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54 A review of marine finfish culture experiments in India

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ABSTRACT

Although India is blessed with many culturable marine finfishes, their seeds and unpolluted coastal water bodies, commercial culture of this resource has remained in a primitive condition all along. The traditional methods practised in West Bengal, Kerala, Goa, etc. fall short of the advanced technology developed in countries such as Indonesia, Philippines and Taiwan. Certain experiments undertaken have revealed that by resorting to systematic and scientific steps of pond preparation, water management and selective stocking, the growth and production of most of the species could be enhanced considerably. However, certain drawbacks observed in most of the experiments are: lack of published data on the cost of cultivation, lack of technologies to grow ideal food for species such as milkfish and to construct and maintain grow-out structures in relation to the environmental and soil conditions, lack of adequate water supply to culture facilities and lack of seeds. The paper examines these aspects and presents suggestions for a more effective approach to solve the problems as well as to ensure commercial culture of marine finfishes as a successful proposition.

Introduction

The Indian coast is dotted with many estuaries, creeks, bays, inlets, lagoons, brackishwater canals, salt pan channels and has about 1.4 million ha for implementing aquculture operations. The soil properties of these areas vary considerably from loose, porous and sandy condition to calcareous, loamy, clayey or laterite soil and with varying conditions of suitability for construction of ponds. By and large, the quality of sea water or brackishwater in these areas is suitable for supporting active biological life. Also, although industrialisation has been advancing in and around certain coastal cities, with possibilities of pollution in the neighbourhood, the vast majority of the coastal belt is devoid of it. Similarly, instances of certain natural phenomena such as "red tides" and superhaline and superthermal conditions are few and transient.

India is also blessed with many culturable marine finfishes, of which the most important single species is the milkfish *Chanos chanos*, which is cultured extensively in Indonesia, Philippines and Taiwan. It is highly euryhaline, has a quick growth

rate in the first year of its life, attaining upto about 45 cm length and one kg in weight, subsisting at the bottom of the food chain and is remarkably free from parasites and diseases, all ideal qualities needed for a culturable marine organism. In India it is distributed widely, from Orissa in the east coast through Karnataka in the west.

Equally important and with many similar qualities is the group of grey mullets (Mugilidae), comprising valuable species such as *Mugil cephalus*, *Liza macrolepis*, *L. dussumieri*, *L. tade*, *Rhinomugil corsula* and *Valamugil sehali*. The Asian seabass *Lates calcarifer* is another such species and one of the most valued table fishes, growing to more than a metre in length and 3 kg in weight. The groupers (Serranidae) such as *Epinephelus tauvina* and *E. malabaricus*, the red snapper *Lutjanus johni* (Lutjanidae) and the sea breams (Sparidae) viz *Acanthopagrus berda*, *A. latus*, *A. bifasciatus* etc. all predaceous and carnivorous, have recently emerged as culturable species in Asian countries including India. One backishwater culturable species feeding mostly on filamenous algae is the "pearlspot" *Etroplus suratensis* (Cichlidae), found mostly along the southwest coast of India. Other species of minor importance are: the sand whiting *Sillago sihama* (Sillaginidae), the rabbitfishes *Siganus javus* and *S. canaliculatus* (Siganidae), the silver biddies *Gerres oblongus*, *G. setiferus* and *G. filamentosus* (Gerreidae), the "ten pounder" *Elope saurus* (Elopidae), species of *Oreochromis* (Cichlidae), etc. The seeds of most of these species are available adequately along Indian coasts. The research contributions on the subject from Indian region are by Naidu (1942), Devanesan and Chacko (1943), Hora (1944), Venkataraman (1944), Basu (1946), Pillay (1947, 1948), Jacob and Krishnamurthy (1948), Ganapati *et al.* (1950), Chacko (1951, a, b), Panikkar *et al.*(1952), Chacko *et al.* (1953), Pillay (1954), John (1955), Chacko and Mahadevan (1956), Alikunhi (1957), Sarojini (1958), Gopalakrishnan (1968), Pati (1969), George (1970, 1971), Rao (1972), Tampi (1973), Ghosh (1973), James *et al.* (1984), Bensam (1988), CMFRI (1989), etc.

Inspite of these assets available along Indian coastal areas, most of the culturable areas are at present lying without much use and are serving only to harbour the culturable finfishes which manage to enter there in the natural state, remain and grow for varying periods of time until they are hunted by predatory animals and/or fished out by man, without paying any attention for their stocking and growth.

Traditional culture practices

It is only in the estuarine and coastal areas of West Bengal, Kerala and Goa that some kind of traditional culture of finfishes is being practised from time imme-

morial. But, these are without technological backing, management procedures and adequate water supply; and hence the production is considerably low. Stocking is mostly nonselective and sea water replenishment is usually accomplished with the aid of natural tidal amplitudes. Infact, most of the culture ponds are only seasonal and a few alone are perennial.

In West Bengal, the low-lying lands near estuaries and deltaic areas enclosed by embankments of clay and called "bheries" are used for traditional finfish cultivation mostly for mullets, especially during rains. Detailed accounts of these and similar operations are given by Hamilton (1822), Hora (1944), Pillay (1954) and Thompson (1966). Culture of mullets and the seabass is also undertaken in partly saline paddy fields of West Bengal (Hora and Nair, 1944, Pillay and Bose, 1957), before as well as during paddy cultivation. In Kerala, marine fin fishes are traditionally cultured in coastal areas and backwaters including the "Pokkali" paddy fields (Pillay, 1947, 1948). In Goa also the low-lying paddy fields called "Kazan" lands are the farming areas in which finfishes are cultured, usually after paddy cultivation (Gopinathan and Dani, 1973). Apart from these, in the estuarine regions and deltaic zones of rivers in Orissa, Andhra Pradesh, Tamilnadu, Karnataka, Maharashtra and Gujarat insignificant traditional practices may be said to exist, with low production rates. In all these cases, stocking takes place by natural tidal inflow of estuarine water and the seeds so impounded are harvested after about 3 to 6 months.

Regarding growth and production of cultured stocks, adequate information is not published so far; and what is available has shown much variation. Seeds of *Mugil tade* of 7.6 cm are reported to have grown to about 360 gm. by the second year of culture; and those of *M. parsia* weighed about 227 gm at the end of 8 months. According to another account, *M. tade* has grown to 253 mm by the second year and may survive upto the third year reaching 369 gm. The production rate in bheries is stated to range from about 111 to 168 kg/ha of fishes and prawns, while in the paddy fields of Bengal, the proportion of mullets harvested is 62% and that of Seabass is 34%. In Goa, about 40% of the harvest is made up of finfishes (grey mullets, pearlspot, silver biddies, seabass, milkfish).

Experiments on finfish culture

One of the earliest attempts to culture milkfish was by the then Government of Madras during 1941, as reported by Chacko and Mahadevan (1956). Pillay (1948) has described a mullet farm in the then Cochin State. However, it was only after the Indian Independence and the establishment of Central Marine Fisheries Research Institute that marine finfish culture experiments have received a fresh fillip in an attempt to generate additional resources to meet the growing demand for sea fish.

Quite a number of experiments were undertaken in coastal ponds, salt pans, polythene lined ponds, etc, in monoculture and/or polyculture exercises, mostly at Mandapam, Tuticorin, Madras and Calicut. The important contributions are those of : Tampi (1960) , Evangeline (1967), Mohamed and Bensam (1975), Mohan and Nandaumaran (1981), Bensam and Marichamy (1982), Shanmugham and Bensam (1982), Marichamy and Rajapackiam (1982, 1983) Mohan (1983 a, b, c) Mohanraj *et al.* (1983), Lazarus and Nandakumaran (1986, 1987, 1988), Nammalwar and Kathirvel (1988), Gandhi and Mohanraj (1988), Gandhi *et al.* (1988), Mohan (1990) Hamsa and Kasim (1992), etc. In pond culture experiments production varying from 499 kg to 1, 865 kg/ha and in pen culture a production capacity of 2,000 kg/ha are indicated in the above experiments. The results from most of these exercises are already reviewed by James (1985), Mahadevan (1985), Marichamy (1987) and Nammalwar and Mohanraj (1990), including some problems faced such as suitable locations for culture practices, need to identify more cultivable species, using artificial feeds for the stocked material, need for artificial propagation, impact of environmental and meteorological conditions on fish pens, cages, etc. However, quite a few more basic and vital problems pertaining to finfish culture experiments seem to have been lost sight of by the workers themselves and/or by the reviewers, as analysed below.

Basic drawbacks observed

Although quite some results are published, some drawbacks were also observed in these experiments as given below:-

(1) Lack of data on cost of cultivation

The most important need in aquaculture is to ensure maximum production with minimum expenditure; to achieve this it is essential to maintain and publish the full accounts on the cost of cultivation as well as the economics involved. But, surprisingly and with one or two exceptions (Lazarus and Nandakumaran, 1988; Hamsa and Kasim, 1993) in none of the experiments undertaken, either the cost of cultivation, a break up of the various expenditure incurred or the net profit realised from the production are documented. In view of this basic omission, the results from the various experiments on finfish culture are of little value for both a follow-up of the experiments as well as for the commercial fish culturists.

(2) Lack of technology to grow "Lab-Lab"

The lack of technology input to enhance the growth of the benthic complex called "Lab-Lab" composed mostly of *Phormidium, Oscillatoria, Lyngbia*, diatoms etc. and the associated fauna such as nematodes, amphipods, flagellates, flat worms,

rotifers and molluscs, which is the ideal food material for herbivorous species, is a notable constraint in milkfish and grey mullets culture. It is seen that the sustained growth and maintenance of Lab-Lab in culture ponds has been the key factor for the high production of milkfish in south-east Asian Countries. They evolved appropriate technology to enhance the growth of Lab-Lab in culture ponds. In India attempts were made to enhance the growth of Lab-Lab by Tampi (1960) using certain compost manures; Mohanraj *et al.* (1983) by fertilising the ponds with "organic manure", Gandhi and Mohanraj (1988) by fertilizing Polyethylene lined pond with chicken manure; and Bensam (1991) using cowdung, groundnut cake, rice bran and compost of the leaves of *Tephrosia*; and the results yielded no standard prescription. In short in culture ponds and in net pen enclosures for milkfish and grey mullets no meaningful attempt has been undertaken so far to enhance the growth of Lab-Lab, comparable with the technology prevalent in south-east Asian countries.

(3) Lack of technologies for construction and maintenance of ponds, pens and cages

Another factor responsible for poor implementation of commercial marine fin fish culture in India is the lack of adequate technologies and expertise for construction and maintenance of earthern culture ponds and net pen enclosures, in the context of erosion due to rains and wave action of pond water. Since agro-climatic factors, soil conditions and tidal amplitudes of the sea may differ from one locality to another in a country with a long coastline such as India, adoption of any one principle on technology for pond construction and maintenance in all the localities may not solve the problems encountered in each area. For instance, in a region such as Kerala in the south-west coast the soil is mostly clayey, cohesive and firm; hence seepage is little and erosion due to rains and wave action of ponds water is not enormous. A review of literature shows that the quality of earth there is so good for maintenance of embankments with elaborate protective measures are not necessary. But, along the coastal areas of Tamil Nadu in the south-east, the soil is rather sandy, incohesive and loose, seepage is marked and erosion due to rains and wave action of pond water is enormous. Observations at Veppalodai, Killai and Mandapam have shown (Bensam, 1990) that even within Tamil Nadu itself the quality of earth varies from one locality to another, depending upon the proportion of the components. Thus, the soil is mostly silty clay in Veppalodai, silty gravel in Killai and sandy gravel in Mandapam. Among these three localities, the soil at Veppalodai is the most suitable one for pond construction followed by the one at Killai; and the soil at Mandapam is the least suitable. Hence, the principle or the technology of pond construction has to be so modified as to suit the condition in each and every centre. If coastal aquaculture has to be implemented on a national basis in India, an adequate survey and study of

all the localities has to be carried out and suitable technologies of construction in each and every centre may be taken up as a national research and development project.

(4) Lack of adequate water supply

A much more important factor for successful coastal aquaculture is the tidal flow of sea water or brackish water in and out of the ponds, for effective exchange of water. As is well known, the tidal amplitudes are higher in northern latitudes of India than in the southern latitudes, both in the west coast (Arabian Sea) and east coast (Bay of Bengal). Also, the net annual differences between the lowest and the highest tidal values in the northern localities are much higher than in the southern localities for both the coasts. And, between the two coasts, the values are higher in the west coast and lower in the east coast, perhaps one reason for this being the more oceanic conditions prevailing in the Arabian Sea, caused by upwelling and strong currents than in the Bay of Bengal. It may also be seen that south of Lat. 15 N, the tidal amplitudes decrease rapidly, although the values are slightly higher in the south-west coast than in the south-east.

When compared with any other segment of the Indian coast, the poorest tidal amplitudes are observed in the south-east coast. The net annual differences between the highest and lowest tides are 1.3 m at Madras, 0.9 m at Nagapatnam and Tuticorin and a meagre of 0.9 m at Pamban. The reason for the lowest value at Pamban may be the presence of the island of Sri Lanka, which deflects the North-East monsoon warm current away from the south-east coast of India. This is particularly accentuated during the summer and premonsoon (North-East) months, due to the south-west winds forcing the sea water away from the coast and making the tidal levels reaching so low as to 0.3 m below Mean Sea Level (Bensam, 1990).

The problem of adequate sea water supply to culture ponds has been encountered in northern centres also which are located much interior, away from the coast. Naturally, the tidal amplitudes decrease in magnitude towards interior localities and hence the lesser water supply. Pillay (1954) attributes the important factor for deterioration of fish culture in bheries of West Bengal to the unsatisfactory water supply due to small tide amplitudes in the enighbourhood of rivers. Pillay (1954) further states that the excavation of river bed may not solve the problem in the long run because sand is deposited by water flow and the adverse conditions of sand accumulation are reverted within a short period. Under these circumstances, some amount of engineering research and development is needed, in order to prevent sand deposition in the river beds adjoining the bheries which receive brackish water from the rivers.

Still another factor responsible for poor supply of sea water to culture ponds especially in the south-east coast is the deposition of sand on the beach in the postmonsoon season, resulting in the formation of sand bars opposite sluices and cutting of the entry of sea water, as drawn attention to in the case of lagoons and estuaries by Tampi (1959), Jhingran (1982), Bensam *et al.* (1987) and others. It has been observed that unless the sand bar is removed by excavation there is no possibility of getting sea water supply to estuaries, lagoons and culture ponds during this period. It is only during the North-East monsoon rainy period accompanied by strong waves and land drainage of rain water that the sand bars are damaged and sea water supply to lagoons and pond is re-established.

The need for prevention of formation of sand bars opposite estuaries, creeks and lagoons in the southeast coast of India by undertaking coastal engineering research projets has been drawn attention to in recent years (Tampi, 1960; Jhingran, 1982; Bensam *et al.*, 1987). Bensam (1990) has carried out experiments with two types of breakwaters opposite the main sluice in the farm of the Central Marine Fisheries Research Institute at Mandapam and has recorded small quantities of reduction in the deposition of sand. The experiments were not quite successful because the breakwaters were overtopped by waves during North-East monsoon season, bringing in and depositing sand in between the breakwaters themselves. In this connection it is suggested that experiments on coastal aquaculture engineering research and development on a larger scale, with adequate height for the breakwaters above Mean Sea Level and length beyond the region of waves would go a long way for developing a technology to prevent sand deposition and formation of sand bars not only opposite supply canals of fish farms but also opposite estuaries and lagoons for the material well being of the fish stocks there.

Localised problems such as the ones faced in West Bengal and southeast coast of India may be prevalent in other segments of the Indian coast also. In order to achieve meaningful progress in coastal aquaculture along different parts of India, especially in regions such as the southeast coast, it is time that such problems are identified and coastal engineering projects are launched on a priority basis.

(5) Lack of seed production technology

Another area which should be given priority attention in India at present is induced breeding of such of the finfishes in which technology of induced breeding of these species has already been achieved in Malaysia, Singapore, Kuwait, etc., as the technology is well documented (Bensam and Nammalwar, 1991; Bensam 1993). Hence, it should be possible to develop induced breeding of these species in India

also. One essential prerequisite for culture and breeding of these fishes is to select a few suitable centres and sites like bays and lagoons where the water is unpolluted, calm, deep and with enough tidal amplitude, in order to establish cage farms and hatcheries with modern facilites. The areas should also be free from strong winds, waves and tidal conditions throughout the year, in order to make the operations economically viable. Also, facilities may be built up to study and treat diseases of culture stocks. Work for establishment of hatcheries and nurseries and selection of areas for culture operations may be taken up at an early date.

Although the techniques of culturing microalgae and rotifers for feeding the postlarvae in the hatcheries have been developed in Central Marine Fisheries Research Institute, it is essential to develop a proper, balanced diet acceptable to various growth stages of the candidate species. Some amount of basic research is essential to formulate pelletted feed and to manufacture it on a large-scale basis, for feeding in grow-out systems. This aspect may be taken up as a research project. After achieving a continuous supply of seeds and experimental culture in selected areas for working out the cost of cultivation and economic viability of the projects in relation to the environmental conditions prevailing in the localities, large-scale commercial culture may be attempted.

It may not be out of place here to draw attention that the hatchery seed prodection technology of such an amiable finfish as the pearlspot (*Etroplus suratensis*) has also not yet been developed in India, thus making it as another problematic area. It is high time that concentrated attention is paid to the hatchery seed production of the pearlspot without any further delay.

Suggestions for the future

It may be seen from the foregoing that marine fin fish culture in India on a organised commercial scale is still in a primitive condition, when compared with other parts of the world. For instance, *Chanos* culture in Indonesia, Philippines and Taiwan has reached a high level of sophistication with 3 to 5 hectare farms, elaborate and intensive pond preparation and management procedures and high production. The culture stock is made to depend upon the benthic algal pastures induced to grow in ponds; and a system of stocking and cropping by rotation has been adapted, resulting in production of upto 1,900 kg/ha (Tang, 1967). Also, stock manipulation using different kinds of natural food has been developed (Tang, 1972). Recent work on culture of *Chanos* in pens in Philippines has given returns as high as 10 tonnes/ha (Mane, 1975). Similarly, culture of mullets has reached high levels of production in countries like Italy. The culture ponds there are constructed in such a way that

either salt water or fresh water can be flown in according to needs, because mullets grow more rapidly in an admixture of salt water and fresh water than in pure salt water (Angelis, 1960). In the United Arab Republic, use of phosphate fertilizers in the culture ponds has increased the production of mullets (Zarka and Fahmy, 1966). Also, intensive cultivation of mullets in Taiwan and Hong Kong has resulted in production so high as 3,500 kg/ha during a growing season. In addition to these, even stenohaline and pelagic species have been domesticated and cultured in the sea itself as exemplified by net cage culture of yellow-tail and puffers in Japan. One significant development in yellow-tail culture is stocking and cropping by rotation, resulting in a production of upto 280 tonnes/ha (Bardach, *et al.* 1972). Encouraged by these results, experiments for the commercial culture of even tunas are being carried out in Japan (Ueyanagi, 1972). In cage culture of the seabass in Singapore, a production rate of 76.8 t/ha/year has been achieved (Bensam, 1993). Another line of development on the culture of flatfishes in artificially heated waters in Scotland has shown that the fish can be grown from egg to marketable condition in eighteen months.

These advances in different parts of the world including the recent researches on *Chanos* culture in India as well as the growth and production of the more important culturable species in culture ponds observed, highlight great potentialities for development; and point out the need for implementing commercial cultivation of our resources also. In the case of *Chanos* and mullets, the lead given by Indonesia, Philippines, Taiwan and Hong Kong call for similar projects work in India without any further delay. With the availability of vast expenses of culturable areas amounting to 1.4 million hectares of estuarine and brackishwater masses and shore facilities, commercial cultivation of these euryhaline species could be undertaken on a crash programme basis. Even at present in locations like the Godavari delta, mullets, *Chanos* and *Lates* are cultured along with prawns on a very small scale. As pointed out by Sekharan (1976), the main problem in such areas is the construction of culture facilities with adequate provisions for inflow of tidal water. The existing operations do not bring in high production rates mostly because of the unorganised system of stocking and harvesting, unsatisfactory water replenishment, failure to eradicate predators and lack of adequate pond preparation procedure. Once such defects are rectified, the operations are bound to yield high dividends. It may be noted in this connection that in a tropical country like India, herbivorous or plankton feeding fishes like *Chanos* and mullets are the most suitable ones for culture in the more or less natural amenities present, such as vast low-lying coastal areas, availability of solar energy, and the natural or man-enhanced fertility (Bardach *et al.*, 1972). The estuarine system such as Hooghly-Matlah, Mahanadhi, Chilka, Godvari, Krishna,

Cauveri, Vaigai, Tambiraparani, Pulicat, Kerala backwaters, Coondapur, Netravati, Zuari and Mandovi estuaries of Maharashtra, marshes of Kutch, etc. offer ideal grounds for developing commercial culture of *Chanos* and mullets without any delay. Similarly the culture of *Elops*, *Eleuthronema*, etc. could be taken up in less important areas.

Apart from these species, we have a few others which could be cultured profitably in coastal ponds and/or net cages such as *Lates*, *Epinephelus*, *Sillago*, *Etroplus*, *Gerres*, *Pampus argenteus* and *Siganus*. The main constraint in the way of their commercial culture appears to be the scarcity of their seeds in the natural state. Although surveys of the natural seed resources of these species are yet to be completed, one way of augmenting the seeds is by artificial propagation. It may be noted in this connection that artificial propagation of marine fishes in India still remains as a great technological challenge, although in countries like Japan, U.S.A. and U.S.S.R. even stenohaline species (such as Fugu in Japan) have been propagated artificially. As mentioned earlier, *Lates*, *Epinephelus*, *Sillago*, *Etroplus*, *Gerres*, *Siganus*, etc. are euryhaline and hence possibilities of collecting their breeders and propagating them artificially are very great. The induced maturation and spawning achieved by CIBA on *Lates* recently is a break through in this type of research.

In addition to the above, one line of development that could bring success is the establishment of culture ponds, pens, net enclosures and net cages in estuaries, lagoons and creeks for culturing some species for atleast a few months in an year when adequate growth and production could be achieved. Commercially valuable species such as *Eleutheronema*, *Epinephelus*, *Psammoperca*, *Lutjanus*, *Caranx*, *Sphyraena*, *Stromateus* and *Seriola* could be included in this category. The pomfrets (Stromateidae) deserve special mention in this connection for culture in both intertidal ponds and floating net cages, either singly or with other species because of their nonpredaceous habits.

Another line of action requiring urgent attention is the construction of net enclosures or similar impoundments in the sea itself. Along certain sections of the coast such as off Kanyakumari, Quilon and Goa, the inshore area is rocky and fishing operations by boat-seines or trawl nets are not practicable. In such areas, one advantage for the construction of enclosures is the presence of rocky outcrop, affording facilities for the erection of barriers, thus making construction costs cheaper (Sekharan, 1976). And, once the stability of the barriers is ensured and the machanism of water replenishment is perfected, fin fishes could be cultured successfully. Also, in such rocky areas, artificial habits or shelters in mid water or sea bed may be provided, resulting in 'sea farming reefs' or 'fish apartments' in the form of used car

bodies, stones, concrete blocks, rubbles, etc. to which fishes are attracted and around which they grow and breed as in Japan and U.S.A. (Iversen, 1968).

In the evolution of mariculture techniques, the development of net cages suspended from rafts in the sea may be considered as the latest innovation, for culturing pelagic and free-swiming fishes such as yellow-tail, seabass, tuna, groupers, seabreams and puffers. In India, although culture of pelagic fishes from young stages to marketable condition might appear as costly exercise at present, it would be worthwhile to attempt the culture of such valuable pelagic fishes like seer fish (*Scomberomorus*), tuna (*Euthynnus*), pomfrets (*Stromateus*), certain carangids, etc atleast on an experimental basis so that their commercial culture could be taken up later. The Japanese people by their enterprising net-cage culture of yellow -tail, tuna and Fugu have demonstrated that it is certainly possible to culture even the stenohaline and pelagic forms. As such, it is obvious that the developments in the culture and propagation of many a marine fish species achieved in different parts of the world call for immediate implementation of such programmes in India also for increasing our fish production.

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