus to be placed on pearl processing for improving value.