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A REVIEW OF MARINE FINFISH CULTURE IN INDIA ITS PROBLEMS AND PROSPECTS*

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ABSTRACT

Details of various ecosystems utilised for finfish culture, the species of fishes used, mono-and polyculture systems adopted, the low cost technology developed for culture of various species of fishes in pens, cages and net impoundments and coastal fish farms development are given.

The culture work in India mainly concerned with milkfish, mullets, Indian sand-whiting and prawns in mono-or polyculture systems in sea water ponds. These and other species like rabbit fishes and groupers are cultured in pens, cages and net impoundments. Details of development of coastal fish farms with simple methods of construction, lining of ponds by polythene film to prevent bund erosion and retention of water against seepage and turfing of bunds are dealt with.

The paper also outlines the constraints experienced in culture of finfishes under various systems and the prospects of further development of finfish culture in India.

INTRODUCTION

HITHERTO, emphasis on fisheries development in the country has been on the capture fisheries sector, with the result highly advanced and sophisticated technologies are now available for capture of fishes from diversified environments. The challenges of providing food for the ever growing human population, continued exploitation of land and limited scope for cultivation of new areas on land and high investments required to realise marginal increase in fish production from the seas have led to greater awareness of the importance of coastal aquaculture and its vital role in augmenting fish production, improving rural economy and providing large employment opportunities. The concept of blending of capture fisheries with culture fisheries developed by the Central Marine Fisheries Research Institute not only provides occupation, but augments the per capita income of small scale fishermen who operate indigenous craft and gear which still contribute to greater part of marine fish production. The concept would also create a sense of involvement and participation by the fishermen in the sea farming techniques evolved by the Institute in recent years.

Commercial culture of some species of marine fishes was carried out traditionally in India, especially along the coasts of Kerala, Goa and West Bengal (Pillay, 1949, 1954; Saha *et al.*, 1964 a, b ; Pakrasi *et al.*, 1964 ; Gopinathan and Dani, 1973). But these have been small-scale ventures without much technological innovations. Production rates have been poor since practically no management practices were applied in such culture operations. However, such experiments have demonstrated the possibilities of successful salt water fish farming.

* The data presented in this paper are derived from various published papers and reports on projects in operation on finfish culture under the Central Marine Fisheries Research Institute, supplemented by observations made by the author.

With the recent thrust for aquaculture development, more serious attempts are being made to increase fish production by developing suitable technologies for culture of marine fishes in inshore waters as well as lagoons, backwaters, brackishwater lakes and estuaries in the country. The present paper reviews briefly the traditional culture of marine fishes in India, recent research and development of technology for coastal aquaculture for various species of fishes, problems and prospects of salt water fish culture in India.

Traditional Culture of Marine Fishes

Traditionally, culture of sea fishes has been practised in low-lying estuarine and coastal areas, subjected to tidal influence. The tidal flow is controlled by sluices. Most of the areas in Kerala and Goa where such methods are employed are seasonal, others being perennial. Although a variety of fishes are cultured by this method, emphasis has been on the culture of prawns which fetch higher unit value. Mullets (*Mugil* spp.) and milkfish (*Chanos chanos*) are the most important fishes extensively cultured by this method. Other fishes which are commonly found in such ponds include *Stolephorus* spp., *Thryssa* spp., *Etroplus* spp., *Ambassis* spp., *Gerres* spp., *Lates calcarifer* and *Tachysurus* spp. In West Bengal, mullets and cock-up (*Lates calcarifer*) are the important fishes cultured, in addition to prawns. Eels, cyprinodonts, gobies, *Ilisha* sp., *Setipinna* sp., *Thryssa* sp., *Ambassis* sp., *Therapon* sp., *Scatophagus* sp. and other estuarine fishes are also recorded from these ponds (Pillay, 1954). Chacko and Mahadevan (1956) and Evangeline (1967) dealt with prospects of culture of the milkfish in and around Rameswaram Islands and at the brackish-water fish farm at Adyar (Madras) respectively.

Culture practices are similar in all the areas. There is no selective stocking in the ponds. Fish and prawns are allowed to enter the ponds with tidal flow. No artificial feeds are given. The method is simple in that the fishes and prawns are kept in the ponds for varying periods of time. Therefore, there is considerable inter-seasonal variation in production. George (1974) estimated the average annual prawn production in the seasonal and perennial ponds in Kerala at about 900 kg/ha and 840 kg/ha respectively. However, fish production data are not available. In Goa, fish production is about 1,300 kg/ha and prawn production about 2,000 kg/ha annually (Gopinathan and Dani, 1973). In the *bheris* of West Bengal fish and prawn production was stated to be 110-170 kg/ha/year (Pillay, 1954).

Research on the Culture of Marine Fishes

The coastal lagoons, estuaries, backwaters and mangrove swamps offer an immense potential for mariculture within the country. In order to utilise the vast stretches of low lying areas along the east and west coasts of India which lie fallow at present and also to utilise the coastal areas for production of fish by culture methods, experiments on finfish culture have been conducted at Mandapam, Tuticorin, Narakkal (Cochin), Calicut and Mangalore. Monoculture and polyculture experiments have been conducted in salt pans, pens and ponds in coastal areas, in cages floated at sea and in plastic pools and tubs with running fresh water facility in the laboratory. The abundant, naturally occurring seed resources of commercially important species of fishes and prawns have been used in these experiments. Attempts have also been made to produce quality seed by hypophysation.

Culture of fishes in salt pans

Experiments were conducted to culture the milkfish *Chanos chanos* and the mullet *Liza macrolepis* in salt pans at Tuticorin. Four ponds of an area of 23×15 m each with a depth of 0.6×1.0 m were utilised for this purpose. The ponds were provided with wooden sluices for regulation of tidal flow. In the ponds, surface temperature ranged from 24 to 31°C, salinity from 34 to 37‰, dissolved oxygen from 3 to 5 ml/l and pH varied around 8.0. Plankton volume was poor, zooplankton being dominant. Studies indicated distinct differences in the hydrobiological factors of small ponds and larger ponds, the former being generally more productive than the latter.

Results of stocking indicated a growth rate of 20 mm in two months for milkfish. During the same period the mullet *L. macrolepis*, 35 to 45 mm in length and average weight of 0.25 g attained a size of 60 to 100 mm and weight varying 12 to 49 g. In an year, the latter species attained a size of 295 mm and a weight of 220 g. Rice bran and groundnut oil cake were used as artificial feed. Polyculture experiment with *Penaeus indicus*, *C. chanos* and *L. macrolepis* in the ratio of 3 : 1 : 1 respectively indicated that growth rate of individual species was encouraging, though production and survival of mullets was poor due to large scale depletion of original stock, natural mortality and heavy predation by crabs, snakes, eels and birds (flamingos, pelicans, and storks). Details of recent polyculture experiments and their results are given in Table 1. Without much complicated manages ment procedures, culture of fishes such a- mullets and milkfish with production rates upto 587 kg/ha per annum were made possible. The serious constraint for culture of fish in the vast salt pan areas appears to be the predation by birds mentioned above. In ponds constructed in the salt pan area at Tuticorin a production of 850 kg/ha/year was obtained for the same fish (Nair *et al.*, 1975). In the salt pans, Milkfish, 155-246 mm (52-96 g), average 205 mm (73 g) had shown an increase of 35 mm/month ; mullets 165-230 mm (55-112 g), average 193 mm (78 mm) had shown an increase of 15 g/month. There was better growth in weight for mullet. *P. indicus* 121 mm (136 g) showed a growth of 13 mm (2.5 g) per month. Finfishes showed better growth than prawns. Fishes were fed on rice bran, oil cake, fish meal and tapioca powder at 1 : 10 ratio (body weight). Phytoplankton in the ponds included *Thalassiosira*, *Nitschzia*, *Pleurosigma*, *Oscillatoria* and *Coscinodiscus*. Zooplankton consisted mainly of calanoid copepods. Salinity in the ponds varied from 35.14 to 38.62‰ and dissolved oxygen 3.8 to 4.7 ml/l. Predatory fishes included *Polynemus* and *Elops* which were eradicated by fishing.

Culture of fishes in pens

For culture of fish in pens, a suitable bay-like site was selected in the coastal area of Gulf of Mannar, adjacent to CMFRI jetty at Mandapam Camp. To prevent direct wave action on the pen, a crescent shaped barrier (57.9 m) made up of casuarina poles (4.9 m length and 0.2 m dia) was erected. The vertical poles were braced by means of bolts and nuts to horizontal poles. Granite stones were laid along the outer and inner sides of the barrier to prevent wave action and siltation.

The pens were made up of double layered bamboo screens (*Thatties*), the outer layer made of bamboo splits of 9 mm thickness and an inner layer of 5 mm thickness. These were firmly joined together by iron straps. Each screen was 3 m in length and 3 m in height. Three screens were joined together to form one side. The pen was square in shape and covered an area of 81 sq. m. Tar was applied upto a height of 0.5 m from the bottom of the screen and over it kriside was painted. The screens were strengthened by wooden reapers (3 m length' 0.2m breadth and 13 mm thick) by fixing them horizontally on either side of each screen at 0.6 m interval. In addition, two runners (9 m length and 0.1 m width) were fixed to screens at 0.6 m intervals and these ran on all four sides of the pen. The pen was supported by each side by 15 casuarina

TABLE 1. *Details of polyculture experiments at Tuticorin*

Species	Date of stocking	No. of fish stocked and weight (kg)	Size range and mode (mm)	Average length (mm) & weight (gm)	Date of harvest	No. of fishes harvested and weight (kg)	Size range and mode of fish harvested (mm)	Average length (mm) and weight (kg) of fish harvested	Survival rate (%)	Rate of production per hectare (kg)
L. macrolepis	May/June '78	2062 (1.3)	22-55 (33-45)	40 (0.8)	17-3-'79	402 (84)	297-331 (310-325)	314 (210)	19.5	325
C. chanos	April '78	200 (0.16)	40-45	42 (0.8)	17-3-'79	94 (32)	324-400 (340-350)	346 (268)	49	190
P. indicus	May/April '78	12096 (11.0)	40-60	51 (0.9)	17-3-'79	979 (19.5)	135-187 (150-165)	160 (20)	8	76

TABLE 2. *Details of experiments on pen culture at Mandapam*

Species	Date of stocking	No. of fish stocked	Size of fish at stocking and mean size (mm)	Date of observation	Size of fish observation (mm)	Growth per month (mm)	Increase in average weight (gm)
Mugil spp.	Mar. '77	3,288	20 - 60 (32)	June '77	87	18	0.8-15
C. chanos	Mar. '77	77	60-90 (77)	June '77	227	50	3 - 77
	Feb. '78	80	46-108 (84)	Mar. '77	226	47	4 - 110
	June '78	80	226	Sep. '78	380	51	110 - 448

TABLE 3. *Details of experiments on pen culture at Tuticorin*

Species	Date of stocking	No. of fish stocked	Size range and mean (mm)	Mean weight (gm)	Date of observation	Mean size (mm)	Mean weight (gm)	Average length per month (mm)	Average weight per month (gm)
Mugil spp.	May '77	300	14-33	0.29	Dec. '77	190	1,809	23	26
	May '77	100	15-36 (26)	0.20	Oct. '77	169	590	29	18
C. chanos	May '77	200	26-66 (44)	0.89	Oct. '77	301	240	50	48

poles. The reapers, runners, screens and casuarina poles were firmly attached to one another by bolts and nuts. The screens were joined together at the corners with a wooden pole 4 m in height so that no gaps were left at the corners. The depth of water in the pen ranged from 1.2 m at low tide to 1.8 m at high tide. The bottom was mostly sandy. Sea water freely flowed in and out of the pen through the screens.

In the year 1977, salinity inside the pen ranged from 23.75 to 35.00 ‰, dissolved oxygen from 1.40 to 5.78 ml/l and oxygen values were very low during June (1.70 ml/l) and July (1.40 ml/l) when *Trichodesmium* bloom occurred in the sea. In 1978, salinity ranged from 33.36 to 36.72 ‰, dissolved oxygen from 2.34 to 5.25 ml/l and pH from 7.2 to 8.0.

Fingerlings of the milkfish and the mullets collected from Chinnapalam creek and tidal pools at Pamban, Pillaimadam and Athankarai Estuary were utilised for experiments in the pens. Minced fish meat and oil cake paste in equal proportions were fed once a day in the morning at a rate equal to 1/10 of body weight of fish. The feed was kept in an aluminium tray (0.5×0.5×0.2 m) which was fixed at the centre of the pen in such a way that the tray was just above the low tide water level. The fishes also fed on natural food like algae, phyto and zooplankton available in the pen. Details of experiments and the results are given in Table 2.

At Tuticorin four pens, each of 20×10 m (200 sq. m) made up of split bamboo screens were constructed. The sticks of the screens were interwoven with synthetic twine. The screens were erected in the bay supported by casuarina and teak poles. The bamboo screens were supported at regular intervals by casuarina or teak poles of 3 to 4 m length and also driven into the sea bed to sufficient depths. Props were also provided on all the sides to prevent the pens from falling down due to strong winds and currents.

The depth of water in the pen ranged from 0.75 to 1.60 m with a slush of about 10 to 20 cm. Salinity ranged from 31.00 to 35.00 ‰, dissolved oxygen from 7 to 8 ml/l and pH around 8.0. Plankton inside the pens consisted of *Oscillatoria*, *Pleurosigma*, *Nitszchia*, tintinnids, copepods etc. The details of the experiments are given in Table 3.

At Mandapam, the grey mullet *V. seheli* was stocked in association with *C. chanos* at the stocking rate of 500 each/81 m^2 (62,000/ha) in a pen made up of palmyra leaf stalks and erected in the coastal waters of Palk Bay. The average size and weight at the time of stocking were 35.2 mm (0.5 g) for *V. seheli* and 66.4 mm (6.2 g) for *C. chanos*. In the pen, the average size and weight increase recorded for *V. seheli* were 22.6 mm (9.6 g) in 30 days, 51.1 mm (14.5 g) in 60 days and 73.8 mm (18.5 g) in 90 days. On the other hand, *C. chanos* showed an average size and weight increase of 25 mm (4.3 g), 46.8 (8.0 g), 81.9 mm (27.9 g) and 120.3 mm (48.4 g) in 30, 60, 90 and 120 days respectively. Thus, the average monthly growth increments for *V. seheli* and *C. chanos* were 24.6 mm (6.2 g) and 30.1 mm (12.1 g) respectively.

The results indicated that the growth rate of mullet has been better in the pen in coastal waters when compared to that obtained in the ponds although Bardach *et al.* (1972) mentioned that most Indian mullet ponds are fertile enough to provide fairly rapid growth. Similarly *C. chanos* also showed good growth in the pen than in the ponds.

During the above experiment, apart from the natural food available in the pen, artificial feed composed of rice bran and groundnut oil cake mixed in equal proportions in the form of a paste was given. It was observed that mullets accepted the supplementary feed readily.

Attempts to culture *Sillago sihama* (5 to 8 cm) in bamboo screen pen (182 sq.m) in the estuary at Mulky near Mangalore were not successful since the fish escaped through the gaps at the bottom caused by tidal action.

Pond culture

Results of experiments undertaken in 1950's on the culture of the milkfish by the Central Marine Fisheries Research Institute at Mandapam were given by Tampi (1967). Despite the poor quality of the soil, meagre organic content, low nutrient level and hypersaline conditions for most part of the year, production of milkfish was of the order of 450 kg/ha/year. Elsewhere, experiments were conducted with milkfish, mullets and the Indian sandwhiting *S. sihama*. The milkfish stocked in ponds along with prawns at a density of 3,000 fingerlings per hectare at Narakkal (Cochin) without any artificial feed grew from 45 to 450 mm (average weight, 420 gms) in a period of 4½ months, yielding a harvest of 435 kg/ha with a survival rate of 60 to 70%. Yields upto 2,500 kg/hectare in 9 months have been obtained through polyculture of fish and prawns. They fed actively on the blue green alga *Anabaena*. Culture of fish for longer durations of over five months indicated that the growth rate levelled off after six months.

Monoculture

At Mandapam, the grey mullet *L. vaigiensis*, the seed of which is available in plenty in the area was stocked in a sea water pond at the stocking density of 1,125/225 m² (50,000/ha). At the time of stocking, the size ranged from 35 to 77 mm with an average size and weight of 58 mm and 3.3 g. Measurements were taken at an interval of 30 days to minimize mortality due to handling. The average size increased to 65.4 mm (5.5 g), 78.3 mm (7.9 g), 77.2 mm (8.1 g), 78.6 mm (8.3 g), 80.2 mm (8.5 g) and 82.5 mm (9.2 g) during 30, 60, 90, 120, 150 and 180 days respectively. Thus, an average growth increment 7.4 mm (2.2 g), 20.3 mm (4.6 g), 19.2 mm (4.8 g), 20.6 mm (5.0 g), 22.2 mm (5.2 g) and 24.5 mm (5.9 g) for 30, 60, 90, 120, 150 and 180 days was obtained for the species. An overall monthly average growth of 4.1 mm (0.98 g) was recorded.

Polyculture

At Mandapam, grey mullets *L. macrolepis* and *V. seheli* were stocked in association with *C. chanos* and *P. indicus* at the stocking rate of 600, 100, 1,000 and 300/450 m² (13,000, 2,000, 22,000 and 7,000 / ha for *L. macrolepis*, *V. seheli*, *C. chanos* and *P. indicus* respectively). The average size and weight shown by each species at the time of stocking were 60.5 mm (5.4 g) for *L. macrolepis*, 32.6 mm (1.0 g) for *V. seheli*, 61.4 mm (2.6 g) for *C. chanos* and 34 mm (0.3 g) for *P. indicus*. The average size and weight increase shown by each species in 60, 90, 120 and 150 days period were 43.7 mm (4.6 g), 54.5 mm (7.5 g), 58.2 mm (13.6 g), and 67.1 mm (24.6 g) for *L. macrolepis*; 23.8 mm (7.4 g), 35.2 mm (9.4 g), 62.2 mm (13.4 g) and 83.9 mm (24.6 g) for *C. chanos*; 29.8 mm (1.1 g), 42.1 mm (1.6 g), 44.5 mm (2.7 g) and 47.2 mm (3.1 g) for *P. indicus* respectively. The seed of *V. seheli* was added to the stock during May 1979 only because of the non-availability of the fry in April. The average size and weight increase recorded for the above species were 19.9 mm (3.5 g), 44 mm (9 g), 65.9 mm (14.0 g) and 76.6 mm (29.0 g) during 30, 60, 90 and 120 days respectively. Thus, an average monthly growth rate of 13.4 (4.9 g), 16.8 mm (4.9 g), 9.4 mm (0.6 g) and 19.2 mm (7.3 g) was recorded for *L. macrolepis*, *C. chanos*, *P. indicus* and *V. seheli* respectively. The results indicate that *C. chanos* showed better growth, followed by *V. seheli*.

In another experiment, *V. seheli* (29-44 mm) was stocked with *C. chanos* (31-59 mm) and *Sillago sihama* (24-48 mm) at the stocking rate of 750/450 m² each (17,000/ha). The average size and weight at the stocking time for *V. seheli*, *C. chanos* and *S. sihama* were

33.9 mm (0.4 g), 45.6 mm (1.1 g) and 31.00 mm (0.2 g) respectively. After 30, 60, 90 and 120 days, the average size and weight increase shown by these species were 25. 44 mm (5.1g), 37.1 mm (5.8 g), 53.1 mm (8.8 g) and 63.3 mm (12.3 g) for *V. seheli*; 35. 6 mm (5.9 g), 61.5 mm (11.7 g), 72.9 mm (17.0 g) and 82 mm (20.5 g) for *C. chanos* and 22.1 mm (2.8 g) 34.6 mm (3.8 g), 38 mm (5.4 g) and 45. 8 mm (7.8 g) for *S. sihama*. Thus, the average monthly growth increments for the species were found to be 15. 8 mm (3.1 g) for *V. seheli*, 20.5 mm (5.1 g) for *C. chanos* and 11.4 mm (1.9 g) for *S. sihama* respectively. In this experiment, *C. chanos* showed better growth than in the first experiment, whereas *V. seheli* showed good growth in the first experiment. Perhaps it may be due to the stocking density which was lesser for *V. seheli* in the first experiment and for *C. chanos* in the second experiment.

Seed resources at Mandapam

In order to study the diurnal variations in the occurrence of mullet seed, collections were made with a drag net once in a fortnight 3 to 6 days after the full moon and new moon days from August 1978 to July 1979 and also 2-3 days before full and new moon days from August 1979 to October 1979 in addition to the regular collections made on other days at Theedai near Mandapam along the Palk Bay.

The data indicate that the seed of the grey mullet *Liza vaigiensis* (10-90 mm) dominate the collection with *Liza macrolepis* (15-107 mm) and *Valamugil seheli* (15-95 mm) occurring in fewer number occasionally. Other species of fishes which occurred along with mullets include *Therapon* sp. 20-30 mm total length ; *Hemirhampus* sp. 17-123 mm; *Chanos chanos* 40-125 mm ; *Allanetta* sp. 12-85 mm ; *Sillago sihama* 12-80 mm ; *Tachysurus thalassinus* 27-81 mm ; *Nematolosa nasus* 20-90 mm ; *Leiognathus brevirostris* 30-40 mm ; gobids 30-40 mm ; belonids 80-102 mm ; *Gerres* sp. 14-84 mm ; *Megalops* sp. 19-55 mm and *Plotosus* sp. 21-65 mm. Prawns were represented by *Penaeus indicus* 25-30 mm total length and *Metapenaeus burkenrodi* 30-50 mm.

Quantitative studies revealed that greater quantities of seed were available in August, November 1978 and January, February, May June and July 1979 than in other months. Better collections could be made during early morning and late night hours than at other times. Abundance of seed was observed usually an hour before the high tide reached its peak. It was found that tidal streams, pools and adjacent lagoon areas are suitable spots for collection of seeds at the receding high tide.

Attempts were made to culture the Indian sandwhiting *Sillago sihama* at Mulky near Mangalore. Fingerlings, 45 to 80 mm were found abundant in the upper reaches of Coondapur Estuary from October. 1,800 fingerlings (20-100 mm) released in experimental ponds at Mulky (0.2 ha) in January were harvested in May when the length varied from 70 to 229 mm and weight from 3.5 to 99.0 g. The rate of recovery was about 2%. Experiments were conducted in the induced breeding of the fish with pituitary extracts of fresh water and marine cat fishes. The fish responded to the treatment and in many cases, vary nearly oozed the eggs. On one occasion, it spontaneously released the eggs in an experimental plastic pool. Attempts to fertilise the eggs, however were not successful. Two sets of experiments were conducted on induced breeding of *Sillago* in September 1979. Fish (228 mm) readily released eggs when held in hand by jerking its body. Attempts to fertilise the eggs were not successful. 500 fingerlings (50-60 mm) of the milkfish were released in the ponds at Mulky in May 1979. By September, the fish attained a size ranging from 244 to 262 mm and weight varying from 100 to 120 g.

At Calicut, fish culture experiments were conducted in eight polythene lined ponds of the size $15 \times 8 \times 1\frac{1}{2}$ metres (7 ponds) and

20 × 8 × 0.5 metres (one pond). Sea water was pumped into these ponds. Salinity in the ponds ranged from 0.5 to 64.1 ppt ; dissolved oxygen 0.25 to 7.6 ml/l and surface temperature 25 to 45°C. Fish meal was used as artificial feed.

463 fingerlings (15-17 mm) of *M. dussumieri* stocked at the rate of 90,000 per hectare in October 1977 attained a size of 110 mm in seven months. Artificial feed at the rate equal to 1/10 of body weight was given. Good growth of *Microcystis* and phytoplankton production were observed.

In another experiment, 240 fingerlings of *M. dussumieri* (10-12 mm) and 5 *Chanos chanos* (14-17 mm) were stocked in one pond in January 1978. By May 1978, *M. dussumieri* attained a length of 132 mm and weight of 29.9 g. *Chanos* attained a length of 300 mm.

Cage Culture

Culture of anchovies at Vizhinjam (Trivandrum) by suspending nylon net cages from rafts in the Bay had shown that all species sustain a very high initial mortality which decreased thereafter. *Stolephorus buccaneeri* was found to be relatively hardier than all the other species. These experiments are aimed at supplementing the resources of bait fishes for tuna live-bait fisheries of the Lakshadweep islands.

At Mandapam, experiments have been designed to investigate the possibilities of culturing a few species of economically important marine fishes in suitable low cost cages suspended in coastal waters. Cages (1.5 × 1.0 × 1.0 m and 1.0 × 1.0 × 1.0 m) were fabricated out of nylon netting, bamboo splits and palmyra stem splits. The cages had been kept tied to casuarina poles such that they may rest on the sea bottom at a depth of about 0.75 m at low tide, in coastal waters of Palk Bay.

Rabbitfishes (*Siganus canaliculatus* and *S. javus*), groupers (*Epinephelus tauvina* and *E. hexagonatus*) and the Indian sandwhiting *Sillago sihama* were cultured in the cages from March 1979 to October 1979 when the Palk Bay remained calm.

The initial sizes of *S. canaliculatus* ranged from 78 to 120 mm (7.5 to 24.0 g) and the stocking density was 60 nos./sq. m. In the case of *S. javus* reared in two cages, the size range was 67 to 90 mm (5.52 to 13.0 g) with a stocking density of 200 nos./sq. m in one cage and 87 to 117 mm (11.5 to 32.3 g) with a stocking density of 160 nos./sq. m in another cage. The fishes were fed on artificial feed made out of seaweed, prawn heads, fish meat and rice bran mixed in equal proportions. In another combination of feed, fish meat and rice bran were substituted by fish meal and groundnut oil cake. For *S. canaliculatus* the average growth increment per month was found to be 8.5 mm (3.1 g) and for *S. javus* it was 5.6 to 6.2 mm (2.0 to 3.4 g).

The initial sizes of *E. tauvina* and *E. hexagonatus* were 173.0 to 354.0 mm (80.0 to 580.0 g) and 224.0 to 300.0 mm (190.0 to 380.0 g) respectively. They were stocked together in a cage at a density of 13 nos./sq. m. The fishes were fed with chopped trash fish. Average growth per month was 19 mm (87.3 g) for *E. tauvina* whereas *E. hexagonatus* did not show any consistant growth pattern.

The initial size of *S. sihama* was 63.0 to 95.0 mm (2.8 to 6.0 g). The stocking density was 70 nos./sq. m. The fish was fed with fish meal and groundnut oil cake mixed in equal proportions. The average growth increment per month was 10.0 mm (1.6 g).

The results of the above experiments indicated that, of all the species cultured, *E. tauvina* registered good growth per month and the yield had been 2-5 times in 6 months. The survival rate was 73%. Therefore, this species appears to be ideal for cage culture in coastal waters. However, during the present investigation, juveniles of this species could not be collected in large numbers for extensive culture.

Of the four types of cages used, those made up of nylon netting were found to be better in respect of durability, cleaning and resistance to fouling. They are also light and easy to handle. The palm leaf stalks and bamboo splits had become soft due to leaching in sea water and they were found to be highly susceptible for attacks by fouling organisms. The G.I. wire mesh got rusted and yielded at places. Another problem encountered in cage culture was the entry of predatory fishes like *Therapon* sp., in larval and juvenile condition. They not only compete for food with the species cultured but also injure them as they grow, thus leading to certain amount of mortality.

Running water culture

The eel *Anguilla bicolor* has been successfully cultured in running fresh water. The estuaries and coastal areas of Tamil Nadu have been surveyed for the occurrence and distribution of glass eels and elvers of this species. As a result of this survey, 47 collection centres have been identified and they were classified according to the abundance of the young ones of the eel. A special elver collection net has been designed for their collection. Good collections of elvers are usually obtained at night and the best season for collection has been found to be from October to March, although they could be collected in smaller quantities at other times as well. The young ones thus collected were transported over long distances in oxygenated plastic bags and wooden frames with bolting silk bottom without any appreciable mortality. Elvers could be alive in oxygenated plastic bags for about 24 hours at room temperature (30-31.5°C).

Culture experiments were conducted in plastic pools (3' and 12' dia.) and in rectangular tufflite tanks [1.2 (L) × 0.75 (W) × 0.75 (H) m]. The size of elvers at the beginning of the experiments is usually around 10 cm, which is also the common sizes at collection from nature. Fresh water circulation is provided to all tanks. Experiments on conversion efficiency of seven types of feeds have shown that clam meat, silverbellies and mixed fish gave higher conversion ratio (6 : 1) when compared to other feeds. Differential growth pattern of individual eels in experiments is a common phenomenon which recessitates periodic sorting out of the eels according to their sizes.

Results of the experiments on the growth of eels indicated that elvers 120 mm in length and a weight of 2.1 g attained a length of 200 mm and weight of 48 g at the end of first year. The average lengths at the end of the second and third years were 324 and 420 mm and weights 123 and 177 g respectively. The rings found on the scales of the cultured eel were not annual in nature. A total weight of elvers of 6.2 kg at the beginning of the experiments increased to 20, 30.8 and 44 kg at the end of first, second and third years respectively. The annual survival rates were 87, 44 and 39% for the first, second and third years respectively. Percentage increase in total weight was found to be higher in bigger than in smaller tanks.

In order to conserve fresh water, an experiment was designed to culture eels in recycled water. An outdoor cement tank (6 × 3 × 1 m) with natural bottom was constructed. By sluice gate arrangement, the bottom water was drained by gravitational flow and passed through gravel, stones, charcoal and sand filters. The filtered water was allowed to settle in a settling tank. The clear water from the settling tank was made to overflow into an oxidation pond from where the water was pumped up into a small overhead tank and fed into culture tank by pipe line arrangement. Thus, the recycled water was re-used again and again after filtration and oxidation. Once a week, about one-third of the total quantity of the water in the culture tanks was replenished with fresh water. The eels were fed in a shaded area by suspending a tray with the feed, so that the tray just touches the surface of water. The eels crawl over to the tray from all sides, take in mouth fulls of the feed and slip back into the water. The process is repeated till the eels are satiated and return no more to the tray, although enough feed may be present in the tray. This method ensures maximum utilization of feed and absolutely no waste by dissipation into water. The water could also be maintained uncontaminated from left over parts of food for longer periods of time. The feed is made into a paste composed of minced fish (silverbellies), rice bran and oil cake in 2 : 1 : 1 proportion with 0.2% multivitamin. The eels were fed daily once with a ration ranging between 5 to 10% of their body weight. The results showed that the total weight had increased from 9 to 47.7 kg in about 5 months (August '78 to January '79) and average weight from 43 to 232.8 gms indicating an increase of 430% of the initial weight. The net production rate works out to 2.15 kg/sq. m in five months. The gross food conversion ratio was 1 : 4 and the survival rate 98.56%.

Coastal Fish Farm Development

Tampi (1960) discussed the first results of marine fish culture experiments at Mandapam. The poor and porous soil in the area are largely responsible for inhibiting the fertility of the ponds. The biological productivity has been found to be low. Tampi (1960) also discussed the advantages and disadvantages of establishing a marine fish farm in the area.

The significance of application of compost manure in increasing the biological productivity of saline waters has been discussed by Pillai (1955). Pillai (1956) analysed the mud from these regions and pointed out that the surface layers are relatively rich in organic matter and nutrients. However, below this rich surface layer, almost pure sand is found which is not suitable for retention of water as well as for construction of strong bunds. Further, because of this loose nature of bunds, the inner sides of bunds cave in at water level, constantly damaging the bunds. Heavy rains in monsoon months (October to December) also damage the bunds because of the loose sand.

Udaya Varma *et al.* (1963) studied the chemical conditions existing in the experimental ponds at Mandapam. The results revealed the lack of several factors conducive for a balanced growth of animal and plant communities. They indicated that wide fluctuations in salinity often reaching hypersaline conditions, combined with very low concentration of essential nutrient salts and their lack of regeneration or replenishment are some of the main reasons for the low level of biological productivity. Artificial manuring (with super phosphate, 16.5%) had resulted in the increase of production from 0.106—0.122 gm/m^3 to 0.955 gm/m^3 in one pond and from 0.609 gm/m^3 to 1.725 gm/m^3 in another pond.

Taking all the factors analysed in earlier studies (Tampi, 1960; Udaya Varma *et al.*, 1963) into consideration, a recent study of the development of small experimental fish farm in the same area has been initiated. The objectives of this experiment are to construct a viable farm using various techniques and locally available raw materials to secure the bunds, present erosion and caving in of soil. Initially, sea water was pumped into ponds both during day and night by diesel pumps to maintain a depth of about 0.75 m in all the ponds.

For preliminary observations, portions of some bunds of the ponds were turfed with locally available grass on the inner and outer sides as well as on the top. After one year it was found that the grass had well established in spite of lack of water for about eight months. This indicates that with proper planning and careful setting it should be possible to keep the bunds intact. Observations are needed to study the effect of wave action inside the pond due to rough weather and whether the turf grass would survive in the sea water.

A large pond, 60 × 40 m has been lined with polythene film on the inner sides of the bunds from the bottom of the pond to a height of about 2 m above which the bunds were turfed with grass. The top and outer sides were also turfed. Provision was made on the top of the bunds to drain off rain water by a mediun channel by giving slope from either side. This system had prevented caving in of inner sides of the bunds because the force of waves is felt only on the polythene film. However, when strong winds prevail in the area from November onwards, it was found that waves developed in the pond and hit the bund on the windward side with the result that chunks of the bund inside the lining have been found to fall down, leaving hollow spaces which make the lining beat about and bring down more of soil. Further experiments to overcome this problem are needed.

At present, the ponds are supplied with sea water through pumping. This is found to be costly. It is proposed to supplement this facility by erecting a few wind mill pumps, taking advantage of high winds prevailing in the area throughout the year.

In a long range development programme proposed by the Central Marine Fisheries Research Institute for culture of marine fishes in the area, the occurrence of seed of commercially important fishes (mullets, milkfish, *Sillago* etc. and prawns) is an added advantage. Besides, the accessibility of the place by road, sea and its proximity to rail road communication provides facilities for transport of fish and fish seed. The large quantities of seaweeds and sea grasses washed ashore along the Gulf of Mannar coast can provide a rich organic manure for increasing the low fertility rate of the ponds. Once a suitable technology is developed for the construction and maintenance of ponds in the coastal area, it should be possible to utilise the vast low lying areas along the coast to produce fish and fish seed in large quantities.

Problems in the Culture of Marine Fishes

Tampi (1967, 1969) and Sekharan (1976) outlined the problems and possibilities of culture of marine fishes in India. The major problem in culture of marine fishes in India is that of locating suitable sites for culture. The straight coast line without many indentations does not provide suitable sheltered areas and calm conditions for erection of structures like pens and cages in coastal waters. On the other hand, there are extensive stretches of low-lying areas along both east and west coasts which get flooded with sea water during certain periods of the year. These could form suitable areas for development of fish farms. Though occurrence of seed of a number of commercially important species of fishes is known at several places, precise qualitative and quantitative assessments, seasonal abundance, diurnal variations and related environmental data are still lacking which are essential for embarking on large scale culture of sea fishes. The Central Marine Fisheries Research Institute had initiated this study recently in a few regions and extensive data have already been collected.

Marine fish culture experiments so far had been restricted to only a few species like the mullets and milkfish, but recently, studies have been extended to other groups like groupers, rabbitfishes and the Indian sandwhiting. There is need to identify more species with faster growth rates for culture under suitable conditions. Experiments are now being conducted in several situations using artificial feeds like the conventional feeds (combination of rice bran, oil cake and fish meal) as well as pelleted feeds, dry and wet feeds using locally available raw materials. This development has to go a long way to standardise artificial feeds keeping in view the nutritional requirements of various species and the economics of preparation of such feeds.

Breeding and artificial propagation of marine fishes is still a big technological challenge in this country, with only a record of limited success in the breeding of mullets. Attempts are currently under way to breed the important species of mullets, milkfish, Indian sandwhiting and the pearlspot. Studies on the parasites and diseases of marine fishes and development of control measures for the same are in urgent need, for very few observations have so far been made in this field up till now.

Constraints Identified During Recent Research in Culture of Marine Fishes

Although pioneering efforts were initiated by the Institute in the year 1972, a large scale thrust was given to aquaculture research programmes in 1977, to develop suitable technology for the culture of fishes, crustaceans, molluscs and seaweeds. Considerable progress has been achieved and the work is being intensified to perfect the simple techniques already developed.

Mariculture and coastal aquaculture methods are beset with several problems in the field, depending on local environmental conditions. Pens have been erected for the first time in the sea at Mandapam. Some constraints were observed in the construction, maintenance and operation of pens. The constant impact of strong winds, the force of waves, the effect of tidal flow and currents have to be reckoned with. The materials used for construction deteriorate with time due to action of sea water as well as the damage caused by boring and fouling organisms. Silting, accumulations and decomposition of wastes in and around the pens creates changes in hydrological conditions. Experience gained so far indicates that bamboo screens do not last for more than a year in the sea and the casuarina poles may serve the purpose only for about 2 years, both of them deteriorate faster due to fouling and wear and tear due to action of waves and winds.

One of the major problems encountered in the operation of the pens at Mandapam was the large scale accumulation of sea grasses in and around the pen during the south-west monsoon period (May to September). The hydrogen sulphide gas released by the decomposed sea grass polluted the sea water and brought down the dissolved oxygen content thereby causing mortality of fish. Blooms of the blue-green alga *Trichodesmium* were also observed during the above months which also caused mortality of fish inside the pens. These difficulties could be overcome by carrying out culture work in the Gulf of Mannar from September to May when calm condition prevail in the sea and no effects of pollution of the type mentioned above could be found. Maintenance work could be attended to during the rest of the period.

Experience at Mandapam where a pen was constructed in the Palk Bay out of palmyra stalks and sliced palmyra stem pieces indicated that due to action of waves on the sides of the pen, especially on the eastern side, the silt is heaved up and accumulated inside the pen. Such a phenomenon was not noticed in the case of net impoundment which was erected in the vicinity. However, in the case of net impoundment, crabs have been found to make holes in the net upto water level in certain months. Another problem in this case was fixing of the net securely to the sea bottom without gaps. For this purpose, two feet long bamboo pegs were driven into sea bottom at every one metre interval fixing the net tightly to the bottom. This method has been found satisfactory.

Among the different cages used, cages with nylon nettings, though costlier, seem to be more suitable than others in view of their durability, lesser weight and easiness in cleaning. Palm leaf stalks and bamboo splits become soft and decay in sea water though they are less expensive. They have been found to be highly susceptible for fouling. The G.I. wire mesh corrodes quickly and hence not found suitable.

Although initial growth, survival and production rates were very encouraging for a number of species, experiments for longer duration and in larger areas have to be conducted to obtain marketable sizes for commercially important species. The stocking and feeding rates have to be standardized. However, the various constraints already identified in the several experiments conducted so far have to be taken into consideration in future work.

Prospects

Based on the studies so far conducted on the culture of marine fishes in India, it has become clear that there is vast scope for coastal aquaculture of finfishes, crustaceans and molluscs because of the availability of vast stretches of water suitable for this purpose. The extent of estuarine and brackishwater areas in the country is estimated to be about 2 million ha. While only a few species of finfishes have been experimented with so far, there are possibilities of finding out other species for culture under suitable conditions. Promising growth rates have been found for species of mullets, milkfish and groupers. Since a breakthrough had not yet been made in the breeding of marine fishes, culture of these species is still dependent on naturally available seed resources. In this context, detailed assessments of seed resources of commercially important species are needed to boost up culture of the same. Intensive culture of marine fishes in confined systems like ponds, pens or cages calls for studies on the parasites and diseases of cultivable species and methods of control for maintaining fish in healthy conditions, reducing mortality and increasing fish production. The valuable experiences so far gained indicate the possibilities of culturing a variety of marine fishes in widely different salt water environments and the problems that have to be solved for improving the technology already developed.

Preliminary studies conducted on the fisheries potential and productivity of brackishwater areas, lagoons and coastal fish ponds indicated vast scope for converting such areas into suitable fish farms for production of fish, prawns and molluscs. Once the low cost technology for coastal farms is developed, it should be possible to reduce the cost of production and also utilize the abundant seed resources and organic water for production of fish. Therefore, it may be concluded that there is great future for marine finfish culture in India. The immense prospects of mariculture/coastal aquaculture are however, linked with a strong research base, availability of trained personnel, facilities for education and training, development and extension. Planned organisation of these activities would lead to significant strides in coastal aquaculture development which in turn could play a key role in national and rural economy.

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