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16-18 September 1987

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Sessions III & IV

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(Indian Council of Agricultural Research)
P. B. No. 2704, E. R. G. Road, Cochin-682 031, India

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RESEARCH IN THE ASSESSMENT OF CAPTURE AND CULTURE FISHERIES ALONG THE INDIAN COAST

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ABSTRACT

A review of the research conducted at National Institute of Oceanography, Goa, to assess the capture and culture fishery potential of India is presented in the paper. The primary, secondary and benthic productivity of estuaries and backwaters are elucidated by taking the Mandovi-Zuari estuarine system as an example. The productivity of the coastal and oceanic waters around India are discussed. The expected fishery yield and present level of exploitation are assessed and further course of action discussed in this paper. In culture fisheries the contributions of NIO in the fields of mussel culture, shrimp culture, brine shrimp culture, seaweed culture, horse-shoe crab culture and fish culture are reviewed and discussed.

INTRODUCTION

India, with an extensive coastline of over 6,100 km and an exclusive economic zone (EEZ) of above 2 million sq. km, contributes about 46% of the total exploited living resources from the Indian Ocean. The marine fisheries of India are dominated by pelagic fishes like sardines and mackeral, though demersal fishes like butter fish, pomfrets, sciaenids, and more importantly the shrimps, contribute substantially. Unlike the pelagic, the demersal fisheries show less annual and seasonal fluctuations. Research and scientific management have greatly helped in the development of Indian Ocean fisheries. Although the growth rate in fishing industry has come down during the last few years, it had registered a growth rate of over 4% in the 1950s and 1960s (Dalal and Parulekar, 1985). This growth rate has been possible due to the research and development efforts in the field of fishery science, technology and oceanography by various central and state organisations and Universities.

The present paper briefly describes the salient findings of research conducted at the National Institute of Oceanography (NIO), Goa to assess the capture and culture fishery potential of India.

AREAS OF STUDY

The role estuaries and backwaters play in the productivity of coastal waters of India need not be over-emphasized. The National Institute

of Oceanography has conducted a number of studies at major estuaries and backwaters of India. The Cochin backwaters has been studied for nearly two decades and the results have been published periodically (Qasim *et al.*, 1969; Qasim, 1970; 1973 and 1979). The Mandovi-Zuari estuarine system (Goa) situated along central West coast of India (lat. 15°25'-15°30'N long 73°45'-73°55'E) has been extensively studied. It is a tide dominated estuary which is homogenous vertically with lateral variations in salinity. It also develops a salt wedge. Annual variations in salinity are large (0-34°/$_{oo}$) while the variations in temperature are about 5-6°C (Qasim and Wafar, in press). The depth of the euphotic zone varies from 0.75 to 6 m with greater depths during the inter - monsoon period (Devassy, 1983).

Several programmes have also been undertaken in Vembanad Lake (Madhupratap, 1978), the Auranga, Ambika, Purna and Mindola estuaries of Gujarat (Nair, Gajbhiye *et. al.*, 1981), and the Shastri and Kajvi estuaries of Maharashtra (Achuthankutty *et al.*, 1981) to assess the part played by the major estuaries in the west coast of India on its productivity potential and fishery. Along the east coast of India the Hooghly and Mahanadi estuaries have been studied.

Biological oceanographic studies in the Indian Ocean received considerable impetus during the International Indian Ocean Expedition (1960-65). A number of reports and Atlases have been published as an outcome of this major effort. Subsequently, primary, secondary and benthic productivity of the Indian Ocean have been estimated based on samples from more than 170 cruises of R. V. *Gaveshani* and more than 40 cruises of ORV *Sagar Kanya*.

From the coastal and oceanic areas of the seas around India, studies conducted upto 10°S lat. only are included in the present paper, although a number of oceanographic cruises and expeditions had been undertaken by the National Institute of Oceanography beyond this region including the Antarctic continent.

BIOLOGICAL PRODUCTIVITY AND CAPTURE FISHERIES POTENTIAL

Estuaries and Backwaters

Phytoplankton production: In Mandovi-Zuari estuarine system maximum abundance of phytoplankton occurs during the post-monsoon period. On an average, annually the phytoplankton cell counts vary from 4.75×10^3 to 1370×10^3 cells/l. Primary production values in the Mandovi estuary during post-monsoon, monsoon and pre-monsoon are 1077, 262 and 570 mgC/m^2/day respectively (Verlencar, 1982). Average primary production for the entire estuarine system is 510 mgC/m^2 /day (Devassy, 1983).

Zooplankton producton: Secondary productivity of Mandovi-Zuari estuarine system was calculated from the biomass data and it ranged from 1 to 83 mgC/m^2/day (Bhattathiri *et. al.*, 1976; Goswami, 1979). The average production rate was 22 mgC/m^2/day (Goswami, 1979). The mean biomass of zooplankton in this estuarine complex was reported as 0.12g/m^3 (Goswami and Selvakumar, 1977). The total secondary production from this area was estimated to be 1078 tonnes C/yr by Selvakumar *et al* (1980). The zooplankton abundance in tropical estuaries is basically controlled by the prevailing salinity regime and flushing effect. In the Cochin backwaters biomass is high during the pre-monsoon period, very low during monsoon period and intermediate during the post-monsoon period (Qasim *et al*, 1969; Wellershaus, 1974). The average secondary productivity of Cochin backwaters is estimated to be 15.4 gC/m^2/Year (Madhupratap, 1987).

Benthic production: The macro benthic biomass and production in this estuarine complex was studied by Parulekar *et al.*, (1980). The annual mean biomass calculated by these authors was 4.08 gC/m^2. Low production was found in the monsoon months. High production rates were obtained both during pre-and post-monsoon seasons depending upon the area and its proximity to the sea.

Predictions and fish yield: Based on the above studies using a conversion of 1% primary

production or 10% secondary production (Qasim, 1977), the tertiary production of this estuarine system of approximately 92km² is estimated as 1,200 tonnes/year (Qasim and Wafar, in press). The present fish yield from the brackish and freshwater regions of Goa is about 1,400 tonnes/year of which nearly 80% comes from the Mandovi - Zuari estuarine system. Thus the calculated tertiary yield is reasonably accurate and helps to maintain a sustainable yield.

Although a prediction of the final biological yield from an estuary is possible by an assessment of the productivity rates at various trophic levels as has been made above, in certain estuaries like the Cochin backwaters and the Hooghly-Matlah estuary, detritus also plays a very important role in the trophic chain and final fishery yield. In such cases, the demersal fishery would nearly dominate. In the Cochin backwaters settled detritus production is on an average 14.96 gC/m²/day (Qasim and Sankaranarayanan, 1972) whereas average primary production is only 0.77gC/m²/day (Qasim *et al.*, 1969). Thus the energy available for intake in the case of demersal fishes is nearly 20 times greater than that available for pelagic forms.

Coastal Waters

Biological productivity of coastal waters ranks in importance next to estuaries. The average primary production in the shelf waters is about 164 gC/m²/year (Whittle, 1977). Within the coastal waters primary productivity rates differ considerably. In areas < 50 m depth where the major fishing effort is concentrated, the primary productivity is at least six times higher than that of the coastal waters of <60m depth (Qasim, 1979).

Primary production: Along the west coast of India, upwelling occurs during south-west monsoon and reaches its peak in July-August. During this process the nutrients from deeper waters are brought to the surface in addition to the amount added through river run-off. Measurements on primary productivity along the Indian coast and from the Indian Ocean were made from about 480 stations north of 10°S lat. during the IIOE and later on board INS *Darshak*, R. V. *Gaveshani*, and ORV *Sagarkanya*. About 150 stations were occupied for primary productivity studies from 28 cruises of R. V. *Gaveshani* (V. P. Devassy, pers. comm.). The primary production attains its highest values during the post-monsoon period which range from 0.48 to 2.45 gC/m²/day with an average value of 1.19 gC/m²/day (Nair *et al.* 1973). Pooling all seasonal data Qasim *et al.* (1978) obtained an average production rate of 0.76 gC/m³/day.

Secondary production: Throughout the coastal, area zooplankton abundance is generally bimodal with two peak periods. February-April and September-October (Rao, 1979). The studies carried out on zooplankton samples of IIOE and R. V. *Gaveshani* indicate pockets of high zooplankton biomass in the areas off Bombay, Goa, Mangalore and Cochin. The Bay of Bengal showed a gradual southward increase in zooplankton biomass with higher values in the region between Visakhapatnam and Madras. Goswami (1985a) has obtained an average secondary production of 24.52mgC/m²/day along the central west coast of India which is less than the values reported by Qasim *et al.* (1978) for the west coast and Goswami (1985b) for Goa coast. Nair *et al.* (1981) observed an average biomass of 17.6ml/100m³ along the east coast of India in June. Madhupratap *et al.* (1981) estimated the average secondary productivity of the Andaman Sea as 288 mgC/m² with a range from 185.6 to 608.6 mgC/m². Studies based on IIOE (IOBC, 1968-73) have shown that some part of Bay of Bengal is equally rich in zooplankton as the Arbaian Sea. Qasim *et al.* (1978) estimated the secondary productivity of coastal waters of Indian Ocean as 2.5 x 10⁶ tonnes C/Year.

Benthic production: Parulekar *et al.* (1982a) have estimated the benthic production of Arabian Sea, Lakshadweep Sea, Andaman Sea and the Bay of Bengal based on the OCEANOX cruises (1973-74) on board INS *Darshak* and data obtained from 56 cruises of R. V. *Gaveshani* (1976-80). The nearshore areas of >30m depth mainly contribute for high biomass

production and the standing crop decreases with the increasing depth. The macrofauna is the chief contributor for biomass production in the shelf region while along the slope and deeper areas the meiofauna dominate (Parulekar *et al.*, 1982a).

The biomass for the whole area varies from 0.01 to 610 g/m². The mean biomass was 17.61 g/m² for Arabian Sea, 7.32 g/m² in the Andaman Sea, 5.32 g/m² in the Bay of Bengal and the lowest of 0.74 g/m² in the Lakshadweep Sea. In the shelf region of Arabian Sea the benthic productivity ranged from 1.0 to 2.3 gC/m²/year while it varied between 0.6 and 3.1 gC/m²/year in the Bay of Bengal. In the Andaman and Ladshadweep Seas the annual production is of a low magnitude and it varies from 0.7-7.8 gC/m²/year (Parulekar *et al.*, 1982a).

Prediction and fish yield: Adopting the previously mentioned trophic conversions, the tertiary yield was calculated as 0.185 $\times$ 10^6 tonnes C/year. Using the live weight conversion factor of 10 the potential yield was calculated to be about 2 million tonnes/year. Qasim *et al.*, (1978) have calculated a sustainable yield of 0.8 million tonnes/year from these values.

The potential demersal yield computed from the studies of Parulekar *et al.*, (1982a) was 0.75 million tonnes for Arabian Sea and 0.33 million tonnes for the Bay of Bengal, totalling to about 1.08 million tonnes/year for the shelf waters of India. At present only 0.45 million tonnes are exploited from a possible 0.65 million tonnes which suggests that there is a scope for increased efforts to further our demersal fisheries.

Oceanic Waters

Oceanic waters are relatively less productive. However, this is compensated by the enormous area (almost 92%) they occupy of the total marine expanse. Such low rates of primary production in the oceanic waters are directly related to the impoverishment with macro-nutrients, particularly inorganic nitrogen (Wafar *et al.*, 1986). The same holds good with zooplankton production as well. The availability of lesser number of phytoplankters to form food of zooplankton itself would be the main reason for this poor secondary productivity. Pant (1981) observed a primary productivity of 4.4 mgC/m³/hour at Great Nicobar Island which was higher than any other region in the Andaman Sea. Qasim and Ansari (1981) found that detrital carbon in the Andaman Sea constitutes about 92% of the total particulate carbon while phytoplankton and zooplankton constitute small fractions of the total suspended matter.

In deeper waters (>1000m) Parulekar *et al.*, (1982a) observed an average benthic production of 1.3, 0.04, 0.39 and 0.75gC/m²/year in Arabian Sea, Lakshadweep Sea, Andaman Sea and the Bay of Bengal respectively. The macrofaunal biomass varied from 0.47g/m² to 13.32g/m² with an overall mean value of 2.62 g/m² in the central Indian Ocean (Parulekar *et al.*, 1982b). The areas along the slope and the deep sea can support a potential yield of 0.4 million tonnes in the Arabian Sea, 0.13 million tonnes in the Bay of Bengal and 0.07 million tonnes in the island groups.

MARICULTURE POTENTIAL

Besides its contributions in the field of Oceanography and fisheries the National Institute of Oceanography has also undertaken considerable research work in mariculture. The areas covered include molluscan culture, crustacean culture, seaweed culture and fish culture. For most of the studies the existing running seawater aquaculture facility (Chatterji *et al.*, 1983) has been made use of.

Molluscan culture: Of all the cultivable species of marine and estuarine plants and animals, the bivalves, because of their sedentary and gregarious habits, short food chain, and fast growth, form the most ideal organism for undertaking commercial cultivation on a large scale. By far the modest success achieved in the culture of edible bivalves pertain to mussels, *Perna viridis* and *Perna indica*. The techniques of culture of green mussel and the economics of the entire operation has been published (Qasim *et al.*, 1977; Parulekar *et al.*,

1984). An annual production of 368 kg/m² has been achieved by applying these techniques with *P. viridis* (Qasim *et al.*, 1977). Under aboratory conditions an annual growth of 89 mm has also been achieved with the above species (Chatterji *et al.*, 1984). Attempts to culture oyster, clams like *Paphia malabarica*, *Villorita cyprinoides*, *Donax incarnatus* and *Meretrix casta* from coastal waters of Goa have also been made with reasonable success (Parulekar *et al.*, 1984).

Crustacean culture: The brine shrimp *Artemia* which is present in large quantities in high saline lakes and salt pans has become a much sought after food organism for a large variety of aquatic animals. The National Institute of Oceanography has conducted a survey all along the coastline of India to find out potential resources of *Artemia*. This has led to the finding of new *Artemia* grounds along Saurashtra and Kutch coasts of Gujarat (Royan, 1979). The annual cyst production from these natuaral areas run to a few hundred kilograms which is not sufficient to meet the demand. Considering this NIO has been concentrating on the culture of *Artemia* since 1975 and has worked out the requirements for optimum growth and survival. The Indian strains *Artemia* requires 35°/$_{oo}$ salinity and 30°C seawater for efficient hatching (Royan, 1976). All the life stages of *Artemia* thrive well on unicellular algae as well as bacteria, yeast and rice bran.

It is observed that decapsulated *Artemia* cysts, when directly fed to the juvenile prawns *Metapenaeus monoceros* more than 50% food conversion efficiency could be attained (Royan, 1980). Similarly, when adult *Artemia* were fed to three species of penaeid prawns *M. dobsoni*, *M. monoceros* and *Penaeus indicus*, good growth and conversion efficiency were obtained (Royan *et al.*, 1987). Complete information on the population dynamics and growth characteristics of the Indian strain of *Artemia* from the salt pans in Tuticorin (Tamilnadu) and Mundra (Gujarat) are available (Royan *et al.*, 1978). By monitoring the salinity, temperature and the level of water in the condensor pans, a cyst production of 30 kg/ha/season could be achieved.

Among the 55 species of shrimps and prawns accuring in commercial landing, 15 species are found suitable for aquaculture. Among them, priority is accorded to *Penaeus monodon*, P. *indicus* and *P. merguiensis* because of their demand and profitability. Seed survey has been carried out in all the major backwaters and estuarine systems, coastal lagoons besides the surf waters by various agencies. The seed resources of *P. monodon* are confined to certain localities. According to one estimate (Nair, 1986) about 1.5 billion postlarvae of penaeid prawns are immediately required to put 30,000 ha. of brackishwater area under shrimp culture. Trials to improve the hatching rate, survival and growth rate of penaeid larvae in hatchery are undertaken continuously as part of the mariculture programme. With the cooperation of traditional shrimp farmers, studies were conducted to improve the traditional method of paddy-cum-shrimp culture by incorporating more modern methods such as introduction of nursery pond, supplimentary feeding, retrieval of under sized juveniles and other management techniques (Gopalan *et al.*, 1978). Studies have indicated that short term high density farming of selected species like P. *indicus* would double the present annual yield of shrimps from paddy fields. A production of about 2300 kg/ha of marketable shrimps would be possible from the fertile Pokkali fields of Kerala in two short term crops of 12 weeks duration (Gopalan and Rao, 1981). *In vitro* fertilization of banana prawn *Penaeus merguiensis* has also been successfuly achieved and larvae reared with 28.6% survival rates upto mysis III stage (Nair, 1987).

The horse-shoe crab, a living fossil, has so much usefulness for humans that their value for biomedical research is ever increasing. The most important use of this crab lies in the presence of a reagent (LAL-lysate amoebocyte limulus) in its blood which is capable of detecting bacterial endotoxins, even if they are present in extremely minute quantities. Realising its commercial importance, the National Institute of Oceanography has undertaken a survey of the distribution of this crab along the Indian coast and it is observed that only

two species are available along the Orissa and West Bengal coasts. They are *Carcinoscorpius rotundicauda* and *Techpleus gigas* (Anil Chatterji, pers comm.). Observations made in the laboratory and fields indicate that the crabs breed year round. The females responded to 6 volt DC current and released a number of ripe eggs (Anil Chatterji, Unpublished data). Further work on the mass culture of these crabs is in progress.

Seaweed culture: The marine algae are important as food, feed and pharmaceutical compounds. The limited resource potential of the desired marine algal species and the increasing demand of the raw material have forced the need for marine algal cultivation. It is estimated that about 25,000 tonnes of dry seaweed is available from the areas already surveyed (Untawale, 1981). Rope net technique is the most commonly used method to culture marine algae and the techology is standardised. (NIO, 1985). A growth rate of upto 42.5 g/m²/day was achieved for *Gracilaria, Sargassum* and *Hypnea* by adopting these techniques (NIO, 1985). Coral stones have also been used to culture some small sized species like *Gelidiella acerosa*.

GENERAL REMARKS

From the voluminous work done on productivity of Indian waters the following are few of the outstanding conclusions. The productiviy of estuaries and backwaters of India is quite high although they exhibit strong seasonal pattern with very low values during the monsoon season. As an example the average primary productivity of Mandovi-Zuari estuarine system is 510 mgC m²/day while the secondary productivity is about 22 mgC/m²/day. The annual average macrobenthic biomass of the same area is about 4.08 gC/m². A comparison of the present fish yield from this area with the annual predictions shows that the exploitation here is nearly at the sustainable rate.

Pooling all seasons an average primary production of 0.76 gC/m²/day is observed in the coastal waters of India. The average secondary productivity along the central west coast of India is about 24.52 mgC/m²/day. The benthic productivity of shelf region of west coast of India was about 1-2 gC/m²/year. It is also computed that there is scope for further expansion of demersal fisheries of India in general.

Considerable research has also been carried out in the field of mariculture of mussels, oysters, clams, prawns, brine shrimps, horseshoe crabs and seaweeds. In many cases, like mussel culture the technoloy has been tested in the field for economic viability and are passed on to users. The results also indicate that there is tremendous scope for undertaking large scale culture of selected species from the above mentioned groups.

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Paper - 37

ROLE OF BRACKISHWATER PRAWN CULTURE IN THE FISHERIES DEVELOPMENT OF INDIA

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ABSTRACT

The Seventh Plan envisages an export target of Rs. 1000 crores from the fisheries sector. For attaining this target the emphasis appears to be on exploitation from fishing grounds away from the conventional/traditional grounds beyond the 30 fm line. These fishing grounds can be fished only by bigger trawlers, purse seiners and shrimpers which have the facility to remain at sea for a fortnight or more. Our experience has shown that the shrimp component from offshore grounds is negligible, less than 5%. Shrimp is the major component of our marine exports and if we have to achieve the targets laid down the shrimp catch has to be enhanced in a big way.

We have almost reached a saturation point in exploitating shrimp from coastal waters. Therefore the only alternative appears to be culture of shrimp on a large scale. Fortunately the country has plenty of Kharland along the east and west coasts. Pilot-scale projects in shrimp culture by research institutes have produced encouraging results. Hatchery production of shrimp seed in respect of commercially important species has been achieved. So we have the natural resources, and the technical know how. All that is needed is a boost to shrimp culture by the Government in providing incentives to farmers and industrialists by way of allotment of Kharlands on lease basis on easy terms, funding by banks, etc. If proper incentives are provided, as in agriculture, it should be possible to increase our shrimp production and achieve the export targets within five years.

The present world production of shrimps, realised mainly through capture fishery, is of the order of 1.8 million tonnes. The trend of production during the last ten years has been more or less the same although the effort expended was more. India is one of the leading shrimp producing countries in the world, but here also the trend of production has almost followed the world shrimp production pattern. The peak production of prawns and shrimps in the country was of the order of 2,22,700 tonnes in 1975 and thereafter it declined to 1,85,000

tonnes in 1978 and has remained fluctuating around this figure since then. This is inspite of the fact that our fishing effort has been constantly on the increase all along the coast. Contrary to production, the global demand for shrimps and shrimp products is continuously increasing year after year. Nearly 90% of our export earnings from the marine sector come from shrimp and shrimp products. It is, therefore, necessary for the country to increase the shrimp production substantially if we want to have a hold in the international shrimp market. The Ministry of Commerce, Government of India has set a foreign exchange target of Rs. 700 crores from marine products by the end of the VIIth Plan. How are we going to achieve this?

There are only two ways by which production could be increased.

a) By identifying and exploiting new fishing grounds and

b) by culturing shrimps in coastal waters.

Culture of shrimps in coastal brackishwater areas is emerging as a prospective sector and it should be possible to produce large quantities of desired species of prawns by adopting techniques which are relatively less expensive. About 1.7 million ha of brackish water coastal area is available for aquaculture in India. Out of this, a meagre 30,000 ha (1.75%) is currently under culture, mostly in west Bengal, Kerala and Karnataka. Considering the needs of the country in the matter of food, socio-economic and rural development, it is imperative to convert the unutilised derelict areas into productive lands by adopting the modern technologies developed in prawn culture in the country. The potential brackish water areas available in different states in the country are given below.

State	Potential area available for culture (Mill. ha)	Area under culture (ha)
Gujarat	0.376	88
Maharashtra	0.081	—
Goa	0.019	—
Karnataka	0.008	4,800
Kerala	0.243	5,700
Tamilnadu	0.080	—
Andhra Pradesh	0.200	—
Orissa	0.299	—
West Bengal	0.405	20,000
	1.711	30,588

Although, this estimated area may not be entirely suitable for aquaculture, the surveys carried out so far have shown that considerable extent of this potential area is suitable for immediate conversion into culture fields. Further, we have also biologically and economically suitable species for culture.

The technology for prawn culture on a scientific basis is now available in the country. Considerable research work on prawn breeding, hatchery production of prawn seed of the cultivable species, their feed requirement at different stages of growth have been carried out in the national research laboratories such as the Central Marine Fisheries Research Institute, the Central Institute of Fisheries Education, the Central Inland Fisheries Research Institute and the Agricultural Universities with fisheries faculty (the University of Agricultural Sciences, Bangalore; Konkan Krishi Vidyapeeth; Tamil Nadu Agricultural University, Kerala Agricultural University). Considering the results of these researches, it should be possible to organise small hatcheries along the coast to produce the seed of cultivable species of the particular area. Already the Government of Kerala and Maharashtra have put up hatcheries at Azhikode and Bada Palkhran respectively, as demonstration units as well as on commercial basis. In the private

sector, M/s. Hindustan Lever Ltd is operating a prawn hatchery near Madras. Hatcheries are also being established in Orissa, Andhra Pradesh, Tamil Nadu, Kerala and Karnataka by the Marine Products Export Development Authority and the State agencies.

From the published information on the yield of prawns from the culture operation, we can easily expect to realise about 400 kg/ha of quality prawns within 90-120 days. This production rate works out to about 800-1000kg/ha in a year by taking at least two harvests if not three in a year. Besides the realisation of relatively higher unit production rate through the culture source, the sector affords other advantages relating to employment to technical, skilled and unskilled persons, establishment of ancillary industries to meet the requirements of inputs such as ice and cold storage, feed compounding units, construction of sluice gates, transportation and marketing.

Against these advantages, there are several constraints detering the accelerated development of brackishwater prawn and fish culture fisheries in the country at present. The main developmental constraints encountered relate to the land and water use strategies and the connected policies and guidelines. Endeavours to develop large-scale operation of prawn culture in most of the states are severely handicapped because of non-availability of lands to entrepreneurs, the land distribution policy of the state, conflict between the use of land for agriculture versus aquaculture and ownership of land by different agencies. The other important constraint relates to the timely availability of finance, seed and feed.

In spite of these constraints, it is desirable to introduce coastal aquaculture in a big way. Shrimp is an important foreign exchange earner and we can easily double or even treble our marine exports in the next ten years by utilising these fallow, derelict lands along the coasts of India. Realising the importance of aquaculture, the National Planning Commission and the Government of India have assigned priority for this development activity, particularly prawn culture in all the maritime states.

It is now realised that establishment of aquaculture enterprises is not simple, but involve complex operations entailing cultivation of prawns to marketable size under several environmental and socio-economic conditions. In this context economic feasibility of the enterprise forms the foremost concern of the entrepreneurs. A comparison, is therefore attempted below to understand how the economics of aquaculture of prawns compare with the capture fisheries in the offshore/deep sea fishery sector employing larger trawlers.

In the model for discussion on aquaculture, estimates are made for the development of 400 ha of Kharland into farms and culture of prawns involving stocking, feeding, maintenance of farms, harvesting and marketing.

From 400 ha derelict Kharland on conversion into farms, we would get 240 ha of farm under water. The remaining 40% would be covered by bunds, partition bunds, canals etc. The construction would be in stages of 40 ha, 60 ha, 60 ha and 80 ha in the I, II, III and IV years. The yield is assumed at 400 kg/ha in the II year, 600 kg/ha in the IIIrd year, 800 kg/ha in the IV year, 1000 kg/ha in the V year, 1200 kg/ha in the VI year and 1500 kg/ha in the VII year. Value of farm bred prawn is taken at Rs. 50/-kg and incidental fish catch at Rs. 4/-kg. At the beginning i. e. in the I st year, the farm will be managed by 43 personnel (5 Scientists + 38 labourers) and from the IV year onwards by 225 personnel (23 scientific + Technical and 202 labourers). Increase in the yield is possible by providing suitable *compounded* feed to the stocked population. The project provides for hatchery of its own to meet the seed requirements of the farm. The anticipated expenditure and results are as below at the end of the VII year.

		Rs.
A.	*Capital outlay :*	
	Cost of construction of bunds, Sluice gates with filters, etc. at Rs. 60,000/-ha. Construction of laboratory and office, construction of hatchery, essential staff quarters, feed compounding units, pumpsets, vehicles, Electrical installation, compressors and other machinery etc.	2,00,75,000
B.	*Operational Cost :*	
	Cost of seed, cost of brooders, manure and fertilizers, compounded feed. repairs to plant, machinery and vehicles, fuel and electricity, etc.	38,90,000
C.	*Establishment charges :*	
	Salary of staff, casual labour wages, Contingencies.	1,21,66,000
D.	Depreciation on Capital Cost A at 10% over a period of 7 years.	1,00,43,000
E.	Interest on Capital at 15% over a period of 7 years.	1,43,63,000
F.	Lease rent of Farm at Rs. 20,000/year for seven years.	1,40,000
	Total expenses B + C + D + E + F	4,07,02,000
	Income from sale proceeds of Prawn and fish	5,57,88,000
	Net Profit at the end of VII year	1,50,86,000

It will thus be seen that with a capital investment of Rs. 2.00 crores and working capital expenditure of Rs. 4.07 crores (which includes operational investment at 10%, interest on capital at 15%, lease rent on farm land over a period of 7 years, there would be a net profit of Rs. 1.50 crores at the end of VII year. The break even point of the project is reached at the end of the IV year.

In the capture fisheries sector, it is proposed to introduce 500 bigger trawlers/tuna liners/purse seiners at an estimated cost of Rs. 1000 crores in the VII Five Year Plan. What will be the likely production from these 500 vessels with 250 fishing days? Assuming each boat lands 2500 tonnes of catch in a year, the total landing would be 12.50 lakh tonnes giving a return of Rs. 1,250/- crores. The working expenses of the 500 boat with wages of crew, fuel expenses, port dues, cost of ice, loading and unloading charges, maintenance and repairs of machinery, engines, gear, etc, would be more than Rs. 1000 crores. With all these expenses, the quantity of exportable variety of shrimp would be less than 1%, and fish, less than 10%.

Thus, the return from aquaculture enterprise as against that of the capture fisheries in the deep-sea/offshore fishing shows profit and greater economic feasibility. At present, the Government of India is subsidising the cost of trawlers imported/built within the country. It is also subsidising the cost of fuel by giving excise duty rebate on fuel consumed. Similar facilities for aquaculture, may be extended by the Government, as aquaculture as an industry is not yet established. These facilities may include-reduction in land value as given to salt pans, subsidising construction costs to the extent of 25% of the capital outlay, provision of lower interest rates on capital through agencies such as NABARD.

Further, the Kharland available in each coastal District may be proposed to be allotted to small individual farmers, co-operative societies of fishermen. It is suggested that in each District or two adjoining coastal districts, an area of 500 to 1000 ha of land may be allotted to industrially established entrepreneurs with the following conditions :

1. The Entreyreneur should establish a hatchery within three years to produce required prawn seed.
2. He should spare at least 10% of the seed produced by him to small farmers in the area and meet their requirements.

3. He should also buy the produce in the vicinity of his farm at market prices for processing and export.
4. He should set up a feed compounding unit on the premises to meet his needs as well as those of the small farmers around his farm in the District.
5. All technical know-how and assistance to be provided to small farmers as they cannot afford to employ Scientists/Technicians for 5-10 ha. farms.

If programme on these lines are drawn up and executed by the Government at State and Central level with the incentive proposed, it should be possible for the country to achieve the target of Rs. 1000 crores in the next 5-8 years. In this context, the recent announcement by the Union Agriculture Ministry to throw open brackish water fish farming to the private sector to exploit its full potential is most welcome. It should be implemented by the States in letter and spirit if the country has to achieve the targets of the VII Plan.

Paper 38

ON CONSTRUCTION AND MAINTENANCE OF MARINE FISH CULTURE PONDS ALONG SOUTHEAST COAST OF INDIA

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ABSTRACT

The most expensive input in coastal aquaculture operations is construction and maintenance of culture ponds and farms. Experience gained on construction and maintenence of culture ponds in three localities along southeast coast of India during 1972-'85 has shown that since the earth is porous and incohesive in this region, adequate precautions have to be taken. For instance in order to overcome such problems as erosion of dykes due to prevailing rains, wave action of pond water at dyke bases and deposition of sand inside the ponds, suitable steps have to be devised. Another problem encountered has been poor tidal amplitudes, particularly during premonsoon months, closure of bar mouths in the postmonsoon season and the consequent paucity of sea water supply to culture ponds. The paper gives an account of the experience gained to minimise and/or counter these problems, in the context of the varying climatic and soil conditions in the three localities. Also, the ways and means of applying such techniques for successful management of culture ponds and farms in similar problem-prone areas are discussed.

INTRODUCTION

The most expensive input for culture of marine resources in coastal areas is construction and maintenance of ponds and farms. In India traditionally "bheris" (Pillay, 1954) and prawn or fish cum paddy culture ponds are constructed in West Bengal (Pillay and Bose, 1957), Kerala (Panikkar, 1937; Gopinath, 1956; Panikkar and Menon, 1957) and Goa (Gopinathan and Dani, 1973). Construction of experimental coastal ponds was first reported in India from the forties in Krusadai Island, Tamilnadu (Pillay, 1947; Chacko and Mahadevan, 1956) and Cochin (Pillay, 1948). Pioneering work involving some amount of skills to make the ponds and the dykes durable was carried out by Central Marine Fisheries Research Institute at Mandapam in the fifties (Tampi, 1960). A pilot farm was constructed in Lower Sunderbans by Central Inland Fisheries Research Institute in the sixties (Jhingran,

et, al., 1972). Continuing the work of CMFRI, a few ponds were constructed at Veppalodai in early seventies (Bensam and Marichamy, 1981). A private firm, M/s Shaw Wallace & Co Ltd has constructed some prawn culture ponds at Killai (near Porto Novo) in the late seventies. During 1979-85 C M F R I developed an inexpensive technology for construction and maintenance of culture ponds at Mandapam (Bensam, 1986), and has also taken steps to minimise deposition of sand opposite the supply canal to the Fish Farm for ensuring the flow of sea water.

MATERIAL AND METHODS

Data for the present paper are based on construction and maintenence of culture ponds at Veppalodai (Long. 78° 12' E and Lat. 8° 54' N) during 1972 – '77, Killai (Long. 79° 39' E and Lat. 11° 29' N) during 1977 - '79 and Mandapam (Long. 79° 48' E and Lat. 9° 14' N) during 1979 – '85. Five ponds were constructed at Veppalodai of which four were of 0.035 ha in area each (Bensam and Marichamy, 1981) and the fifth pond of 0.28 ha was constructed north of the smaller ponds, total area being 0.42 ha. Four ponds were developed at Killai, vide Fig. 1, of 0.36, 0.37, 0.42 and 0.45 ha for culture of prawns, with a total area of 1.6 ha In Mandapam a set of experiments was carried out in eleven ponds with a total area of 0.8 ha (Bensam, 1986).

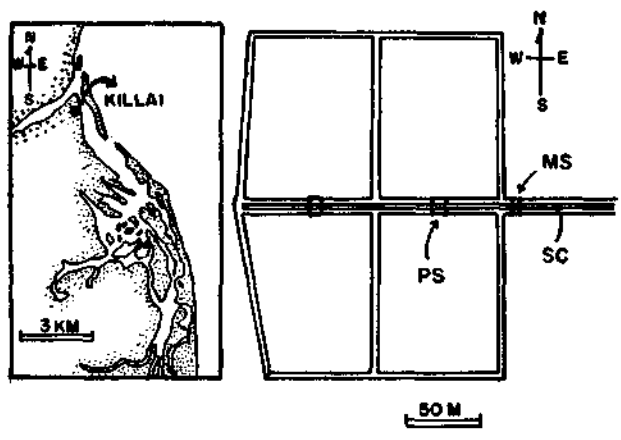

Fig. 1. Location of the prawn culture farm at Killai in the Vellar - Coleroon estuarine system and Lay - out of the ponds at Killai; M S: Main sluice; P S: Pond sluice; S C: Supply canal.

For examining the physical property of soil, sampling pits of 0.5 x 0.5 m area and 1.5 - 2 m depth were excavated, at 10 - 25 m distances. The soils were classified based on the sizes of grains, followed by Rahim (1968), Denila (1984) and Bensam (1986). The proportion of particles larger than 5.0 mm such as pebbles, molluscan shells, coral pieces and the like was dealt with separately.

Based on the quality of earth in each locality, the basal width of dykes in relation to height was determined approximately, peg markings were made and excavated earth was arranged in layers. Basal width and height of dykes were measured as per the procedure adapted by Jhingran *et al.* (1972). The methods followed for calculating erosion, deposition of sand, etc. are the same as described in a recent paper (Bansam, 1986). Since the reduction in the volume of dykes due to subsidence is only due to compaction of earth and not due to any loss, subsidence is not taken into account for calculating the quantity of earth lost. At Mandapam erosion was studied in a dyke by undertaking protective measures namely turfing and providing an inner strip of original ground (Bensam, 1986) as well as without them in another dyke, as a control. Percentages of earth lost from the dykes in each locality, including the control at Mandapam were monitored at the end of each year, for 5 to 7 years. The rainfall data for the localities were treated as the ones collected from the nearest observation centres of Indain Metereological Department, viz. Tuticorin for Veppalodai, Cuddalore for Killai and Pamban for Mandapam. The data on wind velocities for Mandapam were collected from the Pamban Centre.

For monitoring the actual tidal amplitudes at the entrances of the supply canals in relation to Mean Sea Level (M S L), a bench mark was first determined with the help of a civil engineer and scales were fixed. Since at Veppalodai water was pumped from a branch of Kallar Estuary, the scale was positioned there at the site of pumping. Daily recordings of the high and low tidal limits were made and monthly means were worked out in relation to M S L. At Mandapam the scale was also used for measuring the height of sand deposited

opposite the supply canal as well as inside the breakwaters constructed. During 1985 such monitoring was made both inside and outside the breakwater, the latter as a control for comparing sand deposition and for determining their efficacy to reduce sand deposition. To assess the quantity of sand present in the waves at Mandapam, a pail was used for collecting water from the waves and the sand in the water so collected is expressed as gm/L of water by wet weight. The first experimental breakwaters constructed at Mandapam were partly curved and the second ones were linear. All of them were of the "rubble mound" type, made of granite and coral stones, without pointing.

PHYSICAL QUALITIES OF SOIL

The physical qualities of soil in the localities of pond construction may be judged from Table 1. Clay, silt and sand were predominant at Veppalodai (76%), but much lesser at Mandapam (44%). Gravel was minimum at Veppalodai (14%) and maximum at Mandapam (24%). In the latter locality, coral pieces and molluscan shells contributed to so high as 32%; but large components formed only to an extent of 10% and 7% at Veppalodai and Killai respectively. Following the types designated by Rahim (1968) and Denila (1984), the earth may be designated as "silty clay" in Veppalodai, "silty gravel" in Killai and "sandy gravel" in Mandapam. From these it is obvious that the soil at Veppalodai is the best one for construction and maintenence of culture ponds, followed by the one in Killai. But, the soil at Mandapam is the least suitable among the three localities because the predominant proportion there is composed of large particles, gravel and sand (81%).

Table 1. *Percentage composition of the types of soil in the three localities of pond construction.*

Locality	Veppalodai	Killai	Mandapam
Type of soil/ Size of Particle (mm)	Mean Percentage weight in total quantity		
"Clay" <0.002	27	18	3
"Silt" 0.002-0.5	25	19	16
"Sand" 0.5-2.0	24	23	25
"Gravel" 2.0-5.0	14	23	24
Larger ones >5.0	10	7	32

The profile of soil in Veppalodai was silty clay in the upper 1.2 m depth, followed by 0.8 m depth of sand. In Killai the upper 50 cm was clay, followed by 90 cm of silt and 60 cm of sand and gravel. In Mandapam there was clay and gravel in the upper 30 cm, resting on a 70 cm thick layer of coral pieces and molluscan shells, below which silt and sand were found.

STRUCTURAL WORK OF DYKES

The structural work of dykes constructed and the profile of soil in them are depicted in Fig. 2. Since the earth in Veppalodai was cohesive, it was decided to construct the dykes with the structural proportion of 4 base : 1 height, in the diamension of 4.8 m and 1.2 m (Fig. 2 A). Width of the crest was 1.2 m and the excavated slopes were at an

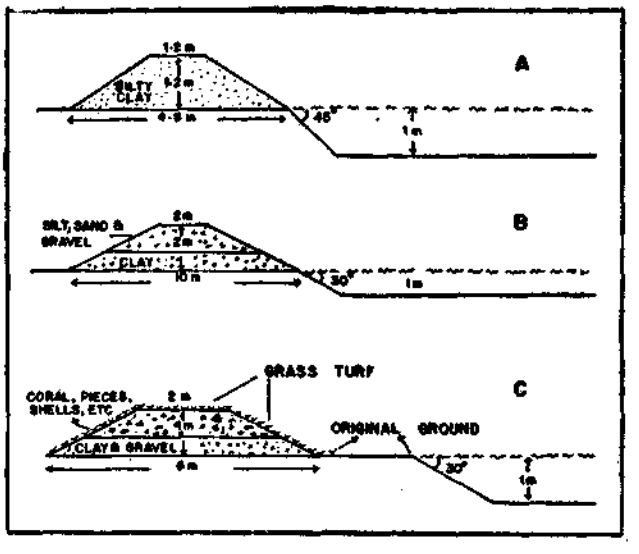

Fig. 2 Semidiagrammatic vertical sections of the dykes constructed at A: Vappalodai, B: Killai and C: Mandapam

angle of 45°. In Killai the structural work was of 10 m base and 2 m height (5 : 1), with a crest of 2 m width and excavated slopes at an angle of 30° (Fig. 2 B). In Mandapam the structural work considered for the present paper is the one with 6 m base, 1 m height, 2.5 m crest width, excavated angle of 30°, with a strip of original ground unexcavated on the inner sides and with grass turfing on crests and slopes (Bensam, 1986), vide Fig. 2 C.

SUBSIDENCE AND EROSION OF DYKES

The estimated quantities of earth lost due to subsidence and erosion in the respective years of experiments are presented in Table 2;

Table 2. *Subsidence due to compaction and erosion due to rains on dykes at the three localities, including a control at Mandapam.*

Locality	Veppalodai		Killai	Mandapam
Description of dyke	Without turfing and inner strip of original ground (ledge)			With turfing and ledge
Year	1973	1978	1980-81	1980-81
Duration of Subsidence (Days)	60	90	68	63
Vol. of subsidence (cu m/m length)	0.24	0 36	0.73	0.75
Rainfall during subsidence (mm)	1.9	6.0	8.8	
12 monthly rainfall (mm)	952	1,788	671	
Vol. eroded from crests & slopes (cu m/ m length)	0.928	0.840	0.78	Nil
Vol. eroded from bases (cu m/m length)	0.25	0.12	0.52	Nil
Total loss (cu m/ m length)	1.418	1.32	2.03	0.75

Table 3. *Estimated loss of earth from dykes due to erosion at the end of successive years at the three localities, including a control at Mandapam.*

Locality	Veppalodai		Killai	Mandapam
Description of dyke	Without turfing and inner strip of original ground (ledge)			With turfing and ledge
End of the years	Percentage loss of earth from the original condition			
I	27	7.5	30	Nil
II	30	12	59	,,
III	34	18	63	,,
IV	40	25	77	,,
V	45	28	82	,,
VI	*	30	91	,,
VII	*	32	*	*

* Not observed.

and the percentage quantities lost at the end of successive years monitored are given in Table 3. The volume of subsidence was lowest at Veppalodai, higher at Killai and highest at Mandapam. This appears to be related to the type of soil which is silty clay at Veppalodai and hence most compact, with least subsidence. But, the soil at Mandapam being sandy gravel has undergone the highest subsidence. From Tables 2 and 3 it may also be seen that the quantity of earth eroded from the dykes was the highest in the one without turfing, etc. at Mandapam, followed by the one at Veppalodai. Such a trend was also observed in the long run, with highest erosion in the dyke without turfing, etc. at Mandapam by the end of the 5th year, followed by the ones at Veppalodai and Killai. But, the dyke constructed with turfing, etc. at Mandapam has not undergone any erosion, even after a passage of six years.

The quantity of sand and silt deposited inside the ponds during 1973 at Veppalodai, with 951 mm annual rains was estimated to be 460m³/ha/12 months. At Killai the quantity was 320 m³/ha/12 m during 1978 with 1,788mm

rains. At Mandapam, with turfing and the structural work provided, the quantity was only 160 m³/ha/12 months, with 671 mm rains. The source of this sand was neither from crests nor slopes, but from the edges of the inner strips unexcavated and which were subjected to wave action of pond water.

TIDAL AMPLITUDES

The monthly mean values of low and high tides in relation to M S L at the three localities are shown in Fig. 3. From the month of

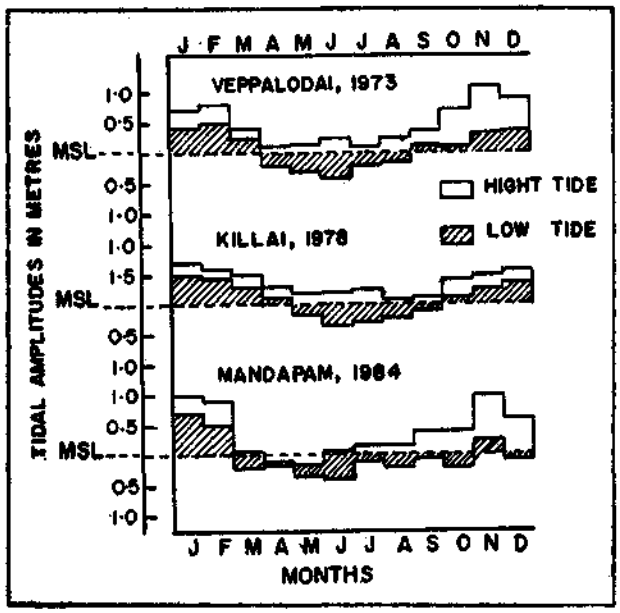

Fig. 3 Mean monthly tidal amplitudes in the three localities in relation to Mean Sea Level, during 1973, 1978 and 1984.

about April or May, the amplitudes became weaker in all localities, resulting in poor water supply to ponds. Higher tidal amplitudes were observed to resume only with the onset of the north-east monsoon winds, from about the month of October until April or May.

SAND DEPOSITION OPPOSITE SUPPLY CANAL AT MANDAPAM

The data collected on the quantity of sand present in the waves of the Palk Bay opposite the supply canal during 1984 are presented in Fig. 4. Sand was present in the waves

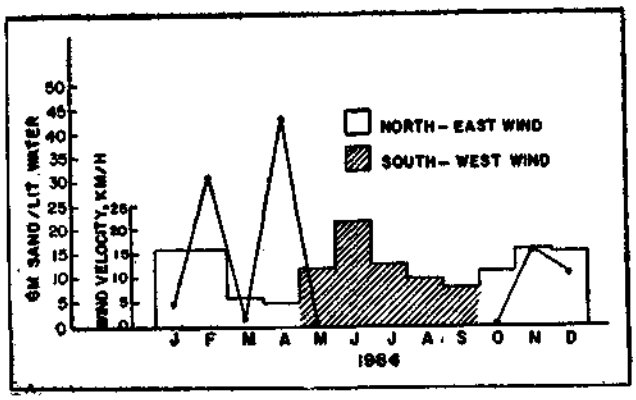

Fig. 4 Monthly mean weight of sand present in the waves at Mandapam and monthly mean value of wind velocity.

only during north east monsoon and post monsoon months, in quantities varying from 1.5 to 43 gm/L. During May to September, coinciding with south-west monsoon winds the wind direction in relation to the physiography of the locality is such that the winds neutralise the waves, push sea water away from the coast and deposit only negligible quantities of sand ranging from only 2.5 to 15 cm height in the course of 1 to 30 days. But, during north east monsoon months the wind direction is reversed, waves become strong and deposition of sand reached so high as 50 cm height on a single day. Some observations made in this connection along with the wind velocities prevailing in Mandapam are presented in Table 4.

Table 4. *Intensities of sand deposition on the Palk Bay side of Mandapam during certain periods of south-west and north-east winds.*

Duration (From-To)	Wind Velocity (Km/h)	Height before deposition (cm)	Hight after deposition (cm)	Net height deposited (cm)
(A) South-west winds				
11 to 30-9-'83	7-21	55	60	5.0
1 to 31-5-'84	1-22	62.5	65	2.5
(B) North-east winds				
28 to 30-11-'83	21.6	140	185	45.0
26 to 27-12-'84	27	100	140	40.0
31-12-'84 to 1-1-'86	37	90	140	50.0

EXPERIMENTS ON MINIMISING SAND DEPOSITION AT MANDAPAM

To begin with, two partly curved breakwaters with a mean height of 0.65 m above M S L were constructed during July-August, 1984 (Fig. 5 A). The western breakwater had two arms terminally, partly covering the terminal part of the eastern one, for flowing water in between. A reduction in sand deposition upto 31, 51 and 33% was recorded during October, November and December of 1984 due to construction of the breakwaters, when compared to the corresponding months of the previous year. But, from the end of October '84, waves overtopped the breakwaters and deposited sand inside, revealing that the height provided was inadequate. As may be seen from Fig. 5 B, the length, breadth and height of the space inside the breakwaters got filled up by 31-1-1985, blocking the flow of water. Hence, the structural work had to be modified.

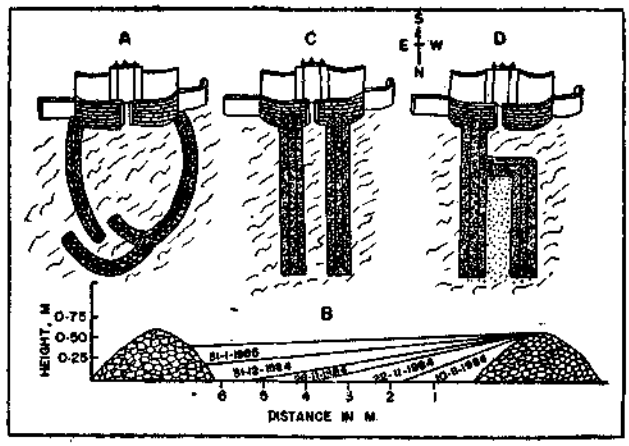

Fig. 6. Semidiagrammatic sketches of experimental breakwaters constructed at Mandapam. A: the curved breakwaters; B: The extent of sand deposition inside the curved breakwaters on days of overtopping; C: The linear breakwaters; D: The linear breakwaters with passage made at the southern end of the western breakwater.

In the second experiment the breakwaters were linear (Fig. 5 C), the eastern one of 23.4 m length and the western of 27.4 m length, the mean height being 1.4 m above M S L. The mean height of sand deposited inside in this experiment is compared with that in the previous experiment as well as with that in a control outside the breakwaters. (Table 5.) From the Table it may be seen that in the new

Table 5. *Height of sand deposited inside experimental breakwaters (B W) at Mandapam during North-East monsoon months of 1984 and 1985 and comparative reduction in height.*

Mean height deposited above (+) / below (—) Mean Sea Level (cm)				Reduction inside linear B W during '85 (precentage)	
Year	1984		1985		
B W type/ Experiment Months	Curved	Control	Linear	From '84	From Control, '85
September	+ 6.5	+ 12	— 5	11.5	17
				(20)	(92.5)
October	+ 19	+ 23	— 3.6	21.6	26.6
				(31)	(95.3)
November	+ 96.5	+ 78.2	+21.9	74.6	56.3
				(51)	(44)
December	+117	+102	+62.4	54.6	39.6
				(33)	(26)

structural work the reduction in sand deposition was 51% lesser in November, 1985 when compared to 1984 and was 95.3% during October, 1985 as compared to the control in the same month. But, due to overtopping of the breakwater after October the interspace gradually got filled up by February, '86. And, to flow water in the subsequent months, at the southern end of the western breakwater, a passage of 5 m was made by removing the stones there (Fig. 5 D) and using the same stones to make a bar in between the breakwaters. In this manner, water was flowed into the supply canal during 1986 - '87. However, periodical removal of the sand deposited in this passage was found essential, in order to ensure continuous flow.

DISCUSSION

Since the strength, stability and durability of marine fish culture ponds depend solely upon the quality of the soil, it is essential to acquire a sound knowledge of the quality of the soil, before taking up construction. Ideal soil for pond construction is clayey, available along the southwest and certain other parts of India. This is firm, cohesive, water - retentive and slow to erosion by rains and wave action of pond water. For instance, in Kerala the soil quality is so good that elaborate precautionary measures are not needed for construction and maintenance of ponds (Panikkar, 1937; Gopinath, 1956; Panikkar and Menon, 1957). The soil along south-east coast of India is not so good, as may be seen from the present studies. Along this coast three kinds of soil were encountered in the three localities studied, viz, silty clay, silty gravel and sandy gravel, depending upon the proportions of the components. Thus it is obvious that the soil from one locality is different from the soil from another locality. In all the three localities, the soil is loose, incohesive, with poor water retention and susceptible to erosion. Again, based on the qualities of the soil, the degrees of erosion were observed to vary from one place to another. Therefore, in order to make the dykes durable, different proportions of structural work had to be developed, as a research and development effort. Thus, in the locality of silty clay the least basal width was provided; in the place of silty gravel a little wider base was given; and, in the area of sandy gravel the greatest width was afforded. But, inspite of the adequate structural work provided in the last locality, only the degree of erosion could be reduced. And, for ensuring absolute protection for the dykes, turfing and provision of a ledge had to be made. A comparison of the long term durability of the dykes in the three centres reported in the present paper has revealed that even though the soil in a locality is not quite suitable for construction, it is possible to maintain durable dykes by undertaking suitable protective measures. In the course of the present studies, certain unidentified grasses and creepers were found to grow on and around the dykes at Veppalodai and Killai. If only these were transplanted on the dykes there, as was done at Mandapam subsequently, the dykes would not have undergone so much erosion as was recorded.

Experience papers published on pond constuction in India are rather few so far. The dykes described by Tampi (1960) had coral stone pitchings resting on a toe wall. The provision of a puddle core wall is the salient feature of the dykes developed by Jhingran *et al.* (1972). The structural work designed at Mandapam recently (Bensam, 1986) has a ledge all along the inner sides. Certain methods have been suggested by some authors for protecting dykes against erosion. However, for a developing country like India, with availability of inexpensive labour at present, grass turfing is found to be cheaper than granite pitching or lining with asbestoes, bricks and the like, suggested by Bardach *et al.* (1972) and Chen (1976). A perusal of literature shows that nothing tangible is known of the durability of the dykes constructed at various centers. At Mandapam, the dykes constructed during 1980-'81 (Bensam, 1986) have remained durable even beyond six years, without any damage. The measures taken at Mandapam have also resulted in considerable reduction in the deposition of sand inside the ponds.

Another crucial factor for economical and successful marine fish culture projects is the availability of sea water supply to culture ponds through tidal amplitude. Jhingran (1982) has drawn attention to poor tidal amplitudes along southeast coast of India during summer and premonsoon months, along with closure of bar months due to sand deposition and the resulting death and decay of organisms in embanked estuaries and backwaters. In this connection the steps taken to minimise deposition of sand opposite the supply canal at Mandapam by constructing breakwaters are perhaps the first of their kind in India. From the experience gained with the two experiments carried out, it appears that for achieving much more success under the prevailing conditions of the sea at Mandapam, it is essential to increase the height of the breakwaters to atleast about 2.5 m above M S L. Also, the length of the structural work appears to need much more enhancement upto a suitable distance away from the waves breaking region. More experiments involving engineering skills seem to be essential in order to arrive at much more success in this regard.

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Paper 39

MARINE PRAWN FARMING ALONG THE COAST OF THE GULF OF KUTCH - ITS PROSPECTS AND PROBLEMS

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ABSTRACT

Along the 250 kilometer coastline of the Gulf of Kutch, there are no prawn farming activities. Millions of juveniles of prawns ascending the creeks in the little rann of Kutch are trapped by staked bag nets and marketed for meagre revenue. The fishermen remain in perpetual poverty due to drought prone conditions of the coast during remaining period of the year. A tidal range of 2.6 metres and high salinity conditions of the Gulf of Kutch necessitate capital investment for supply, retention and exchange of seawater in farming operations. The avaiable seed are not of quick growing variety of prawns. An experimental project was initiated in 1979 firstly to explore the feasibility of utilisation of low saline reservoirs of solar saltworks in Okhamandal for extensive prawn farming using the indigenous seed and there after to assess the culturability, economic viability and management problems associated with small scale intensive farming. During September 1986 to March 1987, seed of *Penaeus merguiensis* and *Metapenaeus kutchensis* @ 36332 nos/hectare were stocked in three ponds of 1.92 hectare each. A growth rate of 0.437 mm/day length and 0.056 gm/day weight in respect of the former and 0.33 mm/day length and 0.037 gm/day weight in respect of the latter species in 187 days of rearing was achieved. The harvested prawns were acceptable to freezing industry and fetched Rs. 14000-23000 (Headon) per tonne. The advantages of employment generation, economic upliftment and utilisation of the monsoon seed resources for farming are discussed.

INTRODUCTION

The coast of the Gulf of Kutch is a a. drought prone area receiving scanty annual rainfall. During the southwest monsoon, the rivers Banas and Machhu, empty into the Little Rann of Kutch. Millions of prawn juveniles ascend from the Gulf of Kutch into

the Kandla-Hansthal creeks and remain in the rann area from july to September. The fishermen of the area, trap these juveniles in staked bag nets and sell for a meagre price. Lakumb (1960) and Ramamurthy (1965) have described several aspects of this monsoon fishery. The juveniles occur in other creeks and mangrove channels of the Gulf of Kutch in good numbers during this period (Gopalakrishnan, *et al*, 1987). The tidal wastelands along the coast are sparsely populated by mangroves of the species *Avicennia* sp. The fishermen are economically most backward and except during the monsoon fishery, remain in perpetual poverty. With a view to exploring the possibility of developing prawn farming along the coast, the suitability of the juveniles in short term farming was studied by stocking them in ponds adjoining a saltworks in the Okhamandal area near Port Okha (Lat. 22° 28' N Long. 69° 05'E). The present study was in continuation of an earlier experiment using indigenous prawn seed in large scale farming integrated with primary reservoirs of saltworks.

MATERIAL AND METHODS

Three identical ponds constructed by impounding the rann area near the salt works were used in the present study. Each pond had 1.92 hectare area and was provided with screened sluices individually connected to a feeder channel. The feeder channel received seawater from adjoining source through pumping The suction and delivery areas of the pump were screened with 25 mm mesh monofilament and 20x20x40 mesh 'garfil' webbing respectively to prevent entry of trash and predators. Each pond had an overflow pipe of 30 cm diameter fixed at 0.75 metre from the botom and a drain pipe of 60 cm diameter fixed along the pond bottom for draining.

Details of pond preparation are given in Table 1. Twigs of mangroves were made into bundles and distributed along the bottom.

The prawn juveniles of *Penaeus merguensis* and *Metapenaeus kutchensis*, collected from nearby mangrove channel were conditioned

Table 1.

Details of preparation of ponds and manuring schedule during the prawn culture.

Item (kg)	Pond 1		Pond 2		Pond 3		Remarks
	Initial	Bimonthly	Initial	Bimonthly	Initial	Bimonthly	
Lime ($CaCo_3$)	200	-	-	-	-	-	1. Rearing period in pond-1.187 days pond-2.157 days pond-3.127 days
Mahwa oil cake	-	-	-	-	1000	-	2. In pond 1 lime was applied as the pond could not be totally dried prior to manuring.
Raw cowdung	1000	-	1000	-	-	-	3. In pond 2 neither lime nor mahwa oil cake was applied as a test case.
Superphosphate	-	96	-	96	-	96	4. In pond 3, the raw cowdung was not applied as mahwa oil cake was used.
Ammonium sulphate	-	96	-	96	-	96	

for 24 hours after which the healthy surviving seed were stocked in the ponds. Feeding at the rate of 5% of the body weight was done using groundnut oil cake, between 6 to 7 pm daily.

The hydrological data of the ponds was monitored at regular intervals.

The rearing of juveniles was for 187 days in pond 1, 157 days in pond 2 and 127 days in pond 3, using different size groups and manuring practices, between September 1986 to April 1987.

Harvesting was done by total draining gradually over 4 to 5 nights. During day time water was pumped into the ponds. Handpicking and treatment with Mahwa oil cake at the rate of 250 kg/hectare were tried to remove any residual prawn stock.

GROWTH AND PRODUCTION

The hydrological data showed salinity range of 35 — 55 ppt in pond 1, 38-49 ppt in pond 2 and 39 — 55 ppt in pond 3. The temperature ranged from 17°C — 31.2°C. The dissolved oxygen content ranged from 7.2 to 8.2 ppm. The pH was from 7.2 to 7.5. The water depth in the ponds was maintained between 0.5 to 1.0 metre.

Prawn juveniles stocked at an overall average rate of 36332/hectre showed an overall 14.3% survival. In pond 1, both *Penaeus merguensis* and *Metapenaeus kutchensis* were stocked, which yielded 6.44% and 19.36% survival respectively. The total survival rate for pond 1 was thus 25.8%. In this, the juveniles of *P.merguensis* had a mean size of 29.36 mm growing to 99.45 mm with a mean weight of 10.47 gms. The average growth rate/day for the species in the 187 days culture was 0.44 mm and 0.056 gms. Similarly, *M. kutchensis* of 37.27 mm recorded 99.52 mm with a mean growth rate of 0.33 mm and 0.037 gm/day. In ponds 2 and 3 only *M. kutchensis* were stocked. The advanced juveniles, 78 — 79.6 mm grew to 101.17 — 101.95 mm in 157 and 127 days respectively recording a growth rate of 0.13 mm and 0.029 gm/day and 0.18 mm and 0.041 gm/day and survival of 16.58% and 8.81% respectively (Table 2).

Table 2. *Details of growth experiments*

Species/Pond	Stocked	Rate of stocking/ hectare	Mean length	Mean weight	Duration of experiment	Survival	Mean harvested length	Mean harvested weight	Mean length gain per day	Mean weight gain per day
	(nos)	(nos)	(mm)	(gm)	(Days)	(%)	(mm)	(gm)	(mm)	(gm)
Pond. 1										
P. merguiensis	11962	6230	29.36	0.19	187	6.44	99.45	10.47	0.44	0.056
M. kutchensis	60513	31517	37.27	0.69	187	19.36	99.52	7.43	0.33	0.037
Total	72675	37747	—	—	—	25.80	—	—	—	—
Pond. 2										
M. kutchensis	69464	36179	79.60	3.30	157	16.58	101.17	7.93	0.13	0.029
Pond. 3										
M. kutchensis	67216	35008	78.00	3.20	127	8.81	101.95	8.46	0.18	0.041

The experiments showed a total unsuitability of *P. merguensis* in the local conditions. Despite around 54% of the prawn seed resources of this area being represented by this species, *P. merguensis* does not figure in the prawn catches of Okhamandal or the Gulf of Kutch (Gopalakrishnan *et al* 1987; Ramamurthy, 1965). Ramamurthy (1965) estimated a growth rate of 0.16 to 0.23 mm/day in a lower salinity range of 29.9 to 41.88 ppt in respect of the size group of 56-60 mm of the species in the Kutch fishery. The experiments thus indicated the advantage of farming utilising the *M. kutchensis* juveniles in raising short term crops.

The harvested prawns were healthy and had no symptoms of any disease, infection or the 'soft shell' problem An average value of Rs. 17000 per tonne, contributed by 30% of the prawns being medium fetching Rs. 23000 per tonne and 70% being small, fetching Rs. 14000 per tonne could be realised. The quality of the prawns was superior to trawl catches and prices were also improved by 30 to 40%.

POTENTIAL AND PROBLEMS

Ramamurthy (1965) had estimated the landings of the monsoon fishery at 814 tonnes comprising almost entirely of *M. kutchensis*. The modal size of 56-60 mm weighing 1.6 gm represented juveniles. Thus an estimated potential 500 million prawns seed will be available in the region when the catchment areas of the river Banas received good rainfall, enabling adequate discharge from the Dantiwada dam on the river flowing into the little rann of Kutch diluting the salinity in the creeks there (Table 3). Based on the present study, a 20% survival in the six month period of growth of the seed in prawn farming would be substantial for providing employment to 3000 fishermen and increased revenue.

Neverthless, the task of prawn culture in the highly saline backwater areas of the Gulf of Kutch is formidable and not as easy as reported from elsewhere along the brackish-water and estuarine areas of the country. The high tidal range necessitate strong dykes for water retention. Pumping seawater into the farm would be necessary, during day and night As a result of these the capital cost of farming would be high. Besides, inadequate and unsure seed supply of even the slow growing prawn species is also a deterrant. However, by judicious use of local seed and selective introduction of suitable quick growing species of the Indian white jumbo prawn *Penaeus indicus*, reported to be well suited for salt pan areas (Marichamy and Motha, 1986) and a similar good performer *Penaeus monodon* (Marichamy and Rajapackiam, 1982), the seed problem could be solved. The Marine Products Export Development Authority, through their hatcheries under construction now in different parts of the

Table 3. *Production during monsoon prawn fishery in the Gulf of Kutch* (Data provided by the Supdt. of Fisheries, Kutch)

Year	Quantity (tonnes)	Price offered by merchants (Rs) per tonne Fresh	Dry	Remarks
1982-83	89	3000-7000	10000-15000	The low production directly
1983-84	1484	,,	,,	related to poor water discharge
1984-85	1443	,,	,,	from Dantiwada dam on river
1985-86	85	,,	,,	Banas during the years monsoon
1986-87	7	,,	,,	failed.

country's coastline, should be able to meet the seed demands. Through long term lease of the land on nominal rental, to fishermen groups or societies, as in the case of salt-works and by liberal soft loans and adequate subsidy to cover capital cost, monitored through agencies like the Fish Farmers Development Agency, the Government can in a big way promote prawn farming in this region tormented by droughts and economic backwardness. In order to help the poor fisherfolk, the construction of the prawn farms could be taken up as a scarcity relief work through the engineering agencies similar to construction of checkdams, roads etc. during scarcity period every year. Besides the marketing of the prawns through a non-profit oriented organisation would help to achieve better price for the produce and more attractive returns to the fishermen.

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PROSPECTS OF TIGER PRAWN CULTURE IN KERALA

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ABSTRACT

Results of the experiments conducted on the culture of tiger prawn, *Penaeus monodon*, in Vyttila Fish Farm, Cochin during the period 1981-83 are presented in the paper. Prawn production rates in these experiments ranged from 71 kg/ha/45 days to 615 kg/ha/3 months, with retrieval rates varying from 41.4 to 80.5%. Important ecological conditions of the culture ponds during the experimental period are also mentioned in the paper. The main problems in the development of tiger prawn culture in this region and the probable solutions to these are discussed.

INTRODUCTION

Kerala has got an estimated 1.21 lakh hectares of brackishwater area amendable for fish and prawn culture. But for the traditional prawn culture prevalent in about 5,000 hectares of pokkali paddy fields, virtually this entire area is presently left unutilised for fish or prawn culture. Although prawn accounts for the lion's share of our export earnings from the aquatic products, a close study of the production scene shows that the quantity of prawn harvested from Kerala coast is gradually declining. Thus, to support the export industry it is imperative to think in terms of increasing the prawn production through culture.

The tiger prawn, *Penaeus monodon* is considered to be the best species of prawn suitable for culture in brackishwater ponds, because of its fast growth and hardy nature. Blessed with the natural abundance of seed, its culture is extensively practiced along the east coast of India, particularly in the brakishwater area of West Bengal. In the west coast, on the other hand, its culture has not yet reached any commercial status.

In Kerala, where the white prawn, *Penaeus indicus* is the principal species presently cultured, the tiger prawn holds a special advantage in that it can withstand a wider range of salinity fluctuations and can attain a much higher size compared with that of *P. indicus*. In the peculiar climatic conditions of Kerala, culture of *P. indicus* has to be restricted to the period December-May, when the salinity is high. By adopting the culture of tiger prawn which can grow well in low-saline conditions the prawn culture period can easily be extended and atleast one additional crop can be taken in this region.

MATERIAL AND METHODS

With a view to develop a suitable technology for the culture of *Penaeus monodon* in this region, experiments were conducted at Vyttila Fish Farm of Kerala Agricultural university. Results of three experiments conducted during the period 1981-83 are presented in the paper.

Vyttila Fish Farm is situated in the north eastern part of the Vembanad lake, about 10 km from the Cochin barmouth. Water exchange in the farm is effected through a feeder canal from the Kaniampuzha which is connected with Vembanad lake. The annual rainfall in this area is about 3.0 m which shows considerable fluctuations. More than 75% of the rainfall is recorded during the south-west monsoon, which occurs during June-September, while the rest during the north-east monsoon in October and November. The tidal amplitude in the farm is 75 cm.

The present experiments were conducted in ponds of 0.10-0.15 ha water-spread area. The pond bottom soil consisted of sandy clay.

The water level in the ponds fluctuated between 40 and 75 cm. Each of the pond was provided with a wooden sluice for water feeding and draining. Water exchange was done through a fine mesh velon net screen fixed in the sluice. The sluice also had provisions to control the water flow as and when required. Before each experiment the ponds were drained off during the low tide and then mahua oil cake was applied @ 250 ppm in the remaining water to ensure complete elimination of unwanted fishes. After this, lime was applied @ 500 kg/ha in a single dose and water was taken into the ponds through the velon screen. No liming or manuring was done during the second experiment. During the first experiment cowdung and urea were applied in single doses in the beginning respectively @ 1250 kg and 60 kg/ha. In the third experiment, while no organic manure was used, inorganic manures like urea and rockphosphate were applied as a single dose in the beginning respectively @ 20 and 50 kg/ha. Supplementary feeding was not done in the first and second experiments, while it was done for a limited period in the third experiment. Daily water exchange was allowed in the experimental ponds taking advantage of the tides.

Fortnightly observations on the important physico-chemical parameters of water were made during the experimental period in all the three cases.

RESULTS

Physico-chemical conditions of water

The range of important physico-chemical parameters during the experimental period are show in Table-1.

Prawn growth and production

In the first experiment when monoculture of *P. monodon* was conducted with post-larvae of 15 mm/66 mg @ 10,000/ha during the period 12-5-1981 to 26-6-1981 a production of 71 kg/ha/45 days was obtained with a retrieval rate of 47.5% and a final average size of 110 mm and 15.0 g.

In the second experiment *P. monodon* post-larvae of 15 mm/70 mg was stocked @ 24,000/ha on 25-4-1981 in a pond where the fish, *Mugil cephalus* of 285mm/215 g size was stocked @ 800/ha on 16-3-1981. Later *Etroplus suratensis* of 135mm/50g was also stocked in the pond @ 400/ha on 12-5-1981. The prawn was harvested on 13-8-1981 after 110 days' rearing. The final average size of the prawn was 41 mm and 26.65 g, with a retrieval rate of 41.42%. From this experiment prawn production of 265 kg/ha was obtained in 110 days. In addition, fish production of 580 kg/ha was also obtained from the pond. The final average size of *M. cephalus* was 376 mm/500g, while it was 170 mm/129 g for *E. suratensis*.

In the third experiment, monoculture of *P. monodon* was carried out in a pond, where stocking was done with juveniles of 62 mm/2.0 g @ 20,000/ha on 20-3-1983. Fifteen days after stocking brakishwater fishes, *Chanos chanos*, *Mugil cephalus* and *Etroplus surantensis* in the ratio 2:1:3 were introduced into the pond at the rate of 600/ha to control algal blooms. The initial average weights of the three species were 250 g, 200 g and 67 g respectively. Supplementary feed prepared locally with fish meal, ground nut oil cake and ricebran as the chief ingredients, with an approximate protein

TABLE 1. *Range of physico - chemical paremeters in the experimental ponds.*

Expt. No. Parameter	I	II	III
Water temp. (°C)	30 — 35	29 — 35	30 — 32
pH	6.4 — 7.0	6.3 — 7.5	7.08 — 7.67
Salinity (ppt)	0.4 — 14.0	0.4 — 15.9	26.0 — 30.0
Dissolved oxygen (ppm)	4.2 — 12.3	5.0 — 12.6	2.76 — 16.10

content of 42% was given to the prawn daily @ 2.5% body weight of the standing crop estimated at 50% survival during the period 20/5 to 31/5 and @ 5% during the period 1/6 to 13/6, while no feed was given during rest of the rearing period. The total quantity of feed given during the experiment was 16.2 kg. The mean weight of the prawn observed on the 19th, 33rd, 47th, 63rd, 78th and 90th day were respectively 5.0, 10.0, 18.0, 25.0, 30.0 and 38.5 g. The prawn was harvested on 20-6-1983 after 90 days rearing. The final average size of the prawn was 172 mm and 38.5 g with a retrieval rate of 80.5%. Gross production rate of *P. monodon* was 615.5kg/ha/3 months, while the net production was 575.5 kg. In addition to *P. monodon*, a net weight of 193 kg/ha of other prawns and fishes were also harvested from the pond. The final average weight of *C. chanos*, *M. cephalus* and *E. suratensis* were respectively 450, 380 and 107 g.

DISCUSSION

Yield of *P. monodon* obtained from semi-intensive culture so far in the country shows a wide range from 57.9 kg/ha/crop (Anon, 1983 a) to 514 kg/ha/ crop (Sunderarajan *et. al*, 1979). From a set of experiments conducted in the Sunderban area of West Bengal during 1984-85 production of *P. monodon* obtained varied from 322 kg/ha/8 months to 400 kg/ha/4 months (Anon, 1985). Bhowmik *et. al*. (1984) reported that when *P. monodon* post-larvae were stocked @ 30,000 to 50,000/ha production ranged from 275 kg/ha/120 days to 250-318 kg/ha/150 days with survival ranging from 30.0 to 57.3%. Subsequently they have reported a prodnction rate of 224 to 250 kg/ha when prawn was harvested after 2 months and 350-400 kg/ha when harvested after 4 months (Anon, 1985). They also found that better survival and production was obtained when culture period was 60 days, irrespective of the stocking density.

When *P. monodon* post-larvae of initial size 13.2 mm/0.01 g was reared at a density of 35,000/ha in brackishwater ponds of Kakdwip fish farm with 3 types of supplementary feeds, the prawn production obtained varied from 109.7 to 239.0 kg/ha/110 days. The final size of the prawn ranged in the different ponds from 82.5 mm/3.5 g to 132.3 mm/19.5 g, with survival rates varying from 35.9 to 77.9%. The daily growth rate of prawn ranged from 0.6 mm/0.03 g to 1.2mm/ 0.18 g (Rajyalakshmi *et. al*, 1982). Out of the sixteen trials conducted at the different centres of All India Coordinated Research Project on Brackishwater Fish Farming, the average yield, growth and survival of *P. monodon* at Madras centre were 109.3 kg/ha/85 days, 20.0 g and 20.0%; at Kakdwip (W. B.) centre 223.2-332.5 kg/ha/4-5 months, 13.6-35.0g and 47.5-70.0%; at Keshpur (Orissa) centre 57.9-232.1 kg/4-6 months, 30.0-33.0g and 11.5-39.7% and at Kakinada centre (A. P.) 75.0-300.0 kg/ha/4-6 months, 15.0-40.0 g and 18.9-40.0%, respectively (Anon, 1983 b). Production rates of 171,317 and 382 kg/ha/120 days, with survival rates of 85,83 and 74% respectively, have been reported from Philippines when the post-larvae of 15 mm/90 mg were stocked @ 10,000, 20,000 and 40,000/ha. No supplementary feed was given in these experiments for the first two months, while feed was given @ 6% body weight during the 3rd month and 4% body weight during the 4th month. When the prawn stocked @ 20,000/ ha were transferred after 60 days' rearing to another well-prepared pond and reared for 60 more days production rate of 525 kg/ha was obtained (Tiro *et. al*, 1986).

Thus, the production rate of 615.5 kg/ha/ 3 months obtained at Vyttila is the highest ever reported for this prawn in semi-intensive culture systems. The growth, recovery and production rates obtained here in the third experiment compare well with that obtained by Sunderarajan *et. al* (1979) where the stocking rate was the same. Of course, production as high as 971.5 to 1129.0 kg/ha/ 90 days has been reported from the intensive culture of *P. monodon* stocked @ 1.5 lakhs/ ha with heavy feeding and artifical oxygen supply (Anon, 1985).

Growth of *P. monodon* has been reported as 31.5 to 43.0 g /135 days and 60.0 g/210 days (Anon, 1984) and 27.0 g/94 days at a low stocking density of 4900/ha (Anon, 1982). Monthly growth rate reported for this prawn varied from 38.4 to 41.0 mm (Sebastian et. al, 1980; Anon, 1983 and Chakraborti *et. al*, 1986). In the trials conducted at Kakdwip where the prawn was cultured at a density of 20,000/ha the prawn reached only 33.7 g in 120 days (Jhingran, 1977). Mean weights of 31.6 and 32.6 g. at a stocking density of 20,000/ha have been reported at harvest after 120 days of rearing (Tiro *et. al*, 1986). Kungvankiji *et. al* (1976) and Liao (1977) have also reported similar size atharvest in intensive culture systems at much higher stocking rates. In Taiwan at comparatively low stocking densities of 5,000 to 8,000/ha a higher growth rate of 40.0 g in 90 days was achieved in ponds where *Chanos chanos* and the prawn were grown together (Chen, 1976). In the culture trial conducted by Sunderarajan *et. al*, (1979), the prawn showed a growth of 1.59 mm and 0 39 g/day, thus attaining an average size of 169.5 mm and 32.26 g in 80 days of growth. In Vyttila farm the prawn when stocked @ 20,000/ha grew from 62 mm/2.0 g to 172 mm/ 38.5 g in 90 days, showing a net growth of 1.22 mm and 0.405 g/day. It is much higher than the growth rate of 0.11 to 0.27 g reported by Tiro *et. al* (1986).

Sebastin *et. al* (1980) reported very fast growth for *P. monodon* during the first 30 days. Chakraborti *et. al* (1986) also found a fall in growth after 2 months. In this farm under the third experiment, while there was a decline in the rate of increase in total length after the second month, the weight showed a steady increase till the end of the rearing period. The retrieval rate of 80.5% observed here is very much similar to that obtained by Sunderarajan *et. al* (1979) who reported a retrieval rate of 79.77% and compares well with the 74.85% reported by Tiro *et. al* (1986). Krantz and Norris (1975) stated that survival rate of 60-80% is to be expected for *P. monodon* under suitable rearing conditions.

A comparative study of the growth of *P. monodon* under culture in three farms in Sunderban area of West Bengal by Chakraborti *et. al* (1984) showed that growth and yield of the prawn was better at low range of salinity (15-25 ppt) than at higher salinity (25-32 ppt). In the experiment conducted by Sunderarajan *et. al* (1979), where the growth rate and yield were much closer to that obtained in the third experiment at Vyttila. the salinity ranged between 10.9 and 22.4 ppt. The retrieval rates of 47.5 and 41.4% obtained respectively in the first and second experiments at Vyttila Farm with satisfactory growth rate, even when the salinity went as low as 0.4 ppt. show the suitability of this prawn for commercial culture in this region, where low-saline conditions prevail for almost six months in a year.

The introduction of fish in *P. monodon* culture ponds was found to be effective in controlling the algal blooms. Since the fishes introduced were essentially herbivores and detrivores there would have been no serious competition for food with the prawn. Eldami and Primavera (1981) have pointed out the mutual compatibility of *P. monodon* and *C. chanos* in brakishwater ponds. In the mixed culture of these two they have found that the main food of *C. chanos* was a mixture of diatoms, blue-green algae and a few filamentous algae and unidentified animal forms. In contrast food identified in the prawn stomach included small crustaceans, chironomid larvae, polychaetes and other annelids and detritus. Marte (1980) described *P. monodon* as more of a predator of slow moving benthic macro-invertebrates rather than a scavenger or detritus feeder. Thomas (1973) listed crustaceans, fishes, polychaetes and vegetable matter as the food of *P. monodon* in the order of importance.

The yield of 615.5 kg/ha obtained at Vyttila in 90 days shows that more than a tonne of *P. monodon* can be harvested from

the brackishwater ponds of Kerala from one hectare in 6 months in two crops. Taking into account the wide salinity tolerance of this prawn it may even be possible to take 3-4 crops in a year, thus harvesting 1.5 to 2.0 tonnes of high quality prawn from one hectare.

The main problem in taking up its culture in this region is the non-availability of the seed. Unlike in the east coast *P. monodon* seed is not abudant in this coast. Occurrence of the seed has of late been reported from the coast of Cochin (Sebastin *et. al*, 1980; Jose *et. al*, MS) and hatchery production of the seed is picking up fast. Considering its high yield potential, it will be worthy of transporting the seed from the east coast, where it is available in plenty, and expanding its culture in the brackishwater areas of Kerala. The unawareness among the farmers about its culture potential and culture techniques is yet another impediment in the development of the culture of this highly priced prawn and proper extention work alone can solve this problem. Further knowledge on the biology of this prawn is essential for the proper development of its culture. More studies on optimum stocking density, rearing period, managerial practices like pond fertilization, supplementary feeding etc. are also needed. Large-scale hatchery production of the seed is in fact the most urgent need of the time.

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DEVELOPMENT OF PRAWN CULTURE IN TUTICORIN AREA

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ABSTRACT

The coastal zone along Tuticorin in Chidambaranar District of Tamilnadu affords suitable environment for the occurrence, survival, growth and production of commercially valuable prawns. The prospects of prawn culture are discussed in relation to the available resources of land, water and wild seeds as well as the recent developments made in the area. Growth and production of *Penaeus indicus* cultured in the salt pan area near Tuticorin during 1985-87 are presented. The results of prawn culture experiments were highly influenced by the stocking density and also the hydrological features of the culture site Best result in growth (27 mm/4.2 g/month) and production (1347 kg/ha/crop) was recorded when the stocking was kept at 75 000-80,000/ha. The maximum production of 1,600-1,700 kg/ha/crop was attained in high stocking density, but the period of culture was more. A total production of 10, 407.5 Kg of *Penaeus indicus* was attained from 7 ponds of a total area of 4.2 ha by raising 2-3 crops in a period of 26 months and fetched a gross income of Rs. 3,90,161/-. The results of the experiments are highly encouraging for the fast development of semi-intensive farming in the area. Various problems encountered in the development of prawn farming and suggestions for better management practices are highlighted. Information covering the suitable areas for the development of coastal farm, economics of culture, culture operations, the sources of financial and technical aids available in this profitable venture are presented.

INTRODUCTION

The development of prawn farming in Tamilnadu is known only from recent years, although the state offers a rich potential. The production of prawns in these farms was found to vary from 200-400 kg/ha/crop, fetching an income of Rs. 3,000-10,500 (Srinivasan *et, al.* 1982). Inadequate facilities for extension, strict flow of finance and scarcity of seeds of desired species at desired time are some of the major constraints attributed to the poor progress in the field. There is vast scope for the development of shrimp culture even in slightly high saline sites in Tuticorin area. Published information support this view (Nair *et. al.*, 1974, Suseelan, 1975, Rao and Narasimham, 1978, Mohamed, *et, al.*, 1980, Marichamy and Rajapackiam, 1982 and Victor and Venkatesan, 1982).

Encouraging results with a maximum production of P. *indicus* at 1,604 kg/ha/crop with an average rate of production at 1,154 kg/ha/crop has been attained and reported by Marichamy and John Motha (1986) from new site developed at Veppalodai. Culture operations started in a few centres by private parties close to Vembar estuary, Vaipar, Palayakayal and Punnakayal in small scale, resulted in poor production. None of these centres can be said to be totally free of shortcomings such as insufficient experience, unscientific management of environmental factors etc. Many entrepreneurs have come into the field of prawn farming in Tuticorin area, since recent experiments by utilising the saline fallow coastal lands including salt pan areas for culture practices have proved to be profitable. Proposals are with the State Government for the development of 50 ha of brakishwater farms at Punnakayal (Dixitulu, 1986). In the present account, various techniques of prawn culture and the related problems are analysed to determine suitable management procedures for better production and profit so as to help the prawn culturists to progress in Tuticorin area.

MATERIAL AND METHODS

Semi-intensive culture system was followed. Construction aspects of prawn culture ponds

and farm management techniques suitable for the area have been described by Marichamy and John Motha (1986). Hydrological factors of most of the sites surveyed in Tuticorin area were found conducive for the growth of prawns The Productivity of the water was enriched by manuring with chicken or cow dung at 500 kg/ha. About one fifth of volume of water was drained from ponds daily in early hours and replenished with seawater pumped from the creek. Two separate 10 HP low head Kirlosker pumps were used to feed 4 ponds in an extent of 4.2 ha (Fig. 1 A). Construction of ponds in an elevated ground helps the culture practices in many respects. Provision of radiating canals around the bunds of the pond converged in the catching pit facilitates the cultured stock to assemble in this limited area and the crop easily lifted by a dip net laid in advance (Fig. 1 B & C). This improvised harvesting technique enables the field workers to take the valuable product in a healthy condition in less time (Fig. 1 D).

The growth and yield directly depend upon a number of factors like the species selected, natural fertility of the culture site, efficiency of supplimentary feed, stocking intensity, size of seed etc. and it has to be determined emperically for each area. In view of this, experiments were designed to stock *P. indicus* at different stocking intensity varying from 44,000 to 275,000/ha. The best season for the collection of seeds of *P. indicus* was found to be February-May and August-September. Most of the culture operations were started with wild seeds measured in the range 11-46 mm and the last few experiments were purposely planned to stock with juvenile prawn in the size group of 65-90 mm with

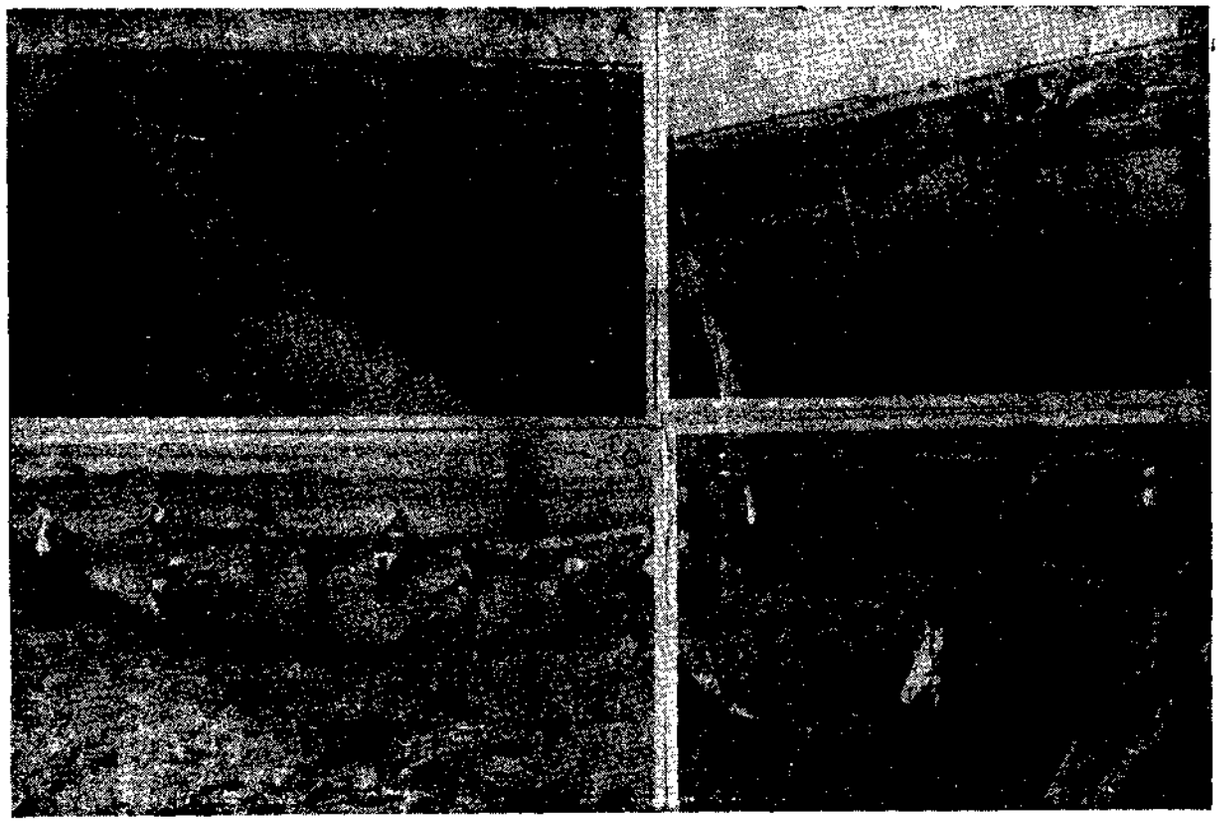

Fig. 1. A. view of prawn culture ponds. B. Pond showing the radiating canals and catching pits. C. Lifting the net from the catching. D. Harvesting of cultured prawn.

an aim to see the difference in the trend of growth in the process of fattening and production. Pelletized feed obtained from TOMCO at subsidised rates constituted the diet in early experiments but for later culture operations, pellets of better quality were prepared at Veppalodai and supplied to the stock at the rate of 7-10% of prawn biomass and the quantity was divided and broadcast 4 times a day, avoiding the peak noon hours. When the stock grow in size, instances of "animal stress" was noticed followed by oxygen depletion in rearing ponds in early hours, particularly in overstocked ponds as well as in ponds of excess "green water" or bloom. On such occasions adequate exchange of water from the ponds was arranged in addition to the use of floating poddle wheel for generating more oxygen in the culture site. When the values of dissolved oxygen content fell below 3 ml/l, organic manure at the rate of 100 kg/ha was added to maintain good primary production (above 700 mgC/m^3/day) and thereby oxygen generated by natural process. Based on the characteristics of water qualities the system of culture was broadly classified as monsoon crop extending from August to January and summer crop covering the period February–July. In summer season, occasional formation of H_2S was observed in corners of pond due to soil condition and poor exchange of water. However, treatment with lime powder in such spots improved the situation. Cessation of feeding on supplementary diet was noticed at times when water replenishment was interrupted, and quick action taken for adequate exchange of water in rearing ponds solved the problem. Baking of the muddy bottom before raising each crop and increasing the depth of water in ponds during summer were some other measures in the management of quality of water. Excess feeding also spoil the water and the determination of correct feeding dose for the prawn biomass at every stage formed the main part of monitoring the culture.

RESULTS

The difference in hydrological factors observed throughout the year exhibit clear influence on the progress of different experiments carried out during 1985-'87. Out of 18 experiments completed by August, 1987, eight experiments were covered during premonsoon/monsoon period, when the mean surface water temperature fluctuated in the range 25.2–27.4°C and the salinity varied from 36.74-42.90ppt. (Table 1). Summer crop faced slightly adverse environmental characteristics (Table 2) with increased mean temperature

TABLE 1. *Hydrology of prawn farm—monsoon crop*

Month	Water temp at 0830 hrs ° c		Salinity ppt		Dissolved Oxygen (ml/1)		pH		Productivity mgc/m^3/day	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Aug.	26.1-27.2	26.7	38.99-39.39	39.19	4.21-4.28	4.25	8.14-8.19	8.17	806-926	866
Sep.	25.0-27.7	25.9	40.97-44.53	42.90	4.14-4.35	4.25	8.15-8.35	8.27	669- 952	849
Oct.	26 7-27.2	26.7	40.42-44.09	41.86	3.24-5.17	4.38	7.90-8.08	8.02	725- 725	725
Nov.	27.2-27.7	27.4	30.26-40.60	35.80	3.05-4.50	3.68	7.90-8.02	7.98	825-1647	1041
Dec.	25.5-26.3	26.0	35.17-40.08	37.91	2.95-4.50	3.76	7.70-8.10	7.92	463-1458	961
Jan.	24.3-26.3	25.2	35.25-39.76	36.74	2.90-4.80	3.88	7.60-8.10	7.86	775-1916	875

TABLE 2. *Hydrology of prawn farm — summer crop*

Month	Water temp' at 8830 hrs°c Range	Mean	Salinity ppt Range	mean	Dissolved oxygen (ml/l) Range	Mean	pH Range	Mean	Productivity mgc/m^3/day Range	mean
Feb.	26.3-28.4	27.1	36.25-38.87	37.84	3.77-4.22	4.05	8.08-8.20	8.13	826- 926	880
Mar.	27.5-28.5	28.2	36.50-39.53	38.04	4.07-4.37	4.16	8.00-8.16	8.08	685-1055	922
Apr.	28.3-30.7	29.8	36.08-42.90	39.00	4.00-4.42	4.18	7.90-8.16	8.00	290- 835	636
May.	28.9-29.8	29 3	37.49-50.03	43.90	3.09-4.81	3.97	7.60-8.28	7.95	592- 876	705
June.	27.3-28.6	28.1	38.77-48.00	44.94	38.0-5.74	4.80	7.90-8.18	8.05	600-1003	975
July.	27.3-27.7	27.5	40.65-45 70	43.52	3.04-3.48	3.27	7.64-8.13	7.94	214-1062	500

TABLE 3. *The results of culture experiments of P. indicus and P. monodon*

Expt. No.	Seed size at stocking mm/g	No. of prawn stocked	Period of culture days	No. of prawn harvested/ kg	Size at harvest mm/g	Over all growth mm/g
1.	11.3/0.2	19000	166	16150/290.0	135.7/18.0	22.5/3.22
2.	28.0/0.3	22820	153	14833/277.0	138.3/19.8	21.6/3.82
3.	20.0/0.3	40000	174	37500/600.0	125.0/16.0	18.1/2.64
4.	22.0/0.3	66500	224	63460/835.0	123.4/13.2	13 5/1.73
5.	15.0/0.2	115000	232	106380/1169	116.0/11.0	13.0/1.40
6.	25.0/0.3	135000	172	100625/805.0	106.0/ 8.0	14.1/1.43
7.	25.0/0.3	45000	166	40260/330.0	108.0/ 8.2	15.3/1.49
8.	24.0/0.4	75000	128	56700/720.0	123.7/12.8	23.4/2.91
9.	46.0/1.0	28000	85	24000/300.0	124.8/13.0	27.5/4.24
10.	30.0/0.4	34000	126	27374/355.0	123.5/13.0	22.3/3.00
11.	30.0/0.4	91000	124	50050/550.0	118.1/11.0	21.6/2.60
12.	18.0/0.1	260000	143	213616/1027	93.0/ 4.5	15.7/1.00
13.	20.0/0.2	110000	130	96720/465.0	92.0/ 4.8	16.6/1.06
14.	65.0/1.3	55000	103	30887/349.0	120.0/11.3	16.0/2.91
15.	65.0/1.3	40000	99	39396/670.0	132.0/17.0	20.3/4.75
16.1	93.0/5.0	17375	67	16153/227.5	127.5/14.0	15.5/4.03
16.2*	70.0/2.5	160	67	158/ 10.5	210.0/83.0	62.7/36.0
17.	25.0/0.3	61000	168	58985/629.5	115.0/10.6	16.1/1.84
18.	60.0/2.5	59200	124	56700/810.0	128.0/14.2	16.5/2.83

* Expt. No. 16.2 *Penaeus monodon*

in the range 27.1-29.8°C and salinity between 37.84-44.94ppt. These variations resulted in the poor rate of growth in most of the experiments but not in mortality.

Wild seeds of *P. monodon* in the size, 70 mm released together with *P. indicus* in one experiment revealed good results in growth and survival. The tiger prawn attained the marketing size at 210 mm/83 g in a culture period of 67 days indicating an overall growth rate of 63 mm/36 g/m. Similarly, seeds of *P. indicus* of advanced size reached marketing size within a short culture period and found much tolerant even in high temperatures and salinity (Table 3). *P. indicus* grew to harvesting size at 127.5 mm/14 g in a short spell of 67 days (Expt. No. 16), and in earlier round of experiment also the seeds released at 65 mm progressed to 132 mm/17 g in 99 days showing an overall growth rate of 20.3 mm/4.75 g/m. Such fast growth was possible because of the well suited stocking intensity (43000-80,000/ha). This observation appeared to be an important consideration in the commercial development for realising quick profits. The growth was fast during early days of stocking, particularly in monsoon crops when campared to the summer crop. The trend of growth sharply declined with increase in stocking density.

The crops raised during monsoon season, generally revealed a better growth as seen in experiments 1, 2 and 8-11 indicating an overall growth of 22-27 mm and 2.60-4.24 g/m. But at the same time poor growth at 16 mm/1 g/m was well noticed in experiments 12 and 13 which was exactly due to high stocking at 2.75 lakhs/ha (Table 3). The crops raised during summer season exhibited a poor growth at 13-16 mm / 1.4-2.8 g/m, although the stocking intensity was kept at 62,500/ha as in the case of experiment No. 18. The trend of growth observed in these two different seasons are plotted in Fig. 2 and 3. The growth curves for *P. indicus* indicated a clear inverse relationship between stocking density and growth.

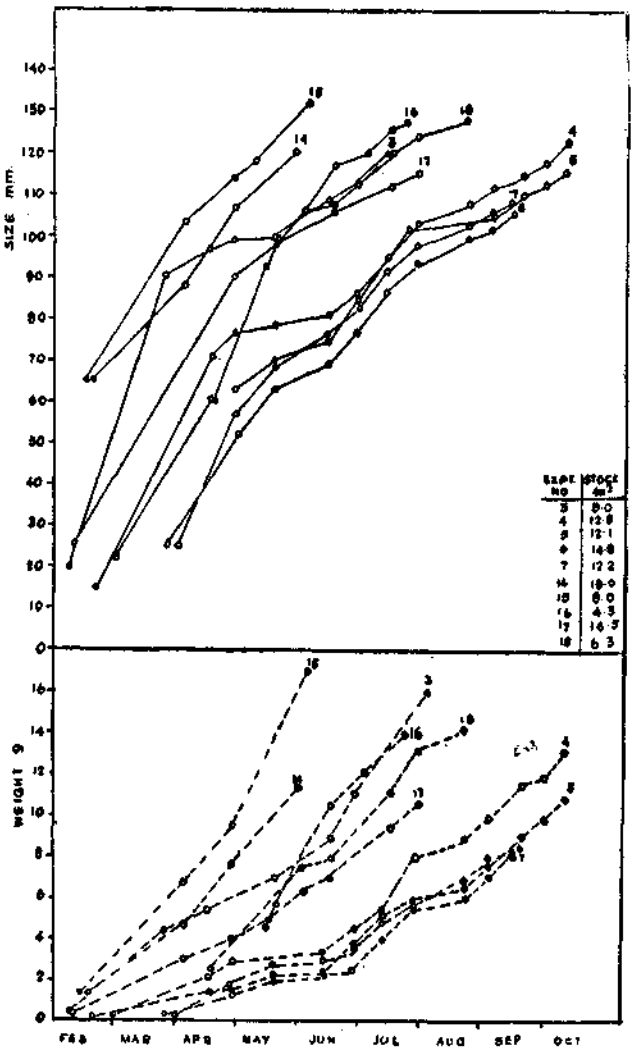

Fig. 2. Trend in the growth rate of *P. indicus* cultured in summer season.

The changing pattern of growth rate in different stages or size group of *P. indicus* are depicted in Fig. 4. Seeds of *P. indicus* released during monsoon at 11 mm and 24 mm have grown fast at the rate of 38 mm and 43.6 mm/m respectively as seen in experiments 1 and 8. Significantly, the seed released in summer at 15mm (Expt. No. 5) have indicated a poor growth rate at 25.3 mm/m even during early stages. The rate of growth declined suddenly after 80 mm size, invariably in all experiments. Weight increase was not steady in the growth of prawn. Two prominant modes were seen in the histogram drawn for the rate of increase of weight in the cultured prawn. Maximum weight input was noticed when the prawns reached the size at 110 mm

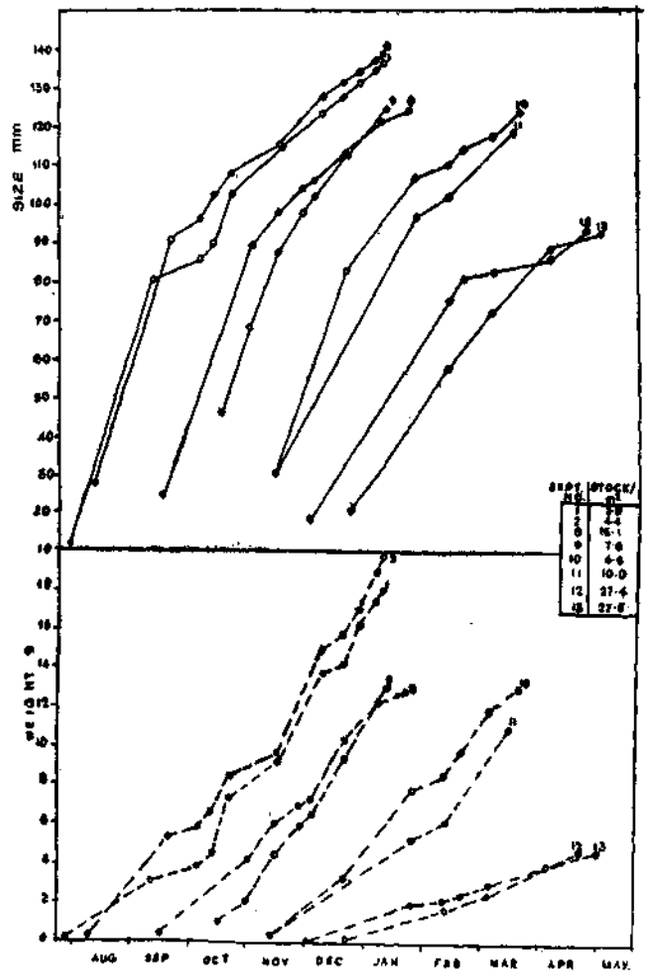

Fig. 3 Trend in the growth rate of *P. indicus* cultured in monsoon season

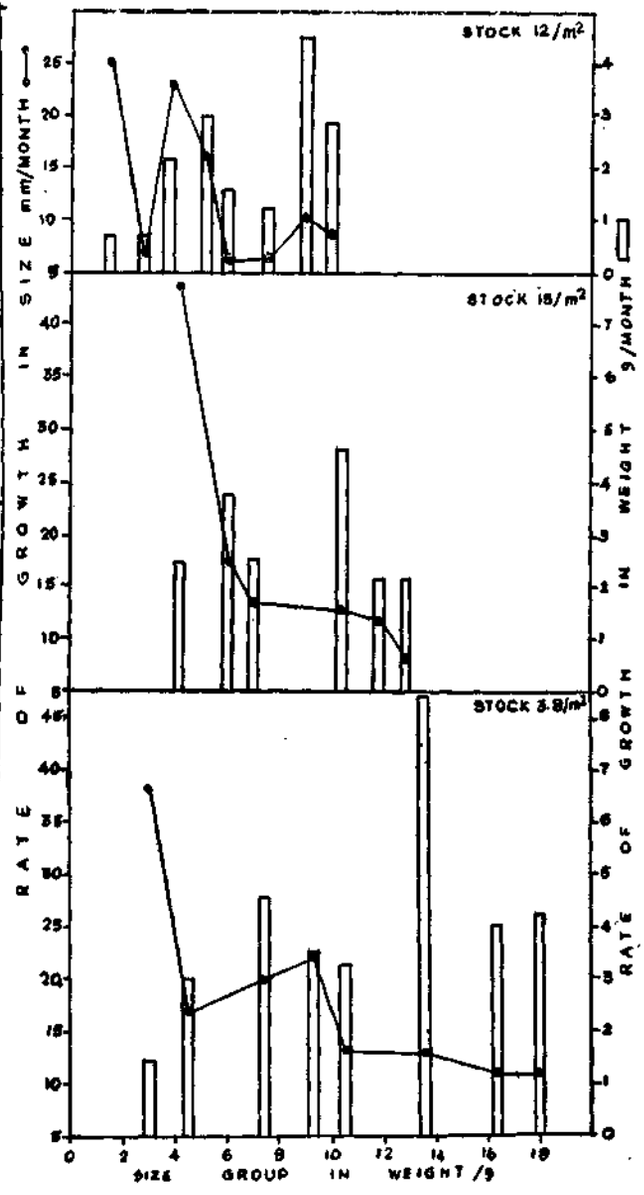

Fig. 4. The growth rate of *P. indicus* at different steges.

and above. Maximum gain in weight (8.5 g) was noticed in the first experiment in prawn belonging to 120 mm size group and it may be due to conducive environmental conditions and low stocking. In another experiment (No. 8) although it was carried during monsoon, the maximum gain in weight (4. 6 g) was noticed with 110 mm sized prawn and this low rate may be attributed to high stocking density. This observation confirmed that environmental factor alone was not the criteria for promoting the growth but the stocking intensity constituted the primary concern. This trend was also noticed in the fifth experiment and in confirmity with the observations made by Muthu *et. al*, (1981).

The production and marketing details are presented in Table 4. A total production of of more than 10 tonnes of *P. indicus* was attained from 7 ponds in a total area of 4.2 ha by raising 2-3 crops in a period of 25 months and fetched a gross income of Rs. 3,90,161/-. Best result in growth and production was recorded when the stocking

TABLE 4. *Results of production, marketing and income of the experiments*

Expt No.	Culture period	Pond size m^2	Percentage of survival	Production Kg	Rate of production kg/ha/crop	Value realised Rs. Ps.
1.	26.7.85-8.1.86	4973	85.0	290.0	583.0	9,976.00
2.	8 8.85-8 1.86	5205	65.0	277.0	532.0	10,664.50
3.	8.2 86-2.8.86	4973	93.8	600 0	1206.5	33,000.00
4.	1.3 86-10.10.86	5205	95.4	835 0	1604.0	38,410.00
5.	20.2.86-10.10.86	9472	92.5	1169.0	1234.0	43,253.00
6.	25.3.86-13 9.86	9139	74.5	805.0	880.8	17,710.00
7.	1.4.86-13 9.86	3677	73 2	330.0	897.5	7,260.00
8.	15.9.86-21.1.87	4973	75.6	720.0	1448.0	43,200.00
9.	15 10.86-10.1.87	3677	85.7	300.0	815.9	18,000.00
10.	12.11.86-18 3.87	5205	80.5	355.5	683.6	16,708.00
11.	12.11.86-16.3.87	9139	55.0	550.0	601.8	20,350.00
12.	1.12.86-22.4.87	9472	82.2	1027.0	1084.3	15,405.00
13.	21.12 86-30.4 87	4000	87.9	465.0	1162.5	6,975.00
14.	19.2.87-28.5.87	5500	56.2	349.0	635.0	12,215.00
15.	15.2.87-4.6.87	4973	98.5	670.0	1347.3	24,790.00
16.	15.5.87-21.7.87	4000	93.0	227.5	569.0	9,782.50
17.	10.2.87-28.7.87	3677	96.7	627.5	1706.5	21,962.50
18.	18.4.87-20.8.87	9472	95.8	810.0	855.0	40,500.00
	Average	5930	82 6	578.2	991 5	21,676.00

TABLE 5. *Production and conversion efficiency*

Expt. No.	Prawn Production kg.	Food supplied kg.	Conversion quotients
1.	290.0	1740.0	1: 6.0
2.	277 0	1608.0	1: 5.8
3.	600.0	3179.0	1: 5.9
4.	835.0	4833.0	1: 5.8
5.	1169.0	6288.0	1: 5.4
6.	805.0	3243.0	1: 4.0
7.	330.0	1972.0	1: 6.0
8.	720.0	2906.0	1: 4.0
9.	300.0	859.0	1: 2.9
10.	355.5	2490.0	1: 7.0
11.	550.0	3714.0	1: 6.8
12.	1027.0	5404.0	1: 5.3
13.	465.0	3037.0	1: 6.5
14.	349.0	1960.0	1: 5.6
15.	670.0	4154.0	1: 6.2
16.	227.5	954.0	1: 4.2
17.	627.5	2860.0	1: 4.6
18.	810.0	4000.0	1: 4.9
Average	578.2	3067.0	1: 5.4

rate was kept at 70,000-80,000/ha. The rate of production/ha/crop varied from 532 to 1706 with an average production of 991.5 kg. Annual production in a ha fluctuated in the range 1064-4344 with an average at 2434 kg. Survival was high and the average income per crop of 144 days worked out to be Rs. 21,676/-. The cost of expenditure on various accounts roughly came to 50-60% of the income.

The conversion quotients of the experiments were calculated in the range 2.9-7.0 : 1, with an average of 5.4 : 1 (Table 5).

DISCUSSION

Considerable efforts were made to improve the growth, survival, production and profit with the existing developed grow-out facilities. High production of quality prawn was realised by designing short term culture operation to facilitate to raise 3 crops in a year. The occurrence of seeds of high quality, desirable

species like *P. indicus* without the mixing of poor growing species was another added advantage for the progress of culture in this area. Periodical stocking and harvesting in different ponds, leaving sufficient days of gap, promotes the collection efforts easier, besides creating prospects for regular flow of income for smooth management of farm.

The results on the production were compared with earlier works to realise the value and feasibility of present experiments. Andhra Pradesh is leading in the development of prawn culture in vast coastal belt, but still the rate of production is low. Srivastava (1984) analysed the production results and reported the average production of prawn under monoculture experiments as 264 kg/ha only. Srinivasan *et. al.* (1982) reported in brackishwater prawn farm of Tamilnadu to vary from 200 to 400 kg/ha/crop. Polyculture of milkfish and *P. indicus* at Kakdwip have shown a total production of 2196 kg/ha/6 months (Rao, 1978). Suseelan (1976) recorded a maximum production of 1134 kg/ha/year. Nandakumar (1982) observed in *P. indicus* a production of 231 5 kg/ha/5 months with supplementary feeding practice. Venkatesan and Victor (1982) recorded a maximum production of *P. monodon* at 521 kg/ha/ 3 months in brackishwater in Madras, although it is a fast growing species. Varghese *et. al.* (1982) obtained a maximum production of *P. indicus* at 511 kg/ha/3 months in converted filtration fields in Kerala. In Tuticorin area, some of the private farmers have produced 300-400 kg / ha / 4 - 5 months without any scientific management. The production figures (991kg/ ha/crop) from Veppalodai farm are several times more than the results published for *P. monodon* and *P. indicus* from different areas.

CONCLUSION

The productive areas are Pinnakayal estuary and Palayakayal which consist of low deltaic land intersected by winding creeks. The lands adjacent to Korampallam creek, Arasalodai creek, Kallar estuary, Vaipar and Vembar estuaries are the other identified sites for the development of prawn culture in this zone.

Extention and research are the major immediate needs for the development of prawn farming in a new area. Present extension service has aimed to improve the level of production in existing conditions, increasing area of operation by monitoring progress of fish farmers. Environmental and resource evaluation are in progress and the investigation will provide adequate information for new entrepreneurs in this zone. Improved management and greater operational efficiency executed at Veppalodai prawn farm have set examples for the development potential and for follow up action. A perfect technology has been developed for a guaranteed production of one or two tonnes per hectare. The involvement of different organisations are essential for the development of the sector. The action plan of Marine Products Export Development Authority has already evoked interest among entrepreneurs for enjoying the incentive schemes in the form of subsidy for development of new farms, establishment of seed bank and hatchery and subsidy on prawn feed. Central Institute like CMFRI also extends technical guidance to promote this industry as at present. A well planned area development programme with integrated approach as exemplified in the field of agriculture, could accelerate the progress of aquafarming in near future as there is considerable scope for further development in production techniques and high income.

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SUITABILITY OF KILLAI BACKWATERS FOR PRAWN FARMING—A PRELIMINARY MICROLEVEL SURVEY

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ABSTRACT

Brackishwater areas have been given much importance for prawn farming. No information was available on the Killai backwaters about factors like water quality, topography, contour, extent of the area, tidal amplitude, seed potential and possibilities of flooding etc. Hence during 1982-'84 Killai area was thoroughly surveyed on the above aspects and the results have been discussed in this paper. From this it is inferred that a total area of about 165 ha is readily available for undertaking both pond and pen culture in this backwater.

INTRODUCTION

In our country, prawn farming is identified as a major component of the brackishwater fish culture. Besides its role in augmenting food production, prawn culture is vitally important for improving the rural economy and for providing gainfull self-employment for large number of fishermen, fish farmers and other entrepreneurs of coastal regions. Following the identification of enormous potential available for prawn farming and also in view of the urgent need for developing indigenous expertise, intensive researches are being carried out by several organisations in our country. The modern aquaculture has emerged as a multidisciplinary science covering various aspects such as selection of species, survey and location of sites, construction of farm, feed development, culture techniques, control of diseases, maintenance of water quality, harvesting, processing and marketing. Suitability of Porto Novo waters for prawn farming has already been brought to light (Sriraman and Ananthan Narayanan, 1986) and many works have been carried out in Porto Novo waters (Anon. 1987). But studies pertaining to Killai area especially with reference to its suitability for prawn farming (both in Pond & in Pen) are lacking and hence the present study.

DESCRIPTION OF STUDY AREA

The Killai backwater system is situated in the Chidambaram taluk of South Arcot District in Tamil Nadu. (Long. 79°45'-79°50'E and Lat. 11°20'-11°30'N). This is connected to Vellar river in the north and Coleroon river in the South. This has many connecting channels which harbour luxuriant growth of mangrove vegetations and a very rich fauna. Thus it presents an ideal site for prawn culture ventures.

MATERIALS AND METHODS

Four stations were fixed in the study area and a micro level survey covering the following aspects *viz.*, survey of land areas, accessibility, water qualities like salinity, dissolved oxygen, pH and temperature, fertility, soil type, barmouth conditions, tidal levels, land elevation, ground water table, rainfall and seed resources, was carried out. Other details regarding feed resources, availability of power, marketing, cold storage, transport, availability of labour and socio economic status were also covered during the survey and presented in this paper.

RESULTS AND DISCUSSION

1. Survey of land areas

The Killai backwater comes under two revenue villages namely Killai and T. V. S.

Table 1: *Land details of Killai and T.V.S. Pettai area*

S. No.	Survey No.	Gross potential area suitable for farming in ha.	Net water spread area for farming ha.	Classification
1	R. S No. 406	48.00	25 to 30	River poromboke (Revenue)
2	R. F. No. 142	65.00	25 to 30	Reserve forest
3	R. F. No. 143	30.00	20.00	Reserve forest
	Total	143.00	70-80	

Pettai. In Killai village part of the area is under survey No. 406 (Revenue Poromboke) and part under Reserve forest (R. F. No. 142). The TVS pettai area comes under reserve forest (R. F. 143). Two stations each were fixed to analyse the water quality at Killai and T.V.S. Pettai. The land areas of Killai and T.V.S. Pettai are given in the Table 1.

Location: R. S. No. 406 lies along both sides of the channel connecting Vellar and Killai backwaters with Mudasodai hamlets in the north and Muzhukkuthurai - M. G. R. Thittu in the South.

R. F. No. 142 lies mostly in the southern sides of Killai-Muzhukkuthurai road. The land areas lie in between the finger shaped water tips.

The site R. F. No. 143 lies on the northern side of the road leading to the ferry site from T.V.S. Pettai village.

2. *Water quality*

Water samples collected during fullmoon, newmoon and halfmoon periods were analysed for salinity, oxygen, temperature, pH and fertility. Data for Killai area (from October 1982 to September 1983) and for T.V.S. Pettai area (from March 1984 to February 1985) are given in the Figure 1.

Salinity: Salinity of the Killai area was fluctuating between 5 and 37.6°/$_{oo}$. The salinity was low during the monsoon and high during summer.

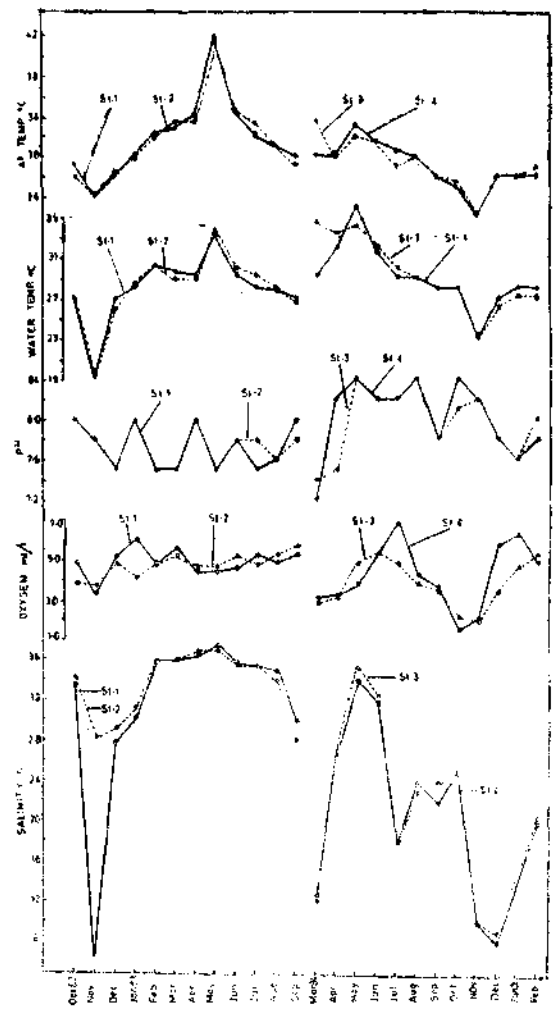

Figure 1. Hydrographical conditions of the four stations of the study area.

Salinity of T.V.S. Pettai area fluctuated between 8 (December '84) and 35.4°/$_{oo}$ (May 1984).

Dissolved Oxygen: Dissolved oxygen of Killai varied from 3.4 (November 1982) to 6.1 ml/l (January 1983). Similarly the $D.O_2$ of T.V.S. pattai varied from 1.6 (October 1984) to 6.8 ml/l (July 1984).

Temperature: The atmospheric temperature of Killai area was from 26 (November 1982) to 42°C (May 1983) whereas the atmospheric temperature of T.V.S. pettai was from 24 (November 1984) to 33.6°C (March 1984).

The water temperature of T.V.S. pettai area was from 23 (November 1984) to 36°C (May 1984). In Killai area it was from 19.2 (November 1982) to 33.7°C (May 1983).

pH: The pH of Killai area varied from 7.5 to 8 whereas the pH of T.V.S. pettai area was from 7.2 to 8.4.

Fertility: This system is comparatively more fertile than many other systems in Tamilnadu. The water is nutrient rich and harbours many aquatic fauna and flora. The planktonic sediments vary from 0.3 ml/50 l to 0.9 ml/50 l. The common representative phytoplanktonic organisms were *Coscinodiscus* sp., *Skeletonema* sp., *Biddulphia* sp., *Navicula* sp., *Pleurosigma* sp., *Rhizosolenia* sp., *Planktoniella* sp., *Nitzchia* sp., *Trichodesmium* sp., and *Ceratium* sp. Among the Zooplankters, *Oithona* sp., Lucifer, calanus, other copeponds, fish eggs and mysis stage of prawns are the dominant forms.

Pollution: Many studies carried out in this area on pollution (Anon, 1987) reveal that this area is free from pollution.

3. *Soil Type*

R. S. No. 406: The top soil to the depth varying from 20 to 30 cm is clay while the bottom soil is predominantly sandy. The particle size analysis done in soil engineering research station, P.W.D. Chepauk for the top soil revealed the following.

Sand	= 10%	Liquid Limit	= 59%
Silt	= 33%	Plastic index	= 37
Clay	= 57%		

R. F. No. 142: The soil profile for 1 m depth is sandy from the top to the bottom. Clay matting has to be given to minimise percolation and seepage loses through the bed and bunds.

R. F. No. 143: A trail pit of 90 cm depth shows that the soil is clayey throughout the depth and the same nature appears to extend down below also. The particle size analysis revealed the following.

Sand	= 0%	Liquid limit	= 76%
Silt	= 38%	Plastic index	= 42
Clay	= 62%		

4. *Bar Mouth Conditions*

The Killai area is influenced by 3 bar mouths namely (1) Vellar barmouth (2) Chinnavaikkal barmouth and (3) Coleroon barmouth. The Vellar and Coleroon barmouths are perennial ones whereas the Chinnavaikkal is a seasonal one. The Chinnavaikkal barmouth is located in between Vellar and Coleroon barmouths and is about 6 km from the Vellar barmouth, opens during the monsoon periods and closes in the remaining periods of year. The Vellar and Coleroon barmouths are always open even during summer months, though at times the barmouth narrows down and becomes shallow.

The T.V.S. pettai area is influenced by the barmouth of river coleroon, which is about 7-8 km from the side and it remains open throughout the year.

5. *Tidal Levels*

The tidal levels are correlated to the nearest Port Nagapattinam taking the spring tidal level occurring at the site to be equal to the level in the tide chart for the particular day and the other levels are accordingly deduced giving necessary correction. The deduced tidal levels are:

R. S. No. 406

MHWL (Spring)	+ 0.82 m
MHWL (Neap)	+ 0.58 m
MLWL (Neap)	+ 0.23 m
MLWL (Spring)	+ 0.00 m
MFL	+ 1.70 m
Ground level	+ 0.67 to + 0.82 m (average)

R. S. No. 143

MHWL (Spring)	+ 0.86 m	
MHWL (Neap)	+ 0.61 m	
MLWL (Neap)	+ 0.23 m	
MLWL (Spring)	+ 0.00 m	
MFL	+ 1.70 m	
Ground level	+ 0.75 m	(average).

A working sheet for the correlation of levels is given in Table 2.

6. Land Elevation

Ground level varies from +0.67 near the fringes of the water course to + 0.82 m in the interior side with a maximum of +1.17m in some pockets of Killai area.

Table 2. *Working sheet for the correlation of tidal levels against standard port Nagapattinam*

Standard port - Nagapattinam — Site : R. S. No. 406 of Killai

Date	Time	Tidal level	Range	Time	Gauge reading	Range
28.6.84	0809	0.55	0 38	0900	0.72	0.50
(Newmoon)	1600	0.17		1600	0.22	

Tidal levels of Nagapattinam port	Correction factors	Corresponding levels at R. S. No. 406 of Killai	Taking MLWL (S) as 0.00 the corresponding levels at R. S No. 406 of Killai
MHWL (S) +0.65	-nil-	+0.65	+0.82
MHWL (N) +0.47	$\frac{0.50}{0.38}$ x 0.18= 0.24	+0.41	+0.58
MLWL (N) +0.20	$\frac{0.50}{0.38}$ x 0.45= 0.59	+0.06	+0.23
MLWL (S) +0.03	$\frac{0.50}{0\ 38}$ x 0.62= 0.82	—0.17	0.00

Standard port - Nagapattinam — Site : R. S. No. 143 of T.V.S.Pettai

Date	Time	Tidal level	Range	Time	Gauge reading	Range
13 6.84	0839	0.60		0930	0.80	
(Fullmoon)			0.64			0.46
	1632	0.14		1545	0.16	

Tidal lelels of Nagapattinam port	Correction factors	Corresponding levels at RS No. 143 site	Taking MLWL (S) as 0.00 the corresponding levels at RS No. 143 site
MHWL (S) = +0.65	-nil-	+0.65	+0.80
MHWL (N) = +0.47	$\frac{0\ 64}{0.46}$ x 0.18= 0.25	+0.40	+0.61
MLWL (N) = +0.20	$\frac{0.64}{0.46}$ x 0.45= 0.63	+0.02	+0.23
MLWL (S) = +0.86	$\frac{0.64}{0.46}$ x 0.62= 0.86	—0.21	0.00

Table 3. *Rainfall particulars of Porto Novo station (in mm)*

Months	1970	1971	1972	1973	1974	1975	1976
January	7.0	90.4	—	—	—	—	—
February	—	—	—	—	28.7	—	—
March	—	69.4	9.2	4.3	—	68.7	—
April	28.0	—	—	—	17.2	—	—
May	80.4	27.2	46.9	40.5	25.0	29.3	11.2
June	13.0	40.7	7.3	40.0	41.1	13.3	1.1
July	88.1	39.5	86.7	29.0	48.7	149.9	92.1
August	131.4	17.6	86.4	79.1	43.6	149.3	172.9
September	111.3	105.8	52.0	123.8	118.2	70.8	59.9
October	63.1	158.4	512.4	312.8	245.9	220.5	272 5
November	788.3	107.0	347.8	141.5	67.6	391.5	556.8
December	94.5	479.8	380.3	94.9	125.4	112.5	196.6
Total	1405.1	1335.8	1529.0	865.9	761.4	1205.8	1363.1

Months	1977	1978	1979	1980	1981	1982	1983	1984
January	9.9	—	1.0	—	67.5	—	—	54.0
February	12.4	—	5.5	—	—	—	—	291.0
March	—	—	10.0	—	0.2	—	—	255.0
April	62.5	—	—	10.0	0.1	—	—	43.0
May	35.0	10.4	11.0	—	77.8	—	25.0	—
June	48.0	51.5	23.5	15.5	22.5	14.4	—	37.5
July	19.3	37.0	12.5	31.5	199.6	43.0	91.5	194.0
August	140.8	54.8	18.5	72.0	140.3	23.0	174.0	67.0
September	173.5	253.1	300.1	57.0	44.1	93.5	178.0	268.0
October	661.6	212.0	310.4	191.5	536.5	11.7	237.6	68.0
November	702.1	435.9	667.2	233.2	276.1	358.9	101.6	416.0
December	56.5	503.9	212.6	61.4	149.7	150.0	503.5	59.0
Total	1921.6	1558.6	1572.3	672.1	1514.4	794.5	1311.2	1752.5

In T.V.S. pettai area the ground level varies from + 0.70 near the estuary to +0.80m at the farther end. The average ground level may be taken as + 0.75 m. During MHWL (Spring) conditions the land is getting submerged to a depth of 5-10cm.

7. Ground Water Table

In Killai area, on 28th June 1984 the ground water table was found to exist at +0.30 m i.e about 50 cm below the average ground level of +0.80 m whereas in T.V.S. pettai the ground level did not appear at all even at 1 m depth-may be due to the nature of soil, being highly plastic clay which does not form an acquifer.

8. Rainfall

Rainfall being an important factor controlling the salinity, its data for the 15 years duration from 1970 to 1984 was collected from the nearest materological station at Porto Novo and given in Table 3. This gives a fair idea of the rainfall distribution over months of different years.

9. Exposures To Flood And Cyclone

Floods do occur in Vellar and the ordinary flood level (OFL) is about 50 to 60 cm over the average ground level. The highest recorded storm surge level on 1-12-1984 was 1.65 m over the average lower low water level and this has submerged the land area to a depth of about 1.0 m. This may be taken as the highest water level, either due to floods or due to storm surge.

T.V.S. pettai site is not directly exposed to flood currents since they are far away from the main rivers. However, the flood water level will rise and the MFL at site is observed to be +1.70 m.

10. Fauna and Flora

Fauna: The productive and fertile complex of Killai area harbours many aquatic fauna. The predominant fishes found in the system are *Mugil* sp., *Chanos chanos*, *Lates calcarifer*, Sciaenids, *Therapon* sp., *Tachysurus* sp., *Plotosus* sp., *Congresox* sp., *Muraena* sp., *Johnius* sp., *Polynemus* sp., *Gerres* sp., *Belone* sp., *Etroplus* sp., *Platycephalus* sp., *Scatophagus* sp., *Thryssa* sp., *Ambassis* sp., *Epinepheles* sp., *Syngnathus* sp., *Sphyraena* sp. and puffer fishes.

The predominant shrimp species are *Penaeus indicus*, *P. monodon*, *P. semisulcatus*' *Metapenaeus* sp. and *Macrobrachium* sp.

The crab fishery of this complex involves *Scylla serrata*, *Portunus pelagicus*, *P. sanguinolentus*, *Uca* sp., *Ocypoda* sp., *Thalamitta* sp., and *Calappa* sp.

The molluscan fauna includes *Crassostrea madrasensis*, *Catalysia opima*, *Arca* sp., *Anadara* sp., *Tonodolium* sp,, *Clython* sp.

The main representative of the benthic organisms include *Apsudes* sp., Amphipods, Isopods, Nereids, Polychaetes and Nematodes.

Flora: Both micro and macro vegetations are abudant in this backwater. The micro vegetations include the phytoplankton and the macro vegetation comprises the mangrove plants and marine algae. The important mangrove vegetations are *Rhizophora micronota*, *Avicennia* sp., *Sonneratia apetala*, *Suaeda* sp., *Bruguiera* sp., *Excoecaria* sp, *Salicornia* sp., and *Serruvium* sp etc.

The algal forms include the following viz. *Halophila ovalis*, *Gracilaria edulis*, *Enteromorpha* sp., *Chaetomorpha* sp and the seagrass *Cymodocea isodiphollium*.

11. Seed Resources

The Killai backwater system is a potential area for shrimp seed collections. The most common seeds occurring here belong to *Penaeus indicus*, P. *monodon*, P. *semisulcatus*, *Metapenaeus* sp. and *Macrobrachium* sp. Of the above forms P. *indicus* is the most abudant and could be collected in all the seasons. The month wise collection (average catch per man per hour) of prawn seeds are given in the Tables 4 & 5.

Table 4. *Seed resources of Killai (Dragnet collection) (catch/man/hour)*

Station	*P.indicus*	*P.monodon*	*P. semi-sulcatus*	*M. mono-ceros*	*Macrobra-chium* sp.	Mullet
October '82						
Station 1	64	—	58	—	—	5
Station 2	14	—	40	—	—	—
November '82						
Station 1	27	15	—	—	1	—
Station 2	4	—	—	—	—	—
December '82						
Station 1	1	—	51	14	—	—
Station 2	4	—	70	16	—	4
January '83						
Station 1	34	—	74	—	28	156
Station 2	42	—	90	—	—	165
February '83						
Station 1	1215	—	135	—	12	—
Station 2	1177	—	27	—	—	—
March '83						
Station 1	126	—	63	46	—	—
Station 2	241	—	58	11	—	—
April '83						
Station 1	64	—	122	241	—	—
Station 2	50	—	39	—	—	—
May '83						
Station 1	—	3	46	36	—	—
Station 2	2	—	86	50	—	—
June '83						
Station 1	8	—	100	21	5	1
Station 2	3	—	94	36	8	—
July '83						
Station 1	37	—	44	20	—	—
Station 2	31	—	46	25	—	—
August '83						
Station 1	60	—	50	25	10	—
Station 2	40	—	30	15	5	—
September '83						
Station 1	50	4	15	20	28	—
Station 2	30	—	10	10	24	—

Table 5. *Seed resources of T.V.S. Pettai (Dragnet collection) catch/man/hour*

Months	*P. indicus*	*P. monodon*	*P. semi-sulcatus*	*M. mono-ceros*	*Macrobra-chium*	Mullet
March '84	21	0	0	24	9	—
April	676	18	15	99	150	—
May	180	—	9	111	51	—
June	30	—	—	33	9	—
July	42	—	69	36	21	—
August	150	12	48	6	42	—
September	132	0	51	27	30	—
October	45	—	—	156	36	—
November	45	—	—	33	129	—
December	48	—	—	36	111	—
January '85	54	12	—	42	42	30
February '85	60	10	—	30	25	20

The identified potential seed grounds in the Killai area are (1) Vadakku Kuttai (2) Naduthittu (3) Chinnavaikkal (4) M.G.R. Thittu (5) Pattarayadi (6) Killai Karithurai and (7) Muzhukkuthurai.

Similarly (1) Adalnthakutti (2) Oorkidavu (3) T.V.S. Pettai, Karithurai and (4) Pillu-medai are some of the identified seed grounds of T.V.S. Pettai area. The above said areas are muddy with profuse growth of vegetations like *Halophila* sp, *Chaetomorpha* sp, and *Entero-morpha* sp which serve as the ideal nursery ground for the post larvae and junvenile shrimps. Various gears such as velon screen, drag net, cast net and push net were tried for seed collection and among them the push net is the most efficient gear for shrimp seed collection.

Apart from this, culturable fish seads such as *Chanos chanos* and *Mugil* sp. are also available in plenty.

12. Feed Resources

Part of the feed demand can be met by the squids, prawn heads, and trash fishes available in the nearby landing centre at Porto Novo (for Killai area), and Pazhayar landing centre (for T.V.S. Pettai area). For large scale operation artificial feeding has to be resorted to.

13. Power Supply

Three phase power supply is available in the nearby hamlets, Ponnanthittu and Killai about 1 to 2 km from the site. For T.V.S. Pettai area also power supply is available within a distance of 1-2 km at T.V.S. Pettai village.

14. Marketing

Marketing facilities are available in the nearby towns, Porto Novo, Chidambaram and Cuddalore.

15. Cold Storage

At present there is no cold storage facility available at Killai and T.V.S. Pettai area.

16. Transport

There is a motorable road upto the farm site connecting all the nearby towns and railway station. The nearby landing centre Porto Novo can be reached easily by water ways from Killai area.

In T.V.S. Pettai area also there is road connecting the towns and railway station. The nearby landing centre pazhayar can be reached by water ways.

17. Availability Of Labour

Both skilled and unskilled labours are available in the nearby villages.

18. Socio Economic Impact

The implementation of brackish water farming schemes will go a long way in improving the socio economic status of the poor fisherman in these area.

WATER AREA SURVAY

Killai backwater system has an approximate extent of 1000 - 1300 ha of water spread area. A technical microsurvey with the aim of identifying and qualifying suitable water areas for penculture mainly of shrimps was conducted in collaboration with BOBP/FAO.

Water areas having a minimum depth of 30 cm and a maximum of 80 cm during the lowest tide were considered suitable for the purpose. The lower limit of depth was decided in view of the shrimps minimum ecological needs particularly temperature and light. The higher limit was decided keeping in view the construction cost and management aspects.

Table 6. *Tidal amplitudes, flood levels and potential areas for pen culture in Killai backwater area.*

Sl. No.	Location	Gross potential area (ha)	Net area available (ha)	Min. depth range during average lower low tide (m)	Av. tidal amplitude (m)	Max. water depth during floods, over the av. lower low water level (M)	Remarks
1.	Vellar bridge-Porto Novo jetty	1.373	1.375	0.30-0.70	0.40-0.70	2.70	—
2.	Porto Novo Jetty-Fish Landing Centre	2.650	2.650	0.30-0.70	0.40-0.80	1.70	—
3.	Vellar Barmouth Kuttal	2.050	2.050	0.30-0.80	0.40-0.80	1.70	—
4.	Muzhukku Thurai	20.200	10 100	0.30-0 80	0.15-0.40	1.60	50% of gross potential area allowed for water ways.
5.	Water course leading to Chinna vaikkal barmouth	3.500	3.500	0.30-0.80	0.15-0.40	1.60	—
6.	Chillan Kuttai	2.200	2.200	0.30-0 40	0.15-0.30	1.60	—
7.	Vadaku Kuttai	3.100	3.100	0.30-0 60	0.15-0.30	1.60	—
8	Thalakkidavu	19.400	19.400	0.30-0.70	0.15-0.30	1.60	BOBP Pen culture project included
9.	Pattaraiadi	16.150	8.080	0.30-0.80	0.15-0.30	1.60	50% of gross potential area allowed for water ways.
10.	Kerithurai	4.450	2 230	0.30-0.60	0 15-0.30	1.60	as above
11.	Karithurai-Jetty-Kuchipalayam	7.900	3.950	0.30-0.70	0.15-0.30	2.00	as above
12.	Periaakidavu	2.400	2.400	0.30-0.60	0.15-0 30	1.60	—
13.	Sethu Kollidam	38.500	19.250	0.30-0.60	0 30-0.70	1.70	50% of gross potential area allowed for water ways.
14.	Adaincha Kuttai	1.450	1.450	0 20-0.30	0.40-0.80	1.70	
15.	Kodiampalayam Oorkidavu	2.800	2.800	0.20-0.25	0.40-0.80	1.70	
	Total	128.125	84.535				

Depth soundings were taken and the lowest low water depths were arrived and plotted. Then isobathic lines were drawn for 30 cm and 80 cm depths and the area bounded by these lines were computed. Out of the total estimated backwater area of about 1000-1300 ha the gross potential area is computed to be 128 ha only. Which included ferry sites, regular water ways used by canoes and boats. If they are excluded net area likely to be available for penculture may be in the range of 80-90 ha.

The outcome of bathymetic survey with the identified area and average tidal amplitude are given in Table 6.

The studies carried out revealed that a total extent of about 155 ha (85 ha for pen culture and 70 ha for pond culture) of potential area are available for undertaking both pond and pen culture in these backwaters.

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Paper - 43

DEVELOPMENT OF A MINI PRAWN HATCHERY FOR FISHERMEN FAMILIES

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ABSTRACT

The Central Marine Fisheries Research Institute has developed a totally indigenous technology for hatchery production of penaeid prawn seed. This technology has been adopted by the States of Kerala and Karnataka to build large commercial hatcheries at Cannanore and Kumta Bay respectively.

The technology is so simple that it can be adapted by fishermen families living on the sea shore for producing prawn seed on a mini scale in their houses. The equipment needed for this mini hatchery and the economics of such operations are given in the paper. There is great scope for developing it into a cottage industry in the coastal areas.

INTRODUCTION

The Central Marine Fisheries Research Institute, Cochin, has developed a totally indigenous technology of prawn seed production (Silas *et al.*, 1985). Locally available equipment and material are used. The technology differs from those used in other parts of the world in two main respects: (1) Mixed diatom cultures developed by fertilizing raw sea water with plant nutrients are used to feed the larval stages, instead of pure algal

cultures and (2) Simple particulate feed is used for postlarvel stages, instead of brine shrimp nauplii. The larvel rearing procedures have been so simplified that even unskilled workers with some training can take up this work.

It is a modular type of hatchery so that the capacity of the hatchery could be increased or decreased by changing the size and number of larvel rearing containers to suit the financial resources available. The prawn hatchery technology developed by CMFRI has been taken up by the States of Kerala and Karnataka to set up large prawn hatcheries at Cannanore and Kumta Bay respectively. The technical know-how is being provided by CMFRI for these hatcheries.

OBJECTIVE

The objective is to encourage fishermen families living on the shore to make use of the limited facilities available in their houses to produce prawn seed and earn additional income in their leisure time. The fishermen who goes out for fishing every day can bring the spawners and the women and children in the family can take care of the larvae. The procedures are so simple that the family members can learn them by attending short training courses at the Krishi Vigyan Kendra of CMFRI at Narakkal.

REQUIREMENTS

The total investment for setting up a hatchery unit is only Rs. 3000. The equipment used are plastic bins, basins and buckets and aquarium aerators for aerating the water. These containers can be kept on the verandah of the fishermen's house. Electricity should be available to operate the aerators. Clear seawater with salinity of 28–34 ppt should be available for at least 8 months in a year. The seawater for rearing the larvae can be collected in plastic buckets from the nearby sea. The chemical used for developing diatom cultures for feeding the larvae are cheap and easily available. (Please see section on Economics for details of equipment needed).

OPERATIONAL PROCEDURES

A fully mature and impregnated female of the white prawn *Penaeus indicus* (Naran) is to be collected and used as spawner. When the animal is held against light, ovary can be seen through the cuticle on the dorsal side of the animal along its entire length. Fully ripe ovary is dark olive green in colour, and has a lateral expansion in the first abdominal segment. In an impregnated female, the sperm mass can be seen as a whitish substance below the transparent cuticle of the sperm storage organ called thelycum on the ventral side of the head (cephalothorax) between the 4th and 5th walking legs.

The spawners can be collected from the trawlers/gill nets. Immediately on capture, can be kept alive in seawater in buckets and brought to the house. Only one good spawner is needed per run. It can be kept in 50 l of filtered, sediment-free seawater having a salinity of 30-34°/$_{oo}$ in a 100-l bin. EDTA (0.1 g) is added and good aeration is provided. The mouth of the bin is covered with velon screen to prevent the animal from jumping out. Throughout the night the spawner is kept in the dark free from disturbance. Usually the animal spawns the same night. Spawning takes place between 10 p.m.-2 a.m. The female is removed from the bin in the morning. Aeration is continued. An orange scum floating on the surface of the water at the side of the bin is an indication of spawning. Aeration may be stopped for one minute, and a sample can be collected from the bottom of the bin and examined for the presence of eggs. Eggs can be seen as small white round objects. Aeration is continued. Eggs start hatching into nauplii by about 9 a. m. About 3 p. m., nauplii are counted and distributed in the 100-l bins for further rearing.

If females with mature ovaries are not available, the fisherman can bring 14-15 cm long impregnated females of *P. indicus* either from the sea or from the backwaters and make them mature in the house by the following method With a fresh blade one of the eyes is incised and the contents of the eye gently squeezed out while holding the prawn underwater. The incised eye is smeared with antiseptic cream and the prawn kept in a 100-l bin with fresh seawater. The water in the bin is aerated well and the prawn is fed as much fresh clam meat as it would eat (usually 3-4 clams per day). The sediments and uneaten food are removed and the seawater completely changed every evening by siphoning, without handling the prawn. The bin is covered with a black cloth. Every morning the bin is observed for signs of spawning. The prawn usually spawns 4-5 days after the eye treatment.

For counting the nauplii, they are first dispersed in the water in the bin by mixing well. Then 2 samples using 100 ml beakers are taken. The nauplii in these beakers are counted using fillers and the total number of nauplii in the spawning bin is estimated as follows:

$$\frac{\text{Average number of nauplii in 100 ml}}{0.1} \times \text{Volume (in litres) of water in the spawning bin}$$

About 7500 nauplii are transferred to each of the four 100-l bins containing 50 l of sediment-free filtered seawater having a salinity of 30-34°/$_{oo}$.

The different larval stages and their duration are given below:

Nauplii (N1-N6)	—	40-48 hrs
Protozoea (P1-P3)	—	72-84 hrs
Mysis (M1-M3)	—	72-84 hrs
Postlarva (PL1-PL5)	—	5 days

The bins are managed as shown in Table 1. While removing water from the bin, aeration must be stopped and the siphon should be kept in a filter box covered with organdie cloth. Particulate feed is given when the larvae reach M3 stage. From then onwards sediments should be daily siphoned out after stopping the aeration. It should be remembered that Table 1 gives only guideline procedure. By paying careful attention to water quality and condition of the larvae, the volume of water exchanged and the amount of feed given should be judiciously varied to meet the exigencies of the situation. It could be learnt within a short time by experience.

Table 1. *Water management in larval rearing bin.*

Day	larval stage	Sea-water removed (l)	Sea-water added (l)	A'gal culture added (l)	Particulate feed (g)	Total volume of water (l)
1	N2	—	50	—	—	50
2	N5-6	—	45	5	—	100
3	P1	50	44	6	—	100
4	P2	50	44	6	—	100
5	P3	50	40	10	—	100
6	M1	50	40	10	—	100
7	M2	50	35	15	—	100
8	M3	50	35	15	0.5	100
9	PL1	50	40	10	1.0	100
10	PL2	50	45	5	1.5	100
11	PL3	50	48	2	1.5	100
12	PL4	50	49	1	1.5	100
13	PL5	50	49	1	1.5	100

Diatom culture to feed the larvae

Fifty liters of freshly collected filtered seawater (filtered through organdie cloth) having 30-34°/$_{oo}$ salinity is kept in a basin (preferably white in colour). The basin is placed in such a way that direct sunlight falls on it throughout the day. Water is continuously aerated. The seawater (50 l) is fertilsed with the following chemicals.

Sodium nitrate — 0.6 g (12 ppm)
Potassium orthophosphate—0.3 g (6 ppm)
Sodium silicate — 0.3 g (6 ppm)
EDTA disodium salt — 0.3 g (6 ppm)

PRODUCTION CAPACITY

1.	Nauplii stocked in 4 bins (each 100 litre capacity) @ 7500 nauplii per bin	30,000
2.	PL5 obtained after 13-15 days per run (Av. survival rate 50%)	15,000
3.	In 8 months of operation 15 runs can be made (15.000 x 15)	2.25 lakh PL5
	∴ Capacity of the hatchery per year	2.25 lakh PL5

ECONOMICS OF MINI PRAWN HATCHERY

Investment:

A. *Capital on hatchery equipments*:

100 l plastic bin (4 nos for larval rearing and 2 nos for seawater storage) 6 nos.	Rs. 1,380
50 l plastic bin (white colour) (for the transportation of spawners and culture of phytoplankton)—2 nos.	Rs. 210
25 l plastic bucket/pot (for seawater collection)—4 nos.	Rs. 120
Aquarium aerators—8 nos.	Rs. 440
Aeration tube (½ roll), aeration stones, connectors & regulators (1 doz. each), bolting silk-2m, sieve for water changing-siphoning tube (3 m)	Rs. 200
	Rs. 2,350

B. *Operational*: (Spread over 3 years)

Chemicals	Rs. 200
Artificial feed	Rs. 30
Electricity and miscellaneous . .	Rs. 420
Total for 3 years (A+B)	Rs. 650
= Rs. 3.000	

C. *Total recurring expenditure per annum*

Depreciation (1/3 of Rs. 3,000)	Rs. 1,000
Interest @ 12%	Rs. 360
	Rs. 1,360

Income

(1 run - 15,000 seed @ Rs. 15/- per 1000 seed	= Rs. 225
Income from 15 runs in 8 months	Rs. 3,375
Net profit per year Rs. 3,375-1,360	= Rs. 2,015
Profit rate on capital investment (Rs. 2015/3000)—68%	
Net income for 3 years : 2015 x 3	= Rs. 6,345

Sodium silicate must be dissolved first in fresh water and poured into the basin. When the temperature is between 20°-35°C and good sunlight is available a fairly good bloom of *Chaetoceros* sp. develops within 30-48 hours. From this culture 1½ l can be used as an inoculum to start a fresh culture. When this is used as an inoculum it takes 8-14 hours to develop a good culture when salinity, temperature and sunlight are optimal. Thereafter everyday, between 1000-1200 hours, a fresh diatom culture is started and this is maintained until the rearing is completed.

Particulate feed for postlarva

From last mysis onwards, along with diatoms, artificial feed must also be given. For this *M. dobsoni* or 'thelly' (head-on) can be sun-dried and finely powdered. The dried powder can be sieved using 250 micron mesh cloth and can be used to feed the postlarvae.

An average survival rate of 50% from nauplius to postlarva (PL5) is obtained using the above procedure.

REMARKS

The hatchery phase ends at postlarva-5 stage and the fishermen should sell them at this stage. The fishermen cannot keep the postlarvae for a longer period in the small containers. They needed more space for good survival.

He can sell the PL5 to the "Seed banks" being set up by the MPEDA in all the maritime states. These "Seed banks" can rear them in their facilities for about 15 days before selling them to the prawn farmers for stocking in ponds.

Alternatively, the fishermen can sell the postlarvae to marginal farmers with small brackishwater pond holdings (less than one acre) where they can be directly stocked if the ponds are cleared of all unwanted organisms by application of mahua oil cake, crushed seeds of *Croton twiglium* (Neervalam) or ammonia. The PL5 are quite sturdy and can withstand an abrupt change of salinity from 30 to 20 ppt.

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DEVELOPMENT OF A SMALL SCALE SEMI-INTENSIVE PRAWN HATCHERY AND ITS ROLE IN THE DEVELOPMENT OF BRAKISHWATER PRAWN FARMING IN ORISSA

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ABSTRACT

To develop a continuous seed production technology, particularly of *Penaeus monodon*, which has maximum demand in brackishwater culture system, a small scale hatchery was designed at Puri Centre in 1984-'85 under a semi-intensive system and operated using recirculated water through a biological filtration system. The details of hatchery lay out, tanks, filters, water and air systems, maintenance of breeders, and feeds are given. The system is semi-intensive in the sense that developed feeds were used and salinity and pH were controlled to suit the hatchery needs. The problems encountered in the hatchery such as spawner availability, transportation stress, impact of environmental factors, water quality etc are discussed. The system and its cost of management are brought out with a view towards its suitability as a small scale operation under Indian conditions.

INTRODUCTION

The development of a hatchery system for penaeid larvae in India has commenced in the late 1970's following the broad principles of design laid down under the extensive large tank Japanese system (Shigueno, 1975) or the intensive small tank American system (Cook, 1957; Cook and Murphy, 1969). These systems are capital intensive involving the use of *Artemia* nauplii as larval diet in addition to diatoms. In India, the prawn hatchery technology developed by national institutes has dispensed with the use of *Artemia*, instead diatoms and suspension diets are used as larval diets (Hameed *et al.*, 1982; Silas and Muthu, 1985)

The non-availability of the seed of desired species of prawns all round the year is one of the reasons for the slow growth of prawn culture industry in our country. In the context of the recent development of brackishwater prawn farming the importance of prawn seed production need not be overemphasised. In order to meet the needs of the Indian farmers, a small scale semi-intensive hatchery was designed and operated at Puri, particularly for *Penaeus monodon*. The details of the hatchery and its management and relevance in the context of the rapidly developing prawn farming sector in Orissa are presented in this paper.

THE HATCHERY TECHNOLOGY

Hatchery lay out

The small scale hatchery developed at Puri consists of a 20m x 10m shed roofed with Asphalt sheets. Apart from the outer brick lined wall, an inner lining of plywood covers the entire shed on all sides. Windows are provided at intervals of 2.5 m at a height of 1.5 m from floor level.

The larval rearing tanks are made of FRP. These are two 2.5 t tanks (3.7m x 1.3m x 0.6m) and four 0.4 t tanks (1.3 m x 0.7m x 0.6m) presently under use in the hatchery for production and experimental purposes. Seawater is stored in 10-12 diameter plastic pools with a total storage capacity of 30 t. The rearing tanks have

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tube lights (4 in each tank) fixed at 1.7 m interval and 25 cm above the tank surface. Air supply system is arranged at a height of 2m from floor level while the water supply is 1 m above floor level.

The air system consists of one diesel (5 HP) and two electrical (2 HP) compressor units. A generator (5 HP / 3 KV) is installed as a stand-by unit. The air is supplied through GI pipes (16 mm dia) which form the main distribution system and valves are taken from this with control taps. The air passes through 5 mm PVC air lines with regulators and air stones. In each large FRP tank three pairs of air lifts are provided at an interval of 1 m.

The biological filtration system

Water management is the principal technique developed in the present study. The water filtration system is a 2m high, circular concrete unit (1m diameter) with a perforated false bottom 15cm above the base level where filtered sea water collects. The biological filter consists of 4 layers *viz.*, 25 cm of large pebbles, followed on top by 25 cm oyster shells, followed by 20 cm coarse sand and topped by a 15cm layer of activated charcoal retained in a large net bag. Water is pumped to the top level to fall on the charcoal from where it trickles down to the reservoir. The filtered water is taken into the hatchery tanks through PVC pipes connected to the 15 cm long GI outlet (16mm dia,) provided at the base of the filter. The rate of flow of water from the filter is 10 litres/minute.

Backwashing of the filter is done after each rearing cycle. The water in the rearing units is exchanged, at least 30% every day, during larval rearing run. The used water is taken back to the storage tank, buffered with oyster shell powder and allowed to age over 7-10 days and then recycled into the hatchery tanks through the biological filter.

Feeds

The prawn larvae are given progressively, baker's yeast (N_6—Z_1) at a rate of 0.3g/1 ton of water, *Chaetoceros* or *Skeletonema* or mixed diatoms (Z_1—M_1) at a rate of 20×10^3 cells/ml, suspension feeds (150-200 U particles) prepared out of mysids, *Tubifex* and *Artemia* ($M_1 - P_6$). The feeds are given twice a day at 1000 hrs and 1800 hrs.

Diseases and control

To avoid disease incidence, prophylatic treatments with antibiotics are followed using hostacycline or terramycin at the rate of 0.01 ppm. If any ciliate attacks are observed, the entire larvae are discarded and a thorough cleaning of the rearing system is undertaken.

Collection and transportation of brood stock

Breeders of *P. monodon* are collected from trawler catches from Paradip and / or from catamaran catches from Puri. The transportation of brood prawns from Paradip to hatchery takes 6 hours excluding the time taken from trawling site to base.

Spawning and Hatching

The brood prawns ranged in size from 225mm/107 g to 296mm/250 g. If the ovary is fully ripe, as judged from its diamond shaped side-wise extension in the first abdominal segment the prawn is kept overnight in a plastic drum (70 l) containing 50 liters of filtered water for spawning under strong aeration. EDTA at the rate of 10 ppm, is added into the spawning container. Spawning takes place late night or early morning. The mother prawn is removed the following morning and also the spawning debris and the eggs are washed and kept for hatching.

The fecundity varied from 2-8 lakhs. The hatching time ranged from 8-14 hours, subject to the prevailing temperature. The hatching rate varied from 10-80%. The details of spawning and larval development are furnished in Table-1. The nauplii are then siphoned out into rearing tanks and stocked at a density of 50-100 per litre. Aeration was given mildly during nauplius and zoea stages and more vigorous during mysis and post-larval stages. The water level was maintained at 40 cm in the tanks and daily 30% water was exchanged using *fresh*, filtered *sea water*. The larvae were examined daily for their stage of develop-

Table-1. *Details of spawning and hatching of Penaeus monodon at Puri hatchery 1984-'85.*

S.No.	Size of mother prawn (mm/g)	Source	Date of spawning	Nature of spawning	No. of eggs released	No. nauplii hatched	Hatching rate (%)	Remarks
1.	275/170	Offshore	18.2.1984	Full	7,35,000	1,00,000	13.6	Larvae died at Z^1 stage
2.	225/107	Offshore	18.2.1984	Full	3,00,000	2,40,000	80.0	Larvae died at Z^1 stage
3.	228/110	Induced matured	19.10.1984	Partial	1,50,000	30,000	20.0	Complete mortality at Z^1 stage
4.	220/100	Offshore	21.10.1984	Partial	2,00,000	1,00,000	50.0	Motality at Z^1 stage due to overcrowding.
5.	296/250	Offshore	23.10.1984	Full	6,00,000	2,40,000	40.0	Produced 2500 P_5 larvae
6.	240/135	Offshore	12.11.1984	Full	4,00,000	80,000	20.0	Ciliate infection and larvae weak. Discarded at Z_1 stage
7.	236/131 267/179	Offshore	24.1.1985	Partial Full	6,00,000	56,000	9.3	Produced 17 P_5 larvae.

ment, feeding efficiency and general health. Sampling was done daily to estimate their density. The larvae were harvested at P_5 stage.

Salinity, temperature and pH

For normal development and successful hatching of eggs, the salinity and temperature of the water should be in the range of 28-35 ppt and 28-32°C. Below and above these limits, the hatching and development of larvae were either slow or very poor. pH of the rearing water was maintained between 8.1-8.4, which is found to be optimal for normal development. All stages for the larvae showed heavy mortality below 26°C, 25 ppt salinity and 7.8 pH.

DISCUSSION

The hatchery operation of tiger shrimp mainly depends on the wild-caught brood stock from catamaran or trawler catches. The breeders caught in catamaran takes 6-8 hrs and the trawler caught ones takes 7–8 hours to reach the hatchery. Thus the catch are subjected to severe stress during transportation and often the poor maintenance on board the vessel leaves them half-dead. By frequent change of water and constant aeration, transportation stress can be minimised with proper facilities and trained man power. At times, egg loss was also observed due to transportation stress.

In prolonged unusual rainfall season (as observed in 1985-86) the near shore waters show reduced salinity status due to heavy discharg into the sea, and thereby affect the general condition of the prawns. Further, high incidence of prawns with bopyrid parasites (particularly males) was noticed in the catch during this period. The prime spawning season of *P. monodon* in Orissa coast is from August-December with peaks in October and December (Rajyalakshmi *et al.*, 1984). This coincides with the monsoon and post monsoon (winter) period when there is drop in sea salinity and also of ambient

temperature. Thus, both selection of spawners and operation of hatchery are within a narrow range of option.

A fully mature female normally releases all eggs overnight in a single spawning. However, a few instances of non-release of eggs were observed even after keeping them consecutively for 2–3 days for spawning. Sometimes partial spawning was observed and the remaining ovary regressed subsequently.

Out of the seven total spawnings occurred in 1984-85, rearing was completed in two spawnings only. Though this is a low production level, it has shown that this hatchery system has capacity to produce 0.25 million postlarvae per rearing cycle, if the brood prawn is in prime condition and the ambient temperature and salinity are in the range of 28-32°C and 28-34 ppt, respectively. The survival rate from nauplius to postlarvae varied in the two instances, while it was 1.04% in the first, it was 0.03% in the second. Maximum mortality occured between N_6–Z_1 stages. The low survival in the two completed trials is due to low diatom feed and adverse environmental factors.

According to Silas and Muthu (1977) a major bottleneck in large scale prawn seed production is the non-availability of spawners throughout the year. Elsewhere (Rajyalakshmi *et al.*, 1987) it is shown how the development of a suitable maturation system of immature *P. monodon* can develop into a dependable broodstock for continuous supply to a hatchery, thus linking both system to each other as is needed under well managed programme.

The ever increasing trawl fishing off the Orissa coast during the peak breeding season of *P. monodon* (post monsoon and winter months) and the recently started prawn culture activities since 1983 are adversely affecting the recruitment of postlarvae into the estuaries and in turn, the offshore capture fishery stock. The seed produced from this hatchery technology can also be used as a management tool for large scale stocking of coastal waters including the Chilka lagoon (Rajyalakshmi, 1986) as a conservation measure and also to support the inshore capture fishery of tiger prawns as is being done particularly of *Penaeus japonicus* in Japan (Kurata, 1981).

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Paper 45

EXPERIMENTS ON INDUCED MATURATION AND SPAWNING OF TIGER PRAWN (*P. MONODON* FABRICIUS) THROUGH EYESTALK ABLATION

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ABSTRACT

Details of experiments on the ovarian maturation of *P. monodon* through eyestalk ablation in the brackishwater impoundments (bheries) in the lower Sunderbans areas of West Bengal are given. Immature females of tiger prawn (100 g and above) cultured in a bheri (65 ha) were ablated uni/bilaterally and kept with an equal number of healthy mature males (80 g and above) in split bamboo enclosures (2.25 m x 2.25 m) in the impoundment. The test animals were fed twice daily with the minced flesh of freshly caught penaeids and bivalves from the area. Fast gonadal maturation and subsequent spawnings were observed in a period of 10-21 days after the ablation. The prospects of setting up a seasonal tiger prawn hatchery during the dry months of February-July when the fast rate of water evaporation in these shallow coastal water bodies renders the salinity (26-32 ppt) highly suitable for undertaking this venture are discussed.

INTRODUCTION

Much emphasis is given to the controlled reproduction of *P. monodon* due to the highly unstable and limited availability of its post-larvae from the natural habitats. The technology has been more or less standardised (Primavera, 1985). Efforts have been made by various workers (Lio, 1973; Arnstein and Beard, 1974; Alikunhi *et al*, 1975; Muthu and Laxminarayana, 1977; Santiago, 1977; Halder, 1978; Premavera, 1978; Beard and Wicken, 1980 and Ruangpanit *et al*, 1985) to induce gonadal maturation in captive females of the species using eyestalk ablation. All these attempts with varying degrees of success were made either in various matura-

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tion system using sea water or in earthern tanks very near to the coastline. Details of an experiment in inducing maturation and spawning of P. *monodon* in brackishwater impoundments (bheries) located more than 100 km from the main sea (Bay of Bengal) are embodied in this communication.

MATERIAL AND METHODS

Twenty healthy females (100-112 g) were collected from a brackishwater impoundment of roughly 65 ha in the Dwarir's jungle area. Ten of the females were ablated unilaterally and the rest ten, bilaterally following the technique given by Primavera (1978). After first eyestalk ablation, the females were allowed to recover for 2-3 days before ablating the 2nd eyestalk. The uni and bilaterally ablated females were kept separately with an equal numbers of healthy mature males (av. wt. 80-84 g) in split bamboo enclosures (2.25m x 2.25m) installed within the same impoundment (Fig. 1.) The split

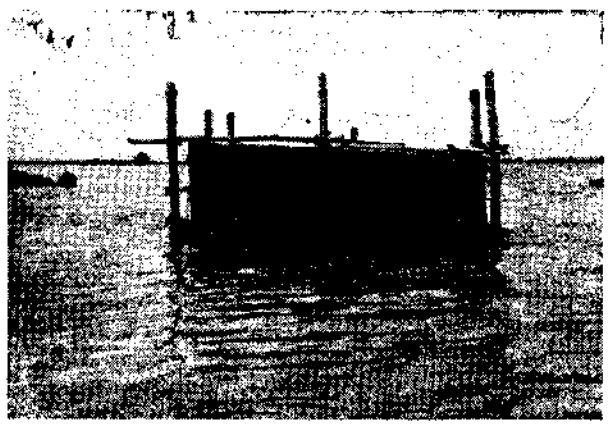

Fig. 1 Split bamboo enclosure in the impoundment to keep ablated females

bamboo *pattas* which were woven tightly at several points were pushed upto 30 cm into the bottom mud and strengthened by means of strong horizontal and vertical bamboo poles. The enclosures were covered with nylon netting cloth to protect the shrimps from predatory birds and snakes from above. The prawns were fed twice daily with fresh flesh of penaeids and bivalves @ 20% body weight using feeding trays. A small quantity of widgeon grass (*Ruppia maritima*) was occasionally put into the enclosures for providing shade and shelter to the test animals. Water level in the enclosures ranged between 0.9-1.10 m and a strong wave and wind action, normally prevailing in the large water spread helped in maintaining high dissolved oxygen values (4.3-16.0 ppm). The *bamboo pattas* were cleaned regularly using a hard coir rope brush to prevent any algal or fungal growth. Various physico-chemical parameters were recorded at regular intervals. Salinity ranged between 26.2-30.0 ppt; temperature, 28.3-31.7°C; dissolved oxygen 4.3-16.0 ppm and pH 7.6-8.4. The brooders were observed regularly for gonadial maturation. On attainment of stage IV (Rao, 1968), one female was transferred to a plastic pool (1000 l) containing clear filtered water from the same impoundment and aerated continuously. In the absence of proper equipment / facilities, observations were made only upto the hatching out of nauplii. Details of the experiment are furnished in Table 1.

RESULTS AND DISCUSSION

As seen in Table 1, there was a cent present survival of the unilaterally ablated females, while 20% of the biaterally ablated females did not survive. Whereas, only 7 out of the 10 unilaterally ablated females became fully mature (stage IV), 7 of the 8 surviving bilaterally ablated females became fully mature. However, viable spawnings could be obtained only from 3 unilaterally and 2 bilaterally ablated females due to the limited facilities available at the experimental site (field). Similar results were also obtained when induced maturation experiments were conducted in a large brackishwater impoundment in the lower Sunderbans at Deulbari area consecutively for three years viz. 1983, '84 and '85. Results of these experiments have been reported somewhere else. In fact, the number of days required to attain full maturation was only 7-8 days at this place where water salinity is not only more but is also free from any agricultural, domestic or

Table 1: Details of induced maturation/spawning of *P. monodon* females

Date of ablation		Total nos ablated	Body length (mm)	Body weight (g)	Nos. survived	Nos. attaining stage IV	Date of spawning	Estimated number (1000) Eggs	Naupli	No. of days	Remarks
30.7.82	unilatereral	10	240	103	10	5	20.8.82	205	122	21	Spawning could be obtained only from 3 uni and 2 bilaterally ablated females due to limited facilities available.
30.7.82	unilatereral		232	100			23.8.82	194	61	24	
30.7.82	unilatereral		237	101			24.8.82	78	46	25	
30.7.82	bilateral	10	244	107	8	7	10.8.82	92	33	17	
30.7.82	bilateral		250	112			9.8.82	117	70	10	

industrial pollution and highly suited for setting up a tiger prawn hatchery. The minimum period required to attain full maturity was 21 days in case of unilaterally ablated ones as against only 10 days in case of the bilaterally ablated females. Ruangpanit *et al.*, (1984) obtained gravidness in 51% of the unilaterally ablated females collected in the Phuket area, a natural spawning ground, as against only 19.51% in Songkhla lake in Thailand which is not a spawning area of *P. monodon*. Santiago (1977) reported 0 and 38 per cent mortality of bi and unilaterlly ablated females of *P. monodon* respectively, after a period of 196 days. Change of environment and the ablation stress are the two important factors, besides handling and nutritional deficiency etc. generally responsible for mortality of the ablated females. Almost cent percent survival of the bilaterally ablated females could be obtained by allowing the first eyestalk to fully recover for 2-3 days before ablating the second one. Further, after ablation the brood stock was carefully maintained in bamboo enclosures installed within the same impoundment where they had been grown from the postlarval (10-12 mm) stage without effecting any change in the environment. The diet of fresh flesh of penaeids and bivalves rich in polyunsaturated fatty acids have helped in successful maturation and spawning of the ablated females. Aquacop (1977) obtained similar results when fresh troca univalves were fed to early maturing ablated *P. monodon*. A strong wave and wind action which normally prevailed in the large coastal water body, not only helped in keeping the maturation chambers pollution free by flushing away the metabolites and left over foods, but also maintained high dissolved oxygen values. Santiago (1977) observed that dissolved oxygen values above the saturation point helped in inducing gonadal maturation in the ablated females. The fact that most of the brackishwater impoundments (bheries) are of large size (40 ha and above) and shallow, which facilitates fast rate of evaporation (to attain desired high salinity) can be made use of for installation of the maturation chambers. Such chambers do not require artificial aeration/water circulation which otherwise, is rather difficult/quite expensive in the absence of an existing electric supply in the Sunderbans. Although most of the bheries are drained and dried every year during November-December, some population of shell/fin fish including *P. monodon* is retained in a deeper canal (a common feature in most of the bheries). These old stock of tiger prawn which are sufficiently large (100 g and above) can be used as the brood stock. Artificial feeding of the brood stock which normally becomes a problem or needs storage facilities can easily be done by utilising the palaemonid/mussel meat, locally available in plenty. Once the females become fully

mature they can be transferred to the spawning and larval rearing tanks. The newly transformed postlarvae can be transferred to nursery pens installed within the same large impoundment thereby minimising expenditure on aeration/water circulation and management. This will also drastically cut down the initial capital costs normally incurred towards the procurement of fibre glass and concrete nursery rearing tanks. The same hatchery facilities can be utilised for breeding and larval rearing of the giant freshwater prawn (*M. rosenbergii*) during July-September months when water salinity comes down to 10-12 ppt in the lower Sunderbans but is still suited for this purpose. The seed so produced can be utilized for stocking the freshwater ponds as well as bheries in the upper zones during the low salinity periods of July/August to November/December. This species too has a great demand in the demestic as well as the international markets.

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PRELIMINARY OBSERVATIONS ON THE GROWTH AND SURVIVAL OF TIGER PRAWN *(PENAEUS MONODON* FABRICIUS) POSTLARVAE IN PEN–NURSERIES

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ABSTRACT

In an attempt to ensure all-time availability of stocking materials of *P. monodon* Febricius, experiments have been undertaken on a large scale in the lower Sunderbans area of West Bengal for growing the wild-caught post-larvae (10-12 mm) of the species to an advanced juvenile (35-45 mm) stage under semi-controlled conditions. Six nursery pens (0.1 ha each) have been installed in a large (50 ha) brackishwater impoundment and stocked at the rate of 2.0-3.5 millions per hectare. Besides encouraging the growth of natural food, the postlarvae are fed with well balanced artificial diets having protein from both animal and plant origin. Encouraging results with high survival (upto 73%) and faster growth rates have been observed in some of the trial runs. Details of stocking density, growth rate, percentage survival and the feeding schedule etc. are presented and discussed. Various physico-chemical parameters recorded at regular intervals are also given.

INTRODUCTION

Shrimp farming has been given a top priority by many of the developing countries for earning foreign exchange and providing employment to the coastal poor. Cultured prawns form only 3-5% of the total 1.7 million metric tons of shrimps annually produced worldwide (Taki *et al.*, 1985). Among cultured prawn, *Penaeus indicus, P. merguiensis, Metapenaeus monoceros, M. dobsoni, M. ensis* etc., *P. monodon* is the dominant species in the Indo-Pacific region (Aquacop, 1985). *P. monodon* not only grows much faster than others, but is capable of withstanding a wide range of environmental fluctuations. However, availability of stocking materials as and when required, is one of the major constraints confronting the development of tiger prawn farming on commercial lines.

Unlike many other south-east Asian countries, prawn farmers in India, in the absence of an operating tiger prawn hatchery, are totally dependant on the wild-caught postlarvae for stocking their ponds. Various estuarine systems with an intricate net work of canals and creeks in the Sunderbans areas of West Bengal (India) are one of the richest collection grounds for *P.monodon* postlarvae. A well-organised prawn seed trade with thousands of collectors, middle men and traders exists at Nazat (24 Parganas). However, the prawn seed industry is unstable since peak periods of seed availability in nature (May-June) do not synchronize with the peak periods of their demand (Jan.-Feb.). Further, the practice of directly releasing the wild-caught postlarvae into vast brackishwater impoundments (bheris) or in large nursery ponds (often more than a hectare) without proper control of predator

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often results in miserably poor production. For intensified pond production of marketable size *P. monodon*, ready availability of healthy juveniles (30-45 mm) in large quantities is most essential. For this purpose, studies on large scale nursery rearing of tiger prawn postlarvae in pens have been taken up in the Sunderbans areas of West Bengal.

MATERIAL AND METHODS

Six rectangular nursery pens with an average area of 0.1 ha each have been erected in a large brackishwater impoundment at Shyamnagar (Deulbari) in the lower Sunderbans. Split bomboo screens (2 m high x 4 m long) woven tightly with coir rope were joined together to serve as the pen walls. Bamboo pattas were driven into the bottom mud (30-35 cm) and are supported and strengthened with the help of strong vertical and horizontal bamboo poles. All the pens are lined inside with a fine meshed strong nylon netting cloth for preventing the entry of predators and also to guard against escape of the stocked tiger prawn postlarvae. To deter displacement of the nylon netting cloth by strong winds especially during the monsoon months, lower ends of the nylon netting cloth have been given a mud lining whereas the upper and middle portions are pressed hard against the pen walls (bamboo pattas) using long narrow bamboo sticks and coir rope. Only one pen could be installed during December-January period and the rest were installed in the month of March when culture operations had already started and creek water drawn into the impoundment.

Four pens have been installed in the middle of a long (about 550 metres) and wide (about 100 metres) canal facing the main sluice gate whereas the other two were installed in the middle of a 2.5 ha pond connected to another 7 ha compartment through a cut in the dyke separating the two. Palm leaves, bundles of paddy straw and tree twigs were kept submerged in all the pens to serve as additional substrates for periphytic growth as well as to provide shade and shelter to the tiger prawn postlarvae. Bamboo ladders have been provided in all the pens for an easy inspection and management.

Stocking of pens with *P. monodon* postlarvae procured from professional seed collectors started from the 2nd week of March, 1987 and continued till April end. All the pens could not be stocked at a time due to the non-availability of seed in large quantities. The baby prawns which were liberated early in the morning or late in the evening did not require any acclimation since they are captured from the nearby areas without any marked differences in water salinity and temperature. Pens were stocked one after the other and stocking of the next pen was undertaken only after completely stocking the first one. A mixture of finely powdered prawn meal, goat intestine, cow-pea leaf and wheat flour was broadcast 5-6 times a day in sections of the pens depending upon direction of the wind so as to ensure a minimum leaching out of the artificial feed. From 3rd week onwards, when the postlarvae started to become benthic, ground fresh flesh of palaeomonid prawns and mussel meat, locally available in plenty, was given using feeding trays as well as by adhering the finaly ground meat to pieces (3 metre x 0.5 metre) of nylon netting cloth kept vertically suspended in water with the help of bamboo sticks. Pen walls and the nylon netting cloth are regularly checked for any damage and cleaned using aquatic weeds or coir rope brush to facilitate free water circulation across the pen walls. Various physico-chemical parameters were recorded at regular intervals. Salinity ranged between 22.5-30.0 ppt; temperature. 28.0-31.5°C; pH, 7.5-8.3 and dissolved oxygen, 3.2-9.7 ppm. Table I gives data on stocking density, growth and percentage survival of the tiger prawn postlarvae in the initial trials.

RESULTS AND DISCUSSION

As seen in Table I, the highest survival (73%) was obtained in pen No. 1. Although stocked at the same rate, survival was only

Table I: *Details of stocking density, growth rate and percentage survival of* P. monodon *seed in various nursery pens*

Pen No.	Pen Area (ha)	Stocking period	Size at stocking (mm)	Number stocked	Stocking density/ ha (in million)	Harvesting period	Size at harvest (mm)	Number harvested	Percentage survival	Remarks
1	0.1	March, 2nd week	10-12	200,000	2.0	April, 4th week	35-42	146,100	73.0	Only few predators found
2	0.1	March, 4th week	10-12	200,000	2.0	May, 2nd week	35-42	58,000	29.0	A large population of predatory fish and crabs also harvested.
3	0 1	March, 4th week	10-12	250,000	2.5	May, 2nd week	35-40	51,150	20.5	
4	0.1	April, 2nd week	10-12	250,000	2.5	May, 4th week	35-40	45,000	18.0	
5	0.1	April, 2nd week	10-12	300,000	3.0	May, 4th week	32-37	78,000	26.0	
6	0.1	April, 2nd week	10-12	350,000	3.5	May, 4 th week	32-37	40,250	11.5	

29% in pen No. 2. Similarly, recovery of tiger prawn juveniles was very poor in the rest of the pens. The low rate of survival in all the pens except pen No. 1, is attributed to the presence of a large population of predatory fish like *Eulethronema tetradactylum, Megalops cyprinoides, Lates calcarifer, Mystus gulio,* gobies and other burrowing animals like crabs and eels which might have been entrapped within the pens since these were installed at a later stage when tidal water had already been taken in to the impoundment. As these pens are installed by the side of a deeper perennial canal harbouring a large population of predators, the same could not be eliminated totally though netting with a narrow-meshed drag net was done before liberating the postlarvae in these pens. However, installation of pen No. 1 in a completely drained and dried area helped in total elimination of predators, thereby resulting in a higher survival of 73%.

These preliminary observations indicate that stocking density seems not to have affected the survival rates except for little differences in the final average length of juveniles which were more (35-42 mm) at low stocking densities and less (32-37 mm) at the high stocking densities. A strong wave and wind action which facilitated free flow of water across the pen walls not only helped in maintaining high dissolved oxygen values (3 5-9.7 ppm), but also minimised the chances of any pollution due to the build up of metabolites and left-over foods in the nursery pens.

Crabs (*S. serrata*) posed a great problem in most of the pens which were installed after drawing of creek water in the bheri. Aside from taking a heavy toll of *P. monodon* junveniles, they were also instrumental in damaging the nylon netting cloth in 2 of the pens which had to be replaced partially. Later, a large number of crabs were removed. Seeds of *M. monoceros* entered almost in all the pens in large numbers and acted as the biggest competitors for food and space with the tiger prawn seed. A sudden and profuse growth of aquatic macrophytes viz., *Ruppia maritima* and *Najas* sp. in four of the pens

was another problem noticed during the brief period. Barring few patches to provide shade and shelter to the prawn seed, especially at the time of ecdysis; rest of the weeds were removed promptly by manual means.

The system has much prospects for adoption by the brackishwater aquaculturists in the Sunderbans because of the relatively large size of bheris and reluctance of the farmers to shift to the semi-intensive and intensive systems as they require greater amounts of inputs, risk & technical know-how. Besides raising juveniles for multiple cropping of *P. monodon*, large quantities of seed can be maintained in a portion of the impoundment during November - December when the bheris are drained and dried. This can be achieved by partitioning the deeper perennial canal (a common feature in most of the large impoundments) with split bamboo pattas and removing predators before transferring the seed. This seed can be used during January-February when practically no seeds are available in the nature. Setting up of such 'Seed' banks will not only help in maintaining a stable supply of healthier juveniles and also provide employment to many in selling and buying of postlarvae/ juveniles and other activities like construction/ installation and management of pens etc.

The importance of nursery rearing before stocking the penaeid seed in grow-out ponds for increased growth and survival has been fully emphasized (Hirasawa, 1985; Pretto, 1983; Aquacop, 1985 and De la Pena *et. al.*, 1985). Juveniles reared in nursery ponds or in net enclosures within the grow-out ponds are normally used in the extensive and semi-intensive culture system in the Philippines to get better production of table size *P. monodon* (Apud, 1985). Stocking juveniles (30-45 mm) instead of postlarvae (10-12 mm) not only resulted in better survival but also a shortened cropping time of *P. monodon* (Janseen *et. al*, 1986). Likewise, 1491.5 kg/ ha/60 days of *P. monodon* were harvested when juveniles were stocked as against a production of only 971.5 kg/ha/ 90 days using postlarvae of the species in brackishwater experimental pens of CIFRI at Kakdwip (Anon, 1985).

The nursery rearing of prawn postlarvae has been attempted in plastic pools, fibre glass and concrete tanks etc. which allows high stocking densities (4-20 nos/l) with higher survival rates of upto 80% and above (Anon, 1976). This system, however, seems impracticable in view of the enormous quantities of healthy juveniles required. Besides much higher initial capital investment, and the non-existance of electric supply in rural Sunderbans is another factor to be considered for routine aeration/replenishment of water in such a system. Very poor survivals (10.9-28.7%) have been reported even at low stocking densities of 75,000-200,000 nos/ha from the land based small earthen nurseries (0.02 ha) without any artificial aeration (Anon, 1982). However, high survivals (upto 80%) are obtained in Ecuador and Taiwan while nursing prawn postlarvae in earthen ponds at high stocking densities (50-200 nos/m^2) with or without fertilization and by supplementary feeding. Using pumps, upto 400% of water is renewed daily and depending upon the species and site conditions, the postlarvae attain an average weight of 0.5-2.0 g in a period of 30-60 days (Aquacop, 1985). This system too, is capital intensive involving too much use of power, equipment and technical skill.

The latest approach in penaeid postlarval rearing is to nurse the baby prawns in floating net cages installed in protected inshore waters like bays and coves (Agbayani *et al.*, 1984; De la Pena *et al.*, 1984; De la Pena and Prospero, 1984; De la Pena *et al.*, 1985 and Walford and Lam, 1987). A survival of 78 and 67 per cent was achieved by Walford and Lam (1987) while rearing *P. indicus* postlarvae from PL_6 to PL_{22} stocked @ 1700-2100 nos/m^2 and 3000 nos/m^2 respectively in floating net cages in the Straits of Johore (Singapore). De la Pena *et al.*, (1985) also obtained similar results in their floating cage nursery rearing experiments with *P. monodon* at the Batan Research Station of SEAFDEC

(Philippines). Though quite promising, allowing high stocking rates with better survival and an easy harvesting of juveniles, the highly turbulent and silt-laden waters of the estuaries and near-shore areas are not suitable for installation of floating nursery cages on the east coast in India.

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REARING OF POST-LARVAE OF *PENAEUS MONODON* IN NURSERY POND-AN EXPERIMENTAL STUDY

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ABSTRACT

In the present experiment, Postlarvae of *Penaeus monodon* received from M/s Hindustan Lever Hatchery, Muttukkadu were reared in a nursery pond at porto Novo. In a span of one month, they were reared to the stockable size of 30 to 48 mm (average size 38 mm) from an initial size of 8 to 12 mm (average size 10 mm). Pond was suitably prepared after the application of cowdung. Coconut and palm leaves were fixed at the sides of the pond to avoid the direct heat of the sun and evoporation. Clam meat (*Meretrix* sp.) was used as the supplementary feed at 100% body weight. Hydrographical conditions of the pond waters in relation to length and weight (growth) have been discussed. About 98% recovery was achieved.

INTRODUCTION

The prawn seed produced in hatcheries in the post-larval stage are to be reared in nurseries before stocking them in grow out ponds. One of the most important steps in prawn culture is the nursery management and successful prawn farming depends on efficient nursery management (Siddharaju *et al.*, 1980). Experimental studies with hatchery produced prawn seeds in nurseries will go a long way in evolving successful nursery management strategies. Therefore in the present study, nursery management of hatchery produced seed of *Penaeus monodon* was considered.

MATERIAL AND METHODS

Postlarvae of *P. monodon* received from M/s Hindustan Lever Hatchery, Muttukkadu were reared in an earthern nursery pond. The nursery pond (0.015 ha) was suitably prepared after the application of cowdung at the rate of 1000 kg/ha. The inlet pipe was tied with P-40 mesh velon screen material of bag type to avoid the entry of any unwanted fish and easy flow of water. Apart from natural exchange of water during the high tide, pumping of water from the feeder canal was resorted to whenever necessary. Coconut and palm leaves were fixed at the sides of the pond to avoid direct heat from the sun and evaporation.

Stocking density tried was 10,200 nos. per pond (6,80,000 nos/ha). Clam meat (*Meretrix* sp.) was used as the supplementary feed at the rate of 100% total body weight in the evening hours of the day after boiling and chopping the flesh. Environmental factors like temperature, salinity, dissolved oxygen and pH were recorded during the rearing period. Random sampling of 50 post-larvae was made once in 15 days for growth assessment. Harvesting was done at the end of 30 days and the percentage of survival and growth rate were recorded.

RESULTS AND DISCUSSION

The initial average length and weight recorded were 10 mm and 4 gm respectively, (size range 8 to 12 mm). The hydrographical conditions in the nursery as well as in the nearby Vellar estuary are given in Table 1. During the rearing period, temperature of

Table 1. *Hydrographical conditions of pond waters during the rearing period.*

Ponds	water temp.	pH	Depth	Salinity	Oxygen
Date of sampling: 15-5-1985					
Nursery pond	33.5°C	8	63 cm	34.1°/$_{oo}$	4.17 ml/litre
Vellar estuary	33°C	8	—	31.60°/$_{oo}$	5.64 ml/litre
Date of sampling: 30-5-1985					
Nursery pond	32°C	7.6	72 cm	34.5°/$_{oo}$	4.75 ml/litre
Vellar estuary	32°C	7.5	—	34°/$_{oo}$	6.42 ml/litre
Date of sampling: 14-6-1985					
Nursery pond	32.5°C	8	60 cm	33.5°/$_{oo}$	4.92 ml/litre
Vellar estuary	32°C	8	—	34°/$_{oo}$	5.12 ml/litre

water ranged from 32 to 33.5°C, salinity from 33.5 to 34.1°/$_{oo}$, pH from 7.5 to 8.0 and the dissolved oxygen from 4.17 to 4.92 ml/l. Other details such as survival and growth are also given in the Table 2.

Table 2: *Stocking particulars of postlarvae of* P. monodon *in Nursery pond.*

Particulars	Rearing of PL 20 *P. monodon* in nursery pond'
Pond area	0.015 ha
Date of stocking	15-5-1985
Species reared	P. *monodon*
Nos stocked per pond	10,200 nos
Rate of stocking	6.8 lakhs/ha
Initial length	10 mm
Initial weight	0.004 g
Supplimentary feed used	Clam Meat (*Meretrix* sp.)
Rate of feeding	100%
Final average length	38 mm
Final average weight	0.520 g
Date of harvest	14.6.85
Total nos. of juveniles recovered	10000
% of recovery	98.04%
Duration of experiment	30 days

After 15 days, samples were collected at random and the average length and weight were recorded as 32.75 mm and 290.3 mg respectively. In a span of 30 days they have grown to the stockable average size of 38 mm (size range 30 to 48 mm) and its average weight was 0.52 g. Out of the 10,200 numbers stocked 10,000 nos were recovered, recording about 98% recovery. These were stocked in bigger ponds for further growth.

This result is quite significant when viewed against 31 to 68% survival rate at Kovalam (Siddharaju *et al.*, 1980). Earlier it was reported (Bose and Venkatasamy, 1978) that for well prepared nursery ponds, the suitable stocking densities could be from 2 to 3 lakhs/ha. But the survival rate reported here was low and varied from 30 to 40%.

Under controlled conditions in the plastic pools with artificial feeding, postlarvae of *Penaeus monodon* reared at an initial stocking density of 10,000/m^2, thinned twice to half the number at fortnightly intervals, a survival of 75% in a total period of 60 days of rearing was achieved with final size of 45-50 mm (Verghese, 1978).

In another experiment conducted in plastic pools postlarvae of *P. monodon* reared

without artificial aeration but with partial daily renewal of water and regular artificial feeding showed 59 to 73% survival rate at stocking densities 1000 nos/m² and 1500 nos/m² respectively. But the average weight obtained in this was from 19.5 to 20 mg (Alikunhi *et al.*, 1980).

But in the present study with stocking density of 6.8 lakhs/ha, higher survival rate was found and the results are quite comparable to the survival rate of 94% in closed raceway systems (Mock *et al.*, 1973).

Survival rate of prawns depends on stocking density as well as stocking size (Ravichandran *et al.*, 1980). It has been suggeted by Siddharaju *et al.* (1980) that nylon cages could successfully be utilised as nurseries for rearing of prawn larvae. But the present study proves that nursery ponds are better than the cages for the rearing of postlarvae.

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STUDIES ON THE MATURATION AND SPAWNING OF GREY MULLETS OF A RESERVOIR FISHERY IN OKHAMANDAL (GULF OF KUTCH) WITH SPECIAL REFERENCE TO RURAL DEVELOPMENT ALONG THE COAST

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ABSTRACT

Grey mullets formed 57% of the annual marine fish production during 1984-87 from the reservoirs of a solar saltworks along the Okhamandal coast of the Gulf of Kutch. *Mugil cephalus* (23.0%), *Mugil macrolepis* (35.03%), *Mugil parsia* (1.29%), *Mugil tade* (0.629%) and *Mugil carinatus* (40.06%) formed the composition of the catch. Maturing specimens of *Mugil cephalus*, *Mugil macrolepis* and *Mugil parsia* were observed in the catch.

In view of the excellent prospects of aquaculture of this highly esteemed group of fishes, and considering the limited seed resources of 1.64 million per annum from the natural sources, a study of the gonadial development and spawning of the commercially important species was undertaken. Based on the data, experiments to induce the development and spawning were also conducted. Conditioning and prevention of diseases from infection due to injury were major problems. Both *Mugil macrolepis* and *Mugil parsia* responded to pituitary hormone injections, developed ovaries and spawned in 7 days and 37 days respectively.

The prospects of rural development through mullet culture in the coastal areas of Kutch are discussed.

1. INTRODUCTION

The Grey Mullets constituted 0.22% of the marine landings in India. Their exploitation steadily increased from an annual average 233 t per year during the 1950-'59 to 3,312 t per year during the 1980-'84 period. Gujarat state contributed 47.8% of the mullet production in India during 1984. Mullets from the mainstay of the littoral fishery of the Gulf of Kutch providing livelihood to the poor traditional fishermen of the coast. Fry and Fingerlings of mullets ascend the backwaters, swamps, creeks and even establish fishery in saltworks reservoirs totaly disconnected from sea (Gopalakrishnan *et al.*, 1987, in press). These fishes tolerate wide salinity changes upto 91.34 ppt Luther (1963). Jacob and Krishnamurthy (1942), Devasundaram (1952), John (1958), Sarojini (1958), Jhingran (1958), Shetty *et al.*, (1969), Jhingran and Natarajan (1969), Rangaswamy (1972), and Das (1977, 1978), have studied several aspects of mullet fisheries. However, no information is available on the fisheries and the biological characteristics of mullets of Gujarat coast. It is well known that the environmental conditions exert a definite impact on the growth, reproduction and survival of the fish population of different regions. The Gulf of Kutch, with widely fluctuating high salinity (35 to 39 ppt), pH (7.7 to 8.5) and temperature conditions (29° to 37°C), is a drought prone arid zone. In the backwaters of the Gulf, these conditions further change (Dave *et al.*, 1982, Gopalakrishnan *et al.*, 1987). In the present paper, the gonadial maturity, development and the spawning behaviour of three economically important mullets are studied with a view to employing hypophysation technique to induce the fish to produce adequate quality seed in hatchery conditions. The data is discussed in retation to practising aquaculture for rural development in the region.

Table 1. *Data of mullets in the reservoir fishery during 1984-87*

Species	1984–85 Production (kg)	% in total catch	% in total mullets	1985–86 Production (kg)	% in total catch	% in total mullets	1986–87 Production (kg)	% in total catch	% in total mullets	Annual average % in total fishery	% in total mullets
Mugil cephalus	889	7.18	32.87	3031	6.32	10.36	14459	18.09	30.16	13.10	23.0
Mugil macrolepis	1210	9.78	44.73	6173	12.87	21.00	20613	29.70	43.00	19.96	35.03
Mugil parsia	463	3.74	17.11	239	0.49	0.82	326	0.40	0.68	0.73	1.29
Mugil tade	143	1.16	5·29	250	0.62	0.85	104	0.13	0.22	0.35	0.62
Mugil carinatus	—	—	—	19577	40.83	66.88	12437	15.56	25.94	22.82	40.06
Total	1615	21.86	100.00	29270	61.03	99.91	47939	59.88	100.00	56.96	100.00

Table 2. *Gonadial condition of mullets*

Maturity Stage	Female (ovary)	Ova diameter (mm) *M. cephalus*	*M. macrolepis*	*M. parsia*	Male (testes)	Corresponding ICES scale (Wood, 1930)
I (Immature)	Occupying 1/3 of body cavity, ova transparent	0.070	0.070	0.070	Thread like, occupying less than 1/2 body cavity, dull white (immature)	I-II
II (Maturing I)	Occupying 1/2-2/3 body cavity, ova partially yolk laden	0.140	0.140	0.140	Occupying 1/2 body cavity, dull white (maturing)	III-IV
III (Mature II)	Occupping 1/2–2/3 body cavity ova fully yolk laden	0.175	0.175	0.175	Occupying more than 1/2 to 1/3 body cavity, creamy white colour (mature)	V
IV (Mature)	Occupying 1/2-2/3 body cavity sometimes 3/4 to full, yolk vacuolated, perivitelline space seen yellowish colour	0.350	0.350	0.350	Occupying more than 2/3 body cavity, oozing on applying gentle pressure, creamy white colour (oozing)	VI
V (Mature-Oozing)	Occupying entire body cavity, deep yellowish colour	0.630	0.735	0.630		
VI (Spent Regressing) recovering	Occuying not more than 1/2 body cavity, degenerating ova seen, reddish, flaccid	0.105 to 0.525	0.105 to 0.630	0.105 to 0.525		

MATERIAL AND METHODS

The fishery data from 1984-'87 was analysed to study the production trend of important species. The gonads of three spcices viz. *Mugil cephalus*, *Mugil macrolepis* and *Mugil parsia* were examined and analysed for maturity, ova diameter progression through maturity stages, the gonado-somatic index (G.S.I. = gonad weight/body weight x 100), fecundity, sex ratio and spawning season. The value of ocular division was calculated at 0.035 mm for studying the ova diameter.

FISHERY

The data on the composition of mullets in the reservoir fishery during 1984-'85 to 1986-87 (Table-1) showed that on an average 56.9% of the catch comprised of mullets represented by *M. cephalus* (23.0%), *M. macrolepis* (35.03%), *M. parsia* (1.29%), *M. tade* (0.629%) and *M. carinatus* (40.06%). The market value of mullets ranged from Rs. 0.18 to 3.22 lakhs during the period.

MATURATION AND SPAWNING

Six maturity stages were recognised in females and four maturity stages were recognised in males (Table-2).

Mugil cephalus

Length at first muturity: It was observed that at 340 mm, 71% of the females and at 380 mm, all the females were maturing. At 400 mm 12.5% of the females were in spent or spent-recovering stage, suggesting that the first maturity in females was around 340 mm. The males showed first maturity at 360 mm when 50% were mature and at 380 mm, 50% males were seen in oozing stage while 66% of them were in spent or spent-recovering stage at 400 mm. However, as males in maturity stage I were not available in the catch, it was possible that first maturity in males might be earlier than 340 mm.

Rangaswamy (1975) estimated the size at first maturity at 376 mm and 425 mm in the Pulicat Lake mullets, and Das (1978) recorded 280 mm and 320 mm in the Goa waters for males and females respectively.

Gonado somatic index : In *M. cephalus*, the advent and advancement of maturity and the monthly fluctuations of the G.S.I. showed a primary peak in November-February and a secondary peak in June-September. This coincided with fully matured gonads in oozing and also spent-recovering stages.

Spawning frequency : The progression of the development of ova diameter indicated the spawning season. In the species, from September to February, one group of maturing ova was seen (Fig. 1 & 2). There was a suggestion of a second group of ova maturing from March-July before degenerating. This was accompanied by the G. S. I. trend and also occurrence of females in the oozing (stage V) and spent (stage VI) conditions. Perhaps, a prolonged spanwing season is suggested by this as observed by other authors. Only one spawning frequency has been noted for the species by Jhingran

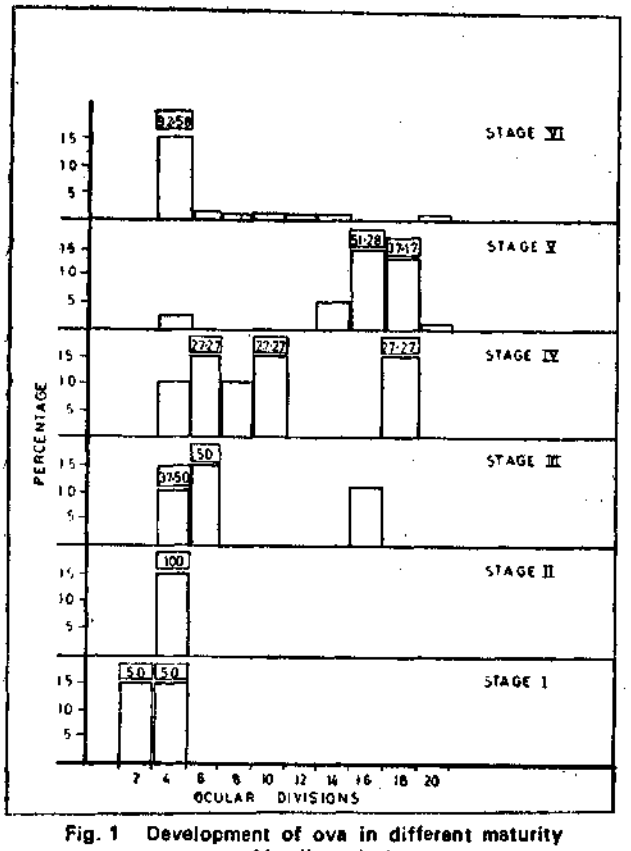

Fig. 1 Development of ova in different maturity stages of *Mugil cephalus*

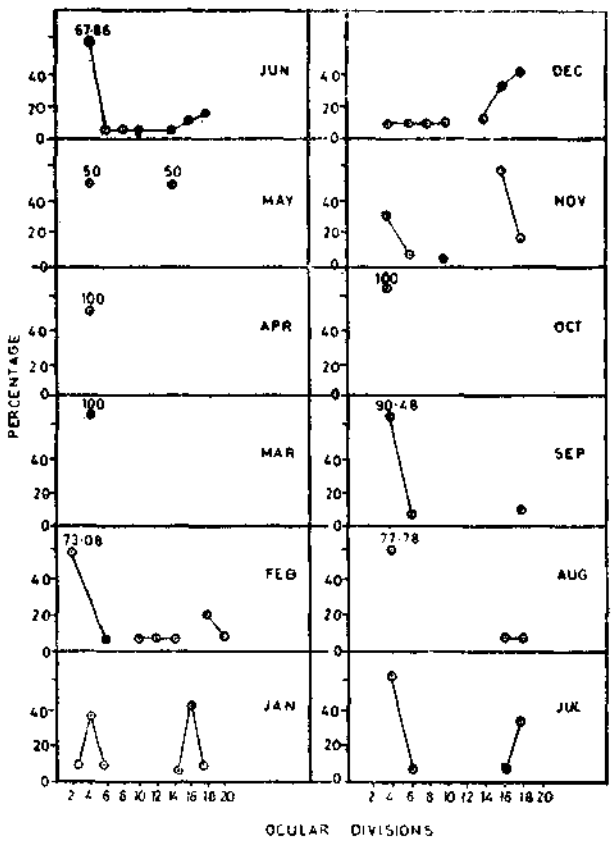

Fig. 2 Size progression of ova during different months in *Mugil cephalus*

(1958, cited by by Das, 1978) where the fishes had access to sea for spawning migration. In the present study the lake had no contact with the sea and therefore the second progression of ova may be due to regeneration after regressed conditions.

Spawning season : The monthly distribution indicated that matured and oozing females were available during November to January and July to August. Spent or recovering females were also seen immediately following these months. Fries and fingerlings of the species occured in the reservoir, but it could not be established that they were spawned by the fishes in the reservoir.

Fecundity : In *M. cephalus* it ranged from 35 to 66.9 lakhs in the size range of 540 mm to 630 mm (total length). The ovaries examined were of 250 grams to 550 grams weight and the egg diameter had size of 0.525 mm to 0.595 mm. The earlier reports of fecundity were 12.75 to 27.81 lakhs in Australian mullet by Kesteven (1942) and 13.2 lakhs by Jacob and Krishnamurthy (1948, cited by Rangaswamy, 1975), 27.2 lakhs to 49.54 lakhs by Patnaik (1962, cited by Rangaswamy, 1975) and 4.34 to 47.17 lakhs by Rangaswamy (1975) in the Indian mullets from different regions.

Sex ratio : A preponderence of females throughout the period except the peak spawning month of December was observed (Table-3). Both males and females tend to congregate during the final stages of maturity. The sex ratio in various size groups showed that the males were present up to 500 mm only. The tendency of differential maturation reported by other workers was observed in this case also.

Table 3. *Sex ratio of* M. cephalus *during different months*

Month	% Male	Female	Ratio of males to 100 Females
January	23.0	76.00	30.00
February	25.50	76.50	30.77
March	14.80	85.20	17.40
April	30.00	70.00	42.86
May	—	100 00	—
June	3.40	96.60	3.57
July	—	100.00	—
August	10.00	90.00	11.11
September	19.20	80.80	23.80
October	28.60	71.40	40.00
November	11.00	89.00	12.5
December	41.30	58.70	70.37

Mugil macrolepis

Length at first maturity : *M. macrolepis* had been reported to achieve first maturity at 170 mm and 160 mm in respect of females and males by Luther (1963). In our study the size was observed at 160 mm for females and at 140 mm for males.

Gonado-somatic index : The data showed that the females above 180 mm size group had a high G.S.I. throughout the year with a peak in 220-260 mm size group. In males also similar trend was observed. No mature males were observed beyond 280 mm. The monthwise G.S.I. showed two distinct peaks during February to March and June to September. Gonads in oozing stage were observed during this period.

Spawning frequeucy : The data (Fig. 3 & 4) indicated a single group of ova maturing through a prolonged spawning season.

Spawning season : The monthly distribution of maturity stages (Fig. 5) showed that a large percentage of Stages IV and V females during January to March and June to August were present. Spent and recovering females also were frequent in the catch during the period. Luther (1963) had also reported June to February as the spawning period for Palk Bay mullets.

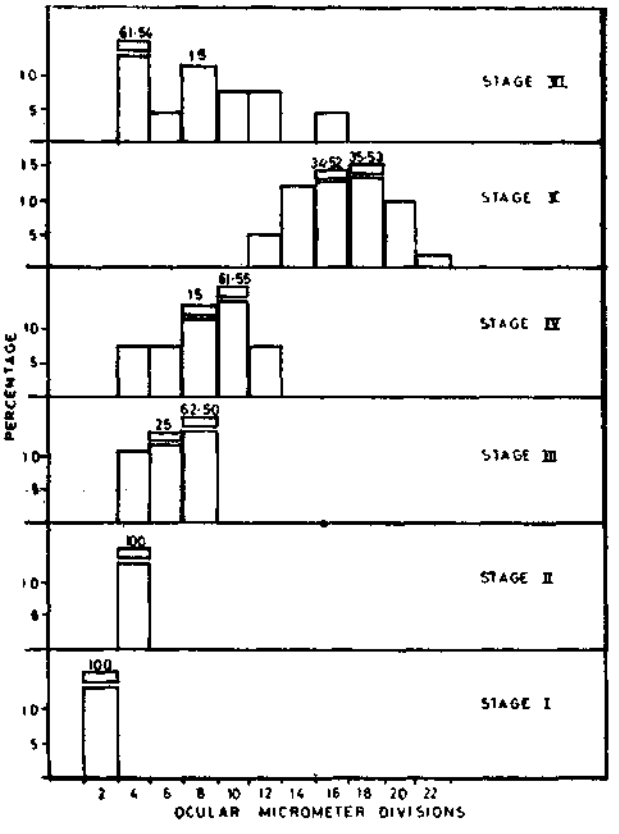

Fig. 3 Development of ova in different maturity stages in *Mugil macrolepis*

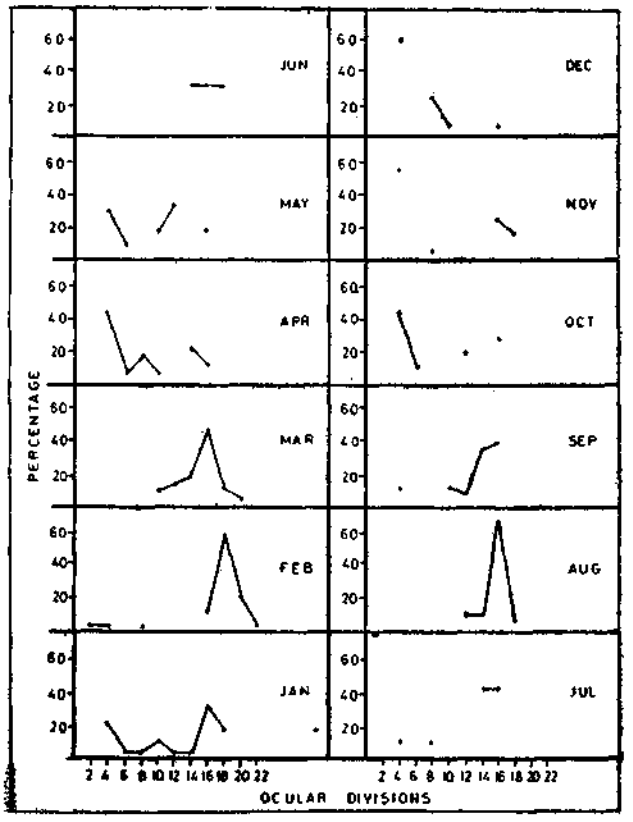

Fig. 4 Size progression of ova during different months in *Mugil macrolepis*

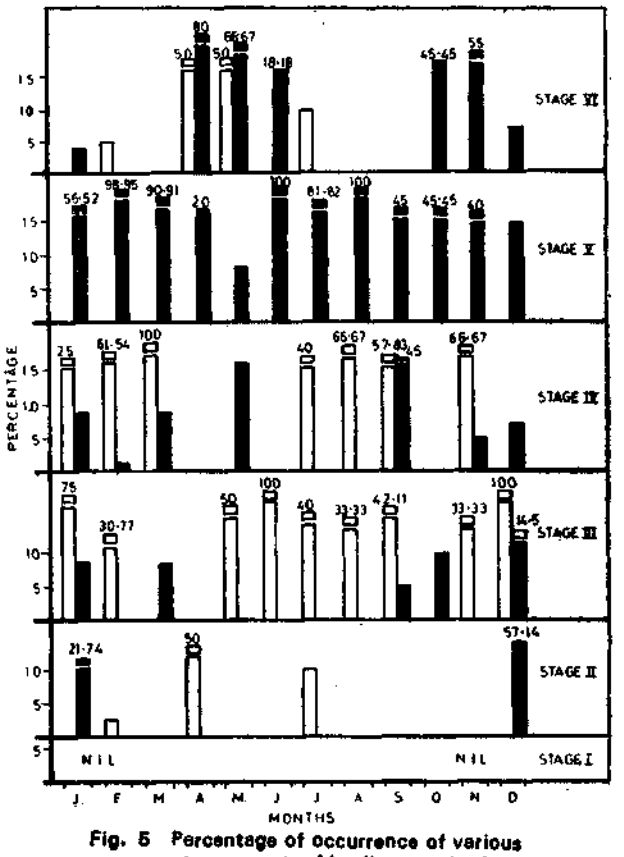

Fig. 5 Percentage of occurrence of various maturity steges in *Mugil macrolepis*

Fecundity : In females measuring 330 mm weighing 300 gms, fecundity of 2.5 to 3.0 lakhs eggs was observed. Luther (1963) reported 1,51,920 to 6,72,600 eggs in fish measuring 230 to 299 mm whereas Alikunhi *et al* (1971) estimated 1.25 to 4.0 lakhs eggs in fishes of 130 to 230 mm length and 40 to 130 grams weight.

Sex ratio : Only during July to September the males were represented in the population in more or less equal numbers, while during the remaining period the males were scarce (Table-4). The data on the sex ratio during different maturity stages showed differential maturation in both sexes, males maturing faster and earlier. The male to female ratio was 1.8 : 1.0 while immediately thereafter, the males declined in strength disappeared. Luther (1963) also recorded 1.2 : 1 ratio during spawning season. Upto 180 to 250 mm groups of the population, males dominated and thereafter slowly declined, totally disappearing after 280 mm.

Table 4. *Sex ratio of* M. macrolepis *during different months*

Month	% Male	% Female	Ratio of males to 100 females
January	14.80	85.20	17.30
February	29.10	70.90	41.00
March	26.60	73.40	36.40
April	9.10	91.90	9.80
May	14.30	85.70	16.70
June	10.00	90.00	11.00
July	47.60	52.40	90.80
August	20.00	80.00	25.00
September	48.70	51.30	95.00
October	—	100.00	—
November	13.00	87.08	15.00
December	6.60	93.40	7.10

Mugil parsia

Length at first maturity : Maturing females were seen in 220 mm group. Spent or regressing or recovering specimens were observed in the same group. The maturity increased from 220 mm group and at 280 mm group the spent or recovering fishes were very high. It appeared that the first maturity was around 220 mm. Sarojini (1957) reported mature females in the 105–115 mm size group. Only fully matured males were seen in the fishery. Spent or recovering fishes were also seen at the size of 161–180 mm. The males similar to females appeared to mature much earlier. Sarojini (1957) also had recorded mature males in the 95-105 mm size group.

Gonado-somatic index : A prolonged period of high G. S. I. in the females of 300-320 mm to 400-420 mm size groups was noticed in the fishery. In males also a similar situation from 220-320 mm size group was observed. The monthly distribution of G. S. I. for different size groups indicated maximum ovarian

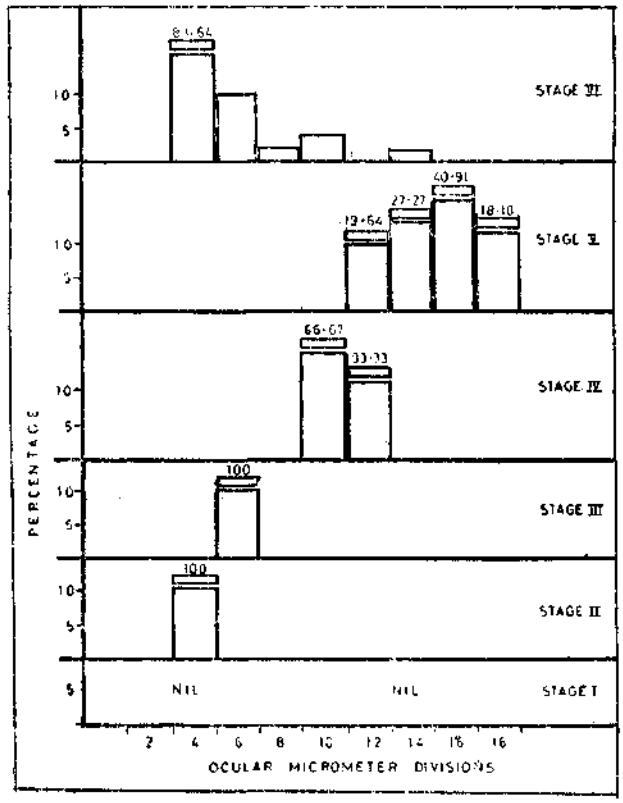

Fig. 6 Development of ova in different maturity stages in *Mugil parsia*

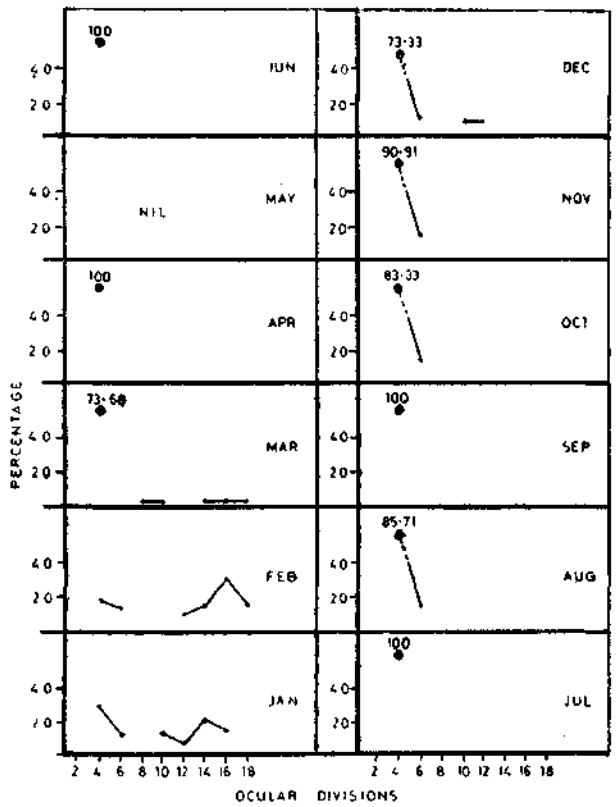

Fig. 7 Size progression of ova during different months in *Mugil parsia*

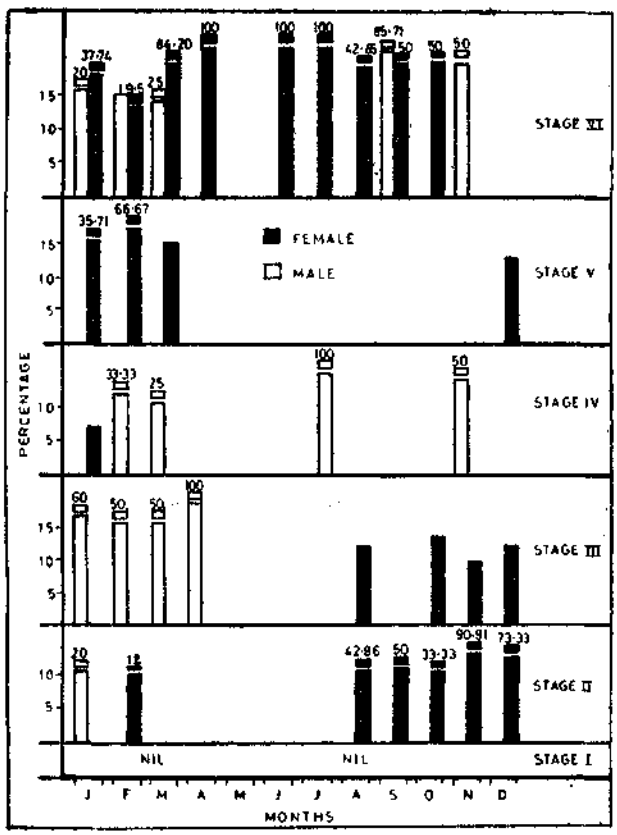

Fig. 8 Percentage occurrence of various stages of maturity in *Mugil parsia*

maturity from December to March with a peak in February. In males, this peak occurred in January.

Spawning frequency : Progression of ova diameter in maturity stages and in monthly distribution (Fig. 6 & 7) suggested a single ova group developing throughout the year.

Spawning season : The monthly distribution of different maturity stages (Fig. 8) showed a maturity peak during December to March in females and November to March in males. The presence of large number of spent or recovering specimens during June to October also, suggested a very long spawning period.

Fecundity : Sarojini (1957 & 1958) reported from West Bengal fecundity rates of 2 to 6 lakhs eggs. In the present study 2.45 lakhs eggs were seen in a 330 mm fish weighing 350 grams.

Sex ratio : Preponderence of females was seen throughout the year. The male to female ratio of 0.5 : 1.0 during the spawning peaks and 0.37 : 1.0 during the remaining months suggested the scarcity of males in the fishery (Table-5). The sex ratio

Table 5. *Sex ratio of* M. parsia *during different months*

Month	% Male	% Female	Ratio of male to 100 females
January	26.00	74.00	35.71
February	47.00	53.00	88.60
March	28.00	72.00	38.80
April	11.00	89.00	12.36
May	—	—	—
June	—	100.00	—
July	30.00	70.00	42.86
August	—	100.00	—
September	50.00	50.00	100.00
October	—	100.00	—
November	26.00	74.00	—
December	—	100.09	—

Table 6. *Details of maturation and spawning*

Fish	Wt (gm) of fish	Dose of hormone injections							
		1		2		3		4	
		Dt.	mg/kg	Dt.	mg/kg	Dt.	mg/kg	Dt.	mg/kg
1	2	3	4	6	6	7	8	9	10
3	250	27/6/86	5.0 HCG+PE (50%)	30/6	10.0 HCG+PE (50%)	7/7	10.0 HCG+PE (50%)	7/8	10.00 HCG+PE (50%)
8	300	20/8/86	16.00 HCG+PE (80%+20%)	26/8	40.00 HCG+PE (50%)	10/9	20.0 (PE)	24/9	40.00 HCG+PE (50%)
9	250	20/8	16.00 HCG+PE (80%+20%)	26/8	40.00 HCG+PE (50%)	10/9	20.00 (PE)	24/9	40.00 HCG+PE (50%)
10	250	,,	,,		,,		,,	,,	,,
11	250	20/8	16.00 HCG+PF (50%)	26/8	40.00	10/9	20.00 PE	22/9	40.00
12	300	12/12	20.00 HCG+PE (50%)	15/12	50.0 HCG+PE (60%+40%)	22/12	20.00 PE	28/12	20.0 PE

5		6		observations	Remarks
Dt.	mg/kg	Dt.	Mg/kg		
11	12	13	14	15	16
20/8	16.0 HCG+PE (80%+20%)	26/8	40.00 HCG+PE (80%+20%)	Ovary regressed after 4th dose; survived 81 days receiving totally 9 doses of hormones	PE: pituitary hormone extract of mullet pituitary
1/10	40.00 HCG+PF (50%)	17/10	40.00 HCG+PE (80%+20%)	Egg diameter progression 20/8 : 0.490 mm 26/8 : 0.525 mm 10/9 regressed survived. 60 days	HCG: crude human choreonic gonadotropin manufatured by INFAR (India) Ltd, Calcutta 700024.
1/10	40.00 HCG+PE (50%)	17/10	40.00 HCG+PE (80%+20%)	Egg diameter progression: 20/8 : 0.385-0.420 mm 26/8 : 0.455-0.525 mm 10/9 regressed survived 71 days	
,,	,,	,,	,,	Egg diameter progression: 20/8 : 0.175-0.210 mm 26/8 : 0.175-0.210 mm 10/9 regressed survived for 80 days	
29/9	40.00 HCG+PE (50%)	17/10	40.00 HCG+PE (80%+20%)	Egg diameter progression: 20/8 : 0.455 mm 26/8 : 0.455 mm 10/9 : 0.490 mm 22/9 : 0.105-0.175 regressed in 30 days survived for 76 days	Kept under regulated photoperiod of 6L/18D for 41 days from 17/9. But no response
9/1/87	20.0 (HCG+PE) (80%+20%)	16/1/87	20.00 HCG	Egg diameter progression: 12/12 : 0.455-0.490 mm 15/12 : 0.455-0.525 mm 22/12 : 0.525 mm 28/12 : 0.455-0.525 mm 9/1 : 0.350-0.525 mm 30/1 : 0.105 mm regressed fully survived for 65 days.	—

1	2	3	4	5	6	7	8	9	10
13	250	9/1/87	40.00 HCG	13/1/ 87	40.0 HCG + PE (80% + 20%)	—	—	—	—
14	250	22/1	30-40 HCG + PE (60% + 40%)	24/1	32.00 PE	30/1	30.40 HCG + PE (60% + 40%)	7/2	30.0 HCG + PE (60% + 40%)
15	350	24/1	20-25	30/1	20.25 HCG + PE (60% + 40%)	7/2	20.0 HCG + PE (60% + 40%)	—	— HCG + PE
16	250	13/2/	10-15 PE	14/2	10-15 PE	17/2	—	—	—
17	300	13/2	10-15 PE	14/2	10-15 PE	17/2	10-15 PE	20/2	10-15 PE
18	300	13/2	10-15 PE	14/2	10-15 PE	17/2	10-15 PE	20/2	10-15 PE
19	300	,,	,,	,,	,,	,,	,,	,,	,,
21	275	,,	,,	,,	,,	,,	,,	,,	,,

11	12	13	14	15	16
—	—	—	—	Egg diameter progression : 9/1 : 0.525-0.530 mm 13/1 : 0.560-0.630 mm 15/1 : 0.595-0.700 mm progressing well but died due to laboratory problems.	——
—	—	—	—	Egg diameter progression: 22/1 : 0.525-0.560 mm 30/1 : 0.595-0.630 mm 7/2 : 0.245-0.335 mm regressed fully after initial developmental symptoms. survived for 26 days	
—	—	—	—	Egg diameter progression: 24/1 : 0.525-0.570 mm 30/1 : 0 525 mm 7/2 : 0.245-0.335 mm regressed fully.	
—	—	—	—	Egg diameter progression: 13/2 : 0.455-0.525 mm 17/2 : 0.700-0.805 mm 18/2 *Partial spawning occurred* 19/2 *Repeated partial spawning* 20/2 *Stripped* spawned in 5 days	Spawned
21/2	10-15 PE	25/2	10-15 PE	Egg diameter progression: 13/2 : 0.455-0.525 mm 17/2 : 0.490-0.560 mm 20/2 : 0.595 mm 25/2 : 0.595 mm spawned in 17 days	Spawned
21/2	10-15 PE	25/2	10-15 PE	Egg diameter progression: 13/2 : 0.455-0.525 mm 17/2 : 0.630 mm 20/2 : 0.665 mm 28/3 spawned in 16 days	Spawned
,,	,,	—	—	Egg diameter progression: 13/2 : 0.455-0.525 mm 17/2 : 0.455-0.525 mm 21/2 Regressed	Regressed
,,	,,	25/2	10-16 PE	Egg diameter progression: 13/2 : 0.455-0.525 mm 17/2 : 0.525-0.595 mm 20/2 : 0.595 mm 28/2 died due to infection	——

distribution in different maturity stages and size groups showed fully matured males in less numbers and upto 280 mm males were more.

INDUCED MATURATION & SPAWNING

The uncertainty and difficulties for collection of mullet seeds from natural sources, not only affect the development of fish culture but also entail extravagant expenditure in transport and sorting out quality seed. The alternative to natural collection being, production in hatchery, many successful experiments had been conducted by scientists in Hawaii, Taiwan, Israel and in India. In India, only wild spawners from the sea had been bred and their larvae raised (Alikunhi *et al*, 1971, Mohanty, 1971, Chaudhuri *et al*, 1977). Yet, no standardised technique for spawning and larval raising in mullet is available. In the present study, shortage of fully ripe spawner females with the proper stage of oocyte development was a serious problem. The percentage of males seen in the fishery also, as reported earlier, was very poor. To overcome the problem, maturation of females with mullet pituitary hormone and crude extract of human chorionic gonadotropin (H.C.G.) was attempted.

Mugil cephalus : The major problem encountered in this fish was mortality in transport and while treatment of injuries afterwards. Improved packing with oxygen in individual plastic bags for transport and treatment with oxytetracycline injuctions at a doze of 20–30 mg/kg body weight, smearing of the oxytetracycline ointment in the injured parts and treating with pottassium permanganate solution of 0.5 to 1.0 mg/litre concentration, the survival could be extended upto 48 hours only. Despite swollenness of the abdomen and the extrusion of 'tissue plug' through the cloaca, none of the specimens responded. The scarificed specimens with gonads extending more than three-fourth of the body cavity showed an ova diameter of 0.515 mm to 0.630 mm only against the critical 0.650 to 0.700 mm egg diameter suggested by Sheadeh and Kuo (1972) prior to initiating maturation inducement. Unlike the spawners collected from the sea-source, the mullets from the reservoir fishery were not in mature condition and therefore failed on inducement. The aggravated injuries leading to bacterial infection tended to delay the process further. Low pituitary hormone dose of 2 mullet pituitaries and 40 RU Synahorin, 2.5 to 3.0 mullet pituitaries and 10 to 35 RU Synahorin spawned 2 out of 4 migratory breeders of the species (Tang, 1964, Lia, 1969, cited by Sheadeh and Ellis, 1972). In the present experiments a dose of 3 to 16 mg/kg mullets pituitaries and 0.48 to 1.2 I.U./gm (16 to 40 mg/kg) H.C.G. did not produce results in 34 females during July and November to January. It therefore, appeared that complete recovery from injuries and a prolonged course of inducement with mullet pituitary glands combined with high dose H.C.G. in specimens with egg diameter of 0.650 mm and above might be able to produce results.

Mugil macrolepis : Altogether 267 females of the species were used in 22 maturation experiments. As seen the case of *M. cephalus*, the injury and mortality due to stress and strain during conditioning was a serious problem due to lack of ready to spawn fishes on which the threshold hormone injuctions could be used to induce the spawning. Treatment with pottassium permanganate, with daily replenishment of 80% sea water in the conditioning tank healed the wounds within 12 to 15 days. Alikunhi *et al* (1971) had spawned and reared larvae from wild spawners. In our study fully matured spawners were not available. Maturation experiments were conducted using mullet pituitary hormone extract and crude H.C.G. (Table-6).

Successful maturation leading to spawning showed that in one case two consecutive doses of pituitary hormone at 24 hours interval at the rate of 10 to 15 mg/kg body weight were adequate to mature the eggs having 0.455-0.525 mm to 0.700 -0.805 mm dia. in 6 days period, resulting in partial ovulation on the 5th and the 6th day and also stripping on the 7th day. The eggs were fully hydrated, each with single oil globule. After

every partial spawning, the abdomen enlarged again. In the second successful experiment, the maturation was complete in sixteen days, the ova of 0.455-0.525 mm dia. maturing to 0.595 dia. The spawning was natural. six doses of mullet pituitaries at the rate of 10 to 15 mg/kg body weight were administrated. In the third successful experiment, spawning occurred on the 15th day in which the ova developed from 0.630 mm dia to 0.665 mm dia. receiving a pituitary dose of 10 to 15 mg/kg body weight six times. The experiments indicated that an initial ova diameter of 0.445-0.525 mm could be stimulated to attain full maturity and spawn naturally by using mullet pituitary glands. However, out of seven specimens having identical morphological and ova diameter characters, physically fit and free from injury, only three responded to pituitary hormone injections. All others, after showing initial signs of egg diameter improvement, regressed quickly, though, the experiments were conducted during the normal spawning season of the species. In other experiments, conducted out of season, no response was noticed even when the H.C G. was administated with pituitary extract.

Mugil persia : The authors are not aware of any research or experiments to mature and spawn either wild or captive *M. Persia*. Thus the present account is the first report.

The species was found to attain ovarian maturity during December to March. However, no specimen collected had the ovary with oocytes in fully developed stage. Injuries and infections were serious problems encountered. Out of 108 fishes collected and conditioned, only 16 survived (Table 7). Three experiments were conducted with long surviving specemens of 330 mm size group having a weight range of 300-350 grams. In one of the experiments, during February to March, the ova diameter increased from 0.455 -0.525 mm to 0.805-0.875 mm in 37 days and 2.45 lakhs ova hydrated with single yolk globule were released spontaneously. In another experiment, during December to January, the ova diameter increased from 0.105 -0.175 mm to 0.140-0.210 mm within 28 days but regressed thereafter even though the fish survived for 77 days. In the former experiment, mullet pituitary extract at the rate of 12 to 18 mg/kg body weight was administrated at 48 hours interval, followed by one dose at the rate of 24 mg/kg body weight after 30 days, on observation of improvement in the egg diameter. Quick development of ova diameter was noticed following the third dose. However, in the second experiment, different higher doses of pituitary and H.C.G. combinations and pituitary alone, were tried with no substantial result. It is possible that the oocytes in the fish during the second experiment were not responding due to low dose of injected hormones. Kuo and Nash (1975) reported use of 50 to 77.6 I.U./gm body weight of H.C.G. whereas in our experiments, the doze was 0.432 I.U./gm only. Nevertheless, the experiments indicated the prospects of induced maturation and spawning of the fish in proper condition with pituitary hormone extract during the spawning season.

RURAL DEVELOPMENT

The coastal area of the Gulf of Kutch is inhabited by poor fishermen who do not have means to procure modern craft and tackle for fishing. In order to generate employment, to produce food and raise their nutritional level, and over and above to raise their living standards, coastal aquaculture can be considered as a profession for them. By suitably modifying aud using the engineering skill, farms can be bunded up in the area. Adequate pumping arrangement for ensuring water supply and seed supply is necessary. But mullet culture alone might not be adequate to sustain the coast of the farm, because these fishes are only moderately priced so that the market value will not be adequate to generate income like many other fish varieties. However, of all the cultivable fishes, mullets are the most suitable fish available in this area. The quick growing fishes like *M. cephalus* are limited in supply. The seed potential of mullets in the Gulf of Kutch is not well-known except for an account

Table 7. *Details of maturation and*

Fish No.	Wt. of fish (gm)	Dose of injections 1 Dt.	1 mg/kg	2 Dt.	2 mg/kg	3 Dt.	3 mg/kg	4 Dt.	4 mg/kg
1	350	2/2/85	12-18	4/2	12-18	4/3	24.0 PE	—	—
2	350	2/2	,,	,,	,,	,,		—	—
5	300	12/12/86	24.0 HCG+PE (50%)	15/12/86	55.00 HCG+PE (70%+30%)	22/12	18.00 PE	28/12	18.00 PE

Table 8. *Feasibility data on composite fish and prawn farming*

Experience Data				Per Hectare			
Operation Area (Hectare)		Harvest (kg)		Value (Rs)		—Yield (kg)	
Prawn	Fish	Prawn	Fish	Prawn	Fish	Prawn	Fish
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1060	1620	20000	80000	57980	21400	18.29	49.39

Capital Expr. (Rs)			Recurring Expenditure (Rs)					
Farm	Pumps	Land	Loan Repayment+ Interest	Land Rental	Farm maintenance+ Insurance	Fishing Nets	Watch & Ward	Total
17	18	19	20	21	22	23	24	25
Nil (free of cost)	22000	Nil (Lease)	18500	100	5000	5000	3600	32200

spawning experiments on M. parsia

5			6	Observations	Remarks
Dt.	mg/kg		mg/kg		
—	—	—	—	Egg diameter progression; 2/2/85 : 0.455 0.525 mm 15/2/85 : 0.455-0.560 mm 4/3/85 : 0.560-0.630 mm 8/3/86 : 0.805-0.875 mm spawned spontaneously (survived 55 days)	Spawned PE : pituitary hormone extract of mullet pituitary
—	—	—	—	Egg diameter progression: 2/2 : 0 455-0 525 mm 15/2 regressed fully (survived 157 days)	HCG: crude human choreonic gonodotropin manufactured by INFAR (India) Ltd, Calcutta 700024
9/1	18.0 HCG + PE (80% + 20%)	16/1	15.00 HCG	Egg diameter progression: 12/12 : 0.105-0.175 mm 15/12 : 0.105-0.175 mm 22/12 : 0.105-0.175 mm 28/12 : 0.105-0.175 mm 9/1 : 0.140-0.210 mm regressed thereafter (survived for 77 days)	HC by one mg= 30 I. U.

in the coastal area of Gulf of Kutch.

Per Hectare			Projected yield & value for 100 Hectare unit				
Revenue (Rs)			Yield (kg)		Value (Rs)		Total
Prawn	Fish	Total	Prawn	Fish	Prawn	Fish	value
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
547	132	679	1829	4930	54700	13200	67900

Net Revenue (Rs) (cls. no 16-25)	Individual earning per annum (Rs)
26	27
35700	8925

Pre suppositions

(1) The land will be provided by the Govt. to a group of 4 Fishermen or Co-op. Society on nominal rent on long term basis.

(2) Farm Construction cost will be fully born by the Govt. as a scarcity or drought relief expenditure under adequate technical and Engineering guidance.

(3) 60-80 HP Vertical Lifting Pumps either on power or disel operated will be installed by Govt. agencies and cost subsidised by 50% and remaining recovered with low interest of 6% per annum.

(4) The harvested catch protected and farm insured against natural calamaties or robberies.

(5) Marketing of catch to be done through a non profit organisation like FFDA if desired by the Fishermen or decided by Govt. as policy towards loan recovery.

of seed availability in the Jodia village (Dave *et al*, 1980) and in the Okhamandal taluka (Gopalakrishnan *et al*, 1987). The percentage of the quick growing *M. cephalus* formed only 11.6% and other mullets 62.7%. Maturation and spawning by hypophysation technique presented in this paper indicated the state of the art, needing much to be done. Therefore, mixed farming appears to be a more viable proposition. With generous aid from the Government, by way of land leased on nominal rent, soft loans for capital cost, attractive subsidy, necessary technical and engineering assistance in pond construction, considering aquaculture as an essential crash programme related to drought relief, the fisherman of the area can be involved in aquaculture. Mixed farming of mullets and the local prawn species *Metapenaeus kutchensis* in large impounded farms provided with pumps for water supply, needing no inputs like manuring and feeding, can raise a low productive subsistence economy for the well being of the Kutch fishermen. The data presented in Table-8 is minisculled from our experience on such an effort with large reservoir areas of a salt works.

An annual revenue of Rs 68,000.00 can be generated from a 100 acre farm by a group of four fishermen. After paying for the loan repayment, interest on capital and watch and ward etc, adequate income could be found for all the members. It may be noted that though prawn constituted only 25% of the annual production, in terms of value, the contribution was 80.6%, which lends solid support for the economic feasibility of mixed farming. The high cost of pond construction due to the high tidal range and the inadequate availability of the quick growing fish seed are factors necessitating composite culture to raise the per hectare total production to economic level.

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Paper 49

PRESENT STATUS ON INDUCED BREEDING OF MARINE FINFISHES IN INDIA

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ABSTRACT

The paper deals with the present status on induced breeding of marine finfishes in India. The role of induced breeding of marine finfishes in aquaculture research and development is emphesised. A review on the seasonal availability of marine finfish spawners such as milkfish and grey mullet from the coastal waters and estuaries in India wes made. The methods employed in the collection of live fish breeders from the wild, constraints encountered in broodstock management and induced breeding for mass propagation of grey mullet, milkfish, rabbit fish and other marine finfish larvae in hatcheries are given. The problems and prospects on induced breeding of marine finfishes in India are discussed.

INTRODUCTION

The success of large scale marine finfish culture is largely dependent upon the continuous and adequate supply of seed for stocking. Although fish seed may be collected from natural sources, its supply is seasonal and unreliable. A more reliable source is to induce the fish to breed in hatcheries (Jhingran, 1969). Some of the herbivorous and euryhaline fishes are traditionally cultured in various confinements. Fluctuation of natural recruitment and unreliability of the seed supply in quantity have necessitated research in developing suitable hatchery techniques. Further, with the increased emphasis given by the Government of India to aquaculture, there is a growing

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demand for seed by the fish farmers. In India, although farming of herbivorous fishes such as grey mullets and milkfish has been practised for many centuries, the seed are exclusively collected from the natural habitat (Pillay, 1972; Tampi, 1973; Nammalwar, 1986).

Many of the major current problems in fish breeding relate to nutrition, reproduction and environmental control. The technique of hypophysation has triggered progress in the induced breeding of fishes. It has been of particular importance in the case of fishes that do not ordinarily breed under confinement. Breeding with pituitary hormones and Human Chorionic Gonadotropin and the current knowledge on fish hybridisation have been encouraging for further development (Chaudhuri, 1966; Radhakrishnan *et al*, 1976). Induced breeding of grey mullets and other fishes was initiated in 1961 in India. This paper reviews the present status of knowledge of research and development on induced breeding of marine finfishes and enlists the problems and prospects for further development in India.

ROLE OF INDUCED BREEDING IN AQUACULTURE

Fish seed collected from the natural waters is not pure and very often consists of a high percentage of uneconomic species. Induced breeding enables the farmer to obtain quality fish seed. Moreover, by genetic manipulation and selection of strains and breeding lines, improved varieties with desirable qualities can be produced.

In general, the techniques for induced breeding can be classified into (i) creating suitable conditions for inducing fishes to breed (ii) creating favourable environment in confined waters and (iii) using hypophysial extract and hormones. The use of a suitable method has to be carefully determined with reference to the species.

SPECIES SELECTION FOR INDUCED BREEDING

The milkfish *Chanos chanos*, grey mullets *Mugil cephalus*, *Liza macrolepis*, *Liza parsia*, *Liza waigiensis*, *Valamugil seheli* and *Liza tade* are the major herbivorous species which have been widely cultivated in coastal and brackish water ponds in India for a long time. The other species such as *Etroplus suratensis*, sand whiting, *Sillago sihama*, rabit fish *Siganus javus* and *Siganus canaliculatus* and groupers *Epinephelus tauvina* and *Epinephelus hexagonatus* and other perches *Lates calcarifer* are cultivated only from late sixties. These species do not breed in ponds or other confined waters and spawning occurs only in the sea. The seed are collected from the natural waters.

MARINE FINFISH BREEDING

The major activities in marine finfish breeding are the collection and maintenance of broodstock, hatchery operations including spawning, incubation of eggs and hatching, larval food production, larval and nursery rearings and raising of hatchery bred fingerings to brood stock level.

SURVEY OF MILKFISH AND GREY MULLET SPAWNERS

Milkfish spawners have been collected from both the west and east coasts of India (Table-1). Based on the availability of milkfish spawners and fry and correlating the observations made by various workers from different localities during different periods, possible spawning grounds along the Indian coasts have been identified (Silas *et al.*, 1985). The occurrence of spawning population of milkfish and fry in the Gulf of Mannar and Palk Bay during January-April (primary spawning season) and October-November (secondary spawning season) indicates the existence of two spawning seasons of milkfish (Gandhi *et al.*, 1986.)

Table 1. *Availability of milkfish spawners in India*

Place	Period of availability	Authority
Calicut	March-April	Devanesan & Chidambaram (1953)
Appa Island (Near Keelakarai)	February-March & November-December	Silas *et al.*, (1985)
Pudumadam	February-March	Tampi (1958)
	November	Silas *et al.*, (1985)
Theedai (Mandapam)	October-November	Silas *et al.*, (1985)
Mandapam	October	Panikkar *et al.*, (1952)
	March-April	Devanesan & Chidambaram (1953)
	February-May	Tampi (1957)
Pamban	October	Tampi (1958)
	March-April	Devanesan & Chidambaram (1953)
Ariyankundu (Rameswaram Island)	January-April	Silas *et al.*, (1985)
Krusadai Island	March-April	Devanesan & Chidambaram (1953)
Sethubavachatram	March-April	Devanesan & Chidambaram (1953)
Pulicat Lake	March-May	Chacko (1951) & Chacko *et al.*, (1953)
	March-April	Devanesan & Chidambaram (1953)
Nellore	March-April	Chacko (1951)
Vizagapatnam	March-April	Devadesan & Chidambaram (1953)
Srikakulam	April-May	Chacko *et al.*, (1953)

Among the grey mullets, the spawners of the striped mullet *Mugil cephalus* are available from September onwards in Goa and Porto-Novo waters, whereas the peak period is from November to January in other areas. Other grey mullet species occur throughout the year with one or two peaks (Table-2)

COLLECTION OF MILKFISH AND GREY MULLET SPAWNERS AND MANAGEMENT

In India, breeders of milkfish, grey mullets and other cultivable marine finfishes are mainly caught from the wild during the spawning migration. The success of collection of spawners from the wild depends largely on the fishing method used. The milkfish spawners are caught by bottom set gill nets and drift nets at Theedai and Ariyankundu (Palk Bay) and by shore-seines at Pudumadam and Appa Island (Gulf of Mannar). The size of the spawners range from 1043-1340 mm and the weight from 7-15 kg. Details on the sex, stage of maturity, gonad weight, ova diameter and Gonado Somatic Index of the spawners have been tabulated by Gandhi *et al.*, (1986).

The grey mullet spawners are caught by the gill nets, seine nets, bag nets, stake nets, Chinese dip net and cast nets in India. Mature fish of *Liza macrolepis* were collected from the stake-net at Manoli Island and from bag net at Thonithurai. The spawners of *Valamugil seheli* were collected from the bag net at Pillaimadam and Thonithurai. Ripe fish of *Mugil cephalus*, *Liza parsia* and *Liza tade* were collected from the bag nets operated in the coastal waters at Kovalam, Adyar and Pulicat.

The grey mullet spawners were selected and transported through rectangular or circular tanks of 300 litre capacity with aeration. At a time, maximum five spawners were transported without mortality. The spawners were

Table 2. *Availability of grey mullet spawners in India*

Place	Species	Period of availability	Authority
Goa coast	*Mugil cephalus*	September-February	Das (1978)
Kayamkulam Lake, Kerala	*Mugil cephalus*	October-January	John (1955)
	Liza macrolepis	November-January	
	Mugil tade	September-March	
	Mugil speigleri	December- March	
	Mugil troschelli	September-December	
	Mugil ophuyseni	November-February	
	Mugil engeli	October-December	
	Mugil cunnesius	September-December	
Mandapam	*Liza macrolepis*	June-February	Luther (1963)
	Mugil troschelli	May-February	Luther (1968)
	Mugil waigiensis	May-February	
	Mugil sehell	May-February	
	Liza parsia	June-August	
	Mugil cunnesius	July-August	
Porto-Novo	*Mugil cephalus*	September-April	Sulochanamma *et al.*, (1981)
	Osteomugil speigleri	December-April	Sathyashree *et al.*, (1981)
Adayar estuary, Madras	*Mugil cephalus*	November-January	Mohanraj *et al.*, (MS-1987)
	Liza macrolepis	January-April	
	Liza parsia	December-March	
	Liza tade	November-January	
	Liza cunnesius	December-January	
Kovalam estuary, Madras	*Mugil cephalus*	October-January	Mohanraj *et al.*, (MS-1987)
	Liza macrolepis	December-June	
	Liza parsia	December-March	
	Liza tade	November-January	
	Liza oligolepis	January April	
Ennore estuary, Madras	*Mugil oeur* (cephalus)	October-May	Jacob & Krishnamurthy (1948)
	Mugil dussumieri (parsia)	October-May	
	Mugil buchanani	October-May	
	Mugil oligolepis	October-May	
Pulicat Lake	*Mugil cephalus*	September-February	Ramaswamy (1975)
		November onwards for few months	Luther (1968)
	Liza macrolepis	Throughout the year *Two peaks* January-July & February-April	Rangaswamy (1980)
	Liza parsia	Throught the year *Two peaks* July-Septem. & March	Rangaswamy (1980)
Mahanadi estuary, Orissa	*Mugil cephalus*	September-December	Shetty *et al.*, (1965)
Chilka lake, Orissa	*Mugil cephalus*	September-December	Jhingran & Natarajan (1969)
		October-January	Luther (1968)
Hooghly-Matlah estuary	*Liza parsia*	October-February	Luther (1968)
Bengal waters	*Liza parsia*	December-March	Sarojini (1957)
	Liza cunnesius	May-July	Sarojini (1958)

maintained in 12' diameter polycraft pools provided with running water system and aeration. The fish chosen for the experiments were held individually in 3' diameter circular tanks. Handling of the fish caused the shedding of body scales making the fish more vulnerable to bacterial and fungal attacks, leading to mortality. This problem was overcome by guiding the fish into a polythene bag filled with water whenever the fish was handled. Loss of slime from the body and scale shedding resulted by rubbing against the hapa whenever the fish were maintained in the hapas. Circular tanks were found suitable than the rectangular tanks. Nylon net screen covers to the tanks prevented fish from jumping out of water.

INDUCED BREEDING OF MARINE FINFISHES

In India much emphasis has been given to induced breeding of the grey mullets, milkfish and rabbit fish. Fish can be induced to spawn either by hormonal treatment or by environmental manipulation. Major carp pituitary hormone, mullet pituitary glands and human chorionic gonadotropin were effectively used in the induced breeding experiments of grey mullets and other marine fishes. Females with eggs at the tertiary yolk globule stage with 0.6 mm diameter and above were used for breeding experiments of milkfish and mullets.

Grey mullets

The grey mullets do not breed in saline or brackishwater ponds or lakes and estuaries although they attain maturity there. They migrate to the sea for breeding during monsoon months. The available information shows that the gonads reach full maturity at 30 ppt and above (Nash and Shehadeh, 1980). Mullet eggs and larvae were collected by Jacob and Krishnamurthy (1948) from Ennore, by Chacko (1950) from Gulf of Mannar and Jones and Sujansingani (1954) from Chilka lake. The development of *Mugil corsula* was studied by Pakrasi and Alikunhi (1952). Studies on embryonic and larval development as a result of stripping on *M. cephalus* were made by Nair (1957). Kuthalingam (1966) was successful in rearing the larvae of *M. cephalus* to early juveniles. Pati (1970) has studied the early development of *Liza troschelli* from the Chilka lake by the artificial fertilization of eggs stripped from spawning females. Embryonic and larval development of *L. macrolepis* were studied from the developing eggs collected from Chilka lake by Natarajan and Patnaik (1972). Though, success has been achieved on an experimental scale in India, so far it has not been possible to rear the induced-bred hatchlings on mass scale. Experiments on induced breeding of grey mullets (Table-3) were initiated during 1961 in Chilka lake and success was achieved in breeding *M. cephalus* by injection of fish pituitary hormones (Anon, 1962). At Azhicode, Kerala, ovulation was induced in *M. cephalus* but the eggs could not be fertilized (Alikunhi *et al.*, 1971; Sebastian and Nair, 1973). The success on the induced breeding of *M. cephalus* in Chilka lake has been reported by Mohanty (1971) but the larvae were reared only for 7 days. The production of hatchlings and rearing of larvae for about 10 days were reported by Chaudhuri *et al.*, (1977). Successful spawning and larval rearing of *M. cephalus* for 10 days were achieved at Narakkal, Cochin in 1987 (Krishnan and George-personal communication).

Induced breeding experiments conducted on *Liza troschelli* resulted in ovulation and spawning but the fertilized eggs did not develop (Anon, 1992; Chaudhuri, 1966). At Azhikode, successful spawning and larval rearing of *L. macrolepis* for 10 days and upto fingerling stage was reported by Sebastian and Nair (1975) and Alikunhi *et. al*, (1971). Induced breeding and larval rearing of *L. macrolepis* for about 4 days at Chilka lake was reported by Kowtal and Gupta (1983). James *et al.*, (1983) have studied in detail the embryonic and larval development of

Table 3. *Induced breeding experiments conducted on grey mullets in India*

S.No.	Place	Name of Species	Environmental conditions of water	Hormones used and quantity	Observation	Workers and year
1	2	3	4	5	6	7
1.	Chilka lake, Orissa	*Mugil cephalus*	Temp 22.5-23.5°C	MPG 8-16 mg/kg	Hatchlings did not survive	Anon (1962), Chaudhuri (1966)
		Liza troschelli	,,	,,	Eggs did not develop	,,
2.	Azhicode, Kerala	*M. cephalus*	—	—	—	Alikunhi *et al.*, (1971)
		L. macrolepis	Temp. 26.0–29°C Sal. 29.0-31.0 ppt	MPG, 1-5 glands/fish	Larvae reared upto fingerling stage	,,
3.	Chilka lake, Orissa	*M. cephalus*	Temp; 19.5-24.°C Sal. 5.3.29.9 ppt D.O. 8.2.11.5ppm	MPG 6-10 glands/fish or 10-18 mg PO and 2.5-3.7 mg S.H./kg	Larvae reared for 7 days	Mohanty (1971)
4.	Azhicode, Kerala	*M. cephalus*	—	MPH	Ovulation achieved but eggs could not be fertilized	Sebastian and Nair (1973)
5.	Azhicode, Kerala	*L. macrolepis*	Temp. 27-30.5°C Sal. 29-31 ppt	MPG 3-9 glands/fish	Majority of the larvae were reared for 10 days	Sebastian and Nair (1975)
6.	Pulicat lake, Madras	*L. macrolepis*	Temp.24.7-31.4°C Sal. 28-40.5 ppt D.O.2.8-8.8 ppm	MPG 4-20mg/kg	Yielded ripe eggs on stripping	Radhakrishnan *et al.* (1976)
		M. cephalus	,,	MPG 20 mg/kg	No spawning	,,
		L. parsia	,,	MPG 5-25 mg/kg	Fertilized eggs perished after 10–30 h.	,,
7.	Chilka lake, Orissa	*M. cephalus*	Temp.16-28.5°C Sal. 4.1-26 ppt D.O. 3.6-8.6 ml/l	MPG 2-6 gland/fish or MPG 6-13 gland and Synahorin 17-45 R. U.	100-14000 hatchlings obtained majority survived for 10 days	Chaudhuri *et al.*, (1977)

1	2	3	4	5	6	7
		L. macrolepis	—	MPG 8-16 mg/kg	Fertilized eggs did not develop	,,
8.	Chilka lake, Orissa	*L. macrolepis*	Temp.15.5-23°C Sal. 13-29.6 ppt D.O.7.19 ppm	MPG 2-6/ fish	Larvae reared for 4 days	Kowtal and Gupta (1983)
9.	Mandapam, Tamil Nadu	*L. macrolepis*	Temp. 27-33.2°C Sal.31.6-32.5 ppt	CPG 600-1200 mg/kg or HCG110000-340000 I.U/kg or CPG 1200mg and HCG 12000-15000 I.U/kg	Larvae reared for 7 days. Attained the size of 2.47 mm	James *et al.*, (1983)
10.	Narakkal, Kerala	*L. macrolepis* *L. parsia*	—	—	1.2 lakh hybrid larvae were obtained. 40% survived for more than 3 months	Krishnan and George (1986)
11.	Madras	*L. macrolepis*	—	—	Larvae reared upto 22 days	Krishnamurthy *et al.* (1986)
12.	Narakkal, Kerala	*M. cephalus*	Sal. 24-31 ppt	CPG 70mg & MPG 15mg& HCG 30000 I.U/kg	Larvae survived for 10 days	Krishnan and George 1987 (Personal Communication)
		L. parsia	—	CPG 200-476 mg/kg	majority of larvae died by 5th day. 2000 juveniles survived beyond 40 days	,,
13.	Kovalam, Madras	*M. cephalus*	Sal. 28-30 ppt.	HCG 1500	No spawning	Nammalwar *et al.* (1987)
		L. parsia	,,	I.U/kg	,,	
		L. tade	,,	CPG 250-500 mg/kg HCG 1000 I.U/kg	,,	

MPG—Mullet Pituitary Gland; CPG—Carp Pituitary Gland;
HCG—Human Chorionic Gonadotropin; SH —Synthetic Hormone

induced bred *L. macrolepis* for 7 days. Krishnamurthy *et al.*, (1986) have reported the success in breeding *L. macrolepis* and the larvae were reared upto 22 days at Madras. An attempt was made towards interspecific hybridisation with eggs of *L. parsia* and milt of *L. macrolepis* and all the fertilized eggs perished within 30 hrs (Radhakrishnan *et al.*, 1976). Hybridisation by crossing the females of *L. macrolepis* with the males of *L. parsia* was achieved by Krishnan and George (1986). The larvae were reared upto the fry stage for about three months.

Induced breeding experiments under laboratory conditions on grey mullets *M. cephalus*, *L. parsia* and *L. tade* were conducted by giving effective dose of HCG (Human Chorionic Gonadotropin) ranging from 250-1500 I. U/kg and crap pituitary hormone (200-500 mg/kg) at Kovalam laboratory. The live ovarian biopsy of the fish revealed that the ova diameter has increased after hormonal treatment. Induced breeding experiments under field conditions on grey mullets *L. parsia* and *L. tade* were conducted by administering HCG ranging between 500 and 1500 I.U/kg and the fish were maintained in the net cages at Muttukadu farm. There was increase in the ova diameter after the hormonal treatment (Nammalwar *et al.*, MS-1987).

Milk fish

Success in breeding the fish has not been reported in India. During the period 1978-80, live milkfish breeders were collected from the gill nets of 17 mm mesh size operated at Ariyankundu (Palk Bay). The fish were conditioned in 15' diameter pen at the collection site and then transported to the fishfarm at Mandapam. For the first time, one ripe female was transported from Ariyankundu to Mandapam during 1978. The fish survived for 2 hr. in the holding pond. Subsequent to that, six spawners were collected and maintained in the broodstock pond at Mandapam for undertaking breeding experiments. It was not possible to keep the fish alive for more than two days since all the fish had received injuries during capture. With a view to overcome the problem posed with the wild spawners collection, 200 milkfish of 5-6 year age group are being raised as broodstock at Mandapam to achieve the goal of induced breeding of milkfish.

Rabbit fish

The spawners of the rabbit fish *Siganus* spp. are caught mainly by the traps from November to February. The traps are placed in the reef areas of Keelakarai, Appa Island and Valai Island (Gulf of Mannar). The size and weight of *Siganus canaliculatus* breeders ranged from 154-235 mm and 75-190 g. Success in breeding the rabbit fish *S. canaliculatus* was achived in 1984 at Mandapam by the administration of HCG at the rate of 28000 I.U/kg. The larvae were reared for four days (Mohanraj, MS-1987).

PROBLEMS AND PROSPECTS

The availability of live mature breeders of marine finfishes from the wild populations are lacking. Further, in the absence of pond grown fish broodstocks, concentrated efforts for mass seed production by induced breeding have to be made at the peak of the natural spawning season. Continuous maintenance of fish broodstocks in captivity, techniques to control and regulate gonadal maturation and development, environmental influence on breeding, inadequate supply of suitable live food organisms at different stages of larval development are some of the problems to be solved.

In India, eventhough some remarkable success has been achieved in developing techniques towards induced breeding of marine finfishes and in obtaining seed in some of the important cultivated fishes, our persent knowledge on reproductive physiology, breeding requirements and spawning behaviour with regard to milkfish, grey mullets and other important marine finfish species is meagre. Therefore, intensive research in this line has to be done to determine the exact breeding requirements of these fish species and develop suitable techniques for their artificial propagation.

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SEAWEED CULTURE IN INDIA-AN APPRAISAL

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ABSTRACT

In recent years there has been a steady increase in the demand for naturally occuring seaweeds as a result of many seaweed based industries coming up. In order to meet the raw material requirement of these industries attempts have been made in this country to develop suitable seaweed farming techniques by some institutes notably the CMFRI at its Mandapam Regional Centre and CSMCRI at its field centre, Mandapam. Experimental culture of economically important seaweeds such as *Gracilaria edulis*, *Gelidiella acerosa* and other species was undertaken since 1972 at Mandapam. In these experiments production rates ranging from 3 to 8 times the initial wet weight were obtained. The techniques of seaweed culture, the favourable seasons optimum duration of culture period and the influence of environmental parameters are discussed in this account with notes on economics of seaweed culture. General information on the seaweed resources along our coasts, their potential for exploitation and culture are also highlighted.

INTRODUCTION

Many commercially important species of seaweeds belonging to the groups Chlorophyta, Phaeophyta and Rhodophyta occur naturally in varying degrees of abundance in shallow bays, lagoons and coastal areas which offer suitable substrata for their growth and propagation. In India, the Gulf of Mannar, Palk Bay, Gulf of Kutch, Lakshadweep and Bay islands are the important areas having considerable natural resources of seaweeds.

Apart from their utility as a source of food, food derivatives, vitamins, proteins etc, seaweeds provide the raw material for many agar-agar and algin based industries. In view of the constant demand for the seaweeds, research programmes on seaweed resources and their culture were taken up by the Central Marine Fisheries Research Institute and Central Salt and Marine Chemicals Research Institute at Mandapam at their Regional and field centre respectively and various other research organisations belonging to the State Fisheries Departments/Universities as at Port Okha and Ratnagiri. As regards seaweed farming experiments were mainly carried out with species of *Ulva*, *Gelidiella acerosa*, *Gracilaria edulis*, *Gracilaria corticata*, *Gelidiopsis variabilis*, *Gelidium pusillum*, *Hypnea musciformis*, *Acanthophora spicifera*, *Hormophysa triquetra*, *Cystoseira* and species of *Sargassum*. The experiments were mainly conducted by the method of vegetative propagation. Some trials were made with spores as well. An appraisal of these farming techniques is presented in this account.

Culture of G. acerosa

Bhanderi (1974) cultured the apical region of the *Gelidiella acerosa* by inserting these fragments in a string and suspended in a seawater aquarium at Port Okha, Gujarat. He observed a linear growth of 0.01 cm/day and an increase of 0.01 g/day in weight. Krishnamurthy *et al.* (1975) conducted some experiments with 2 cm fragments of *Gelidiella acerosa* in a lagoon on the southern side of Krusadi Island. After four months, the fragments grew to full sized plants of about 10 cm in length with seven to eight branches.

In the same area Subbaramaiah *et al.* (1975) carried out experiments on 2 cm length fragments of *G. acerosa* fastened to a nylon string at fixed intervals and the seeded string was wound round a rope kept submerged in coastal waters. The maximum growth attained was 6.6 cm and the rate of production was 3.13 g/m/month (wet). The total production of seaweed was 421 g/m (wet) in a year.

Experimental field cultivation of *G. acerosa* using submerged coral stones as the substrata was done at Ervadi (Patel *et al.*, 1979). An annual yield of 115.83 g/m²/day (dry) on over all basis was obtained which was 33 times over the seed material. Patel *et al.* (1980) reported a maximum yield of 122 g/m² (dry) in one of their six monthly harvests made in January 1979 from the field cultivation of *G. acerosa* at Ervadi.

Culture of G. edulis

Raju and Thomas (1971) cultured *G. edulis* by long line rope method in a sandy lagoon in Krusadi Island. Fragments of 1 cm and 2.5-3 cm length were used for planting and they grew to a length of 35-40 cm in about five months period. Three harvests were made at the end of 5, 8 and 10½ months and the total harvest during the year was about 3.5 kg per 1 m length of rope.

Krishnamurthy *et al.* (1975) carried out cultivation of *G. edulis* in a lagoon in the Krusadi Island. Fragments of 2.5 cm length were introduced in the twists of the ropes, which were tied to bamboo poles planted to the sea bottom. In about five months period the plants attained a length of 30 cm and the average weight of plant was about 300 g. A total of three harvests were made in a period of 10 months.

Culture of other red algae

Bhanderi (1974 b) recorded a linear increase of 0.02 cm/day and an increase of 0.07 g/day in weight in his culture experiments on *Gracilaria corticata* in seawater aquarium. In experiment with *Gelidiopsis variabilis* he obtained a linear increase of 0.12 cm/day with an increase in weight of 0.04 g/day.

Mairh and Sreenivasa Rao (1978) cultured *Gelidium pusillum* in the laboratory under free floating conditions and using nutrient enricher and obtained maximum fresh weight and full size within three to four months. Rama Rao and Subbaramaih (1980) cultured *Hypnea musciformis* and obtained four fold increase in 25 days.

Thivy (1964) conducted culture experiments in ponds at Porbandar by attaching small plants of *Sargassum cinctum, S. vulgare* and *S. wightii* to coir nets with the help of tape. The plants grew to a height of 15-52 cm for an initial 5-10 cm length within forty days.

Bhanderi and Trivedi (1977) made an attempt to study the possibility of culturing *Hormophysa triquetra* by vegetative propagation in an aquarium. The fragments gained 7 times (fresh weight) over the initial weight at a rate of 0.333 g/day.

Seaweed culture experiments at CMFRI

The Central Marine Fisheries Research Institute at its Regional Centre at Mandapam, conducted culture experiments especially with *Gracilaria edulis* and *Gelidiella acerosa*. In seawater aquaria *Gracilaria corticata* was cultured (Umamaheswara Rao, 1973) which showed an increase in length from 1.8 to 5.5 cm in 90 days. Experiments with *Gracilaria edulis* in 0.5 m² coir nets yielded very good results. The average height of the plants varied from 14 to 16 cm at the end of two months and the fragments gained a weight of 213 and 257 g respectively. Experiments conducted in 4 x 2 m size coir rope nets yielded 4.4 kg (fresh wt.) of seaweed per square metre in 80 days (Umamaheswara Rao, 1974 a).

The culture experiments were conducted by introducing fragments of the seaweed into the twists of the coir ropes which in some cases were fabricated in the form of nets of different sizes-which in turn were tied to wooden poles fixed in the coastal waters (Fig. 1—4.)

Experiments conducted in the submerged floating condition (Chennubhotla *et. al.*, 1978) proved to be more beneficial than that at sub-tidal level.

The cultivation was attempted at slightly deeper waters i. e 3-4 m depth on HDP rope nets to avoid intensity of sedimentation and grazing by fish. The yield obtained was about 4 times the initial weight after 70 days. Chennubhotla *et al.* (1977 c) cultured *G.acerosa* by tieing small fragments along with

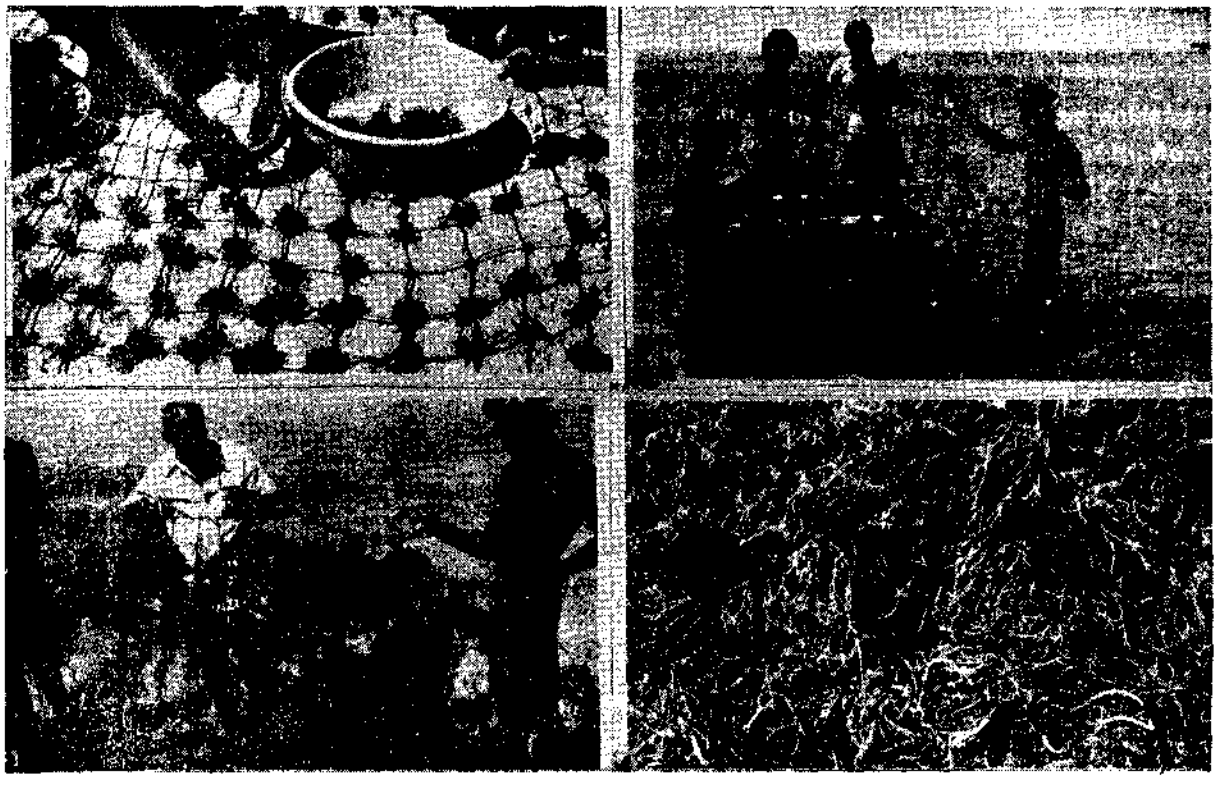

Fig. 1 Seaweed material being seeded in the net; Fig. 2 Seeded net being introduced into the inshore waters; Fig. 3 Cultured seaweed after 30 days growth; Fig. 4 Cultured seaweed after 60 days growth.

substratum (coral piece) to the coir ropes in the net. One frame was introduced with 0.9 kg and the other with 1 kg seed material. An yield of 2.5 and 3 kg were obtained respectively after 76 days.

Experiments conducted by keeping the *G. acerosa* seeded coral stones kept in cages were introduced in 2 and 4 m depth. The growth of the seaweed was found to be very luxuriant.

The culture was attempted by fastening fragments of *G. acerosa* to coral stones with the help of iron nails, reached harvestable size after 5 months and 1 kg of seed material yielded 3.1 kg of fully grown plants.

Fragments of *Sargassum wightii* obtained from the basal portion of plants with holdfast were inserted in the twists of the coir ropes and cultured in inshore waters of Gulf of Mannar at 1 m depth in mid water level. An average growth of 15.5 cm was recorded from an average initial length of 7.7 cm within 60 days. (Chennubhotla *et. al.*, 1976, unpublished).

Cultivation of *Acanthophora spicifera* was carried out on two HDP rope nets in 60 x 30 m size ponds, which are connected through a feeder canal to the sea. An average yield of 22.615 kg (wet weight) was obtained after 45 days from the two nets which was found to be 3.6 times the initial seed material. The remnants were allowed to grow for the second harvest which was made after 35 days. An average yield of 14.4 kg was obtained in the second harvest.

Experiments of *Ulva lactuca*, pre-treated with ascorbic acid were carried out in the seawater of different salinities in the laboratory. It was observed that the trials with 18‰ salinity boosted up the production to eight times in 92 days.

Culture of spores

The number of spores produced by an alga is enormous. In nature only a small number

of spores grow to mature plants since viability, settlement and development of these spores are controlled by hydrobiological factors such as water movement, tidal-exposure, water temperature, competition for space and predators or grazing organisms. When the spores are raised into germlings on suitable substrata in the laboratory or nursery and then transplanted to the field, a high rate of germlings grow to harvestable size plants. Some work in this direction of culturing the spores of economically important seaweeds was carried out in recent years.

Subbaramaiah *et al.* (1967) cultured germlings of *Ulva lactuca*. The germlings were kept growing in attached or in a free floating condition in petridishes containing sterile seawater which was changed once a week. In two months time the germlings differentiated into cylinderical plants with 2-3 branches arising from the basal cells. The floating plants were found to be longer (1.25-1.7 m) and produced branches while the attached ones were shorter (0.75-0.83m).

The effect of different culture media on growth and sporulation of laboratory raised germlings of *Ulva fasciata* was given by Oza and Sreenivasa Rao (1977). Kala and Krishnamurty (1967) studied the effect of plain seawater, Erdschreiber seawater and artificial seawater medium (modified ASP-6) on the growth of germlings of *Ulva lactuca* var *rigida*.

Mairh and Krishnamurty (1968) observed 100% germination of spores of *Cystoseira* and subsequently 94% of their survival. The germlings survived and grew to young and healthy plants under experimental conditions. Chauhan and Krishnamurthy (1967) cultured the oospores of *Sargassum swartzii* in petridishes lined with filter paper. They developed into germlings and some of them grew for a period of five weeks. Experiments were also conducted using different substrata such as coral pieces, shells, granite stones, nylon threads and rough stones. Some of the oospores attached to the substrata developed into healthy germlings while a large number did not survive. Continuous illumination of the culture experiments with a light intensity of 600-800 lux, 23-26°C temperature and circulation of a thin stream of filtered seawater were found favourable for healthy growth of germlings. Chauhan (1972) observed the survival of germlings in *Sargassum swartzii* for about six months under the controlled laboratory conditions. Of the eight different substrata used, the concrete blocks, bricks and filter paper were found to be good substrata as they retained 84.55%, 78.42% and 62% of the germlings respectively. The filtered seawater and enriched seawater were found to be most suitable culture media for the growth of germlings. The use of media like ASP-6 and ASP-12 did not give good growth of germlings. Continuous illumination was found to be more beneficial than 18 hours photoperiod.

Raju and Venugopal (1971) made an attempt to allow the oospores of *Sargassum plagiophyllum* to settle on a concrete substratum with a view to find out the time required for the appearance and growth. The concrete cylinders were lowered in *Sargassum* beds. Observations revealed that the appearance of *Sargassum* germlings on the cylinder took 10 months and another 8 months to grow to maturity. Observations after one year revealed that there were a number of new plants which had germinated from the spores within the year and some had regenerated from persisting holdfasts. There appear to be potentiality for regeneration for a third year in a few plants. Umamaheswara Rao and Kaliaperumal (1976) maintained the oospores of *Sargassum wightii* in a medium of seawater enriched with agar-agar and found that 47.6% of germlings were in healthy condition at the end of 60 days. Krishnamurthy *et al.* (1969) raised the germlings of *Gracilaria edulis* and *G. corticata* on a nylon fabric from carpospores under laboratory conditions. They were transferred to the sea. After four months, young plants appeared and they took another four months to attain maturity and develop reproductive structures.

Chennubhotla *et al.* 1977 (unpublished) conducted laboratory culture experiments on the viability, germination, growth of germlings

of *Turbinaria ornata* and *Gracilaria edulis* under controlled temperature of 18±2°C and light intensity of 4 R lux. The spores of *T. ornata* were found to be viable even after a period of 2 months, but growth of germlings was not satisfactory. Carpospores of *G. edulis* were allowed to germinate and parenchymatous stage of development was noticed.

It is understood tha UNDP/BOBP programme at Madras has embarked on culture of seaweeds by tetraspores in Mandapam-Vedalai area. This may throw light on the aspect of spore culture in the natural environment.

Environmental factors in relation to seaweed culture

In the Central Marine Fisheries Research Institute, the culture experiments were conducted in different seasons of the years from 1976 to 1985 continuously. Although there were variations with respect to the quantity of seed material introduced, the yield rate showed fluctuations during certain seasons. In order to understand these variations, relevant environmental data were collected from the inshore waters where culture operations were carried out.

The average values of each environmental parameters such as surface temperature, salinity, O_2 and nutrients during each culture operation were compared in relation to biomass increase and duration of culture period (Table1). It was observed that no single environmental parameter could be pinpointed as responsible for variation in production. At best it could be inferred that a complexity

Table 1. *Data on seaweed production and related environmental factors*

Year	No. of days of culture operation	Initial weight of seed material (in Kg)	Final weight (Kg)	Ave.gain of seed/ day	Mean values of hydrological data						
					Surface Temperature (°C)	Salinity (‰)	O_2 ml/l	Po_4	No_3 µg-at/l	Sio_6	pH
1976	40	0.90	4.00	0.0775	28.6	29.16	4.57	0.29	0.49	12.59	8.2
Gulf of Mannar	30	1.00	4.30	0.1100	27.7	32.79	4.65	0.45	0.53	8.25	8.2
1977 Gulf of Mannar	88	34	162.17	1.4565	27.3	30.31	4.38	1.55	0.15	0.73	8.13
1979 Gulf of Mannar	60	1800	4.70	48.3300	29.68	32.03	4.59	2.78	12.10	3.65	8.18
1980	90	6.65	16.17	0.1058	29.48	35.29	4.59	0.59	3.13	6.36	8.20
Palk Bay	70	560	733.70	2 4814	28.69	31.76	5.17	0.82	9.85	18.11	8.10
1984-85 Gulf of Mannar	60	2.4	7.50	0.0850	27.3	30.00	4.95				7.9
1985 Gulf of Mannar	55	1.80	9.50	0.1400	29.3	29.72	5.51	0.12	0.44	60.00	7.4

of environmental factors operating in a dynamic inshore area may be responsible for seasonal variation in the yield of seaweeds. The Gulf of Mannar & Palk Bay experience contrasting seasonal changes in wind velocity and direction and wave action. The solar radiation in the region, rainfall, transport of inorganic and organic material into the region are some of the factor other than those observed parameters.

Survey of seaweed resources

The surveys conducted in various maritime states have revealed that the resources of seaweeds along our coasts can be put around 1 lakh tonnes. The break-up figures are given in table 2.

The seaweeds along Indian cost are mainly harvested by small as well as large scale industrialists by engaging drivers. Seaweed collection is a profession by itself and offers employment to rural population. There are a number of agents who deal directly with the collection and supply of seaweeds to the industries. The methods of collection of seaweeds are very crude at present and hence extension work is very essential to educate the people in colletion and management of the natural beds in a judicious way.

Economics of seaweed culture

In view of the importance of marine algae as a source of food, fodder, fertilizer and pharmaceutical compounds, augmentation of this resource by different methods has to be undertaken. The economics worked out by the Central Marine Fisheries Research Institute indicate that atleast a minimum of Rs. 500/- per month accrues to the farmer by taking up cultivation in one hectare area.

Culture experiments conducted in the inshore coastal waters from 1972 to 1986 in Gulf of Mannar and in Palk Bay have revealed that on the culture frames the agarophyte *Gracilaria edulis* reaches the maximum length (harvestable size) within three months while in nature it takes 4 to 5 months time.

These studies have further indicated that the minimum period for the seed material to reach harvestable size is 2 months for *G. edulis* and that the length of the algae at the time of harvest world be 20 to 25 cm. The suitable period for carrying out the culture operations

Table 2. *State-wise annual yield of seaweeds.*

Stn. No.	Area	Annual yield in tonnes (fresh weight)	References
I	Tamil nadu	22,044	Subbaramaiah *et. al.* (1979a)
II	Gujarat	20,000	Chauhan and Krishnamurthy (1968) Bhanderi and Trivedi (1975) Sreenivasa Rao *et. al.* (1904) Chauhan & Mairh (1978)
III	Maharashtra	20,000	Untawala *et. al.* (1979)
IV	Lakshadweep Islands	8,000	Subbaramaiah *et. al.* (1979 b)
V	Goa	2,000	Dhargalkar (1981)
VI	Kerala	1,000	Chennubhotla *et. al.* (1987)
		73,044	
VII	Unexplored area	27,000	
	Total	1,00,044	

are October to April in Gulf of Mannar and May to September in Palk Bay.

Harvesting is done by hand picking or by cutting the crop with sickles leaving the basal portions to the net for regeneration. One Kg of seed material of *G. edulis* yields an average of 3 kg/m² of net after 60 days of growth. In one ha area of nets (i. e. 1000 nets) 30 tonnes of fresh *G. edulis* could be harvested. Based on the above studies the economics of culture of *G. edulis* has been worked out for a hectare area and details are given below:

For the cultivation of *G. edulis* in one ha area, 1000 coir nets of 5 x 2 m size, 2000 casuarina poles of 1.5 m height and 10,000 kg of fresh seed material (for initial introduction) are required. The cost of 2000 casuarina poles is Rs. 6000/- (approximately) and the cost of 1000 coir rope nets is Rs. 33,000/- including charges for fabrication. The seed material will be collected for the initial introduction from the natural beds and from the cultured crop for the subsequent seeding. Wages for seeding, harvesting and maintenance of the farm for 4 persons at the rate of Rs. 10/- per day for 360 days workout to Rs. 14,400/-. The total expenditure for one year would be Rs. 54,000/- including a miscellaneous expenditure of Rs. 600/-. The estimated cost is arrived at on the assumption that a minimum of four harvests could be made in a year. A total of 120 tonnes (fresh weight) of crop could be obtained from the four harvests in a year when the yield is 3 kg/m². If the seaweed is dried (75% moisture) and marketed at a rate of Rs. 2000/- per tonne, the net profit would be Rs. 6000/- for one year.

If the harvested seaweed is dried and converted as agar-agar, the profit will be around Rs. 1,00,000.

Predators

At Mandapam, the culture frames were often the target of attack by certain fishes like *Siganus javus* and *S. canaliculatus*. The crabs *Thalamita crenata* and *T. integre* caused extensive damage to growing parts of the seaweeds by merely clipping them with their chelipeds as they crawl about amongst the seaweed (James *et. al.* 1980). The problem of predators can be solved to a great extent by enclosing the cultivation area with latticed fence or a net of a suitable mesh size.

Effects of hormones on the seaweed growth

Studies on this aspect are very limited. Oza (1971) has found that low concentrations of IAA progressively stimulated the growth of *Gracilaria corticata* while higher concentrations were found to be lethal. Raju (1971) conducted experiments on the effect of hormones and fertilizers on the photosynthetic carbon assimilation in *Ulva fasciata*, *Sargassum* sp and *Gracilaria corticata*. The photosynthetic uptake of C^{14} was found to be maximum in *G. corticata* followed by *U. fasciata* treated with gibberellic acid. In *Sargassum* maximum effect on photosynthetic C^{14} assimilation was observed in plant supplied with ammonium sulphate. Tewari (1975) found that Chlorflurenol in hormonal range increased the fresh weight and the number of proliferations. But the elongation growth was found to be inhibited. Chauhan and Joshi (1979) reported that Indole-3-acetic acid at the concentration of 10^{6} proved a stimulant on the growth of *Sargassum swartzii* germlings than the other concentrations tried. The 10^{-3} to 10^{-6} M concentration of Gebberellic acid helped in increasing the length of pseudophylls of the sporelings.

Conclusions & Recommendations

1) Attempts have to be made to simplify the seaweed culture technology so as to reduce the cost of production and to make the technology economically viable.

2) The seaweed farmer and his family members or some families jointly have to undertake on co-operative basis, the cultivation of seaweeds and extract agar-agar.

3) The cultivation of seaweed is beset with problems such as grazing by fish in the sea and hence some times the yield in

the crop and thereby the production may come down from the expected level. Hence, some attempt should be made to find out the methods of controlling the grazing of the crop by fishes and other predators.

4) In order to enable the fishermen or landless labourers to undertake the seaweed cultivation, the Government may offer credit facilities with subsidies under the programmes such as IRDP, DPAP etc. which will be of immense use to them.

5) Use of hormones and fertilizers must be tried in the culture fields or the seed material may be pre-treated with hormones.

6. Evolving of hybrid varities of seaweeds by genetical methods may be given due consideration.

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AN ECONOMIC ANALYSIS OF PRAWN CULTURE IN ANDHRA PRADESH-SOME PRELIMINARY FINDINGS

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ABSTRACT

Inadequate supply of quality seed is one of the chief constraints that impedes the quick development of prawn culture. Estuaries still remain the largest source of prawn seed supply. They are likely to remain so atleast for sometime in offing before the hatchery production of seeds is undertaken commercially and massively. The Marine Products Export development Authority assists the prawn farmers in setting up prawn seed banks by providing technical assistence on prawn culture, undertaking site selection and farm surveys, preparing project reports for submitting to the banks to get financial assistance, releasing subsidy to the tune of 15% on the capital cost of the project and providing continued technical assistance throughout the culture period. Already some prawn farmers have started establishing such prawn seed banks and supplying prawn seed commercially. This paper presents and discusses results of case studies on the economic feasibility of setting up prawn seed banks by fish farmers/prawn farmers.

INTRODUCTION

The export of Indian Marine Products earned Rs. 4,607 million during 1986-87. It registered more than elevenfold increase over Rs. 400 million earned during 1971. Frozen Prawns continued to be the main item of the export accounting for a share of 57.32 per cent (49203 tonnes) in terms of quantity and 82.03 per cent (Rs. 3,779.3 million) in terms of value. India is no longer the largest producer of prawns and production from marine capture fisheries is claimed to have levelled off possibly due to economic over fishing, if not biological over fishing. Obviously, increased production of prawn is possible through aquaculture only. However, traditional forms of prawn culture occupy about 43000 ha and produce 15000 to 17000 MT of prawns annually. Major production areas are Kerala and West Bengal and Andhra-Pradesh is coming up fast to join the line. Timely availability of adequate credit is one of the crucial needs for development and adoption of prawn culture. But commercial banks are wary of releasing loans for farming operations for want of information on the economic viability of the project. Since prawns command high unit value realisation, and prawn culture operations are generally promising, availability of information on its economics would go a long way in motivating individuals and big firms to take up prawn culture on a large scale. Hence the present study was undertaken to investigate the economics of prawn culture in a 1 ha pond in Andhra Pradesh.

The Status of Prawn Culture in Andhra Pradesh

Prawn culture operations in the state commenced in late seventies. The initial tempo receded in early eighties due to poor returns since most of the farms suffered from technical and physical defects. The adoption of prawn culture operations showed rapid development in the last couple of years. However, only improved extensive culture technique is widely followed. Since the results are encouraging, this tempo is likely to gain momentum, further, which may lead to adoption of semi-intensive culture technique in due course. Such a change is expected to ensure higher returns and desirable also.

Table - 1. *Abstract Estimate* (W.S.A.=0.75 ha)

Sl. No.	Description	Quantity	Rate	Per	Amount
1.	Earthwork excavation in pond and formation of bunds with excavated earth with one extra lead over initial lead and lift including consolidation, formation of berms, sectioning of bunds, including supply of all labour, tools, materials etc., complete.	2350 M^3	7-50	M^3	17,625
2.	Construction of 60 cm wide open type brick masonry inlet cum outlet sluice over concrete foundation, three pairs of grooves on head walls for fixing wooden and screen shutters, plastering of all exposed surfaces with CM 1:3 etc., including supply of all materials tools, labour, etc. complete.	1 no	8000	1	8,000
3.	Temporary Shed.	1 no	L.S		500
4.	Supply of nets, buckets, screen etc.		L.S		500
					26,625
				or say	27,000

Table - 2 (a) *Salient Features of a Prawn Farming Project in Andhra Pardesh*

1.	Name and place of the project/farmer	:	K. Ramudu Tallapalem Village Machilipatnam Taluk Krishna District.
2.	Total land area	:	1.0 ha
3.	Total water spread area	:	0.75 ha
4.	No. of grow-out ponds	:	one
5.	Total Cost of the project	:	Rs. 33,060

Table 2 (b) *Economics of the 0.75 ha WSA of prawn culture pond at Tallapalem Village*

A. *Fixed Cost*

			Rs.
1.	Excavation of ponds, construction of bunds and surface dressing (abstract estimate)	:	17,625
2.	Cost of closed type outlet	:	8,000
3.	Temporary shed	:	500
4.	Other capital items (nets, buckets, velon screen etc)	:	500
5.	Depreciation of pipe outlet @ 10% on Rs. 8,000/-	:	800
6.	Depreciation on shed and other items @ 30% on Rs. 1,000/-	:	300
7.	Annual Interest @ 12.5% per annum on Rs. 26,056/-	:	3,257
8.	Preparation of pond @ Rs. 100/ha	:	75
9.	Maintenance of ponds, canals etc @ Rs. 200/ha	:	150
		Rs.	31,207

B. *Variable Cost*

		Rs.
1.	Cost of Fertilizers & lime @ Rs. 800/ha	600
2.	Cost of seed @ Rs. 70/1000 Nos for 20000/ha	1,050
3.	Cost of feed @ Rs. 2500/ha	1,875
4.	Pump hire charges Rs. 1000/ha	1,300
5.	Harvesting and Marketing charges @ Rs. 200/ha	150
6.	Labour cost - seasonal employment	500
7.	Other contigencies @ Rs. 100/ha	75
		Rs. 5,550

C. *Total Cost*

Fixed Cost	Rs. 31,207
Variable Cost	5,550
	36,757

D. *Returns*

Net Returns were worked out on the variable cost basis.

I Year income as sale proceeds of prawns @ 300/kg/ha/ crop of 50 count @ Rs. 50/kg for two crops	Rs. 30,000
Less	
Variable Cost (5500 x 2)	11,000
Repayment of 1st instalment with Interest	7,312
Items 5,6,8 & 9 of the Fixed Cost	1,325
Total (30,000-19,637)	Rs. 10,363

Table–3

Year	Income	Expenditure/Repayments				Balance
		Variable Cost	Relevant items of Fixed Cost @	Bank Instalment	Interest	
1.	30,000	11,000	1325	4055	3257	10,363
2.	30,000	11,000	1325	4400	2750	10,525
3.	30,000	11,000	1325	4400	2200	11,075
4.	30,000	11,000	1325	4400	1650	11,625
5.	30,000	11,000	1325	4400	1100	12,175
6.	30,000	11,000	1325	4400	550	12,725

@ includes annual recurring expenditures noted as item numbers: 5,6,8 & 9 in the Fixed Cost category.

The economics of prawn culture in a 1.0 ha pond having a waterspred area of 0.75 ha is presented in Tables 1 to 3.

With a moderate production of 300 kg/ha/crop, the farmer was able to meet all his loans and earn a net income of Rs. 10,363 in the first year and from second year onwards his income increased gradually. He is expected to repay all his loan to the bank in the sixth year, after which he would get a steady income of Rs. 17,675 every year. Even though the economics of prawn culture was estimated on the basis of variable cost inclusive of certain chosen items of fixed cost, a high income of Rs. 17,675 annually and the scope for stepping up the production with added experience would take care of the cost included under fixed costs, in a few years. It should also be noted that the MPEDA's subsidy on feeds was not included (50% of the feed cost).

SUMMARY AND CONCLUSION

The present economic investigation conclusively showed that a farmer can obtain promising revenue by undertaking prawn culture. The minimum subsidy of 15% made available by the MPEDA for prawn culture was considered whereas the BFDA extends high subsidy to the tune of 25%. With passage of years, production can be increased remarkably. It seems that a break through in producing pond-raised prawns is possible since every governmental and non-governmental agency besides the private sector, is competing with each other in developing prawn culture. What is required is a well-knit, co-ordinated approach in ensuring timely and adequate availability of inputs like quality seed, feed equipments, credit, chemicals for tackling diseases, that would result in massive adoption of the technology. Then it could be followed-up with increasing the unit production, keeping the cost of production low and ensuring a balance in the environment.

STATUS OF BRACKISHWATER PRAWN FARMING IN ANDHRA PRADESH

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ABSTRACT

Andhra Pradesh is estimated to have 762.51 ha of brackishwater area under prawn culture. Prawn culture in brackishwater ponds as well as in paddy fields converted into prawn ponds is picking up fast in the coastal districts of Andhra Pradesh, especially in East Godavari, Krishna and Guntur districts. There are more than 200 ha of brackishwater areas suitable for prawn culture in West Godavari district alone. More and more are being brought under prawn farming in this district. Semi-intensive culture technology is employed by the fish farmers. The average yield is estimated at 450 kg/ha/crop. This paper presents and discusses the status of prawn culture in Andhra Pradesh, identifies the constraints and suggests strategies for bringing the abudantly available brackishwater areas under scientific prawn culture to increase the yield from these ponds.

INTRODUCTION

Prawn culture ensures very high returns in India. Increasing international demand for penaeid shrimps, especially from Japan and USA, has triggered of commercial penaeid prawn culture in the country rapidly. Prawn culture activities commenced in Andhra Pradesh in late seventies and gained momentum during 1978-81. To start with, some enthusiastic farmers including a big multinational company initiated commercial prawn culture in the state. Soon a big prawn farm measuring 207 ha came into being in West Godavari in 1982. However, these operations could not last long since most of the farms suffered from physical and technical defects. This made the farmers as well as financial institutions wary of prawn culture. Meanwhile some farmers accidentally found that tiger prawn (*P. monodon*) could survive and grow in freshwater ponds and culturing of tiger prawn with Indian major carps became popular, notably in Krishna District. Motivated by high returns (in some areas poor returns from paddy fields encouraged farmers to take up prawn culture also), the farmers started prawn culture on large scale. The success of commercial prawn culture in Krishna, West Godavari, East Godavari and Guntur Districts led to an unprecedented rate of development of prawn culture operations bringing about 1000 ha under prawn farming within a short span of 2-3 years. The state government brought 300 ha under prawn culture. It is estimated that the area under prawn culture during 1986-87 is likely to exceed 2000 ha. Production of pond raised prawns increased from an estimated 1.5 tonnes in 1981-82 to 354 tonnes in 1986-87 and has already started feeding processing plants in Visakhapatnam.

POTENTIAL BRACKISHWATER AREA

The state is endowed with a long coastline (982 km) and its vast brackishwater sources including brackishwater lakes, open estuaries and adjoining low lying swamps have been estimated at 0.2 million ha. The State Department of Fisheries conducted a survey in 1980 covering 64000 ha of low lying areas adjoining open estuaries spread over 176 sites and identified about 17000 ha as suitable for prawn culture. The district-wise distribution of these areas is shown in Table-1.

Table-1. *Area Suitable for Prawn Cuture* (with details of ownership)

Sl. No.	District	Fisheries Department	Revenue Department	Forest Department	Salt Department	Port Department	Private	Total
1.	Srikakulam	136.00	336.00	—	324.20	—	520.00	1316.20
2.	Vijayanagaram	—	0.53	—	—	—	9.47	10.00
3.	Visakhapatnam	—	368.73	—	—	—	351.47	720.20
4.	East Godavari	—	1795.00	1300.00	—	10.00	240.00	3353.00
5.	West Godavari	—	610.00	—	—	—	922.00	1532.00
6.	Krishna	—	5854.00	200.00	—	—	185.00	6239.00
7.	Guntur	—	244.00	1132.00	—	—	—	1376.00
8.	Prakasam	—	580.00	—	140.00	—	100.00	820.00
9.	Nellore	—	1601.00	—	20.00	—	19.00	1640.00
	Total	136.00	11389.26	2632.00	484.20	10.00	2354.94	17006.40

Source: Directorate of Fisheries, Andhra Pradesh.

The State Department of Fisheries survey as well as the report of the TCDC mission which surveyed the brackish water areas in the state in 1981 found that the climate, soil and water quality of the coastal sites are generally favourable for prawn culture.

With the development of pump-fed ponds in elevated areas, deemed to be unfit for pond culture earlier, the farmers, and the State Fisheries Department have in due course of time spotted new suitable brackishwater areas which were not included in the earlier surveys. It is estimated that there would be atleast 20000 ha of such unsurveyed yet suitable government and private sites in the state. There is scope for utilising some of the brackishwater lakes in the state for pen culture or seasonal prawn culture operations.

Area under prawn culture

The rapid development of prawn culture, that became perceptibe in the last few years, in the State is chiefly attributed to the active role of the private sector. The State government and their agencies have also taken up effective steps to bring in more and more area under prawn culture to benefit weaker sections. The district-wise distribution of private sector farms is given in Table-2.

Table-2. *District-wise distribution of private prawn farms in Andhra Pradesh*

Sl. No.	District	Area under prawn culture (ha)
1.	Srikakulam	1.40
2.	Visakhapatnam	25.00
3.	East Godavari	215.35
4.	West Godavari	240.20
5.	Krishna	416.70
6.	Guntur	141.66
7.	Prakasam	3.00
8.	Nellore	5.00
	Total	1048.31

Technology employed and production of pond-raised Prawns

The size of the prawn farms ranges from 1.0 to 50 ha and that of individual ponds varies from 0.4 to 3.0 ha. About 90 per cent of the farms use pumps for filling in the ponds and exchange of water.

An improved extensive prawn culture technology is being widely employed by farmers in the state. Initial fertilisation is done to develop natural food. The stocking density in general is from 8000 to 50000 per ha (mostly tiger prawns) and culture period lasts from 3 to 6 months. Supplementary feeds such as rice bran oil cake, soyabean meal, trashfish, and clam meat are also given.

The production of pond-raised prawns varies from 159 to 500 kg/ha/crop. The estimated total production of pond-raised prawns increased from a mere 1.5 tonnes in 1981-82 to 354 tonnes in 1986-87.

FACILITIES AVAILABLE FOR PRAWN CULTURE

Prawn seed resources

The prawn seed resources in general and those of *P. monodon* and *P. indicus* in particular are abundantly available in the State. Post-larve of these species are comercially exploited in various places such as Ichapuram (Srikakulam District), Vakapadu (Visakhapatnam District), Kakinada and adjacent mangrove areas of Godavari estuary (East Gadavari District), Perumpalom (West Godavari District), Kruthivenu and Machilipatnam (Krishna District) and Repalle (Guntur District). A number of potential areas of prawn seed resources remain to be identified and exploited.

Seeds of *P. indicus* are available in all the brackishwaters of the State in considerable quantities whereas those of *P. monodon* are found in good quantities in Srikakulam, East Godavari, West Godavari, Krishna and Guntur districts only. Tiger prawn seeds are collected mainly during the periods July to September and from November to December, the two peak periods of recruitment. It is estimated that at present about 35 million seeds of the two commercially important species of prawns are collected and supplied to the prawn farmers annually.

Prawn seed collection and supply is a well established trade in the various centres of seed collection, offering part-time employment to several hundred people. The gears used for seed collection, include hand nets, scoop nets, push nets and shooting nets. They are mostly transported in buckets for shorter distance and under oxygen packs for longer distances.

Appropriate land policy

The State government have framed suitable policies for leasing out the brackishwater areas for the benefit of weaker sections of the society like fishermen, persons belonging to SC/ST communities, besides small-scale self-employed entrepreneurs and large firms. The leasing policy of the State government is not only development oriented but takes care of the interests of weaker sections of the society. About 300 ha of brackishwater area have already been released and converted into prawn ponds for the benefit of the down trodden. A number of schemes are being drawn to bring in atleast 1000 ha area under prawn culture for weaker sections in the next few years. There are indications that the State government is likely to release brackishwater sites to technocrats (20%) and large-scale enterprises (20%) shortly.

Power supply

The assured and continuous power supply (except during summer when harvest commences) in the State has encouraged use of pumps to feed ponds with brackishwater irrespective of elevation and tidal amplitude. This has avoided expenses in constructing expensive tide-fed ponds in elevated areas and permitted suitable designs to pump in water. The draining is accomplished by

gravity flow to save money. Thus comfortable power supply is an added advantage for the development of prawn culture in the State.

Technical assistance

Some of the Central and State government organisations in Kakinada played a pivotal role in the development of prawn culture in the State by imparting training in the prawn culture and extending technical assistance to the prawn farmers. The Kakinada centre of CIFE, Bombay and APAU were mainly responsible for the development of prawn seed collection as a trade in some of the coastal districts of the State. The brackishwater unit of the State Fisheries Department, has a contingent of engineers and technical personnel at its Visakhapatnam, Kakinada and Guntur offices and has been involved in surveying brackishwater areas hitherto unnoticed. They also prepared project reports for centrally sponsored as well as State government schemes and drew the master plan for the development of Polekuru area for prawn culture operations. The Central Institute of Coastal Engineering for Fisheries (CICEF), Bangalore has also surveyed considerable brackishwater areas in East Godavari and Krishna Districts and prepared project reports for centrally sponsored schems. With the establishment of a regional centre (prawn farming) at Machilipatnam, the MPEDA came into picture. It has been actively involved in the development of prawn culture in the State with its technical and financial assistance schemes. The role of MPEDA in this context is dealt with separately.

Financial support

Institutional finance (refinanced by NABARD) is made available to a large number of private entrepreneurs for construction of ponds and culture operations. Prawn culture schemes implemented by the State government and their agencies have received considerable financial assistance from the DRDAS, SC Societies/Corporations, BC corporation, State Fisheries Department and nationalised banks. Under Area Development Programme, Central Government's assistance is extended to the State for developing prawn ponds. The MPEDA is extending financial assistance to prawn farmers for construction and operation of prawn culture farms and other related activities.

CONSTRAINTS TO PRAWN CULTURE DEVELOPMENT

The constraints to prawn culture development in the state are discussed under two heads: Specific constraints and General constraints in the state.

Non-availability of government land

Non-availability of the brackishwater site is the major bottleneck in the development of prawn culture in the state. Out of the 17000 ha identified as suitable for prawn culture, 14600 ha (86%) are owned by government departments such as revenue (67.0%), forest (15.4%.) and salt department (3.6%). Forest lands are protected by law and salt lands are earmarked for salt production. Hence, revenue porambokes are available for allotment for prawn culture. The State government has not yet come forward to allow the brackishwater sites under revenue department to the two categories, viz., unemployed persons and entrepreneurs as proclaimed in the G. O. MS No. 286 F & RD (Fish II) Department dated, 11th August, 1980. Even though several entrepreneurs are interested in taking up commercial prawn culture, non-availability of lands dissuade them.

Lack of information on brackishwater sites

There are large stretches of brackishwater sites owned by private parties and government in the various coastal districts not covered hitherto by the earlier survey. Information on the suitability of these sites for prawn culture is lacking. Similarly, information on the suitability of vast expanse of fallow lands located near brackishwater drains and

connected to the sea for prawn culture is not available.

Inadequate tidal amplitude and power problems

The tidal amplitude along the coast of the state is inadequate and ranges from 1.0 to 1.6 m; since most of the suitable coastal sites are in elevated position, use of pumps becomes inevitable.

Despite an assured power supply, prawn farmers find it difficult to get power connections. Getting power supply to the remote coastal sites is costly as the electricity board charges heavily for the line, transformer etc. The status of prawn culture vis-a-vis power supply is yet to be decided by the A.P.Electricity Board. Presently industrial tariff rate are applied to the power supplied to prawn ponds. The concessions enjoyed by agriculturists are not extended to aquaculturists.

Dearth of seed supply

The seed supply is exclusively from natural sources like estuaries. It is seasonal and subjected to vagaries of nature making it unreliable. The farmers plan to stock their ponds in June so as to harvest the first crop in November and restock in December when there is seed supply. Lack of seed supply in June extends stocking upto August or even September delaying the second crop. The problem becomes more severe as more and more areas are being brought under prawn culture. There exists a dearth of tiger prawn seeds and the problem will become acute in the next two or three years.

Non-availability of suitable prawn feed

It is a known fact that no suitable prawn feed, especially for tiger prawns, is available in India. The low yield in prawn farms in the State is attributed to this constraint. Most of the farms use rice bran, and oil cake as no animal meat (trash fish, clam meat etc.) is easily available. It is felt that with a suitable cheap feed, nutritious, stable and abundantly available, the production from prawn ponds could either be doubled or trebled.

Marketing constraints

Important problems in marketing of cultured prawns are: (1) seasonal fluctuation in the price of prawns and (2) exploitation by middlemen who procure the pond-raised prawns from producers and supply them to exporters.

Lack of infrastructural facilities

Most of the brackishwater sites are located in the coastal areas and have no approach roads and bridges to cross creeks, resulting in increase of transport charges for inputs. Lack of drinking water is another major problem.

Competition for brackishwater lands

Increased competition for lands for forestry (sanctuaries), salt manufacturing and connected industry, and tourism is yet another constraint. It may be mentioned here that more than 20,000 ha of brackishwater sites suitable for prawn culture have been handed over to salt manufacturers in the State.

Other constraints

The other important constraints to prawn culture developmet in the State are: (1) technological constraints (lack of knowledge in advanced culture techniques, lack of information on suitable pond design, etc) and 2) shortage of experienced engineers and extension workers in prawn culture.

SHRIMP FARMING BY PRIVATE ENTERPRISE- A CASE STUDY

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ABSTRACT

In view of the encouraging results shown by the research organisations of India and other countries in prawn culture on scientific methods, a commercial research and development project on prawn culture was established by the TATA Oil Mills Co. Ltd., at Pulicat. Experiments were conducted in earthern ponds of size ranging from 0.4 to 1.25 ha. Stocking rates ranging from 6.5 to 15 prawns/m² were attempted and production to the tune of 0.5 to 1.0 tonne/ha/crop was achieved. Survival rate over 80% could be maintained in all the crops. An artificial feed formulated with shrimp meal, trash fish and vitamin mineral mix along with other usual ingredients, with a protein content of 40%, proved to be better than the other conventional feed. Effect of design of a pond, aging of pond, stocking density, stocking size and various hydrobiological parameters viz. salinity, dissolved oxygen and pH were also studied. The intensive stocking rate, the successful feed formula and the effective water managements adopted were the important reasons for the successful production of shrimps in this farm. The cost of production of 1 kg of shrimps considering the variable cost, varied from Rs. 20.00 to 34.00 and thus a net revenue of Rs. 8000.00 to 20,000.00/ha/crop was achieved.

INTRODUCTION

Though traditional methods of prawn culture were known for years in the *Pokkali* fields of Kerala and the *Bheries* of West Bengal, the scientific way of culture till recently has not been attempted on a commercial scale. During the last decade significent achievements have been made in prawn farming in many parts of the world as they fetched very high price when sold as luxury food (Wickens, 1976). With continuous exploitation of wild prawn resources in India, the marine landings have come down. Hence considerable importance has been recently given towards scientific prawn farming and expanding the area of culture in brackishwater areas.

Though a number of private entrepreneurs have taken up shrimp farming, most of them are not fully aware of the technology of intensive prawn farming, perhaps due to nonavailability of adequate demonstration ponds. Many Government Institutions including the Central Marine Fisheries Research Institute, Central Institute of Fisheries Education, Marine Products Export Development Authority and State Fisheries Departments which have involved themselves in generating and disseminating prawn culture technology also face considerable constraint such as non-availability of seeds and a policy for the allotment of cultivable areas for culture. The coastal people are not financially sound to take up the capital intensive but rewarding culture practice. Though these are some of the general problems on the way for the development of prawn farming in the country as a whole, there are certain specific problems in prawn farming based on the local environmental conditions. The low tidal amplitude prevailing in Tamil Nadu coast is one such problem for example. Thus there is urgent need for developing suitable technical know-how based on our ecological conditions. Keeping these aspects in mind, an attempt was made by TATA OIL MILLS CO. LTD., at Pulicat for standardising the technique for commercial shrimp production.

MATERIALS AND METHODS

The farm is located 60 km north east of Madras city on the western bank of Pulicat

Table 1. *Stocking rate, size, survival and shrimp production in experiments on the culture of* Penaeus indicus *along with the mean hydrobiological parameters.*

Sl. No.	Pond size	Stocking rate (Nos/m²)	Duration (days)	Size at harvest (g)	Survival (%)	Production (kg/ha)	Hydrobiological parameters		
							Salinity (ppt)	Do (ppm)	pH
1.	1.25	5.5	110	12.3	81.0	548	34.0-40.5	2.42-5 2	7.9-8.2
2.	1.26	7·2	110	11.8	83.1	706	18.6-38.0	2.31-4.0	7.9-8.3
3.	0.40	7.5	115	10.6	80.4	637	20.2-38.5	2.00-4.50	7.8-8.2
4.	0.80	7.5	110	12.1	84.0	762	20.0-36.0	2.6-5.0	8.0-8 2
5.	0.40	10.0	110	11.2	93.7	1050	20.5-38.0	3.4-4.3	8.0-8.3
6.	0.50	15.0	120	7.0	85.0	892	28.7-.40.0	2.0-5.0	8 0-8.1

Hydrobiological data were obtained from water samples collected prior to 0700 hours.

lake. The hydrological parameters of this lake are influenced by the adjacent sea and the Buckingham Canal running parallel to the lake which pours in appreciable amount of freshwater into the system during rainy season. The farm has a total area of 13.3 ha of which water spread area is 7.5 ha comprising of 5 nursery ponds and 10 rearing ponds. The size of the rearing ponds was varying from 0.4 to 1.25 ha. Since tidal influence was appreciably low, pumps were used for watering the ponds. The dimentions of the ponds are given in Table 1. The bundhs were turfed with grass to prevent erosion. A diagonal trench of 3' width and 2' depth was excavated across the pond upto the collection box near the outlet. The outlet was guarded by a net shutter and a wooden shutter. The water, pumped from the lake was filtered at several points using Velon screen nets (40 P) before reaching the culture ponds. The nursery ponds were provided with sprinklers for effective aeration as they had more stock of juvenile prawns (100 to 150 nos/m²) all the time. Cowdung at the rate of 500 to 1000 kg/ha and diammonium phosphate (18:46:0) at the rate of 100 kg/ha were applied to the culture ponds for promoting the development of natural feed. A minimum depth of 80 cm water was thereafter maintained in all the ponds throughout the culture period.

Postlarval stages of white prawns, *Penaeus indicus* collected from the lake were conditioned and fed in the nurseries for a couple of weeks. The rearing ponds were stocked with these juveniles of almost uniform size (30-35 mm) at various stocking densities ranging from 55,000 to 1,50,000/ha. They were fed with pelleted feeds, having 40% crude protein, made out of ricebran (30%), groundnut oil cake (20%), tapioca flour (9%) fish meal/trash fish (20%), shrimp head powder (20%), and vitamin mineral mix (1%). The feed pallets were placed in feeding trays fixed at various points along the sides of the pond. The prawns were fed daily at the rate of 20% of their body weight for the first 30 days, 10% for the next 30 days and 5% for the remaining culture period. Prawn were also fed with fresh clam meat once in a week depending on availability. Fortnightly sampling was done in the ponds to assess the population and to observe the growth rate of the prawns. Hydrobiological parameters viz. temperature, salinity, pH and dissolved oxygen levels were monitored daily (A.P.H.A. 1965). After 30 days of culture, the pond water was flushed frequently to improve its quality.

RESULTS AND DISCUSSION

The details of stocking density, average size of prawns at harvest, prawn production

Table 2. *Operation cost of shrimp culture for one hectare area*

Sl. No.	Stocking rate (Nos./m²)	Seed cost (Rs.)	Feed cost (Rs.)	Fuel cost (Rs.)	Miscellaneous (Rs.)	Total cost (Rs.)	Cost of production (Rs./kg)	Net Revenue (Rs.)
1.	5.5	2200.00	6720.00	3600.00	1000.00	13520.00	24.67	8400.00
2.	7.2	2764.00	7680.00	3600.00	1000.00	15044.00	21.36	13116.00
3.	7.5	3000.00	9085.00	4285.00	1000.00	17370.00	27.27	8110 00
4.	7.5	3000.00	9150.00	4500.00	1000.00	17650.00	23 16	12830.00
5.	10.0	4000.00	12375.00	4500.00	1000.00	21875.00	20.83	20125.00
6.	15.0	6000.00	18420.00	4500.00	1000.00	29920.00	34.23	5040.00

along with some important hydrobiological characters are presented in table 1. The values of cost analysis of each crop are given in table 2. It is observed from the table 1, that among the various stocking densities in this study, the crop with 10 prawns/m² density gave the maximum production of prawn (1050 kg/ha/crop), whereas the pond stocked with the lowest density of 5.5/m² exhibited the least production of 548 kg/ha. The highest production recorded coincided with the highest survival rate of 93.7% and the lowest production was recorded in the pond with least survival of 81.0% and lowest stocking. However, the average weight at harvest was found to be more (12.3 g) in culture pond stocked with the lowest density of 5.5 prawns/m². The lowest average size of 7g was recorded in the pond with the highest stocking density (15/m²) due to over stocking. This is also supported by the fact that without aerating devices, the stocking density in natural ponds cannot be increased beyond 10 prawns/m² as observed by Muthu *et al* (1982). In countries like Japan, Taiwan and Korea, stocking densities of 15-20 prawns/m² are being tried and production to the tune of 2-3 tonnes/ha are generally obtained from aerated culture ponds indicating the importance of water quality management in pond culture systems. Stocking densities to the tune of 5 to 15 prawns/m² were attempted in the present study. Accordingly effective water management practices were adopted and hence higher survival rate (about 80%) and better production of shrimps could be obtained.

Provisions of an adequate and inexpensive artificial diet which ensures faster growth and greater survival has been advocated for successful production of shrimps. In the present study the ingredients of both animal and plant origin supplemented with vitamin mineral mix were used for feeding. Besides, the prawn shell meal incorporated in the feed resulted in positive growth enhancement and improved food coversion. It also adds to the palatabitity of the feed. The ingredient as a protein source is said to increase the efficiency of the diets; in fact even 25-35% protein levels have given good results in *P. japonicus* (Balazs *et al.*, 1973). Similar observations have also been made by Indian workers in penaeid prawns confirming the value of prawn shell meal in the palleted feeds. (Ahamed Ali, 1982; Ahamed Ali and Mohamed, 1982; Ahamed Ali and Sivadas, 1983) With the inclusion of prawn shell meal as one of the components in the preparation of the pellets, the cost of production of feed was kept below Rs. 3.25/kg. Thus, in the preparation of the feed, the low cost and the abudantly available prawn shell

meal can be incorporated in the preparation of shrimp feed.

Growth and survival which together determine the ultimate yield of shrimps are generally influenced by a number of ecological parameters controlled by managerial practices. Salinity is considered to be one of the major ecological factors for brackishwater prawns because any drastic change in this parameter could adversely affect the growth of the penaeid prawns. (Subrahmanyam, 1973; Liao, 1977 and Chakraborti *et al.*, 1985). It is observed from this study that the salinity range between 20 to 30 ppt enables faster growth rate of the white prawn, *Penaeus indicus*.

The second primary factor which influences the survival and growth of shrimps is oxygen in the water. The survival of penaeid prawns in the rearing ponds mainly depends on the maintenance of optimum oxygen level (Varghese, 1980). In the brackishwater ponds temperature, salinity and photosynthetic activity generally influence the O_2 content. It was found from this study that oxygen level has to be maintained in the ponds above 2 ppm to have good harvest of prawns. This level may be considered as a minimum below which shrimps may be adversely affected. Hence, a regular exchange of at least one fourth of the pond water during the later phase of culture period is inevitable.

The economics worked out for the crops revealed that the feed cost accounted for about 50-60% of the total variable cost. The fuel cost however showed about half of the feed cost ranging from 15-25%. it is interesting to observe that the pond which was stocked at the rate of 10 prawns/m^2 showed the lowest cost of production (Rs 20.83). Though the yield obtained from 15/m^2 experiment was fairly good (892 kg/ha) the cost incurred to produce a kilogram of prawn was very high (Rs. 34.23) possibly due to the highest cost incurred towards feed. The stocking densities between 7.5 to 10 prawns/m^2 were found to be ideal from the economic point of view. The net revenue obtained from the crop of 15/m^2 was the minimum (Rs. 5040.00) whereas from the other crops net revenue achieved were from Rs. 8100 to 20,125. The cost of production also varied between Rs. 20.00 to 27.00/kg in all the crops except the crop where the highest stocking density was tried.

The results obtained from this TOMCO Prawn Culture Farm has thus proved the possibility of generating economically gainful farming practice even in areas where the expected tidal amplitude is not experienced Similar programmes of culture using pumps for letting in water to the ponds have also been practiced in a few areas in Tuticorin and rewarding productions have been achieved. Since this technology for shrimp farming has been field tested in TOMCO it could be taken up by other small scale private entrepreneure. Depending on the area of culture and the availability of natural seeds, the profit percentage can be considerably enhanced. Newer techniques can also be developed to make use of the reservoirs used in salt production industries for prawn farming. Such attempts based on case studies will open new ways for increasing the prawn culture area in the state.

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Paper-54

AN ASSESSMENT OF THE POTENTIAL OF SPINY LOBSTER CULTURE IN INDIA

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ABSTRACT

Fluctuating catches and increasing demand in both internal and international markets for lobster tails necessitate augmentation of production through proper management strategies and possible aquaculture practices. The technical feasibility of economically viable aquaculture of few species of spiny lobsters is underway at the Field Laboratory of Central Marine Fisheries Research Institute, Kovalam, Madras. Though captive breeding of various species of spiny lobsters was achieved with ease, rearing of phyllosoma larvae to puerulii under controlled conditions was not successful. So serious attempt to cultivate spiny lobsters should begin with rearing juveniles which are caught in large numbers along with the commercial size lobsters. It has been shown that commercial size (300 g) lobsters can grow in less than half the time that is required in nature, by proper feeding schedules and environment management. A further reduction in this growing period has been achieved through bilateral eyestalk ablation. Enhancement of growth in ablated lobsters up to 20 times of normal rate has been achieved. An objective assessment of the present status of spiny lobster culture and the problems which need further attention for developing commercially feasible lobster culture are discussed.

INTRODUCTION

Lobster culture is getting increasing attention in recent times due to the heavy demand for live lobsters and lobster tails in the internal and export market. Spiny lobster catches were fluctuating widely and the quantity landed are insufficient to meet the requirements. Growing lobsters in captivity is one of the strategies to cope with the increasing demand.

At present there are no commercially viable lobster farming practices anywhere in the world. However, extensive information on the growth pattern of various species of spiny lobsters under captive conditions are available (Table 1). There are several essential requirements for the commercial farming of aquatic organisms, which include adequate consumer demand and profit potential for the species, the ability to reproduce in captivity, simple larval davelopment, high food conversion efficiency and resistant to diseases (Cobb, 1976). Spiny lobsters have some of the essential characteristics which make them prospective candidates for commercial cultivation. However, among the 163 odd species (Philipps *et al*, 1980) belonging to the four families of lobsters, Nephropidae (Clawed lobsters), Palinuridae (Spiny lobsters), Synaxidae (Coral lobsters) and Scyllaridae (Slipper lobsters), only two closely related species of family Nephropidae, *Homarus americanus* and *H. gammarus* are considered to be serious candidates for aquaculture. This is mainly due to the advantage of their simple and short larval history, hardiness and ability to grow them on a variety of natural and artificial diets. These advantages are severely handicapped by their cannibalistic tendency and elevated temperature requirements for faster growth in their temperature habitat. On the other hand, the critical problem facing spiny lobster culture is the inability to grow them from egg to puerulus stage in captivity, as a result of their complex and protracted larval development requiring a variety of feeds. In view of these facts any realistic approach towards spiny lobster culture should involve rearing juveniles caught from wild to commercial sizes. This paper has made an objective assessment of the status of spiny lobster culture, based on the existing information on growth and survival of various species under culture conditions.

BREEDING AND LARVAL REARING

Berried spiny lobsters caught from the wild release viable phyllosoma larvae under captivity. Chittleborough (1974) reported for the first time rearing of puerulii of *Panulirus longipes cygnus* in laboratory conditions to sexual maturity. Later Radhakrishnan (1977) successfully reared a group of juvenile *P. homarus* to sexual maturity and bred them in laboratory. However, rearing phyllosoma larvae through their entire life cycle was not very successful. Inoue (1978) reared the phyllosoma larvae of *P. japonicus* from egg to the final stage in 253 days. Partial success was obtanied by many research workers in rearing the larvae of some of the spiny lobsters (Table 1). The critical problem encountered in most cases were difficulty in handling the delicate larvae and in finding suitable diets in order to satisfy the requirements of the phyllosoma larvae. Most of the researchers have depended intially on *Artemia* nauplii (Inoue, 1978; Saisho, 1966; Dexter, 1972; Radhakrishnan and Vijayakumaran, 1986 and Vijayakumaran and Radhakrishnan, 1986). Some of them have fed the larvae with *Mytilus* gonads, fish larvae, adult *Segitta* sp. and *Artemia* (Mitchell, 1971; Dexter, 1972 and Inoue, 1978). These unsuccessful attempts have caused lobster culture to depend upon the naturally available post larvae and juveniles for stocking the culture systems.

POSTLARVAE AND JUVENILES

The final (XI) stage phyllosoma larvae moults into a temporary pelagic puerulus larvae which swim towards the coastal area and assumes a benthic existance. Several investigators developed devices to trap the postlarvae settling in the coastal areas (Witham *et al*, 1968; Serfiying and Ford, 1975; Philipps, 1972 and Sweat, 1968). A semi-quatitative collector developed by Philipps was most successful in collecting large numbers of puerulii *P. longipes cygnus*. The lunar periodicity in settlement of the larvae, various ecological conditions, and the related behaviour of the puerulii and the seasonal abundance was extensively studied (Philipps, 1972). The species composition and seasonal abundance of puerulii of *P. homarus*, *P. polyphagus* and *P. ornatus* off Madras coast was studied by the present authors. It is not feasible to

Table 1. *Summary of data on culture of lobsters*

Species	Biological information	Reference
Panulirus japonicus	Larval rearing	Nonaka *et al*, 1958 Inoue and Nonaka, 1953 Inoue, 1978
	Field culture	Idyll, 1971
Panulirus argus	Laboratory growth	Lewis *et al*, 1952 Travis, 1954 Sweat, 1968 Witham *et al*, 1968
	Larval rearing	Robertson, 1968
Panulirus longipes cygnus	Laboratory growth	Chittleborough, 1968, 1974a and b, 1975, 1976 Phillips *et al*, 1977
Panulirus interruptus	Larval rearing	Mitchell, 1971; Blecha, 1972; Dexter, 1972; Serfling and Ford, 1975
Panulirus inflatus	Larval rearing	Johnson and Knight, 1966
Panulirus polyphagus	Larval rearing	Ong, 1967
	Laboratory growth	Kathirvel, 1973; Silas *et al*, 1984; Radhakrishnan and Devarajan, 1986
	Oxygen consumption	Kasim, 1986
Panulirus homarus	Larval rearing	Radhakrishnan and Vijayakumaran, 1986; Vijayakumaran and Radhakrishnan, 1986
	Breeding in captivity	Radhakrishnan, 1977
Panulirus homarus	Laboratory growth	Nair *et al*, 1981
	Eyestalk ablation and growth	Silas, 1982; Silas *et al*, 1984 Radhakrishnan and Vijayakumaran, 1982, 1984a and b Vijayakumaran and Radhakrishnan, 1984
	Field culture	Srikrishnadhas *et al*, 1983
Panulirus ornatus	Laboratory growth	Mitchel, 1979 in Tamn, 1980
	Eyestalk ablation and growth	Nair *et al*, 1981 Silas *et al*, 1984 Radhakrishnan and Vijayakumaran, 1987
Jasus lalandii	Larval rearing	Sheared in Robertson, 1968
	Laboratory growth	Fielder, 1964
Jasus edwardsii	Larval rearing	Bantham, 1967 Silberbaur, 1971
Jasus verreauxi	Larval rearing	Mc Koy, 1970
Panulirus versicolor	Laboratory growth	Kuthalingam *et al*, 1980 Silas *et al*, 1984

collect large numbers of puerulii for stocking lobster culture systems as it is highly capital intensive and labour oriented. Serfling and Ford (1975) has also opined that it would not be practical to attempt large collections of puerulii for the purposes of aquaculture. Besides, mortality of puerulus larvae is high in the first two months in captivity and little is known about their physiological requirements.

It is illegal to catch rock lobsters of less than 76 mm carapace length in Western Australia (Chittleborough, 1974). But there is no minimum legal size limit for fishing spiny lobsters in India. At Kovalam, Madras, Juvenile lobsters (20-45 mm carapace length) are caught along with commercial size lobsters and this forms almost 30% of the lobsters caught in this area. An imaginative approach will be to utilize these juveniles for stocking the culture system. But these should be done with utmost caution as indiscriminate fishing of juveniles may adversely affect the lobster fishery. Chittleborough (1974) suggested strictly selective cropping of early juveniles from overcrowded shallow reefs for culture purposes. Information on season and pattern of recruitment of juveniles should be collected and the juvenile population density in major fishing centres have to be assessed before making attempts to catch juveniles.

There is only scanty data on the availability of juveniles of *P. polyphagus* and *P. ornatus* from India. However, there is fairly good information on the availability of juveniles of *P. homarus* from some of the fishing centres. At Kovalam, Madras, trammel net is used for fishing lobsters. This net is a bottom-setgill net with three layers; two outer layers having a mesh size of 24 cm and the inner layer a mesh size of 4.5 cm. A single net catches an average of 6 lobsters in a day in the peak recruitment months of February and March. The juveniles weighing on an average 80 g cost Rs. 1.50/- per lobster and can be collected for stocking the culture system. Large numbers of juveniles of *P. homarus* can be caught from major fishing areas in this way.

ENVIRONMENTAL FACTORS FOR GROWTH AND SURVIVAL

Proper environmental conditions are required for optimum growth and survival of spiny lobsters under culture conditions.

Temperature

Palinurid lobsters live in water temperatures of approximately 15-29°C. Subtropical lobsters such as *P. longipes cygnus* exposed to a wide range of temperature conditions show marked seasonal variations in growth (Chittleborough, 1974). Lobsters inhabiting tropical waters, however, are subjected to only limited temperature fluctuations of 23-29° C, and temperature dependent growth variations are negligible. This is an advantage over their subtropical counterparts which for sustained annual growth should be grown in elevated temperatures which will considerably increase the cost of aquaculture.

Salinity

Most of the palinurids tolerate wide range of salinities (25-45°/$_{oo}$). We have observed that *P. homarus* can endure in salinities from 15-55°/$_{oo}$. *P. polyphagus* can tolerate even wider range of salinities (5-55°/$_{oo}$) according to Kasim (1986). However, 30-35°/$_{oo}$ salinity is ideal for optimum growth of lobsters. Continuous exposure to extreme salinities may adversely affect growth.

Oxygen

Most of the spiny lobsters are oxygen conformers and few are partial regulators. *P. homarus* and *P. polyphagus* are oxygen conformers and can adjust to low oxygen conditions (Radhakrishnan and Vijayakumaran, MS; Kasim, 1986). In closed intensive culture conditions, aeration by compressed air is required to maintain dissolved oxygen close to saturation. The moulting and survival of *P. cygnus* was severely affected when dissolved oxygen fell to 60-67 per cent saturation and mortality of moulting lobsters was reported in 47-55 per cent oxygen saturation levels (Chittleborough, 1974).

Ammonia

In intensive aquaculture systems, the compound that is most critical is ammonia. Knowledge of ammonia excretion rates and safe ammonia tolerance limits of spiny lobsters is restricted and this may not be a problem in culture systems where there is sufficient exchange of water. Seaweeds like *Gracilaria* sp. are useful in controlling ammonia levels in lobster culture systems (Geeta Bharathan and Radhakrishnan, 1987).

Photoperiod

Spiny lobsters are generally nocturnal feeders and always occupy shaded areas of the culture tanks during day time. Normal day length is found conducive for optimum growth of spiny lobsters.

Shelter

Spiny lobsters are gregarious in habit and hide in crevices in their natural habitat. In laboratory conditions they prefer to hide in communal shelters than in individual dens. Chittleborough (1974) found similiar behaviour in *P. longipes cygnus*. He reported high food intake and growth in lobsters provided with sufficient shelter. Tubular shelters have to be avoided as lobsters tend to crowd inside the tubes resulting in reduced growth and survival.

Handling stress

Periodic handling of lobsters, especially newly moulted ones should be avoided, as this may result in internal injuries to the animal. Handling animals within two weeks prior to a moult results in depressed growth at that moult (Chettleborough, 1974). In *P. homarus*, we found increased moulting frequency when more than three walking legs are autotomised. However, there was considerable reduction in weight increase in that moult.

Food

Spiny lobsters are selective feeders with strong preference for molluscs. In nature, they feed on mussels, barnacles, small crabs and polychaete worms. If suitable size mussels are provided, *P. homarus* can break open the shells and feed on the meat. All the three species of lobsters, namely, *P. homarus*, *P. polyphagus* and *P. ornatus* reared at Field Laboratory, Kovalam feed on backwater clams, *Meretrix casta*, though this is not their natural food. Lobsters also accept a wide variety of trash fishes. The feeding rate on mussels and clams were almost similar (a mean of 5% body weight per day). However, mussel fed lobsters had slightly better growth rate than clam fed ones. Mean gross conversion ratio is 5.0 in mussel fed lobsters, 5.8 in clam fed and 6.6 in fish fed animals (both wet weights). Under field conditions, lobsters reared in cages and fed with trash fish showed growth rates comparable to those fed with mussels in laboratory conditions (Srikrishnadhas *et al*, 1983). These lobsters also would have fed on fouling organisms (barnacles and molluscs) attached to the cages, resulting in higher growth rate.

Daily feeding is necessary for optimum growth of lobsters. Chittleborough (1974) found reduced moulting frequency in lobsters fed thrice a week. Food shortage may lead to cannibalism of newly moulted animals. Lobsters prefer fresh to stale, frozen or boiled food. Feeding always commences after dusk and it is advisable to feed lobsters during this time.

Stocking density

Stocking density of lobsters have to be decided on the basis of the floor area of the culture pond, as lobsters occupy only the bottom of the tank. A stocking density of 7 lobsters/m^2 has given fairly good growth rate of *P. homarus* under laboratory conditions. In marine cages, *P. homarus* stocked at a stocking density of 10 lobsters/m^2 gave comparable growth rates.

Growth rate under culture conditions

Growth in crustaceans is a step-wise process, length and weight increasing abruptly at each moult. Various species of lobsters

Table 2. *Estimated growth of lobsters grown in culture conditions (calculated from actual growth data)*

Species	Growth period (days)	
	Puerulii-Juvenile (0.25 g)-(80g)	Juvenile-Commercial size (80g) -(380g)
[1] *Panulirus homarus*	380	365
[2] *Panulirus polyphagus*	480	*365
[1] *Panulirus ornatus*	250	365
[3] *Panulirus longipes cygnus*	455	425

* 80g - 280g

[1] Present study

[2] Radhakrishnan and Devarajan (1986) & Present study

[3] Chittleborough (1974, 1976)

have been reared from different sizes and generally it is opined that growth of lobsters is slow under natural conditions. An estimated growth period of 4 to 5 years was suggested for *P. argus* to grow from puerulii to legally harvestable size of 76.3 mm carapace length (Tamn, 1980). *P. cygnus* was reared from 35 mm carapace length (42g) to 76 mm carapace length (CL), that is 387 g in 68 weeks at an optimum temperature of 25°C (Chittleborough, 1974). Chittleborough (1974) and Philipps (1977) got almost similar growth rates (2.8 years) for *P. cygnus* rearing them from puerulii to 70 mm CL (300 g). Other palinurids which were successfully grown in experimental culture systems were *P. polyphagus* (Radhakrishnan and Devarajan, 1986), *P. homarus*, *P. ornatus* and *P. penicillatus* (Nair *et al*, 1981), and P. *ornatus* (Michel, 1979). *P. polyphagus* took 2.3 years to grow from puerulii to 300 g. The estimated growth calculated from actual growth data of four species of lobsters are given in Table 2. From the data it is evident that except *P. ornatus*, the other species of lobsters took nearly 400 or even more days to grow from puerulii (0.25 g) to juveniles size (80 g). Whereas weight gain of another 300g was achieved in another 400 days (Fig. 1). So, it is advantageous to grow lobsters from juvenile stage (80 g) to the commercial size (300 g) than growing them from puerulii to marketable size.

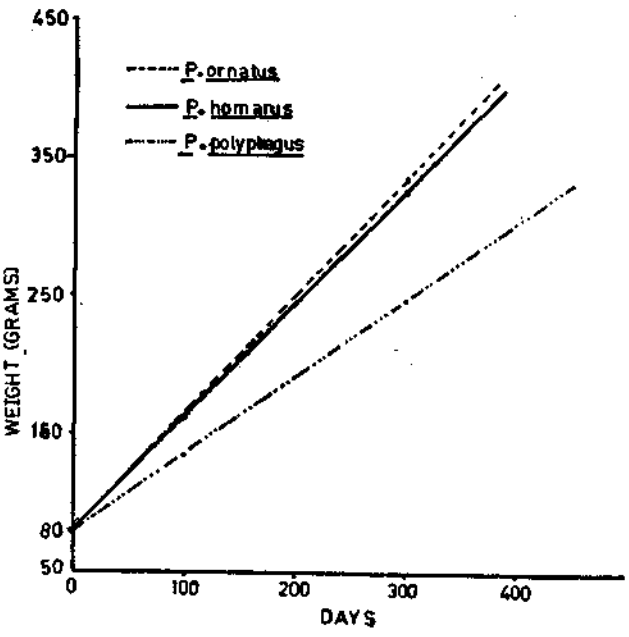

Fig. 1. Fitted regression line showing growth of *Panulirus homarus*, *P. polyphagus* and *P. ornatus* lobsters reared in the laboratory

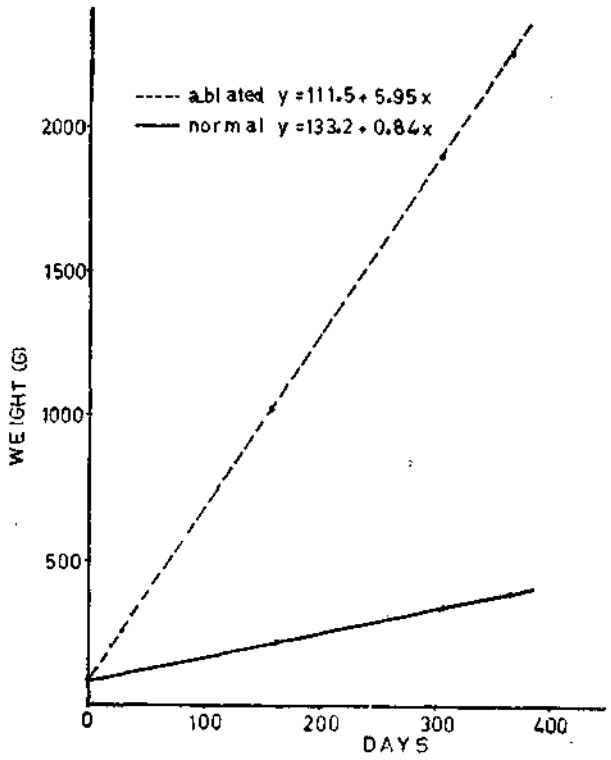

Fig. 2. Fitted regression lines showing growth of normal and bilaterally eyestalk ablated *Panulirus ornatus* in laboratory.

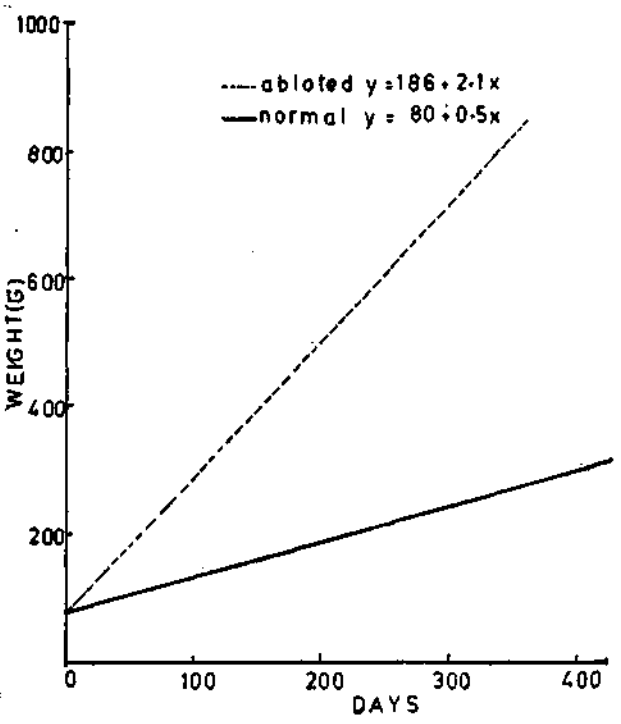

Fig. 4. Fitted regression lines showing growth of normal and bilaterally eyestalk ablated *Panulirus polyphagus* in laboratory.

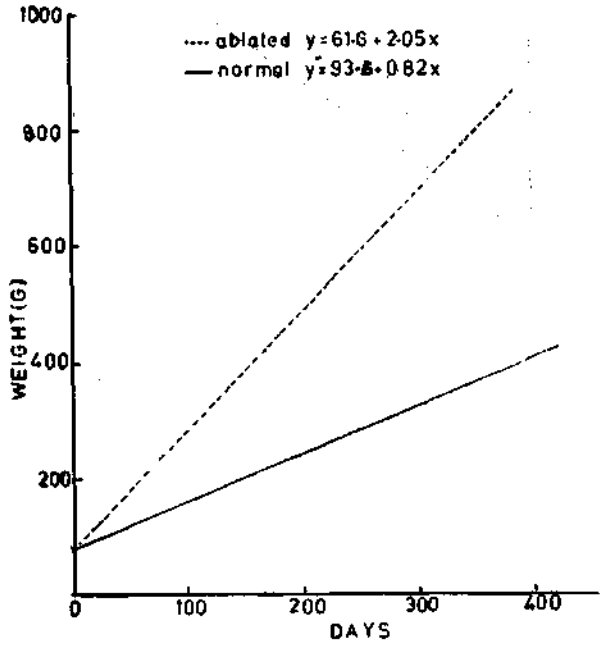

Fig. 3. Fitted regression lines showing growth of normal and bilaterally eyestalk ablated *Panulirus homarus* in laboratory.

Eyestalk ablation

For making lobster culture more feasible, it is necessary to reduce the growing period considerably. Bilateral eyestalk ablation is one way to achieve this. Our experiments show that all the three species, *P. homarus*, *P. ornatus* and *P. polyphagus* responded very well to eyestalk ablation. Among the three species *P. ornatus* looks most promising. The estimated growth of ablated *P. ornatus* is 2173 g/ year, *P. homarus*, 749 g/ year and *P. polyphagus*, 779 g/ year if the initial weight is taken as 80 g (Fig. 2, 3 and 4). When compared to the normal lobsters, the increase is seven times in the case of *P. ornatus*, 3.8 times in *P. polyphagus* and 2.5 times in *P. homerus*.

SITE SELECTION AND CULTURE METHODS

Most of the studies on growth of spiny lobsters were indoor culture tanks involving a

few hundred lobsters. However, there is one report of cage culture of *P homarus* from India (Srikrishnadhas *et al*, 1983). According to Idyll (1971), extensive culture of *P. japonicus* is being practised along the Southern coast of Kyushu. Intensive culture of lobsters in cement cisterns also may be practicable, but needs higher energy inputs. The high stocking density in such systems and the consequent high production may offset this difference. But for a reliable assessment of the culture of lobsters, pilot or demonstration scale culture programmes are necessary.

For lobster culture, sites along the east and west coast of India where lobster fishing is presently carried out may be suitable. The availability of food near the culture site and good source of clean seawater are also essential prerequisites for considering an area suitable for culture. In many places, presently clams are exploited only for the shells and the clam meat could be used as a good source of food. Green mussels from the coastal beds, which are under exploited in many places is also another good source of food. Culture of green mussels on rafts and poles in backwaters or lagoons at low cost are now perfected and mussels which do not fetch good price in the market could be converted to the higher priced lobster. It might be more economical to move the lobster juveniles to the culture site rather than transport the food required to grow the lobster to commercial size (Chittleborough, 1974).

FUTURE PROSPECTS

It is not easy now to predict when cultured lobsters will arrive in the market. Though a great deal of information on the seed availability, growth pattern, environmental conditions,

Table 3. *Status of spiny lobster culture in India*

Characteristics	*P. homarus*	*P. polyphegus*	*P. ornatus*
BIOLOGY			
Species	XX	XX	XX
Suitability for culture	X	X	X
TECHNOLOGY			
Larval rearing	P	P	P
Juvenile availability	XX	X	X
Growth in captivity	XX	XX	XX
Growth enhancement by eyestalk ablation	XXX	XXX	XXX
Adaptability to culture conditions	XXX	XXX	XXX
DIET			
Natural diet	XX	XX	XX
Compounded diet	P	P	P
Conversion rate	X	X	X
DISEASES	X	P	P
MARKETING POTENTIAL			
Internal	XXX	XXX	XXX
External	XXX	XXX	XXX
SITE AVAILABILITY	XX	XX	XX
ECONOMIC VIABILITY	X	X	X

XXX-Excellant; XX-Good; X-Fair; P-Poor.

and other physiological requirements of lobsters are available, a number of uncertainties exist which preclude an objective assessment of viability of lobster culture. Those areas with deficient information or experience and others with adequate knowledge are listed in Table 3. The assessments are based mostly on our experience.

Atleast three spices of lobsters occurring in Indian waters, namely, *P. homarus*, *P. polyphagus* and *P. ornatus* which form a fairly good fishery in both east and west coast of India are promising candidates for culture. But as explained earlier, inability to produce seeds in captivity is one major constraint and solution for this problem does not seem to be imminent. The unsuccessful attempts have caused dependence upon the natural environment for postlarvae. Collection of large numbers of puerulli being difficult, the culturist has to depend upon juvenile lobsters caught along with commercial size lobsters.

A concerted effort to culture lobsters was not initiated until now, probably due to paucity of information on growth, food requirements and lack of technical information on culture systems. Though extensive experimental data on biology, physiology and ecology of lobsters are available, it is highly imperative to have information on the economics of the entire operation. The growth rates obtained in our experiments and in some subtropical lobsters indicate the potential of growing lobsters in captivity. The growth could be further enhanced by eyestalk ablation by which growth period could be further shortend by more than 50%. Though clams, mussels and trash fishes from commercial trawlers could be utilized for feeding lobsters, regular supply of food in large quantities may become a critical factor in lobster culture. Successful aquaculture definitely needs a cheap, growth efficient diet. Development of such a diet is very essential and such a feed should suit the feeding behaviour and digestive physiology of lobsters.

Though extensive culture systems of several hectares look attractive, it may not be practical as such large numbers of juveniles may not be available to stock such systems. Semi-intensive culture system involving a few thousand lobsters will be a reasonable proposition.

The shells of aquarium reared lobsters generally look paler than those caught from the wild. However, there is no significant difference in the biochemical quality of the meat of reared lobster and of wild ones. No major difference in quality of meat of normal and eyestalk ablated lobsters were also found. Cultured lobsters are not generally affected by any major diseases and survival rate is more than 90% in normal lobsters and 70% in eyestalk ablated lobsters.

Culturing lobsters may not be a viable alternative to natural stock management (Taiwn, 1980). High expectations not withstanding, small scale lobster culture has definitely good scope in India.

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Paper-55

A REVIEW OF MARINE FINFISH CULTURE RESEARCH IN INDIA

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ABSTRACT

The paper deals with a review of marine finfish culture research for development in India. Informations on the marine finfish seed resources and culture potential of the various estuaries, backwaters and coastal waters, the different species of finfishes cultured in mono and polyculture systems and development of technology for the culture of various species of marine finfishes in different culture systems are given. In India, the aquaculture practices so far have mainly dealt with milkfish, grey mullets, Indian Sandwhitting, rabbit fishes, perches and groupers in various ecosystems. Details of methods of pond construction, suitable areas for culture and production, constraints met with in maintenance, management and development of coastal fish farms are presented. The problems in marine finfish culture research for development in India are discussed.

INTRODUCTION

Marine finfish culture which has been an established practice in various parts of India is now undergoing rapid development in order to (i) utilise the extensive areas which are now unutilized but which have possibilities for aquaculture development (ii) to increase the production of animal protein to meet the needs of the fast growing population (iii) to develop special market-oriented products for export and consequently for earning foreign exchange (iv) creating employment opportunities (Pillai, 1972; Qasim, 1975; Silas *et al.*, 1976). Although traditional culture of marine finfishes has been practised in estuaries and coastal areas of Kerala, Goa and West Bengal, the production rate was not high. However, the traditional methods of farming, suitably

modified have shown promising results in certain maritime states.

The scope for an organised system of marine finfish culture in our country was realised by Hornell (1911) who suggested the development of coastal saline swamps, backwaters, estuaries, deltaic marshes and salt pans for the purpose of cultivating saltwater fish. Since then, the Madras Government started a marine fish farm at Hare Island area in 1915, converting some of the lagoons in that area and stocking them with mullets (*Mugil* spp) and sandwhiting (*Sillago* spp). The venture was discontinued after a brief period owing to certain unforeseen circumstances. Marine finfish farming in Kerala was started in 1940 at Narakkal, growing mullets and milkfish with encouraging production rate of 1000 kg/ha/yr. The Madras Fisheries Department renewed fish culture experiments in 1944 at Krusadai Island for growing milkfish and mullets. But the recurring hardship of trails and handicaps forced discontinuance of these experiments. Pioneering attempts on marine finfish culture were made at Mandapam, Krusadai Island, Tuticorin, Madras, Calicut, Narakkal and Mangalore. The significant advances and new approaches have been made by the Central Marine Fisheries Research Institute in finfish culture research (James, 1985; Mahadevan, 1985).

In India, an awareness has developed in recent years on the need to carryout aquaculture on scientific basis as a means to augment fish production through various aspect of research. The past experience in farming underlined the need to evolve suitable hatchery techniques and management strategies. The present paper reviews the experimental culture methods in different ecosystems with the naturally available seed of various species of marine finfish.

COASTAL FISH FARM DEVELOPMENT

Tampi (1960) has discussed about the advantages and disadvantages of establishing a marine fish farm with seven culture ponds spread over a total area of 0.88 ha at Mandapam. The low level of biological productivity is attributed to wide fluctuations in salinity often reaching hypersaline conditions combined with very low concentration of essential nutrient salts and their lack of regeneration (Udaya Varma *et al.*, 1963). The development of small experimental fish farm in the same area has been initiated later with a view to construct a viable farm using various techniques including pumping of sea water into the ponds both during day and night. It was proposed to supplement this facility by erecting a few wind-mill pumps. Recently, at Mandapam, the fish farm has been reconstructed and a total number of 28 ponds spread over a total area of about 15 ha have been developed for experimental work on finfish and prawn farming. The bunds of the ponds were turfed with locally available grass to keep the bunds intact (Bensam, 1985). The coastal fish farm construction and development for marine finfish culture experiments at Mandapam, Tuticorin, Madras, Narakkal and Calicut centres of Central Marine Fisheries Research Institute has been already reviewed (Tampi, *et al.* 1983). At Tuticorin, a total area of 2.5 ha has been developed at Karapad into 12 ponds for the culture of finfish, prawns and crabs during 1972. At Madras, a total extent of 93 acres of salt water area at Muttukkadu about 35 km south of Madras was acquired during 1982, from the Government of Tamil Nadu. Of this, an area of 13 ha has been developed into ponds for experimental programmes by the Central Marine Fisheries Research Institute. At Calicut, a total number of 13 polyethylene lined ponds covering a waterspread area of 0.4 ha has been developed (Lazarus and Nandakumar, 1987). At Kakdwip and Bokhali in West Bengal and Puri in Orissa, the fish farm construction was made by the Central Inland Fisheries Research Institute (CIFRI, Reports, 1962). At Kakinada, the experimental fish farm was developed by the Central Institute of Fisheries Education (CIFE Reports, 1978). The Tamil Nadu State Fisheries Department has developed the brackishwater fish farm at Santhome, Madras (Evangeline, 1968).

MARINE FINFISH SEED RESOURCES

Survey on the cultivable finfish seed resources of *Chanos chanos*, *Mugil cephalus*, *Liza macrolepis*, *Liza parsia*, *Liza cunnesius*, *Siganus* spp., *Etroplus* spp and *Sillago* spp have been reported from estuaries, backwaters and coastal waters of India by many earlier workers. (Tampi, 1973; Evangeline *et al.*, 1969; Prabhakara Rao, 1972; Victor Chandra Bose and Venkatesan, 1982 Dorairaj *et al.*, 1984; Silas *et al*, 1985; Nammalwar, 1986). Regarding the occurrence and collection of milkfish fry, from several centres along the east and west coasts of India, special mention has to be made of Ramanathapuram and Tirunelveli coastal belt which sustains the maximum population of milkfish seed. The season for the large scale collection of these fry may vary from locality to locality. The peak season in most of the places is from April to July and the secondary season from September to November.

Grey mullets rank next only to milkfish as far as salt water and brackishwater fish farming is concerned. The seed of *M. cephalus* is abundant only during October-December in the coastal estuaries around Madras. Other grey mullets species such as *L.macrolepis*, *L. parsia*, *L. tade*, *L. waigiensis*, *L. cunnesius* and *V. seheli* occur for the greater part of the year. (Nammalwar *et al*, MS).

MARINE FINFISH CULTURE RESEARCH IN VARIOUS ECOSYSTEMS

Monoculture

At Krusadai Island and Mandapam, monoculture of *C. chanos* in ponds at the stocking density of 500-1000/ha was conducted (Devanesan and Chacko 1944; Chidambaram and Unni, 1946; Chacko and Mahadevan, 1956). The average monthly growth rate was 14.1-27.0 mm. The production details of these early experiments, however, are not available. At Mandapam, monoculture of milkfish in ponds at the stocking density of 6250-12,500/ha was conducted during 1958-59 despite the poor water quality of the soil, meagre organic content, low nutrient level and hypersaline conditions for most part of the year (Tampi, 1960). The monthly average growth was 18.3 mm. The production was 121 to 455 kg/ha.

At Madras, six monoculture experiments with milkfish at the stocking density of 906-39402/ha were conducted (Evangeline, 1967). According to one monoculture experiment with milkfish conducted at the brackishwater experimental fish farm of the Central Inland Fisheries Research Institute, at Kakdwip, an estimated production of 710 kg/ha was obtained by supplementary feeding at a stocking density of 3000 nos/ha (Anon, 1978). At Kakinada, in four monoculture experiments with milkfish, wherein the stocking density was 5000/ha the average monthly growth ranged between 20.6 and 23.6 mm (Dwivedi *et al.*, 1980). At Tuticorin, in two monoculture experiments, milkfish was stocked at the rate of 7820/ha and 75,490/ha and the production ranged between 318 and 857 kg/ha (Bensam and Marichamy, 1981). At Calicut, in polythene lined ponds milkfish was stocked at the density of 5600/ha and the average monthly growth was 32.5 mm/28.3 g. The production was 920 kg/ha (Lal Mohan and Nandakumaran, 1981). At Mandapam, in two monoculture experiments, the milkfish was stocked at the rate of 4000/ha, and the average monthly growth of 15.2 mm (58 g) in one experiment and 23.9 mm (31.2 g) in the other was reported. The production was 216 and 852 kg/ha (Mohanraj *et al.*, 1983; Gandhi and Mohanraj, 1986). Further, Lazarus and Nandakumaren (1987) reported that in six monoculture experiments with milkfish, the production rates ranged between 1765 kg/ha/yr and 4663 kg/ha/yr in different stocking regimes.

In the six monoculture experiments with grey mullets, *Liza waigiensis* and *Valamugil seheli*, the stocking density ranged between 22,000 and 50,000/ha (James *et al.*, 1985 a). The average monthly growth was 3.5 mm (1 g) for *L. waigiensis* and 3.5 to 12.6mm for *V.seheli*. The production ranged between 135 and 782 kg/ha. At Madras, monoculture of milkfish under the stocking density of 3000/ha recorded the average monthly growth of 33 mm/12.7 g.

The production was 45 kg/ha (Nammalwar and Kathirvel, MS). Further, four monoculture experiments with milkfish were conducted (Nammalwar *et al*, MS). The mean monthly growth rate ranged from 14.6 to 31.6 mm (6.6-18.0 g) and the production was 60-385 kg/ha. In two monoculture experiments with *Lates calcarifer*, the stocking density ranged from 2500-3000/ha. The production was from 2000-2500 kg/yr (Anon, 1985). In another four monoculture experiments with grey mullets, *M. cephalus* and *L. macrolepis*, the stocking density ranged from 1500 to 7500/ha. The monthly average growth was 41.1 mm/12.6 g for *M. cephalus* and 19.4 mm (7.1 g) to 22.3mm (8.5 g) for *L. macrolepis*. The production was from 72-226 kg/ha (Nammalwar *et al.*, MS).

Polyculture

In two polyculture experiments at Sunderbans grey mullets, craps and prawns altogether yielded a total production range of 139.8-1549.6 kg/ha (Pakrasi *et al.*, 1975). At Mangalore, in a polyculture experiment, *C. chanos*, *L. macrolepis*, *S. sihama* and *P. indicus* were stocked in ponds at the stocking density of 1000-3600/ha (Ramamurthy *et al.*, 1978). The average monthly growth rates for the above species were 57.4 mm, 28.2 mm, 6.7 mm and 10.6 mm respectively. At Madras, two polyculture experiments with *C.chanos* and *P.indicus* with the same stocking density of 3500/ha and 70,000/ha were carried out (Sunderarajan *et al.*, 1979). The average monthly growth rates were 52.2 mm/52.21 g & 43.5 mm/37.5 g for milkfish and 15.8 mm (1.8 g) to 29.8 mm (2.5 g) for prawns. The estimated production rates were 705-1088 kg/ha for milkfish and 135-312 kg/ha for prawn. At Tuticorin, in a polyculture experiment, *C. chanos*, *L. macrolepis* and *Scylla serrata* with the stocking density of 1450, 3000 and 617/ha were conducted (Marichamy *et al.*, 1980). The average monthly growth rates were found to be 14.9 mm/8.6 g, 25.6 mm/21.6 g and 12.4 mm/6.5 g. The estimated total production was 1644 kg/ha/yr. In three other polyculture experiments at Tuticorin, C. *chanos*, *M. cephalus* and *P. indicus* with the stocking density of 3500-4982, 2428-7364 and 43,200-76,382/ha, the average monthly growth rates were 32.4 mm/27.4 g; 24.8 mm/9.1 g and 25.3 mm/22.2 g for milkfish, 26.6 mm/19.1 g, 30.5 mm/22.2 g and 20.1 mm/14.1g for mullets and 9.1 mm/1.5 g and 10.3 mm/2.2 g for prawn. The estimated total production of 498 to 662 kg/ha of milkfish, mullet and prawn was obtained (Marichamy and Rajapackiam, 1982 a & b).

At Madras, in four polyculture experiments with *C. chanos*, *L. macrolepis*, *M. cephalus*, *P. indicus* and *P. monodon*, an estimated production of 218 to 1617 kg/ha was obtained by Ramakrishna *et al.*, (1982). At Calicut Lal Mohan and Nandakumaran (1981) conducted five polyculture experiments with milkfish, mullet and prawn in polythene lined ponds but no production results were mentioned. At Sunderbans, in a polyculture experiment, milkfish, mullet, carps and prawn together yielded the production of 1390 kg/ha (Pillai *et al.*, 1985).

At Mandapam, six polyculture experiments with *L. macrolepis*, *V. seheli*, *C. chanos*, *S. sihama* and *P. indicus* were conducted (James *et al.*, 1984 a; 1984 b). In the first experiment *L. macrolepis* and *V. seheli* were stocked in association with *C. chanos* and *P. indicus* at the stocking rate of 13,000, 2,000, 22,000 and 7,000/ha. The average monthly growth rate of 10.7 mm/6.4 g, 13.6 mm/8.6g, 20.1 mm/15.6 g and 10.5 mm/2.3 g was recorded for *L. macrolepis*, *V. seheli*, *C. chanos* and *P. indicus* respectively. The total production was 1464 kg/ha. In the second experiment, *V. seheli*, *C. chanos* and *S. sihama* were stocked at the stocking density of 17,000/ha each. The average monthly growth increment for the above species were found to be 10.2 mm/4.3 g and 17.3 mm/9.5 g and 9.2 mm/2 g respectively. The total production was 1865 kg/ha. In the rest of the four experiments *C. chanos* and *V. seheli* were stocked with the stocking density of 8333/ha and 7777/ha.

The monthly average growth of *C. chanos* and *V. seheli* ranged from 20.7-27.7 mm/20.6-25.9 g and 14.9-16.9 mm/6.9-10.6 g respectively. The total production ranged between 1378 and 1560 kg/ha.

At Madras, in two polyculture experiments, *C. chanos* and *P. monodon* were stocked at the rate of 5000/ha and the monthly average growth was 22.4 mm/6.3 g in one experiment and 34.4 mm/15.1 g in the other for milkfish. In the case of *P. monodon*, the recorded monthly mean growth was 16.9 mm/2.1 g in one experiment and 19.5 mm/17.7 g in the other. The total production was 69 and 183 kg/ha (Nammalwar and Kathirvel; M. S). Further, in seven polyculture, experiments with *M. cephalus*, *L. macrolepis* and *L. cunnesius* at the stocking density of 2500 to 5000/ha the monthly average growth was 17.0-40.1 mm/ 8.2-29.3 g for *M. cephalus*; 16.1-23.4 mm/4.9-12.2 g for *L. macrolepis* and 10.3-15.8 mm / 2.9-6.8 g for *L. cunnesius* (Nammalwar *et al.*, MS). Lazarus and Nandakumaran (1987) reported that in polyethylene film ponds a maximum production of 1007.4 kg/ha/211 days and 1303 kg/ha/169 days was obtained in polyculture experiments with *C. chanos* and *P. indicus*.

PEN CULTURE

At Tuticorin, in two polyculture experiments *C. chanos* and *Mugil* spp. were stocked at the rate of 10,000 and 15,000/ha in pens erected with split-bamboo screens (Shanmugam and Bensam, 1982). The average monthly growth rates for the above species were found to vary between 27 and 51 mm (7.48 g) and 23 and 29 mm (18.26 g) respectively. At Mandapam, five monoculture experiments in net pens with *C. chanos* were conducted (Lal Mohan, 1983). The average monthly growth ranged from 33.8 to 60.9 mm (30.6-57.1 g). Further, *C. chanos*, *V. seheli* and *S. sihama* were stocked at a density of 50,000/ha in a pen made of palmyrah leaf stalks (James *et al.*, 1984 a). The average monthly growth increments for *C. chanos*; *V. seheli* and S. *sihama* were 22.7 mm/10.3 g, 26.9 mm/10.5 g and 16.8 mm/8.1 g respectively. At Mandapam, the results of one mono and one polyculture experiments with *C. chanos* and *Mugil* spp. in bamboo pens indicated that the average monthly growth increments for *C. chanos* was 42. 3 mm (24.7 g) and 50.0 mm (63.4 g). For *Mugil* spp, the mean growth recorded was 18.3 mm/4.7 g (Venkataraman *et al.*, 1985). Except for the details of growth of milkfish and mullet, production data are not available for these experiments.

CAGE CULTURE

At Mandapam, experiments were designed to investigate the possibilities of culturing some economically important marine fishes in low cost cages, erected in coastal waters. Rabbit fishes, *Siganus canaliculatus*, *S. javas*, Groupers, *Epinephelus tauvina* and *E. hexagonatus* and sandwhiting, *Sillago sihama* were cultured in the cages (James *et al.*, 1985 b). The average monthly growth increments for *S. canaliculatus* and *S. javus* were 8.5 mm/ 3.1 g and 6.6-6.2 mm/2-3.1 g respectively. The mean monthly growth for *E. tauvina* and *S. sihama* were 19 mm/87.3 g and 10 mm/1.6 g respectively.

PROBLEMS AND CONSTRAINTS

The problems and possibilities of culture of marine fishes in India have been discussed by Tampi (1967, 1969), Jhingran (1969), Nair and Bensam (1974), Seknaran (1976), James (1980) and Marichamy (1987). The major problem in the culture of marine fishes in India is the task of locating suitable sites for culture. The straight coast line without indentations does not provide suitable sheltered areas and calm conditions for erection of structures like pens and cages in coastal waters.

The major constraint in the costruction of ponds for farms so far developed has been water management. In many places the tidal amplitude is not sufficient to bring the optimum water exchange in the ponds. Consequently the ponds have to be periodically deepened and repaired due to damages caused by monsoon floods every year at considerable cost. Many salt water farms are virtually enclosed systems for most part of the year due to closure of the bar mouth and also insufficient tidal flow when the bar mouth is open. In the lagoon at Mandapam and Muttukadu similar problem exists. The fish ponds at Mandapam and Muttukadu do not have enough exchange of

water due to constant sand accumulation at the main sluice. In Tuticorin farm also water exchange is poor. Similar conditions prevail in the farms of other areas also. Layout of farms is different from centre to centre and the pond sizes vary widely. The facilities created at different centres are also not a uniform standard and everywhere, they fall far short of the requirements. Though extensive survey on the occurrence and abudance of cultivable seed resources have been made, informations are still lacking in some areas which are essential prerequisites for large scale culture of marine finfishes.

Research studies on marine finfish culture have been restricted to only a few species of grey mullets and milkfish mostly. More emphasis is now being laid on the rabbit fish, perches, groupers and sandwhiting. There is a need to identify and propagate selected fast-growing species for culture under different conditions. Nutritional requirements of various cultivable finfish species and the preparation of artificial feeds are to be standardised. In most of the ponds, flooding during south west and north east monsoon seasons occured and caused damage to the bunds and fish stocks in the ponds, necessitating repair and maintenance. Poaching of the cultured finfishes also has often been a source of loss in production. The economic feasibility of marine finfish culture in various ecosystems has not been worked out so far. However, with the constraints so identified, present culture experiments conducted in various ecosystems are aimed at working out these details, leading to further development.

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Paper-56

CHANOS FRY RESOURCES OF INDIA

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ABSTRACT

Chanos fry occur along the south east coast of India in fairly large numbers during the months of March–June and October-November. Its abundance, distribution and seasonal variation are discussed. Conservation measures such as regulated fishing and mesh regulations are suggested. Causes for the decrease of Chanos fry abundance are also brought to focus. Measures to be taken to protect the fry resources are high-lighted.

INTRODUCTION

Occurrence and abundance of milkfish seed along the Indian coast was observed by Chacko and Mahadevan (1956), Tampi (1968), Silas *et al* (1980), Mohan (1984) and Mohanraj *et al* (1984). Though investigation on the chanos seed and its possible utilisation for culture started about 80 years back, the culture of milkfish has not become popular in India.

One of the main constraints for the development of chanos culture is the non-availability of the seed to the farmers at the required period in required quantity. Lack of Infra-structural facilities for storing and transport are also the reasons for the unsatisfactory state of chanos culture in India. It has been recently observed that the seed abundance has declined in many areas along the Indian coast due to habitat degradation.

Seed Collection:

Ganapathi *et al* (1950); Chacko and Mahadevan (1956), Tampi (1957), Mohan

(1984) and Dorairaj *et al* (1984) dealt with collection of milkfish seed. 'Kondodi' net, a modified drag net along with a scare-line was used for collecting fingerlings. The mesh size of the net was 15 mm. Fingerlings were collected during the early mornings before the sun rise. The catches declined with the sun rise and the subsequent increase in water temperature. The favourable period of collection was 0530-0730 hrs. At Rameswaram Island, near the Pamban sea shore, large pools were made during the low tide. The milkfish fry that came along with the tide got stranded in the tidal pools and collected by velon screen or cotton cloth when the tide receded.

Areas of occurrence:

Along the south east coast of India the seed of milkfish occur in large quantities from Manouli island, Rameswaram island (Pamban, Chinnapalam creek etc.), Pillaimadam lagoon, Panaikulam, Vaalinokam, backwaters of Vedarnyam, Pulicat lake etc. Apart from these areas the milk fish seed was reported along the west coast from Cochin backwaters, Calicut and Elathur (Mohan, 1984; Lazarus and Nandakumaran, 1987) But their abundance is not appreciable.

Tampi (1959) estimated that 400-600 million chanos fry occur in Peninsular India. but the present estmate is considered to be about 200-250 millions based on the observations along east and west coast.

Seasons of abundance

Milk fish seed occur in south east coast of India during two periods (Evangeline, 1967). The primary season was found to be from March–June and the secondary season from November-December in south east coast. During the primary season the catch per haul was as high as 1200 fingerlings in the Pillaimadam lagoon when a net of 20 meter long dragged for 30 minutes covering 200 meters. Maximum number of seed measuring 20-30 mm were collected during the first week of April from Manouli island, Rameswaram island and Pillaimadam lagoon. During the secondary season the fingerlings were collected from Panaikulam creek near Mandapam during second week of November. About 2000 seed were only collected in 1982. A few fingerlings were obtained from manouli island also. Along the west coast of India, in Calicut the fingerlings measuring 40-60 mm occurred during July August. About 1000 fingerlings per day could be collected for about 10 days during the the first week of August in 1972. Secondary season was not observed in the west coast.

Size range of the seed

Length range of the seed vary according to the period of collection. The needle shaped fry measuring 10-15 mm were collected from Manouli island, Rameswaram island and Pillaimadadam lagoon during March. Feeding on the abundant growth of algae found in the area, the seed grow fast attaining a legth of 20-40 mm, 40-80 mm and 80-110 mm in April, May and June respectively. After July the fingerlings of length more than 120 mm were only collected and at this size range the fishes were observed to migrate towards the sea.

During the secondary season fingerlings of length 40-60 mm occurred during October in the Panaikulam creek near Mandapam.

Along the west coast, fry of length 30-40mm occurred at Calicut coast during July and the fingerlings of length 50-80 mm were collected in August.

Remark

Collection and marketing of chanos seed in south east coast is under the control of Department of Fisheries Tamilnadu, Pamban. The fry is collected from the tidal pools of Pamban sea shore kept in Aluminium containers with perforated lids and transported.

Due to the habitat degradation the abundance of milk fish seed has declined considerably along the Pamban coast which was once valued as the most productive area for the seed. The Chinnappalam creek of Rameswaram island which was also one of the important seed collection centres before 4 to 5 decades is no more a collection centre. The creek, though retains its mangroove vegetation, has silted with heavy organic debris. Further in such areas as Pillaimadam lagoon, the seed

are caught in large quantities and dried. Large drag nets with 8–10 mm mesh were used. Nearly 20 fishermen operate each net.

It was observed that the average number of milk fish seed collected from Ramnad and Tinnevelli coast during 1950-55 was 26.4 million and it has come down to 0.62 million in 1957-1960, (Tampi, 1968) indicating the decrease in the abundance of seed in the traditional seed collection grounds.

The estimate of abundance of milk fish seed in Mandapam-Rameswaram area is as follows:

Rameswaram island	:	3.0 million
Manouli island	:	1.5 ,,
Pillaimadam lagoon	:	3.0 ,,
Sethukarai	:	0.1 ,,
Panaikulam	:	0.1 ,,
		7.7 ,,

With further degradation of the ecology of the habitat, the milk fish seed resource may decline more.

It is important to protect and preserve the traditional chanos seed nursery grounds. The areas should be identified and safe-guarded from human interference and pollution. Fishing should not be allowed in the nursery grounds of Palk Bay and Gulf of Mannar during March–May, the period of peak occurrence of seed. A comprehensive time bound survey should be conducted to study abundance of milk fish resources of India. This study should cover the ecology of the milk fish seed grounds, potential agencies contributing the degradation of the ecology of grounds and other man made causes. A general awareness should be created among the fishermen and the local population that the chanos seed resource is dwindling and proper care should be taken to safe-guard its habitat. Short-term training programme can be arranged for the prospective chanos fish farmers on the scientific handling of the chanos seed. Training should include better mode of collection, transport and stocking procedures. There is good prospects of culturing chanos along the Kerala coast from June onwards during monsoon depending on the seed collected from the south east coast. The main problem of chanos culture in east coast is the summer months which succeed the chanos seed season. Many of the brackish water areas dry during summer months. Chanos can withstand transport for more than 12 hrs. (Ranganathan and Ganapathi, 1949; Dorairaj *et al.*, 1984; Lazarus & Nandakumaran, 1987). Hence the seed can be transported from south east coast to south west coast of India utilising the monsoon months.

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Paper 57

EVALUATION OF CULTURE OF MILK FISH, *CHANOS CHANOS* IN FISH PENS IN A SHALLOW LAGOON AT MANDAPAM, INDIA

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ABSTRACT

Culture of milk fish in net enclosures in the Pillaimadam lagoon near Mandapam is described. Erection of the net enclosure, maintenance, results obtained from culture operations constraints and improvement in the system are discussed. The feasibility of extension of the pen culture to the rural areas is analysed. The results of the trials conducted by the fishermen is also examined.

INTRODUCTION

Milne (1970, 1978) and MΦller (1978) described various type of enclosures for fish culture. Culture of fishes in enclosures is practiced in China, Philippines, Taiwan and other far eastern countries (Delmendo and Gedney 1974, Pillai, 1978). In Phillippines 5,000 ha of fish pens have been established in the Lake Laguna producing 7,000-10,000 tons of milk fish annually (Pillai, 1978). In China about 0.9 million ha, are being used for pen-culture forming about 28% of the potential areas (Tang, 1978). India has about 2.3 million hectres of brackish water area but not even 1% of the potential area is used for fish culture. If we can utilise a small portion of the available lagoons, mud flats and low laying areas for fish culture, our fish production can be increased considerably. Though culture of fishes in net enclosures is practised on large scales in other countries the practise has not been very popular in India. Culture of milkfish in net enclosures

was tried in a lagoon near Mandapam south-east coast of India. *Chanos* was selected for culture as the fry and fingerlings of it were available in the lagoon during April-June. The technology developed, at the Central Marine Fisheries Research Institute during 1981-'86 was imparted to a few fishermen of Valayarvadi village, near Mandapam.

A study of the economics of various methods of culture such as cages, race ways and enclosures show that income derived from enclosures was comparable to other systems (Collins and Delmendo, 1978). It was further suggested that the extensive culture is more suitable when there are highly productive shallow waters, inexpensive labour and lack of moden technology and equipment for manufacturing fish feed.

MATERIAL AND METHODS

Mohan (1983 a, b, c, 1986) has given a detailed account of pens erected in the Pillaimadam lagoon. Palmyra poles of 3 meters length were planted in the lagoon and webbed with 16 mm mesh HDPE net. The webbing was kept firmly in the mud so that it would not get lifted by the strong wind which was prevelent in the lagoon. The head rope of the webbing was held firm to the nails placed at the top of the palmyra poles and the bottom rope was tied to a 3 kg granite stones placed at an interval of 2 m. Pens were monitored daily and the barnacles attached to the webbing and the poles were removed manually (Fig. 1). A canal of 80 m length and 5 m width was made across the sand bar (Fig. 2) to facilitate the flow of water from the sea to lagoon during the summer months when the water level in the lagoon became low and the salinty and temperature rose to 140 ppt and 40°C respectively. Opening of the canal made it possible to culture the fishes during the summer months. As indicated in the Table 1 heavy mortality was observed during summer months before opening of the canal as the lagoon dried.

Fig. 1. Manual removal of Barnacles attached to the webbing and poles

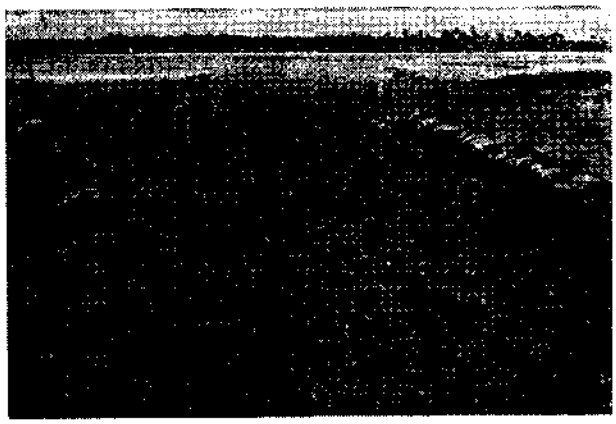

Fig. 2. Artificially made canal across the sand bar for free flow of sea water

RESULTS

Twenty trials were conducted in fish pens during 1981-'86. (Table 1). During the early phase of the trials, from 22-8-1981 to 11-7-1983, before the opening of the canal, the results were not encouraging. A few trails had to be abandoned due to low level of water in lagoon. Some of the trials yielded very low production due to low recovery as a result of drying of the lagoon.

Milk fish was cultured in the lagoon in the fish pens for a period ranging from 110-285 days. The highest production obtained was 455 Kg/ha in 110 days. Salinity during the experiments varied from 26 to 45 ppt and the dissolved oxygen from 4.1 to 5.2ml/l. The stocking size in the

Table-1 *Results of Pen Culture in Pillaimadam Lagoon*

	Area (ha)	Stocking	Harvest	Days	Stocking (number)	Recovery (%)	Stocking Length (mm)	Stocking Weight (g)	Harvest Length (mm)	Harvest Weight (g)	Harvest (Kg)	Remarks
1.	0 06	22-8 81	13-5-82	264	360	1 5	139	20.0	435	520	2.8	Low water
2.	0.06	13-5-82	10 9-82	121	360	3.0	101	7.5	214	66	1,0	,,
3.	0.25	26-6-82	10-9-82	77	2000	0.5	107	10.0	210	74	0.7	,,
4.	0.25	27-6-82	31-8 82	66	1500	0 6	108	9.5	242	103	1.0	,,
5.	0.25	15-7-82	10-9-89	58	1000	nil	146	25,0	—	—	—	,,
6.	0.50	17-8-82	5-10-82	50	635	1 4	185	68.0	236	197	2.0	,,
7.	0.25	18-11-82	31-3-83	134	866	10.1	75	2.0	260	137	11.9	,,
8.	0.50	22-6-83	22-7-83	31	5673	—	113	10.0	—	—	—	Lagoon dried
9.	1.00	29-6-83	11-7-83	13	2593	—	95	4.7	—	—	—	,,
10.	0.50	28-7-83	9-12 83	135	2927	7.8	112	14.2	312	220	50.0	Bar-mouth opened
11.	1.00	6-8-83	9-12-83	126	3698	—	112	14.2	—	—	—	Cyclone damage
12.	0.25	7-3-84	6-4-84	30	1000	—	77	2.9	—	—	—	Low level
13.	0.25	16-3-84	19-10-84	218	2500	13.0	14	1.0	221	80	26.0	Bar-mouth opened
14.	0.25	30-4-84	14-11-84	198	3500	19.0	76	4.0	192	55	37.0	,,
15.	0.25	16-5-84	14 11-84	183	3000	19.6	80	4.5	221	80	59.0	,,
16.	0.50	31-5-84	15-11-84	169	7500	31.1	87	4.6	206	54	133.0	,,
17.	1.00	14-8-84	4-12-84	110	20000	55.0	100	5.0	176	39	455.0	,,
18.	0.50	19-11-84	19-4-85	154	300	62.6	145	18.0	346	289	62.0	,,
19.	0.50	15-5-85	16-11-85	186	4000	51.1	69	2.0	260	136	227.0	,,
20.	1.00	1-7-85	25-3-86	267	10000	21.0	112	11.7	317	213	390.0	,,

trials ranged from 14.0 - 139 mm. It was observed that the recovery was only 13% when the stocking size was 14 mm and period of culture was 187 days. A higher recovery of 55% was obtained when the stocking size was 100 mm and the culture period was 110 days. But the recovery was only 21,%when the period of culture was 268 days with a stocking density 10,000/ha.

Maximum stocking rate tried in the fish pens in the Pillaimadam lagoon was 20,000/ha in a 1 ha pen. Fishes were cultured for a period of 110 days. The stock attained a length of 176 mm weighing 39.5 g from 100 mm weighing 5g. Recovery was 55% for 110 days. The pen yielded 455 kgs of milk fish. But when stocked at a rate of 10,000/ha in a 1 ha pen for 268 days, the fishes grew to 317 mm weighing 213 g from 112 mm weighing 5 g respectively. Recovery was 21% and the yield was 390 Kg/ha (Table 1). Growth of fishes in the above 2 trials was 0.3 g/day and 0.7 g/day respectively. But the production per day of the pens was 3.2 Kg/ha and 1 Kg/ha in the above 2 trials respectively. Though the high level of stocking produced better yield, the growth of individual fish was slow.

Six fishermen of Valayarvadi village near Pillaimadam lagoon organised themselves into a 'Pen culture Society' and availed Rs 36,000 (6,000 for each) with 30 per cent subsidy from the Indian Overseas Bank Uchipulli, Ramnad Dist. They could enclose 2 ha area in the Pillaimadam lagoon. The area of each pen was 1 ha. The pens were stocked with 10,000 milk fish fingerlings measuring 60-80 mm weighing 5-8 g. The pens were harvested after 6 months (April to October) with 55 percent recovery. About 900 Kgs of chanos of average 200 mm weighing 100 g were harvested along with 200 Kg of prawns, *P. indicus* measuring 150 mm weighing 15 g. The ' Pen culture society' could get Rs. 18,500 (Fishes @ Rs. 15/kg and the prawns @ of Rs. 25/Kg).

But the fish culture could not be continued due to the drought condition prevailed in the area and because of the inability of the fishermen to open the bar mouth as the lagoon dried during May-June, 1987.

REMARKS

While conducting the trails the followig constraints were observed.

1. The cost of webbing is a major factor which made the pen culture above the reach of the fisherman. They have to depend on the financial agencies for funds. The HDPE webbing was also liable to damage and its strength decreased progressively. Barnacle settlement on the palmyra poles also damaged the webbing. The settlement was found to be more on the HDPE, knotted-webbing. But the machine made knotless webbing was free from barnacle settlement.

2. Occurrence of milk fish seed was seasonal and there was seasonal incompatibility. The milk fish seed occurred from April to June and this period was succeeded by a spell of dry period alone the east coast. The Southwest wind during June-August also hastened drying of the lagoon. Evaporation due to solar radiation was also high during the Period.

3. In Pillaimadam lagoon the water level during the summer months could be maintained only by opening the bar mouth and facilitating sea water to flow into the lagoon. But it is a costly venture. Many species of coastal piscivorous birds invaded the coastal lagoons during the summer months and fed on the fishes. Eagles (*Milves migrans* and *Haliaster indus*), gulls (*Larus brunnicephalus* and *L. rudibundus*), terns (*Hydropronge caspia, Sterna sandvincensis, Sterna* Spp) and cranes (*Egretta gazetta*) were some of the important species visiting the lagoons.

4. Poaching by fishermen was another problem as the pens were located in remote places and monitoring the pens were difficult during the nights. But if the pens are managed by fishermen this problem can be controlled to a great extend.

5. Unpredictable weather change was another factor to be reckoned with. Cyclones and heavy winds of various intensities hit the Pillaimadam lagoon causing considerable damage to the structures including the webbing. The weather condition clamped restriction on the period of culture as the stock had to be harvested before the onset of north-east monsoon starting from the second week of November. Hence the fish culture could be conducted only from April to November without much risk.

6. The Pillaimadam lagoon was not very productive as indicated by the growth of fish and the estimation of primary productivity. The net primary productivity ranged from 300 to 900 mg/Cm^3/day.

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Paper-58

BIOCHEMICAL COMPOSITION OF SOME MARINE ALGAE FROM MANDAPAM COAST, TAMIL NADU

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ABSTRACT

The present paper deals with some important biochemical components such as proteins, carbohydrates and lipids of 33 marine algae, growing abundantly on the coast of Ramanathapuram District.

The results indicated that the green algae (Chlorophyceae) has the maximum of protein content ranging from 6.9 to 25.8%, next in order comes the brown algae (Phaeophyceae) with 1.3 to 16.6% followed by red algae (Rhodophyceae) with 1.5 to 8.8%. The range of carbohydrate content was from 0.3 to 11.6% in green algae, 3.3 to 24.9% in brown algae and 1.8 to 67.0% in red algae. The lipid content ranged from 0.5 to 8.6% in green algae, 0.5 to 3.7% in brown algae and 0.4 to 6.1% in red algae.

The results of the study give an insight into the biochemical content of the algal species studied could be used to decide their suitability for the formulation of feed to fishes in aquaculture and to other animals.

INTRODUCTION

The importance of marine algae as a source of phytochemicals such as agar-agar, algin and carrageenan and their use as food, fertilizer, manure and pharmaceutical compounds has brought a new awareness in many countries. In recent years, studies were carried out on their chemical composition and also on the properties of their important biochemical products. As a result, some of algal species have been reported to be good alternative sources of aminoacids, proteins, carbohydrates, vitamins and minerals (Hoppe, 1979 and Pillai, 1956). The occurrence of aminoacids like methionine and triptophane not available in other vegetables was also reported (Lewis, 1967).

The marine algal resources of India can be termed as moderately rich (Michanek, 1975) and at present *Gelidiella acerosa and species of Gracilaria, Sargassum* and *Turbinaria* are being harvested for the

commercial production of agar-agar and sodium alginate. Surveys conducted in recent years along the coast of Gujarat (Chauhan and Krishnamurthy, 1968; Bhanderi and Trivedi, 1975; Sreenivasa Rao *et al.*, 1964 and Chauhan and Mairh, 1978), Tamil Nadu (Anon, 1978), Goa (Untawale and Dhargalkar, 1975) Maharashtra (Untawale *et al.*, 1979), Lakshadweep (Anon, 1979) and Kerala (Chennubhotla *et al.*, 1987) indicated that there is a very good resource of marine algae at several places along the Indian coast. As per the reports available a total of 680 marine algae occur in Indian waters (Anon, 1987). The Tamil Nadu coast especially the one from Rameswaram to Colachel has luxuriant growth of marine algae where 22,044 tonnes of algae (fresh weight) is expected to be present over an area of 17,120 ha (Subbaramaiah *et al.*, 1979).

Considering the availability of algae and the contribution of marine algae as food, an attempt has been made to study their important biochemical composition in order to decide their suitability for the formulation of feed for fishes in aquaculture and to other animals.

MATERIALS AND METHODS

Seaweeds comprising 16 green algae (Chlorophyceae), 7 brown algae (Phaeophyceae) and 10 red algae (Rhodophyceae) were collected from the intertidal area of Rameswaram, Pamban, Pudumadam and Kilakarai located on the coast of Ramanathapuram District along the Gulf of Mannar.

The fresh weeds were washed thoroughly with distilled water, moisture removed by using blotting paper and dried up in an oven at 70°C to constant weight. The loss in weight was taken into account for the determination of water content.

The dried plants were powdered using mortar and pestle. The total carbohydrate content was estimated by the method of Dubois *et al.* (1956). The protein was determtned by the method of Lowry *et al.* (1951). The crude liquid was extracted in soxhlet apparatus by using the mixture of chloroform and methanol (2:10/v) and estimated gravimetrically as described by Krishnamoorthy *et al.* (1980)

RESULTS

Proteins: As shown in Table 1, the data indicate that the green algae had high amount of protein compared to other algal groups. It fluctuated between 6.9 and 25.8% among the green algae. The protein content in brown algae varied between 13.0% and 16.6%. Among the red algae the protein content ranged from 1.5 to 8.8%.

Carbohydrate: Among the three algal groups analysed, brown and red algae had higher carbohydrate content and green algae had lesser content. The carbohydrate content in the brown algae ranged from 3.3 to 24.9%. Among the red algae while *Gelidiella acerosa* (57.0%) had maximum quantity of carbohydrate the minimum content was found in *Jania rubens* (1.8%) and *Centroceras clavulatum* (4.8%).

Lipid: In green algae, the lipid content ranged from 0.5 to 8.6%. in brown algae from 0.5 to 3.7% and in red algae from 0.4to 6.1%.

DISCUSSION

Biochemical studies on algal protein, Peptides and free aminoacids were made extensively by Lewis (1962 and 1963). While reviwing his studies he pointed out that the Indian marine algae have all the essential aminoacids needed in human diet.

In India much attention has been paid on commercially important carbohydrate such as agar and sodium alginate and very few studies made on other biochemical products such algal proteins and vitamins. Parekh and Visweswara Rao (1964) recommended a method to extract protein in bulk quantity from the green alga, *Ulva rigida* and Subbaramaiah (1976) studied on vitamins present in algae. Dave *et al.* (1977) assessed the possibility of

Table 1. *Biochemical composition of seaweeds (Dry weight basis)*

Name of alga	Water content %	Protein %	Carbohydrate %	Lipid %
CHLOROPHYCEAE				
1. *Enteromorpha compressa*	91.4	23.8	6.2	6.1
2. *Ulva lactuca*	87.3	25.8	8.7	5.2
3. *U. reticulate*	79.4	24.4	11.6	5.3
4. *Chaetomorpha antennina*	89.1	19.7	6.4	8.6
5. C. *linum*	90.2	16.7	7.6	8.1
6. *Cladophora* sp.	79.1	9.2	6.6	6.5
7. *Caulerpa peltata*	89.4	24.4	1.3	1.6
8. *C. racemosa* var. *macrophysa*	96.4	24.8	8.7	0.8
9. *C .scalpelliformis*	88.9	25.2	10.7	7.6
10. *C. taxifolia*	89.2	23.6	9.7	4,1
11. *C. sertularioides*	81.6	22.7	9.9	4.6
12. *Valoniopsis pachynema*	84.3	18.8	2.5	0.7
13. *Bryopsis plumosa*	72.8	19.2	10.1	2.0
14. *Halimeda gracilis*	44.8	least	least	least
15. *Cladophoropsis zollingeri*	51.9	10.3	0.3	0.5
16. *Codium decorticatum*	89.6	6.9	10.0	4.2
PHAEOPHYCEAE				
17. *Sargassum wightii*	80.4	16.3	24.9	1.2
18. *S. myriocystum*	64.4	15·6	23.8	0.5
19. *S. ilicifolium*	70.6	15.1	24.0	1.1
20. *Stoechospermum marginatum*	79.6	14.9	15.4	3.7
21. *Hormophysa triquetra*	61.0	16.6	3.3	0.6
22. *Padina gymnospora*	71.3	13.0	13.2	1.3
23. *Turbinaria conoides*	72.4	15.2	14.0	3.6
RHODOPHYCEAE				
24. *Jania rubens*	39.4	1.5	1.8	0.4
25. *Centroceras clavulatum*	66.9	3.8	4.8	3.4
26. *Hypnea valentiae*	87.5	6.1	37.8	6.1
27. *Gracilaria edulis*	85.5	3.9	45.8	2.4
28. *G. corticata*	79.3	6.1	45.5	6.0
29. *G. crassa*	88.4	4.3	30.4	0.9
30. *Grateloupia lithophila*	72.0	5.8	36.9	0.7
31. *Gelidiella acerosa*	86.8	8.8	57.0	3.6
32. *Acanthophora spicifera*	86.1	4.8	29.7	0.5
33. *Laurencia papillosa*	87.9	4.3	11.6	0.6

seaweeds to be used as a supplementary animal feed. The seaweed meal prepared from *Sargassum* and the results of its feeding trials on chicks, sheep and cattle are given by Dave *et al.* (1979). The study was mainly to find out the effect of algal-feed on the body weight of the animals. Seaweeds are also widely used for human consumption and they are eaten as salad, curry, soup or vegetables in many countries (Chapman and Chapman, 1980). Some of the edible seaweeds occurring in India are *Ulva, Enteromorpha, Chaetomorpha, Caulerpa, Gracilaria* etc. (Umamaheswara Rao, 1973).

On viewing the ever growing demand for proteinaceous food for human consumption and for other purposes, it is necessary to properly utilize this non-conventional resources. The present study revealed that seaweeds like *Ulva lactuca, U. reticulata,* species of *Caulerpa, Hypnea valentiae* and species of *Sargassum* which are available abundantly along our coastline could be used as additional sources of protein and carbohydrate.

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Technical Session IV

FISHERIES TECHNOLOGY

Paper-59

ROLE OF FISHING TECHNOLOGY IN THE RESEARCH AND DEVELOPMENT OF MARINE FISHERIES IN INDIA

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ABSTRACT

Consequent to the declaration of Exclusive Economic Zone (EEZ) to 200 nautical miles, India has acquired right to explore, exploit, manage and conserve the resources of her seas. This provides, greater challenge by way of financial investment, provision of infrastructural facilities, introduction of different types of large deep sea vessels, modern fishing gear and use of modern technologies in fish handling, processing, storage and marketing.

Great strides have been made in increasing marine fish production of India from 0.53 million tonnes in 1951 to 1.81 million tonnes in 1984. This has been possible by application of various technologies including fishing technology. The introduction of bottom trawls, purse seines, high opening trawls in selected areas, double rig shrimp trawls from deep sea fleet, etc. has made significant impact on the marine fish production. Introduction of synthetic twines contributed to the increase of efficiency of gear like gill nets and trawls. Mechanisation of fishing vessels resulted in economical operations, expansion of fishing range and duration of fishing. Other aspects of fishing which helped the overall fisheries development include exploratory surveys for resources assessment, deck equipment to handle the gear, electronic instruments for finding fish and to navigate the vessels safely.

This paper deals with fishing methods in marine waters, types of vessels in operation, prospective development in fishing technology and recommendation regarding vessel and gear suitability for exploitation of deep sea resources.

INTRODUCTION

Consequent on the declaration of the Exclusive Economic Zone (EEZ) of 200 nautical miles through an act of parliament in 1976, India has acquired right to explore exploit, manage and conserve the resources of the EEZ. This provides greater challenge by way of financial investment, provisions of infrastructural facilities, introduction of different types of large deep vessels, application of modern technologies in fishing, fish processing, fish handling, storage and use new marketing strategies.

Of the total estimated potential of 4.5 m. tonnes, India is now harvesting about 1.8 m. tonnes of marine fish. The importance of harvesting all the resources at sustainable levels needs no special emphasis particularly to meet the animal protein requirements of the large Indian population. Fishing technology has a greater role in the marine fisheries development of India.

The fishing vessel, gear and operations represent in most instances a considerable share of the investment and operating costs of fishery development. Fishing and related shore services also account for a significant share of the employment opportunities. Any short comings or mistakes in planning and implementation of development programmes with respect to fishihg technology, therefore involve correspondingly high risks

of losses in time, funds and efforts. Unlike established fisheries disciplines such as fisheries biology, oceanography, statistics, fish processing, fish marketing and fishery economics, the development of fishing vessels, gear and operations have been taken for granted and left essentially to the fishermen, fishing companies with little or no government inputs. Thus fishing technology has been neglected so far. However in industrial fisheries, the trends have changed during the last few decades.

The following are some examples illustrating the role of fishing technology in the Research and Development of Marine Fisheries in India.

1) *Introduction of Synthetic material for fabrication of fishing gear.*

With the advent of synthetic fibres, fishing net manufacturing industry has made rapid strides. Synthetic fibres are superior to the natural fibres due to their rot proof nature, durability and catch efficiency. The use of synthetic materials for fishing gear fabrication is one of the major aspects of Fishing Technology which has revolutionised the fishing industry. Now there is a wide variety of synthetic materials with characteristic properties and hence sufficient choice to select suitable material to meet the requirements of individual fishing gear.

Indian fishermen especially those of Gujarat and Maharashtra have been able to increase their catch substantially with the use of nylon for gill nets. Just as hemp has almost been replaced by nylon in gill nets, cotton is replaced by nylon in Purse seines, and by H.D.P.E. in trawls.

In India Polyamide, Polyethylene and Polyprophylene are manufactured for fishing gear at present. Polypropylene in multifilament form shows great promise as a substitute for nylon because of its cheapness, strength and stretch properties.

2) *High opening bottom trawl*

The introduction of high opening bottom trawl in Indian waters has demonstrated its greater effectiveness in catching the off bottom fishes like pomfrets, carangids and catfishes besides other demersal fishes. The trials of high opening trawls from small mechanised boats by BOBP in selected places of Tamilnadu, Orissa and Gujarat have shown encouraging results. This effort has considerably improved the marine fish landings of these states. The possibilities of introducing high opening trawls in other places have to be explored.

3) *Aimed trawling*

Development of mid water trawls besides solving the problem of catching column fishes in Indian waters has been with a view to diversify the fishing effort. Two boat midwater trawling was first tried in India about a decade ago. Along the south west coast, two boat mid water trawling has proved to be highly successful during the monsoon months. This indirectly is a boon for the economic operation of small mechanised boats.

Large scale mid water trawling trials were carried out along the south west and north west coasts of India, the results of which proved the utility of the method for the exploitation of columnar fishes like horse mackerel, ribbonfish, pomfrets, catfish, carangids etc.

4) *Double rig shrimp trawling*

Double rig shrimp trawling has the advantage of producing more shrimp per unit of effort than a single large trawl. It is easier to tow and handle the gear too. All the deep sea shrimp trawlers of India have successfully adopted double rigging, contributing for the increased landings of shrimps.

In India, a scientific appraisal of double rig trawling was done on the north west coast during the mid seventies.

5) *Lobster traps*

Lobsters which are highly priced are exploited by trawls and traps mainly. The

traditional colachel traps used by fishermen of south west coast of India lack compactness and the strength to withstand rough sea conditions. Considerable efforts have been made to introduce more effective traps. Rectangular trap, Australian pot and ink well type of traps, made indigenously have been tried successfully along the south west coast. As a result of these gear, non trawlable fishing grounds can be exploited more effectively particularly in the deeper areas of the shelf for deep sea species that are less exploited at the moment.

6) *Kalava traps*

Good Kalava grounds are located in the continental shelf within a depth range of 70-100 m. There is significant potentiality for Rock Cod fishing off the south west coast of India. However trawling is not possible in the region due to bottom obstructions. The operation of hand lining gear for Kalava poses the problem of locating the exact position of the fishing ground and keeping the vessel at the same spot. To overcome these problems, Kalava traps have been operated successfully from small mechanised vessels of about 43' length. This has made it possible to fish in rough weather too.

7) *Squid jigging*

Squids, a resource which has high export value are only marginally exploited in India. They appear along with other fishes in the trawl catch. Squid jigging, a modern technique of fishing operated successfully in countries like Japan has been tried in Indian waters at a depth range of 30-380 m. Experimental squid jigging operated from an FSI vessel in 1981 did not meet with success probably due to lack of expertise. This perhaps has hampered the wide acceptance of the squid jigging in India.

8) *Diversification of fishing methods*

Several small sized shrimp trawlers and larger outrigger trawlers are operating along the Indian Coast. However, the prospects of inshore fishing for shrimps are not as lucrative as it was before. Fishing by other methods is a means to ensure better exploitation of all the marine resources. This calls for diversification of fishing methods. to operate more than one type of gear to offset the economic difficulties due to non-availability of shrimps and to fish for other resources.

Experimental fishing using diversified fishing gear like purse seine, bottom trawl, pelagic trawl, trap etc. have been demonstrated particularly in the southern maritime states of India.

There is an urgent need to carryout diversified fishing activities from small mechanised boats. Other fishing methods for diversification include long lining for sharks, Pole and line fishing for tunas.

9) *Fish Aggregation Devices (FAD)*

Fish Aggregation Devices adopted for luring fishes into a position facilitating easy capture have reduced the time expended for searching fish. FAD's are a boon particularly in the exploitation of pelagic fishes where considerable time and fuel are spent in scouting. The methods adopted for exploitation of fishes around FADs are trolling, pole and line, hand lining, gill netting and purse seining. Experiences of Lakshadweep fishermen in fishing around the floating objects is highly rewarding with the catch doubling with about 40% reduced cost.

10) *Mechanisation*

Mechanisation of fishing craft initiated during the first five year plan, has assumed great importance over the years in the development of marine fisheries of India. It has enabled the fishermen to fish in deeper waters and for a longer period resulting increased productivity and income to the fishermen.

Mechanisation of fishing operations has played a very crucial role in improving the efficiency of all fishing methods. Introduction of several gear handling devices on board which facilitate easy, efficient, faster and safer handling of gear has helped the Indian

fishing industry to grow at a quicker pace. BOBP has successfully demonstrated the use of gantries on fishing trawlers.

With a view to enable hauling of large gear like purse seine, power blocks have been developed. This has made it possible to fish in rough weather too besides increasing manpower efficiency. Line haulers in long liners have increased the operational efficiency of gear by handling longer lines in short time with reduced manpower. Efforts in reducing human effort in fishing is reflected in winches used in trawlers and purse seiners for hauling the gear mechanically. Net drums installed on board fishing vessels provide more deck space, in addition. Smooth release of the catch on the deck made more effective by the use of Cod end clips. Split links help in connecting the riggings quickly effecting saving of time

11) *Deep sea fishing*

With the declaration of the EEZ, there have been several attempts for exploration of deep sea resources bayond 40 fathoms. Deep sea fishing involves high technology, high capital investment besides high risk. Exploratory surveys conducted so far have provided fairly good information regarding the deep sea resources of the Indian EEZ.

The potential areas for increased fish poduction are the upper coast especially for prawns and cephalopods, Laccadive and Andaman waters for Skipjack and other tunas, Wadge Bank for perches and the continental slope of the south west and south east coast for prawns and lobsters. However, deep sea fishing has not caught up in India due to varied reasons like non-availability of established markets, inadequate infrastructural facilities, lack of specific deep sea vessels and due to difficulties in securing the soft loans. Further more, Industrial surveys are needed to establish economic viability of ventures.

12) *Development of electronics*

Electronic Science has revolutionised the fishing industry. Electronic equipments including fish finding, navigation and communication devices have contributed to the increased production. The days of wandering in the sea and shooting the nets blindly have gone. The skipper can now see the fish below and around his vessel, estimate the density of the population, species composition if he is experienced with the use of echo ranging instruments like echo sounder and sonar.

Instruments working on the principle of hydro acoustic give the direct indication of fish availability, bottom configuration, movement of fishes etc. which are taken into account while planning fishing operations.

The use of Net Sonde in trawling gives information regarding the vertical opening of the trawl, fish behaviour in front of the net etc.

Fishing vessels can now navigate more safely and accurately than ever before using electronic instruments like Decca, Loran, Radar, Direction Finder, Satellite navigator etc. Radar increased the capability of inshore navigation and allowed greater safety for round the clock fishing operations. Satellite navigator has modernised the position finding accurately in few seconds. Fishing vessels while at sea can communicate with the shore and other vessels by means of the radio telephone and telegraphy. Till recently fishing vessels fitted with the electronic equipments were few. However, with the addition of large offshore and deep sea fleet, their use will be widespread.

Instruments for monitoring performance of craft and gear have been developed indigenously. The performance of gear under water is measured by instruments like under water tention meter, Tilt meter, Angle of atrack meter, mesh distorsion meter etc. Catch telemeter measures the catch in the net. Handling of several electronic instrumants on board poses problems. However, universal marine tele meter developed indigenously displays all the information one by one in a single meter.

Table 1. *Craft and Gear suggested for major deep sea resources of Indian seas.*

Resources	Depth of abundance (M)	Distribution	Appropriate type of gear	Suitable type of craft
1. Thread fin bream	50-300	All over Indian Coast, More on West Coast.	Bottom trawl, Mid water trawl.	Combination vessel/ Deep sea trawler
2. Bull's eye/ Big eye	50-200	All over Indian Coast.	Bottom trawl.	Deep sea trawler.
3. Black ruff	200-500	Goa, Karnataka, Kerala, A. P., Coromandal Coast.	,,	,,
4. Drift fish	100-500	Goa to Orissa.	,,	,,
5. Scad	100-500	Goa to Orissa.	,,	,,
6. Green eye	200-600	Karnataka, Kerala.	,,	,,
7. Horse Mackerel	40-100	Gujarat, Orissa, W. B.	Mid water trawl, Purse seine.	Combination vessel.
8. Mackerel	50-200	Orissa, W. B.	High opening trawl, purse seine.	Combination / Purse Vessel. seiner.
9. Ribbon fish	20-150	Maharashtra	Bottom trawl.	,, / Deep sea trawler.
10. Lizard fish	100-500	Maharashtra, Goa, Karnataka, Kerala	Trawl	Deep Sea Trawler.
11. Squid and cuttle fish	20-500	All over Indian Coast	Trawl, Squid jigging.	Combination / Squid vessel Jigger.
12. Deep sea lobster	200-500	Karnataka, Kerala, Wadge Bank, Gulf of Mannar, T. N., A. P., Orissa.	Trawl, Traps.	Combination / Trap vessel vessel
13. Deep sea prawn	100-500	Karnataka, Kerala, T.N.	Shrimp trawl.	Deep sea trawler.
14. Deep sea shark	200-600	Kerala, T. N.	Lines.	Long liner.
15. Crabs	100-200	Wadge Bank, Gulf of Mannar.	Pot	Combination / Pot vessel. vessel.
16. Cat fishes	50-150	Karnataka, Kerala, Lower and upper east coast.	Mid water Trawl, high opening trawl	Deep Sea / Combination Trawler. Vessel.

Electronic instruments for testing and standardisation of fishing craft measure different parameters of fishing craft. Development of Bollard pull monitor and speed and distance log has made it possible to measure the bollard pull and to know the speed and distance travelled by the vessel.

Craft and gear suggested for major deep sea resources of Indian Seas

There is a good possibility of increasing the marine fish production through exploitation of deep sea resources of the Indian seas. Deep sea resources are at present least exploited due to varied reasons and constraints. Major deep sea resources, their depth of abundance, distribution, suitable gear and craft are given in table 1.

Thread fin bream fishery offers good scope for increased production from the west coast especially Kerala – Karnataka and South Maharashtra areas between 50-200 m depth. Carangid fishery is under exploited at the moment. Catfishes appear in appreciable quantities all along the west coast and to a lesser extent on the east coast. There is possibility of increasing the production of squids on the west coast. Deep sea lobsters are found in abundance at a depth range of 200–500 m. along Karnataka, Kerala, Wadge Bank, Gulf of Mannar, Tamilnadu, Andhra Pradesh and Orissa.

Single type of gear is suggested for resources found in abundance almost throughout the year. The main gear suggested for the exploitation of deep sea resources of Indian seas are bottom trawl, midwater trawl, high opening trawl, purse seine, traps, pots and lines. Bottom trawls are suggested for resources like Thread fin bream, Big eye, Black ruff, Drift fish, Scad, Geen eye, Ribbon fish, Lizard fish, Squids, Cuttlefish, Deep sea lobster etc. Some of these resources are exploited by more than one type of gear. Midwater trawl is an appropriate gear for exploitation of Horse mackerel, Thread fin bream and catfishes. High opening bottom trawl could be efficiently used for catching Mackerel and catfishes. Though squids appear in bottom trawl, squid jigging is the most appropriate method for commercial exploitation. Purse seiners can be used for Mackerel and Horse mackerel. Lines are most suitable gear for deep sea sharks occuring at a depth range of 200-600 m. Traps and pots are efficient gear for deep sea lobsters and crabs respectively besides trawls. Shrimp trawls are best suited for deep sea prawns.

As regards the vessel, multipurpose vessel of 20 meters and above with layout of wheel house forward appears to be more appropriate for the exploitation of multispecies fisheries of deep sea. Bottom trawling, midwater trawling, purse seining, trapping, jigging would be combined in the multipurpose vessel depending on the requirement. Single purpose vessel is not justified unless the fishery extends for long seasons or throughout the year. Combination trawl and purse seine, trawl and pot, trawl and squid jigging are also relevant for the exploitation of few commercial species as listed in the table. The actual size of vessel depends on the distance of fishing grounds from the harbour, depth of operation, weather conditions and economic feasibility.

CONCLUSION

The Fishing technology has an important role in any well balanced over all fisheries development. So far it has been taken for granted and left to the fishermen and industry. However a begining was made in India in 1950's with the initiation of mechanization to apply the fishing technologies developed by research. The examples listed above have contributed to the increase of marine fish production of India. The research on fishing technology needs strengthening not only for consolidating the gains achieved but also to harvest all the available resources.

IMPACT OF VERTICAL HIGH OPENING NETS IN GUJARAT

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ABSTRACT

Field trials were conducted with an improved version of V. H. O. net of BOBP in Saurashtra waters by the Gujarat Fisheries Aquatic Sciences Research Station, Veraval. Both the fish catch and value improved. This centre has been helping fisherman to fabricate this modified version of net which is popularly known as DISCO net to fishermen. The acceptance is total and within last two years 1500 modified V. H. O. nets were fabricated at Veraval alone. This paper gives the salient features of modified design and comparative statistics.

As per the published Boat census of Gujarat, there are 646 trawlers, 54 mechanised gill netters, 301 dug out canoes with OBM and 18 non-mechanised boats operating from Veraval, in Junagadh District (Table 1). This district with its important fishing ports like Navabunder, Dhamlej, Sutrapada, Hirakot, Veraval, Chorwad, Mangrol and Porbander land more than 50% of the total marine fish catch of Gujarat. Boats from other parts of Gujarat also migrate to these ports as the fishing ground is nearby and infrastructure facilities including approach to port are better developed.

Table 1. *No. of fishing vessels in Veraval and Mangrol*

Sr. No.	Centre	Year	Trawler	Gill netter	OBM	Non-Mech.	Total
1.	Veraval	1983	626	82	277	11	996
		1985	646	54	301	18	1019
2.	Mangrol	1983	168	13	120	8	309
		1985	167	13	122	2	304

During 1982-83 the Department of Fisheries introduced the vertical high opening (VHO) nets among fishermen of Gujarat in collaboration with CIFNET, Cochin. Thereafter trials were carried out and the designs were modified to suit the local conditions. Double bridle of 22 m showed a better performance as compared to the original single bridle system. Adjustable chains weighing 5 kg each was also removed as it was giving difficulties while fishing for prawns in the muddy bottom. The 40 mm piece was replaced by 60 mm. A 75% replacement of 48 mm mesh gave better performance at a reduced RPM and the total weight of the net was considerably reduced.

After intensive extension work in the field, i. e. educating fishermen on the importance of conservation of juveniles and catch-return viability of VHO nets, operational techniques were imparted to fishermen. With the traditional trawl nets, fishermen were finding it difficult to maintain sustainable production. The income per boat was also reducing. Pomfret, seer fish, squid, cuttlefish etc. were landed in negligible quantities in conventional nets.

The catch composition of VHO nets which included fishes like pomfret, seer, perches, squid, cuttlefish, pellona, silver-bar alongwith eels, prawns and lobsters, and good quantity of big scianeids (dhoma), *Lactarius* and ribbonfish was the main attraction. Scianeids, *Lacterius* and sole (Jib) were of big size. They were salted and sun dried for human consumption.

The total catch during 1982-83 was less compared to previous year (Table 2). But as the size of fishes landed was big the return in terms of value was more.

Table 2. *Marine fish landings in Junagadh District*

Year	Catch of Gujarat St.	Catch of Junagadh Dist.
1981-82	2,20,607 MT	1,28,695 MT
1982-83	1,92,669 MT	1,15,241 MT

The above figures show that when the VHO big mesh nets were introduced, there was a slight decrease in the catch. The only attributable reason is that the filtration capacity of the nets is much more, whereby the juveniles are saved and allowed to grow further. This presumption is strengthened by the increase of total catch from 1983 84 onwards (Table 3).

As there is a steady increase of catch year by year, the shortfall in catch during 1982-83 can be attributed towards the filtration capacity of VHO nets. This should be the main reason for increase not only in production but also in size.

Table 3. *Marine fish landing at Veraval and Mangrol*

Year	Catch of Gujarat	Catch of Veraval	Catch of Mangrol	
1982-83	1,92,669	58,036	11,160	figures from July to June
1983-84	2,23,291	63,527	20,962	
1984-85	2,90,708	86,392	21,111	
1985-86	N.A.	1,27,084	16,117	- figures from July to March

Table 4. *Marine fish production by differerent fishing gears*

Year	Total catch by gillnets (t)	Total trawl catch (t)	Total catch by non-mech. boats (t)	Total landings (t)
Veraval :				
1982-83	2,352	52,145	195	58,036
1983-84	7,219	57,063	245	64,527
1984-85	8,033	78,186	173	86,392
1985-86	4,249	118,981	34	127,084
Mangrol :				
1982-83	3,072	7,017	34	11,160
1983-84	5,673	15,253	36	20,962
1984-85	5,907	15,067	137	21,111
1985-98	4,126	11,949	42	16,117

Note : 1985-86 - data from July to March
Other years - data from July to June

The demand for VHO type of nets showed an increase. To cope up with the demand, the craft and gear unit of the Department started training local fishermen to fabricate nets by tailoring from machine-made webbing and this turned out to be a great success. Now fishermen rarely hand-fabricate webbings. After the introduction of VHO nets the sale of ready made webbing has picked up considerably.

From conservation point of view also this net plays an important role. Jamnagar Coast was famous for polynemus (Dara) fisheries. But now Dara remains a rare species compared to olden days. Likewise pomfrets (black and white) landed at Madhwad-Veraval were of very good size. Now-a-days the quantity caught and the size have reduced very much. The hilsa (Palla) catch stands without much change. During trawl net operation the juveniles of Dara, Pomfret and Indian Salmon are caught and destroyed. This may be the reason for the gradual disappearance of Dara and reduced catches of pomfret. In the conventional nets the mesh size used is 40/60 mm on the wings. This is very dangerous from the point of view of conservation of resources. As VHO net starts with 160/120 mm average on wings and front belly, it permits juveniles and all smaller fishes to escape to a great extent.

Table 4 shows a steady increase in the fish catch mainly from trawlers. Now a-days almost all boats are using VHO variations and the upward trend in catch is due to this. The major marine catch contribution in Gujarat is from Veraval & Mangrol (Junagadh dist). During 1984-85, 70% of the total catch was from Veraval and Mangrol.

For resource conservation, it is advisable to impress upon fishermen to use VHO type of nets and avoid destruction of juveniles.

TUNA POLE AND LINE (LIVE BAIT) FISHING TECHNIQUE OF LAKSHADWEEP - SOME SUGGESTIONS FOR IMPROVEMENT

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ABSTRACT

Adding some essential details to the existing scientific exposition of the Tuna Pole and Line (TPL) fishing technique with live bait of Lakshadweep, the present paper deals largely on a comparative study of this technique with the TPL technique operating in Japanese, Californian and Polynesian waters. Based on this comparative study some suggestions are given for improving the craft, gear and gear-making with regard to the TPL fishing technique of Lakshadweep. Besides the need for having better objectives of mechanisation, improvements in : Size and cruising range of fishing boats; general feature of the fishing boats; types of engines used; live-bait equipment used; onboard facilities for the operation of the fishing gear; fish preservation and handling equipment onboard; facilities for crew accommodation onboard; navigation, communication and fish finding equipments onboard; combination fishing boats; alternative fishing boat; ancillary ships; materials used for construction of boats and also improvement in patrol and transport work undertaken by the fishing boats are suggested. Also, the need for introducing the team-gear, bait-hook, lure-hook and striker and for improving the mode of angling, chumming and water splashing is stressed. The urgent need for modernising the TPL gear-making industry by indigenously making TPL hooks, lure-hooks, bait hooks and strikers; by supplying FRP Poles and quality bamboo Poles and the other fishery requisites at subsidy and by introducing quarantine and quality control measures to maintain the quality of bamboo Poles is stressed.

INTRODUCTION

The Indian Union Territory of Lakshadweep forms one of the natural oceanic regions of the World where the Skipjack tuna, *Katsuwonus pelamis* and small yellowfin tuna, *Thunnus albacares* abound in immense potential at surface layers which are being fished by the TPL (live bait) fishing technique. These species support large scale TPL (live bait) fisheries in several parts of the World, especially in the Japanese and Californian waters where a lot of technological advancements have been made in tuna fishing. A comparative study of the TPL (live bait) technique of Lakshadweep with that of other parts of the world would reveal our present and future development needs. No such comparative account is available in exising literature with regard to the TPL (live bait) fishing technique of Lakshadweep, as revealed notably from Hornell (1910, 1934 and 1950), Ellis (1924), Rao (1955), Mathew and Ramachandran (1956), Jones and Kumaran (1959), Varghese (1970), Puthran and Pillai (1972), Ben Yami (1980), Silas and Pillai (1982), Madan Mohan *et al.* (1985) and Livingston (MS), and to this method of Maldives and Sri Lanka which is reported to be the same as that of Lakshadweep (Jonklas, 1967 and FAO, 1975). Therefore, besides adding some details to the existing description of the TPL (live bait) technique of Lakshadweep, a comparison of this fishing technique with that of Japan, California and Polynesia is attempted in the present investigation and some of our craft and gear technological needs for development in this line are brought to light in this paper.

MATERIAL AND METHODS

As part of the tuna fishery biological investigations undertaken in Lakshadweep during 1975-'81, a total of 44 onboard observations were made at Minicoy during the fair tuna seasons of 1975-76 and 1980-'81.

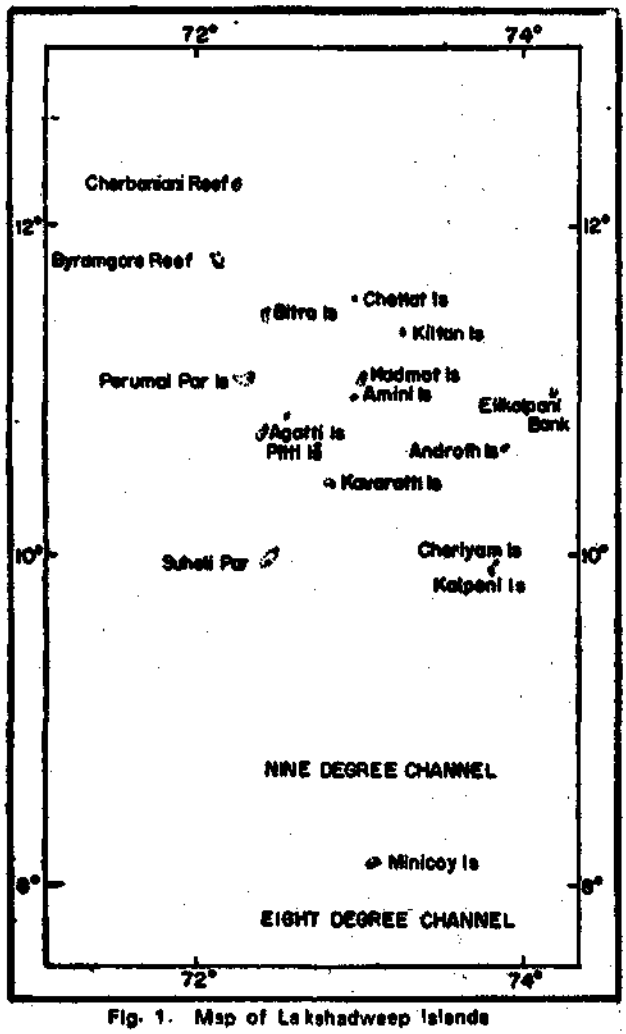

Fig. 1. Map of Lakshadweep Islands

Each trip was of about 10 hours duration between 6 a.m. and 9 p.m., conducted within 20 km radius around the islands. All the remaining nine inhabited islands in Lakshadweep (Fig 1) were also visited for craft and gear survey during the period, 10th May 1976 to 8th Dec. 1978. Information on this fishing technique gathered by extensive enquiries with local fishermen experts in each island were critically examined by the onboard observations at Minicoy. For the present comparative study scientific knowledge regarding the TPL technique operating in other areas of the world was gathered from literature.

OBSERVATIONS ON TPL (LIVE BAIT) TECHNIQUE OF LAKSHADWEEP

The TPL (live-bait) Boat and its Crew:- Details of this craft are given notably by Puthran and Pillai (1972), Ben Yami (1980) and Silas and Pillai (1982). Some more essential features are added here. Fig. 2 shows the parts of a typical boat of 9.14 m OAL. There are six gear positions fixed by convention onboard the fishing platform, three on either half of it, (P_1, P_2, and P_3 in Fig. 5). These gear positions, the operator of the gear from these gear positions, and the gear unit operated by them are locally distinguished as *bandu dhori*, *gudhu* and *enja* in order. There is an

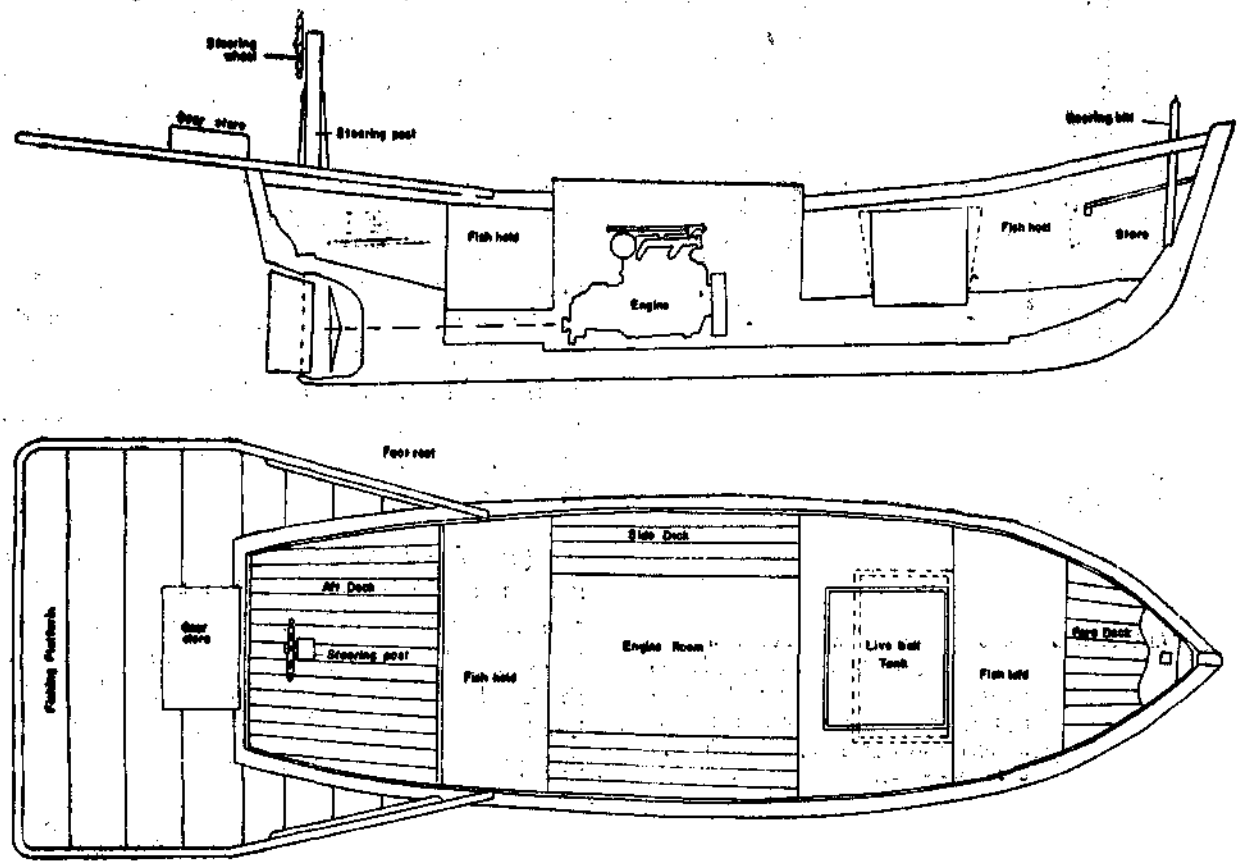

Fig. 2. Parts of typical mechanised Skipjack Tuna Pole and Line (Live bait) boat of Lakshadweep.

aft to fore reduction in length of 25-36 cm between the successive gear unit (Pole) operating from P_1 to P_3, for any of the four varieties of the gear operated from all these gear positions. Typically a crew compliment of minimum 14 men is required : the Chief fisherman, engine driver, chummer, six leading fishermen (operators of the TPL gear), four water splashing men and one man for auxiliary services onboard.

Parts of a typical pole and line gear (Fig. 3 A & B).- This gear is described originally by Jones and Kumaran (1959). However, a more detailed description is given here. A typical unit of the Pole and line gear of Minicoy consists of the following parts, *viz.*, (a) The Pole, (b) The Leader or Leader line (c) The Snood and (d) The Hook.

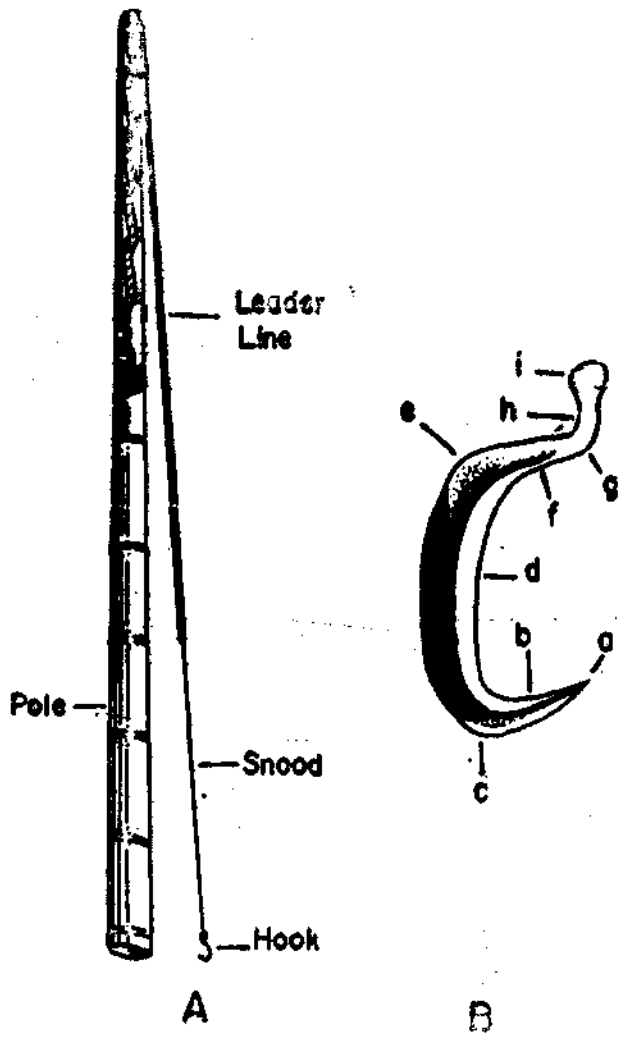

Fig. 3 A & B Parts of typical Skipjack Tuna Pole and Line (live bait) fishing gear of Lakshadweep. (a—Point; b—Fore-leg; c—Fore-bend; d—Shank; e—Aft-bend; f—Aft-leg; g—Eye-bend; h—Eye base and i—Eye).

(a) *The Pole:-* The Pole of this gear is a bamboo rod, about 2 fm (3.66 m) long. Its diameter reduces gradually from the basal end (30-35 mm) to the terminal end (25-39 mm). There are 10-12 internodes contained within the entire length of the Pole. These internodes reduce in length from the basal end towards the terminal end of the Pole. The basal butt of the pole ends just about 3 cm down the lower most node, giving a suitable internodal cup for securing the hook when the gear is at rest. The terminal end of the Pole ends just about 3 cm above the upper most node, giving a suitable marling surface for the rigging of the Leader Line. The adjoining few nodes below also provide suitable marling surfaces for the auxilliary rigging of the Leader line.

(b) *The Leader Line:* The main line through which the snood is rigged to the terminal end of the Pole forms the Leader Line of the gear. It is a three strand (16 x 3), 3-5 mm nylon twine with an S-twist. When detached from its Pole, the Leader measure about 1.5 m in stretched length. It is bent to form two almost equal limbs, each extendable from the terminal end of the Pole to a little down its middle. One limb of the lead Line hangs down freely from the point of its securing at the distal end of the Pole and extends almost upto a little down the middle of the Pole, at which level, this end of the Leader Line is rigged to the upper end the snood coming from the hook. The other limb of the Leader Line is marled around the Pole to secure the former limb in position. The colour of the Leader Line is often blue, to merge with the Sea.

(c) *The Snood:-* The snood of the gear is formed by a piece of 1.0 mm monofilament almost equal to half the length of the Pole. It is rigged to the hook at the basal end and to the Leader Line at the terminal end. Unlike the Leader Line, the Snood is more flexible and this quality of the Snood enables its stretching

upto about 2 cm downward for the securing and releasing of the attached hook in position in the butt socket of the Pole. Typically, the snood also is bue in colour to merge with the sea. The total length of the entire line, including the length of the rigged hook, the rigged snood and the rigged Leader Line together equals the length of the Pole.

(d) *The Hook (Fig. 3 b)*:- Assuming a typical pole and line tuna hook to have some atttributes of a traditional tuna boat, the Minicoy hook makers and tuna fishermen distinguish three major portions in a typical Pole and Line Tuna Hook, *Viz*, (i) the Fore End *(Thundu kolu* or *Dhurmba kolu)*, (ii) The Aft End *(Filathy kolu* or *Kolufus kolu)* and (iii) the Shank or main Body *(Thadi)*. The upper side *(Mathi farai)* of the hook (when the hook is placed in its normal trailing position in water with its projecting limbs upwards), is distinguished from the lower side *(dhe farai)*. The hook measures 4.5-5.5 cm in length. The major sections of the hook and their specific functions may be described as follows:

(i) *Spear (Thundu)* : The spear or point represents the distally narrowing fore end of the hook. It occupies about one fifth of the entire fore aft length of the hook measured along its body. It is of the barbless type. The short piercing edge or point *(thundu kuri)* forming the extreme distal tip of the spear is subconical with roundish sides whereas the remaining portion forming the major parts of the spear is four sided. The piercing tip though sharp is thickly pointed so as to enable easy retrival of tuna once it is hooked.

(ii) *Fore bend (Thundu gudhu)*:- This is the the curved portion of the hook placed between the spear and shank proper. The degree of curvature of the fore bend is considered to be an important attribute in designing hooks; it determines the retrival efficiency, stability and proper bubble formation of the hook while it is trailed in water (Fig. 6). It has an obtuse angle of about 45°. This angle is very important for the formation of bubble (around the hook) which simulates an actively vibrating prey.

(iii) *Shank (Thadi)*: The shank represents the main body of the hook, occupying about three fifth of the total length of the hook, measureable along its aft to fore along the body. Major part of the volume and about two third of the weight of the hook is concentrated in the shank, in a gradually decreasing order from its aft to fore. The shank is streamlined and pisciform in shape. It plays the most important role in forming and regulating the size of the water bubble of hook, which in turn is related to the size of livebaits selected for chumming operations. The diamensions of all other parts of the hook being fixed in proportion to the dimension of the shank, the shank serves as the most useful indicator of the size of the hook in selection of hooks. The size of shank increases as the size of hook increases. The shank is of a keeled type with four fore-aft equidistant keels, one upper, one lower and two lateral in position. The lateral keels are a little more pronounced than the other two; this aids in the floatation of the hook in water. The shank is provided with a slight downward carvature along its middle. This curvature locally referred to an amidship bend (*medhu gudhu*) of the hook, gives stability to the hook. The girth (*falami*) of the hook is measured along the broadest portion of the shank falling just at its aftward end which joins the aft bend of the hook.

(iv) *Aft bend (Filathu gudhu)*:- This bend is placed between the aft end of shank and the neck of the hook. Compared with the fore bend, the aft bend is a little more obtusely curved, this obtuse angle being about 60°. The curvature formed at this bend (aft bend curvature) is also considered important in designing hooks and also in selection of quality hooks. The nature and disposition of the aft-bend largely influence the desired stability of the hook and pisciform shape of the bubble produced by the shank while in water; the aft end of shank merging at this bend acting almost as the head of the small live-bait fish in cutting its way through the subsurface water in which the hook is tailed through.

(v) *Neck (Kanthura) or Aft Leg*:- The upwardly projecting aft limb of the hook separating its eye from the aft bend is referred to as the neck (line attachment-leg) of the hook. Unlike in many other standard hooks which do not possess a distinct neck, the neck in the present hook is markedly distinct from the shank. Unlike the shank, the neck is almost roundish throughout its length. It has no tapered keels which when present would cut the bend of the snood placed over it. The relation between the length of neck and spear with its point, is considered important in designing hooks. The desired trim aft condition of the hook and its stablised trailing position in water also are influenced by the nature and disposition of the neck which also provides a strong supporting base for the eye of the hook.

(vi) *Eye (Filathy)*:- The Eye of the hook forms its aft-most portion. It is subrectangular with its narrow base merging at the aft end of the neck and the broad apex tapering aft wardly to form a flattened knob with a gentle upward slope. The eye has no hole for fastening the snood. Instead, at the point where the base of the eye joins the neck, and aftward acute curvature is formed and this curvature enables the fastening of snood to be placed at the neck. The relatively broad and more tapered nature of the eye is considered good to ensure more safety for the attachment of the snood in position. The above curvature also is considered important in designing hooks.

Typical varieties of the TPL gear:- There are four varieties of the gear locally distinguished as *dhigu dhori, mas varu, mudeng* and *Vinna* operated from each of the 3 gear positions P_1-P_3. These in order are described as variety I to IV here below.

(i) *Variety I (Fig. 4.a)*:- This variety represents the longest variation of the Pole and line gear. Its pole as well as line measures 2.5 fm (4.58 m) in total length. The hook

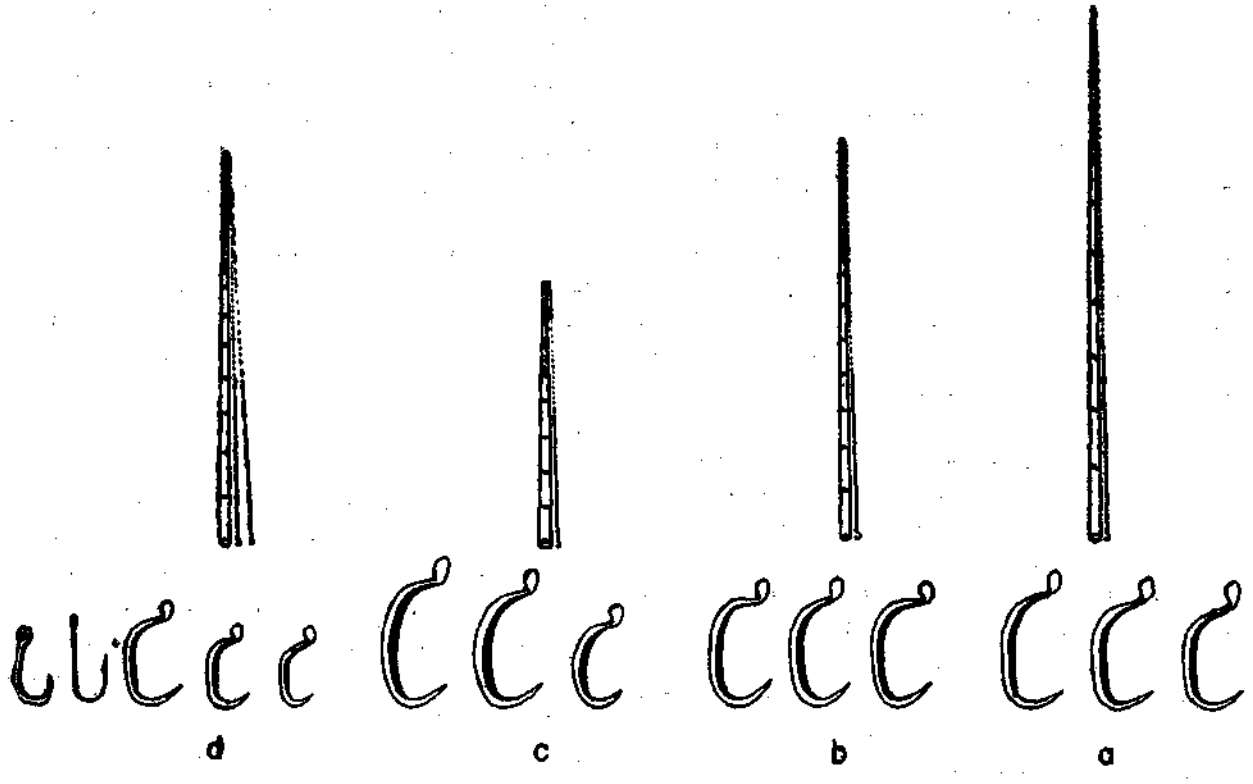

Fig. 4 Four varieties of of Skipjack Tuna Pole and Line (live bait) fishing gear of Lakshadweep (a, b, c & d — Variety I, II, III & IV of the gear

measures 4.5 cm to 5.5 cm in length. The leader line as well as snood shows the thinnest diameter when compared to the other varieties of the gear. Typically, the leader line and the snood measure 1.5 : 1 in length. This variety of the gear is used typically, at a time, as soon as a tuna school is approached by chumming, as well as when tunas are not in good appetlite and feeding frenzy and hence when tunas of the chummed school are keeping a little distance away from the boat in water. Two sub-varieties of this variety of the gear are met with, *Viz.*, the 'long' and 'short' which are used according to (i) degree of proximity of the tuna school to the chummer boat (which first starts chumming with live-baits), within the range or territory of operation of the gear, and (ii) to the degree of skill of the crew operating this sub-variety of the gear; the tall and/or more skillful of the crew preferring a 'long' sub-variety to a 'short' one from the same gear position.

(ii) *Variety II (Fig. 4 b)*:- This may be considered as the medium or typical variety of the Pole and Line gear. Typically, the Pole as well as the line measures 2 fm (3.66 m). The hook measures 4.5 cm to 5.5 cm. The Leader line as well as the snood is a little thicker when compard to Variety I. The hook also is a little thicker and heavier than the previous variety. The obtuse angle of the fore bend of hook is less pronounced in the present variety. This condition favours the relatively quick retrieval of the hooked tuna by this variety than by variety I. As the hooked tuna is taken from relatively short distance from the boat, when compared to variety I, the hooked tuna needs only a relatively short duration of retainment in the gear in variety II, before the hooked game is passed on from the territory of the hook to the boat where it is retrieved.

Variety II is the most commonly used and typical variety of the Pole and line gear. It is used only when the operator crew are sure that the tuna school responds well to chumming and comes nearer the chummer boat showing visibly detectable sings of better appettite and feeding frenzy, and biting hooks indiscriminately at relatively quick intervals. Here also, two sub-varieties, *viz.*, 'long' and 'short' are met with as in the previous case. The use of these sub-varieties also is done in the similar manner, as it is described above for sub-varieties under variety I.

(iii) *Variety III (Fig 4 c)* :- This is the shortest of all varieties of the Pole and line gear. The Pole as well as line typically measures 1.5 fm (2.75 m). The hook typically measures 5.0 cm to 6.5 cm length. The leader line and snood show approximately 2:1 ratio in length. They are a little thicker than their counter parts in variety II and the thickest of all when compared to their counterparts in all varieties of the gear. The Pole though the shortest, is the stoutest, strongest and heaviest of all poles used in different varieties of the gear. The hook also is the biggest and heaviest of that in all varieties of the gear. Its fore bend is relatively a little more obtuse than in variety II, giving maximum retrieval feasibility. This variety is used when the tuna school in the hooked territory is in very good appettite and feeding frenzy, approaching very near the boat and biting hooks in the most indiscriminate manner, and supporting a very handsome tuna fishery. No Sub-varieties of variety II is met with.

(iv) *Variety IV (Fig. 4 d)*:- This is the most lean weakest and lightest of all varieties. Typically, the Pole as well as the line measures almost equal to that of variety I or II in length. But the Pole in this case is a little more lean than that in the above two varieties and also that of variety III. The leader and snood length ratio as well as thickness of leader and snood also is the same as in variety I or II. The hook is the smallest of all varieties. It measures 3.0 to 4.0 cm in length. It is the lightest and smallest of all varieties of hooks. The angle of fore bend of the hook also resembles that of hook of variety I or II. The variety of the gear is used only towards the end of fishing from a school of chummed tunas, when the tuna refuses to take live-baits supplied to it during chumming operations,

when being chummed for a while, tunas get their appetite mitigated considerably and hence they start discriminating hooks and avoiding biting them. Stray numbers of such tunas are taken by this variety of gear towards the tail end of chumming operation.

There are three sub varieties recognised under variety IV *'viz.* big'(*Vinna bodu*), *'small'* (*Vinna kudu*) and *'Gatha'*. In all these sub-varieties, the pole as well as the leader line is the same in length but the hook differs in size. Sub-variety 'big' has 4.0 cm hook typical of this variety and sub-variety 'small' has 3.5 cm hook. The third sub-variety uses a 2.5 – 3.0 cm hook of Minicoy, or an ordinary 2.0 cm to 2.5 cm Japanese hook or an ordinary 3.5 cm Indian (mainland) hook whose barb is removed and the hook dressed with a live fish. Often the pole bears two lines, each rigged with a hook at its free end.

'Techniques of operation :- In order to effect a smooth and orderly operation of each unit of the gear from the onboard gear positions, P_1 to P_3, a definite area of hook action (hook territory) in water is assigned conventionally with respect to each gear position. Accordingly, the hook of respective gear unit from positions P_1 to P_3 on each half of the fishing platform should be trailed in water only along a straight line trailing course as the boat moves forward in 1.5 – 3 knots speed. The hook may be moved in the form of an arc to left or right only for a transverse distance of about 0.5 m. This limited range of the hook territory is always maintained for avoiding snagging of successive gear units. The gear operator stands at the main strength of his backbone on each gear position in a definite manner for operating the gear unit held in both hands. The angle between his heels and toes is fixed and it is indicated by the foot prints marked at P_1 to P_3 in Fig. 5. While shooting the gear unit, the terminal end of the pole is not raised above the eye level of the

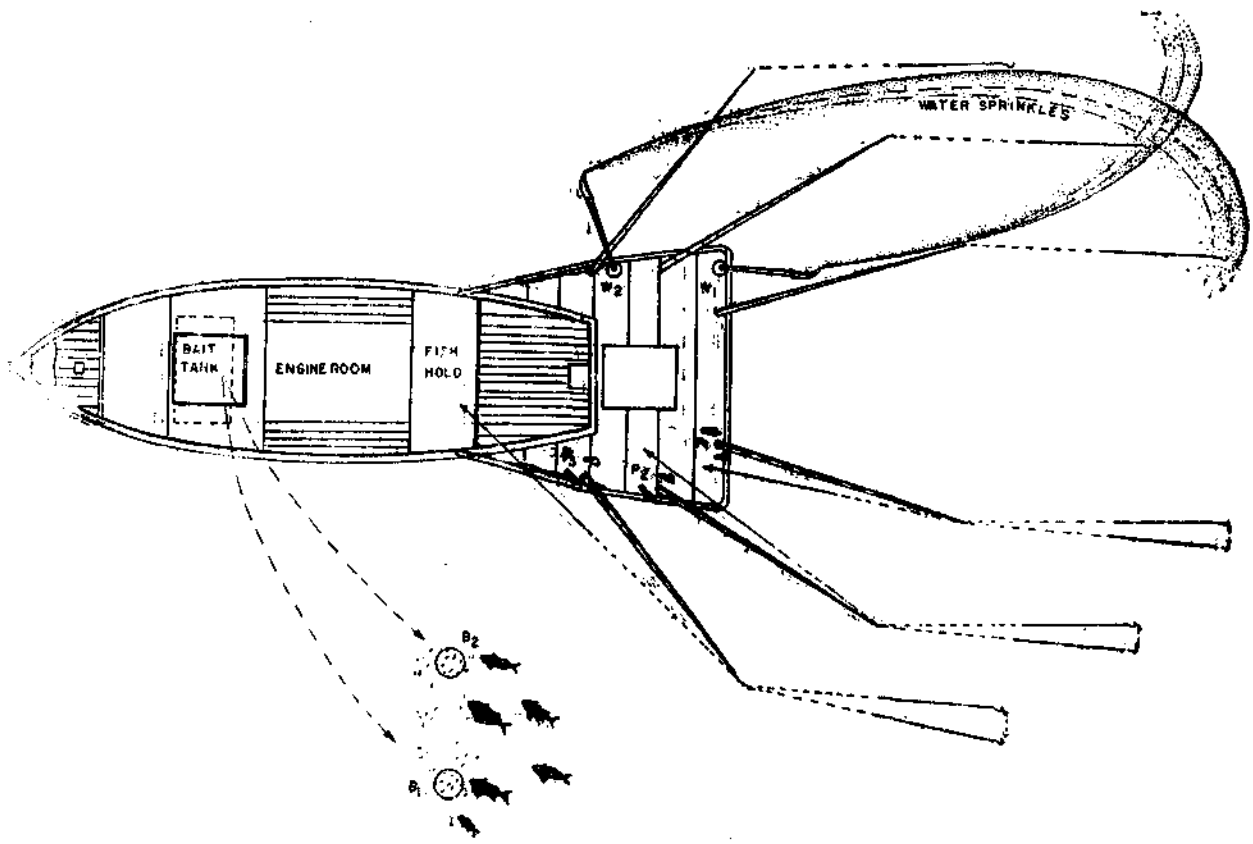

Fig. 5. Operation of the Skipjack Tuna Pole and Line (live bait) gear at Lakshadweep. P_1, P_2, P_3 — Gear positions; W1, & W2 — Positions for the water-splashing men; B1, B2 Chumming positions in water.

operator. There is a defenite slope of the pole held in hands. This slope (Shooting angle) ranges from 20-25° when measured from the imaginary line passing through the butt end of the pole. In order to effect an orderly hauling of the gear unit and quick retrival of the hooked tuna, specific retrival directions are fixed conventionally onboard the fishing platform. These directions as indicated by arrows in Fig. 5 for gear positions P_1, P_2 and P_3 are an anticlockwise, clockwise and anticlockwise in order.

Chumming with live baits as well as water splashing are integral operations of the TPL fishing technique. The purpose of chumming is to attract a sub-school of tuna from the main school to follow the fishing boat (chummer) near the gear positions P_1 to P_3 on either side of the fishing platform. As soon as a tuna school is sighted or its presence indicated, the speed of the boat is reduced to 1.5-3 knots and chumming with live bait starts at the instructions of the chief fisherman. Initially trial chumming is done by the chummer throwing scoopfuls of live baits at the extreme seaward of his stretch on either side of the boat at position marked B_1 in Fig. 5. In case tuna rise to surface to bite the thrown live baits (chum), handfulls or even 5 to 6 specimens of livebaits are thrown in a sustained manner nearer the boat at position B_2 Fig 5, on either side of the boat so as to make the chum available in hook territories of gear position P_1 initially and from there subsequently by the wake to the hook territaries of P_2 and P_3. The positions W_1 and W_2 in indicate the sitting positions of the two water splashing men onboard on the half of the fishing platform. When done correctly, the splashes of water produced from these positions dash each other in air and disintegrate into profuse sprays in the hook territories. The purpose of providing these water sprays appears to be for enhancing the vibrations of the air-bubble around the hook, trailed in water just below the surface (Fig 6), for attracting the tuna; the vibrating air-bubble simulating an agile prey (fast moving squid or small fish). The air-bubble serves as a

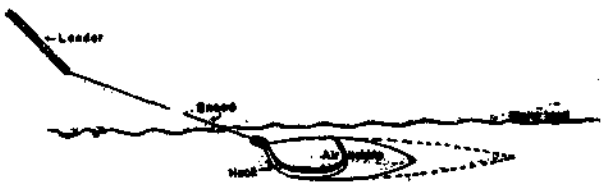

Fig. 6. Air bubble formation of the hook under water in the Skipjack Tuna Pole and Line (live bait) fishing technique of Lakshadweep.

novelty vibrating in the midst of the chum for the tuna to be attracted by the novelty to bite it including the concealed hook.

TPL (live bait) Gear-making:- The hook used for rigging the TPL (live bait) gear is made in an organised manner only at Minicoy from where it is sold to all the Islands. Three inch M.S. rod used for making hooks is brought from mainland at the cost of hook-maker. Traditional hand forging method is used to make hooks. Fig. 7 shows four successive stages in the hand forging of hooks. Hooks are tempered and lead coated to give them

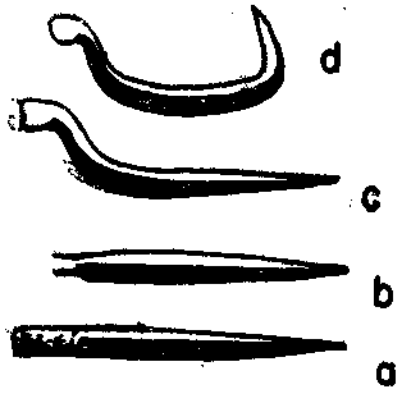

Fig. 7 (a—d) For successive stages in making the Tuna hook of Minicoy, Lakshadweep by hand-forging method.

strength and the characteristic silvery shining. Bamboo poles used for making the gear are brought from Calcutta at the cost of the boat owner, mostly through Minicoy Seamen. Line materials are procured from mainland at the cost of the chief fisherman of each boat. Pliability, handling feasibility, strength and weight are the common citteria used in

selection of Poles. Srength, elasticity, diameter and colour are the common criteria based on which the double strand Polyvinile yarn and monofilament are selected for making the leader and snood in order. Hooks without any structural defects are selected according to the variety of the Pole, size of tuna to be caught, species of live bait used and skill of crew operating the gear. The construction details of the gear are given in Fig 8. The hook maker gets one share of the crew's portion of the daily tuna catch of a boat as hire charges for the entire hooks

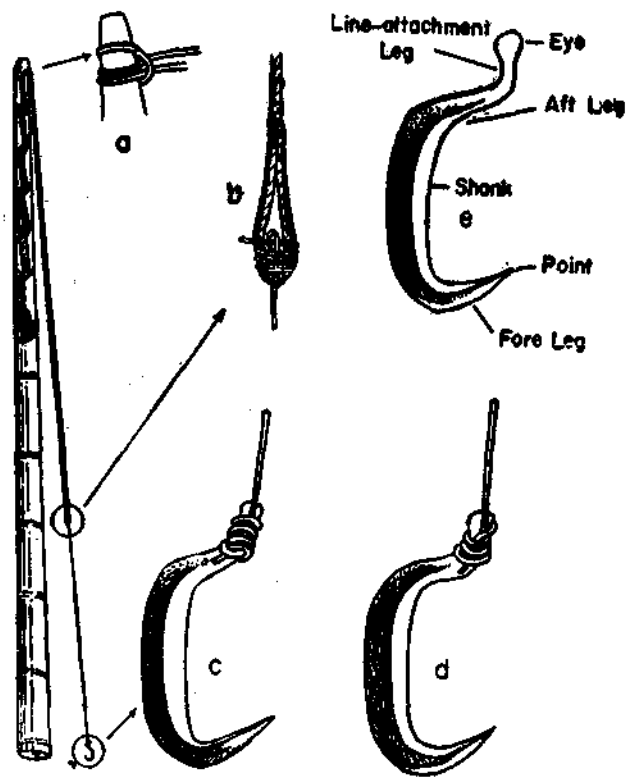

Fig. 8 Construction details of the Skipjack Tuna Pole and Line (live bait) gear of Lakshadweep a—Marling hitch, b, c & d—Double Sheet bend; e — Parts of a hook in relation to rigging of the gear.

he supplies to the boat. The chief fisherman gets half share of the crew's portion of the daily tuna catch as his additional wages for supplying the snood and leader and for rigging the TPL (live bait) gear required by his boat.

SOME DEVELOPMENTAL NEEDS AND SUGGESTIONS FOR IMPROVEMENT

some of the present and future developmental needs of the Lakshadweep TPL (live bait) fishing techniques are pointed out herebelow. Some of the restraints for fisheries development and suggestions for improvement also are discussed in this connection.

(a) *Craft Technological needs* :- (1) It is clear that Japan and California have gained over 90 and 100 year's, experience in the mechanization of their respective fisheries. Their respective TPL (live bait) fisheries have been mechanized since the turn of the present century with the definite goal of developing the oceanic fisheries for the skipjack tuna and the yellowfin tuna for local consumption, export or for reducing import. Their objectives of promoting production of these tuna have been achieved by a step-by-step progress through several developmental plans and governmental aids to fishermen under proper legislation. There is urgent need, in Lakshadweep for licencing the oceanic skipjack tuna and yellowfin tuna fisheries under revised fisheries law and under this law to make available to local fishermen governmental aid in the form of bank loans for constructing medium and large-type TPL (live bait) vessels, combination fishing boats, alternative fishing boats and ancilliary ships supporting the fishing fleet. The local boat building industry should be further expanded with the introduction of advanced technology of naval architecture in building vessels. Necessary improvements should be brought in, in the boat law, port law, and fishermen co-operative law to make available to the fishing industry several modern facilities and infrastructure like the fishing Harbour, Ice plants and canning factories in selected Islands. Until, modern fishing Harbour facilities become available in selected islands, medium and large-scale fishing operations in the offshore and oceanic

waters around the islands may be based at one or two selected mainland ports of the west coast like Cochin and Bombay.

2. Japan and California have achieved step-by-step progress in increasing the size of their respactive fishing craft and their cruising ranges. As the fishing operation extended from the coastal to offshore, oceanic and distant water environments, the size and quality of the fishing craft also gradually expanded over several decades from the small and medium type country crafts to the small-medium-and large-type mechanized vessls. There is urgent need in Lakshadweep to extend the fishing operation to offshore waters lying between the adjacent landmasses and submerged banks. The present day fishing operation is more or less coastal in character. It extending only one day per trip. This is to be enhanced to 3 to 10 days and over 30 days fishing at a stretch in the sea. Medium-type and large-type mechanized fishing vessels, are therefore to be introduced. The submerged banks in the northern reaches, viz. *Basses de Pedro*, Byramgore reef, *Cherbanrani Eli Kalpeni*, etc. are to be fished for live baits and tunas. Also the numerous bays and gulfs along the southwest coast of India including the wadge Bank region are to be fished for potential live baits such as the anchovies and sardines for use as the live baits. Each trip from the west coast port may cover at least a few of the neighbouring islands in Lakshadweep, a distance ranging from about 400-1000 km per trip. Also some fishing trips may be extended to over a few thousand km beyond the islands, in the continguous high seas outside our Exclusive Economic Zone.

Therefore a new generation of two types of fishing vessels is to be introduced in Lakshadweep *viz.*, a medium-type (20 g. t.) and large-type (100 g. t.) vessels, the former for fishing between the mainland and the outlier islands and the latter to fish in the highseas beyond the outlier islands. Experience in California indicates clearly that TPL (live bait) vessels above 100 g. t. are very expensive for maintenance of staff onboard and for procuring live-baits. Japan also is finding it very expensive to maintain large vessels above 100 g. t. since more recent years. Therefore, it is advisable for Lakshadweep not to introduce TPL (live bait) fishing vessels above 100 g. t. for the present even on an investigation basis. Further, as long as the live-bait availability remains scanty in islands, introduction of any medium-and large-type TPL (live bait) boat also may be made only on an investigation-basis to start with. Proper resources survey of the potential live-bait around the Islands submerged banks and also the southwest coast of the mainland and Wadge Bank area and experimental feeding of tuna with potential new live baits like sardine and anchovies from onboard the survey vessel are inevitable for the successful introduction of considerable number of medium and large TPL (live bait) boats in the Islands.

3. While bringing about future improvements in the general feature of the TPL (live bait) boat at Lakshadweep, it would be interesting to provide a crews' nest on the deck, for enabling spotting of tuna schools based on observations on sea-birds. Further, there is no closed drinking water supply system in the islands. The subterranean water table is scarce in islands, it being absent typically on either ends of the landmass. There is no pump system installed to carry the water from the Island to the boat. Therefore it would be ideal to provide sufficiently large water storage tanks in these boats to store sufficient water from the mainland port. The fuel oil tank onboard also should be large to store more fuel oil from the mainland port. The brine tanks should be sufficiently large to serve as fish-hold during the return voyage to the canning factory at Minicoy or at the selected insular or mainland port. As in the case of the clippers, the vessel may be designed to carry the maximum load and the necessary mechanical and electrical equipment in the minimum overall length of hull.

4. High speed diesel is reported to be suitable for 100 g. t. TPL (live bait) boats. This results in reduced weight, saving in space, and greater cargo capacity. The high speed

diesel is also suitable for the 20 g.t. and still smaller boats and for auxiliary services in the tuna fleet.

5. There is urgent need to provide efficient system of live bait storage and handling onboard the Lakshadweep TPL (live bait) boats. As the local supply of live baits available from around the islands is not adequate, live baits (anchovies and sardines) are to be exploited from near the mainland southwest coast. A better system of preservation with large tanks, engine-driven replenishment of the medium by pumps and carrying live baits on board by pumps are essential. Hydraulic pumps are reported to be superior to pumps driven by electric systems. Plastic pipes are considered to be free from corrosion, marine fouling hazards and from electrolysis. Necessary caution should be exercised in not selecting or inventing top-heavy designs of bait boxes which would upset the overall stability of the vessel, as it happened in California during 1926-30.

6. Mechanised power should be used for the operation of the fishing gear in Lakshadweep. More onboard space and facilities are to be provided for the operation of the TPL (live bait) gear, in large number of units. At present a typical number of only 6 units are operated from each small boat. There is considerable scope to increase this number of operable units by providing additional working space at the fore and sides of the hull. Installation of engine driven water sprayer and automatic angling machines in medium and large-type fishing vessels would increase fishing efficiency and reduce the crew requirement.

7. Installation of refrigerated fish-holds and the fish preservation machinery onboard is highly essential in the Lakshadweep boats for extending the preset-day fishing limits. The ammonia compression system is reported to be more suitable than the compression-Freon system for the tuna fishing fleet, almost universily. Brine-freezing being a cheaper method for mass preservation of tuna, this would be suitable for preserving the skipjack catch taken bulk quantities. The air-blast-freezing may be more useful to preserve the yellowfin tuna and bigeye tuna which are taken in relatively small quantities. Therefore, it would be advisable to have both the brine-freezing and air-blast freezing machinery fitted onboard the same vessel.

8. Providing proper crew accommodation onboard is a difficult problem faced in the Japanese and Californian TPL (live bait) boats. The Skipjack TPL (live bait) fishing technique of Lakshadweep takes in a relatively high proportion of onboard crew per size of boat. As such the problem of providing onboard accommodation for crew becomes a more difficult problem in these boats. Therefore, in view of acute scarcity for fishermen in the islands, there is urgent necessity to reduce the number of onboard crew by automation. As many of the Lakshadweep fishermen are not accustomed for prolonged separation from their homes, provision of convenient crew accommodation onboard the medium-and large-type vessels is highly essential to attract the fishermen on long voyages and continued absence from the port.

9. Small-type Pole and liners in Lakshadweep are to be equipped with standard equipments such as radio, radio-telephone, thermometer, echo-sounder, Secchi disc and navigation instruments. Electronic equipments such as Radar, Loran and Radio-telephone to search for fish and to receive information on oceanographic, meteorological and fishing conditions and to report to shore and to other vessels, should be installed in medium-and large-type vessels. As the islands are remote and geographically isolated from mainland, provision of telecommunication facilities onboard the fishing boats would be a boon for fishing operations. As these islands are prone to periodic attack by Cyclones, special weather-warning and rescue operations also can be effected with the help of improved navigational equipments and facilities. Provision of evaporators onboard would enable conversion of Salt water into fresh water at emergent situations. A few of the large-type vessels would be provided with onboard

facilities for the landing of spotter planes used in aerial survey of tuna schools.

10. Combination fishing with pole and line (live bait) and tuna long line would be an ideal plan to ensure year-round tuna catches in Lakshadweep. There are several spells falling within the far tuna season (November to May) in which the Skipjack is not biting the hook and/or chum of the Pole and line gear, thus giving a poor fishery. During the monsoonal months from June to October, the Pole and line (live bait) gear is seldom operated owing to non-availability of live baits. Tuna long line can be operated at such times to augment the catches. The yellowfin tuna and the bigeye tuna which can be fished profitably by the tuna long line gear are available in plently in these waters. Therefore, there is scope for introducing combination fishing vessels in these Islands. At present, head of skipjack tuna is largely being used as long line bait for tuna in the Islands by some of the live-bait boats. Shark is largely attracted by this bait. Therefore, there is urgent need to to use new baits like frozen mackerel and Sardine from along the mainland west coast, as tuna long line bait in the Islands. As the vessel and onboard crew are to be maintained throughout the year at high cost, combination fishing would engage the Vessel and the onboard crew year round in fishing operations, thereby reducing the number of idling days of the vessel in the port.

11. Introduction of tuna purse seining as an alternative fishing method to overcome the problems of bad baiting of Skipjack and scarcity for live bait in Lakshadweep need proper investigation. Purse seining appears to have good scope in Lakshadweep, especially in Islands other than Minicoy, Agatti and Bitra where there is acute scarcity for live baits year round. Purse seining may prove suitable to develop an year-round tuna fishery. Experimental fishing with purse seining for tuna around all these Islands, inter-island waters submerged banks and in the high seas beyond the EEZ is urgently needed in this connection.

12. The services of a pair of Factory Mothership one after another, to co-operate with the tuna fleet of small boats in the different Islands in Lakshadweep, are highly essential. A mother ship can co-ordinate fishing by the small boat-fleets in neighbouring Islands, by supplying fuel oil, gear, provision and fresh water to the catcher fleet and by procuring the catches of the catcher fleet at the close of the day for processing and preservation onboard. Consignments of the frozen fish can be reached to the canning Factory at Minicoy or at any other Island or mainland ports periodically. Spare parts for the engine and medicine for the crew can be reached to the catcher fleet. A base ship which could serve as a floating work shop would be a boon to fisheries development in the Islands. Its services would mitigate the problem of idling of fishing boats for want of work-shop facilities in different Islands.

13. Hulls made of local coconut timber at Minicoy stand motorization. The cost of these hulls is relatively less when compared to wooden hulls made in the department boat building yards using timber brought from the mainland. However, there is a dearth for coconut trees above 16 m in height in the Islands to get good quality timber There is urgent need to use non-traditional material for construction of boats in Lakshadweep. Besides wood, steel should be used as material for building boats. As in Japan, G. R. P. or F. R. P. may be used for building small-and medium - type boats. Goldworthy (1955) observes that aluminium alloy is used to make bridge and upper deck structures and funnal casings, etc. Aluminium linking over wood is given in the fish holds. Materials derived from glass, cellulose acetate or rubber are used as insulation material. Synthetic materials like 'Isoflex', 'Onazate' and fibreglass etc. also are used as insulating material. Such new materials for construction and operation should be made use of by the Lakshadweep boat-building industry to make medium and large type boats.

14. Wartime co-operation of the fishing fleet in rendering auxiliary services to the Navy is well-known in literature (Board of Agriculture and Fisheries, 1920; Asia Kyokai, 1957 and Anderson and Stolking 1952), Fishing

boats of robust construction in Lakshadweep can render additional services of Petrol and transport duties at times of emergency. As per suggestions contained in Rao Plan (Rao, 1948), for developing Deep Sea fishing as a cottage industry, there is need for mechanised vessels which can serve in the Defence service at times of emergency and in fish production at time of peace. It would be proper to make available in Lakshadweep, a special fleet of mechanised vessels which can serve as Honorary Fishery Petrol Vessels at time of peace and as Defence Vessels at times of Emergency under the Navy or Coastal Guard.

(b) *Gear Technological needs:-* The proper type bait-hook, striker, lure-hook and jigs should be introduced in toe TPL (live bait) technique of Lakshadweep to mitigate the problem of tuna not biting the hook or the chum. Special type hook with round and slender type shank is to be introduced for making bait-hook because the Minicoy-type hook with its stout point-leg and stout and keeled shank is detrimental to the live specimen used on it for making the bait-hook. With the introduction of medicm and large type pole and line vessels in Lakshadweep, the two-poles, three-pole etc. team gear as used in the Californian and Polynesian tuna fishery may be introduced. This would prevent the present problem of heavy breaking of bamboo Poles when large tuna above about 0-10 kg average individual weight are lifted out of water.

Introduction of the Polynesian type of yellowfin TPL technique in Lakshadweep for taking medium size yellowfin tuna using the two pole gear is worth consideration. This TPL technique requires relatively much less number of crew per boat and no live bait. This technique, if found successful would open new fisheries for medium yellowfin tuna and skipjack tuna in certain Islands like Ameni and Androt where there is much demand for fiesh tuna but the fishery is beset with the problem of acute scarcity for live baits. Rao (1955) recommends this method for the small Ports along the Indian west coast.

There is much scope to improve the operation technique in the Lakshadweep Skipjack TPL (live bait) technique. With the introduction of medium and large type Pole and liners, improvements may be made in the angling technique by (i) providing more onboard space and facility for operating more number of the TPL gear including the team-gear, (ii) installing the angling machine and mechanical water spray system, and by (iii) provision of chum tanks and connected facilities for chumming tuna with live baits.

(c) *Gear-making and supply needs:* There is urgent need to develop the traditional TPL (live bait) gear-making industry by establishing a modern hook-making factory at Minicoy or Agati Island and by giving training to local hook makers in modern technology of making hooks using machines. Besides the the Pole and line hook, lure-hooks, strikers, jigs and bait-hooks may be manufactured indegenously by borrowing initially designs and technology from Japan, California and Polynesia where these tackles are used in plenty. Raw materials such as horn, hoof, synthetic feathers, bird-feathers, plastic rubber, pearl-shell, stainless steel etc. required for making these implements may be procured from mainland. Insect-proof FRP or GRP Poles may be introduced to replace the bamboo Poles which are vulnerable to heavy insect attack. Indigenous manufacture of FRP Poles would enable tuna fisheries development in the long run. The insects damaging the bamboo Poles may be scientifically studied and control measures adopted against breaking of Poles due to insect attack. Quarantine and quality control measures to maintain quality of the bamboo Poles brought from mainland may be introduced. A centralised subsidy scheme to supply the various fishing implements including the leader and snood material may be made available to Islander fishermen as a measure of encouragement to Oceanic tuna fishing using TPL (live bait) or other combination or alternate fishing techniquee.

(d) *Fishermen training needs :* Acurate knowledge regarding the conventional gear positions P_1 to P_5 and positions of water splashing men W_1 and W_2 onboard the fishing platform, the ethnological identity of the hook, the four varieties of the gear, concept of hook territory, shooting angle, hauling direction, underwater air bubble formation of the hook, the spraying effect involved in water splashing, effect of water splashing in vibrating the air bubble of the hook etc. reported for the first time here are the unique features of the Lakshadweep TPL (live bait) technique. Therefore these aspects are to be taught to the local fishermen in comparison with the TPL (live bait) fishing techniques of other parts of the World. Thus there comes the need for improved fishermen training in Pole and line (live bait) tuna fishing centres in the Islands. The use of lure-hooks, strikers, bait-hooks and jigs also is to be taught to these fishermen by experimental and demonstration fishing and by practical gear-fabrication training. The use of angling machines, mechanical sprayers and the operation of team gear, large-scale live bait storage handling and chumming etc. are also to be taught to these fishermen for a better tuna fisheries development.

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Paper-62

UTILISATION OF BLOOD CLAM *ANADARA GRANOSA*

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ABSTRACT

Blood clam (*Anadara granosa*) forms a fishery of considerable magnitude in the Kakinada Bay where an estimated 2000 t are landed annually. In addition culture technology for blood clam has been standardised in India, throwing open the possibility of large scale farming of this species. Presently clam meat is burnt along with shell to produce lime. In order to optimise the utilisation of blood clam as against the existing gross under utilisation Kakinada Research Centre of CIFT has developed the technologies for icing, freezing and canning of the clam. A pickled product and sausage are the other products developed by the Centre. The paper describes the technologies developed for utilisation of blood clam.

INTRODUCTION

In a number of South-East Asian countries, *Anadara granosa*, referred to as blood clam or cockle, is fished and/or cultured for human consumption. Blood clam constitutes an important fishery in Kakinada Bay where approximately 2000 t are landed annually

(Silas *et. al.*, 1982). Average yields of about 40 t per hectare were obtained by culture in pen enclosures in Kakinada Bay (Narasimham, 1980). Average size at harvest is 4.5 cm in length and 31 g in weight. Shell forms about 65.5% of the whole weight. The cooked cockle has good meaty texture, attractive pink colour, sweet taste and good flavour.

At present, the whole cockles are burnt for production of lime, and the meat, a valuable source of animal protein, is lost. Many of the fishermen are engaged in hand picking of cockles and they get poor returns because of the current under utilisation of this shellfish. With a view to scaling up and rationalising the utilisation of cockle, research was undertaken to develop technologies for its optimum utilisation.

RESULTS AND DISCUSSION

Depuration of cockle

Cockle, like other shellfish, is a filter-feeder and hence sand, mud, enteric pathogens, heavy metals, pesticide residues etc., can gain entry into the digestive tract. If these are allowed to remain, they can cause grittiness to the meat in addition to posing health hazard to consumer. In order to eliminate these extraneous materials, the cockles should be subjected to depuration process before collection and utilisation of meat. Chakrabarti and Khasim (1982–'83) tried different methods for depuration of cockles. Saline water containing salt concentrations ranging from 1 to 2.5% was tried for periods of 24 hours. It was found that 48 hours depuration resulted in 5 to 10% mortality and 24 hours depuration was satisfactory. Attempts were also made to study the effect of keeping the cookles for the last one hour of depuration in saline water containing different concentrations of chlorine ranging from 0 to 10 ppm of available chlorine. It was observed that 1.5 to 2.0% saline water made from tap water was adequate for depuration and only slight improvement in bacteriological quality of the meat was noticed by including the chlorinated water during the last one hour. Acid insoluble ash and total bacterial counts of cocklemeat could be reduced by the above process and further reductions in these values were recorded by removal of gills and mantles immediately following depuration.

Proximate composition

The chemical composition of cockle meat varies depending upon season, sex, maturity etc. As reported by Basu and Gupta (1984) the proximate composition is as follows:

Moisture	:	79.0 to 83.8%
Protein	:	9.6 to 19.0 %
Fat	:	1.26 to 2.36%
Glycogen	:	5.4 to 13.6 %
Total ash	:	0.07 to 0.95%
Acid insoluble ash	:	0.02 to 0.09%

Icing

Cockle meat needs to be stored under proper conditions before its use directly for human consumption or for further processing. Basu and Gupta (1984) studied the ice storage behaviour of cockle. Changes in moisture content, protein, NPN, L-amino nitrogen, TVN, glycogen, free fatty acid, TBC and coliform count were followed every day. The results showed that cockle meat packed in 200 gauge polythene bag and kept in ice remained in very good condition for 4 days while meat stored directly in ice was found to be in an equally good condition for 2 days.

Freezing

Chakrabarti and Khasim (1982-83) studied the amenability of cockle meat to freezing and frozen storage. Meat collected by manually opening the shells as well as by boiling for 20 minutes was frozen in a plate freezer. Cockle meat without gills and mantles blanched in 7% brine for 5 minutes was also frozen in a similar way. Raw meat had more attractive original colour as compared to boiled meat. Coliforms were present to the extent of 10 to 20/g in raw meat while they were absent in boiled and blanched meats. During frozen storage, moisture content showed an increase in blanched meat while it decreased in raw and boiled meats.

All the types of meat used for frozen storage remained acceptable for over an year.

Canning

Steamed cockle meat without gills and mantle was blanched in 7% brine for 5 mtnutes. The blanched meat was canned in 2% brine containing 0.2% citric acid at 10 lbs pressure for 30 minutes. The product was found to be in good condition for three months. After this period, the drained liquid became turbid and meat became soft.

Pickling

Studies were carried out by Gupta and Basu (1985) to develop the technology for preparation of a pickle product from cockle meat. Three different recipes were tried and the recipe given below was found to be the best.

Ingredients	*Amount*
Cockle meat (blanched), kg	1
Salt, g	110
Chilly powder, g	70
Turmeric powder, g	2.5
Mustard (skinned), g	10.0
Garlic, g	80.0
Ginger (small pieces), g	25.0
Green chilly (sliced), g	40.0
Menthya, g	2.5
Pepper powder (white), g	12.5
Vinegar (natural acetic acid content 4%), ml	200
Gingelly oil, ml	350
Lemon (sliced), Nos.	4
Curry leaves,	5

The clam was allowed to depurate. After removing the meat, it was blanched in 7% brine for 5 minutes. The blanched meat was drained well and then cut into 4 portions. The meat pieces were fried in oil until brown in colour and kept apart. Sliced green chillies, ginger, curry leaves and crushed garlic were fried in the residual oil remaining in the pan after frying the meat. When they were brown in colour, the chilly powder, turmeric powder, mustard and menthya were added and again fried for a short while. The pan was removed from the fire, the fried meat was added and mixed thoroughly. After sufficient cooling vinegar was added and again mixed well. The pickle was filled in sterile glass bottle and sealed with acid proof caps. Care was taken to see that there was a layer of oil over the contents in the bottle.

The texture of clam pickle initially was tough but with aging it became softer. The flavour also improved considerably after one month aging. The colour became pale after 165 days of storage. After 200 days the organoleptic analysis revealed slight rancid flavour and pale yellow colour. No mould growth was observed and coliform count was nil throughout the storage period.

Sausage

Basu (1987) was worked on the preparation of sausage from cockle meat. Cockle meat was obtained by the same procedure as described earlier. Fat-oil mixture was prepared by mixing 30 ml melted goat fat and 30 ml peanut oil. Meat slurry from clam (100g), ice cold water (20 ml) and fat-oil mixture or melted hydrogenated vegetable oil or peanut oil (60 ml) was blended in the presence of additive (garlic 3 g, black pepper 2 g and salt 5 g) in an electric mixer for 10 minutes at a constant speed. The meat emulsions thus obtained were stuffered into a sausage casing (salted washed goat intestines) by hand stuffer. The sausage was cooked at 80°C for 30 minutes, boiled at 100°C for 30 minutes and then subjected to deep fat frying. Clam sausage with fat-oil mixture was rated best. Beef sausauge was also prepared with 60 ml fat-oil mixture for comparison, the other ingredients remaining same. The results of organoleptic evaluation showed that in every respect clam sausage compared very well with beef sausage.

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Paper-63

UTILIZATION OF FISH TRASH FOR INCREASING YIELD AND QUALITY OF MILK IN CATTLE

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ABSTRACT

The difference between cost of milk production and its selling price is very thin and is getting thinner due to cumulative increase in cattle food prices on one side and limitations on marketing price of milk on the other. Possible utilization of trash fish converted to liquid silage as a part of cattle food resulting in increased yield of milk and fat content are discussed in this paper. The development of silage and field trials on milking cattles were carried out by Gujarat Fisheries Aquatic Sciences Research Institute, Okha.

INTRODUCTION

Almost 50 per cent or more fish catch in Gujarat does not fetch value and thus is commonly grouped as "trash fish". However, much value negative fish is also equally good in protein and other nutritive contents. With the increasing number of bottom trawlers, the quantity of trash fish caught is on the increase. The landings consist of 70 to 80% trash fish. Unfortunately this nourishing fishes are not commercially acceptable because of food habits of fish eaters and large number of bones in such fishes. While a part of these fishes are sundried, some are converted to fillets and others are used to make manure or meal. Since such products are not highly priced the fisherman is at a loss. These so called trash fishes could be effectively used for making nutritive products for human consumption and for feeding cattle and poultry.

The Gujarat fisheries at its Okha laboratory started a programme of research for trash

fish initially with 75% grant of I.C.A.R. and later fully of its own. During the last decade this laboratory has developed:

(a) Edible protein rich tablets and capsules, the tablets being sugar coated. They have been tested in large number of Ashram Shalas and other places and the feed back reports have been very encouraging. Over three million tablets have been test marketed, and repeat orders have been received.

(b) Fish Kheema has also been successfully produced on large scale and tested.

(c) Other items, like poultry feed superior quality fish fillet, fish cubes, soup powder, papad, chakri, ganthia and biscuits have also been produced.

As a part of its ongoing programme Gujarat Fisheries Aquatic Sciences Research Institute at its Okha processing laboratory has developed fish silage from certain uneconomic trash fishes. The silage has been tested repeatedly for (a) organoleptic conditions, (b) bacteriological counts, (c) nutritional values and (d) shelf life qualities,

This paper discusses the preparation, field experiments and feed back results of the silage.

MATERIAL & METHODS

Silage was prepared on the basis of flow chart given. It was further analysed for moisture, protein, fat, ash, silica and *E. coli*, *Stephylococci*, *Salmonella*, T. P. C. etc. and the results are given in Table 1.

TABLE 1

Analytical data of the fish silage

	Liquid	*Dry*
Moiture	75.50%	19.43%
Protein	16.35%	48.56%
Fat	3.7%	21.17%
Ash	3.81%	—
Silica	0.02%	—
M. E (kcal/kg)	3303	4206
Total plate count	0.08×10^6	0.29×10^6
E. Coli	Absent	Absent
Stephylococci	-do-	-do-
Steptococci	-do-	-do-
Salmonella	-do-	-do-

The names of fishes used as raw material individually or in mixture are given in table-2.

TABLE 2

Names of fishes (raw material) used

Common name	*Species name*
Anchovy	*Collia dussumieri*
Lizard fish	*Saurida tumbil*
Silver bar	*Chirocentrus dorab*
Pellona	*Pellona ditchella*
Moon fish	*Drepane punctata*
Coral trout	*Variola louti*
'Dhoma'	*Otolithus ruber*
Ribbon fish	*Lepturacanthus savala*
Sole fish	*Cynoglossus lingua*
Cuttle fish	*Sepia aculeata*
Silver belly	*Leiognathus fasciatus*
Bony beam	*Nematolosa nasus*
Rainbow fish	*Platyglossus dussumieri*

Pre-primary trials regarding acceptability of this silage were carried out on pigs, chicken and cattles at Gujarat Fisheries Aquatic Sciences Research Institute campus and the approximate suitable percentage of mixing this silage with normal animal food was decided upon. It was them decided to carryout field trials with ensilage mixture of 5 and 10% in the feed of milking cattle.

The field trials were conducted on milking cattle at

(a) Vatsalya Dairy Farm, Jamkhambhalia

(b) Chandaria Trust, Ravalsar

(c) INS Walsura Naval Establishment, Jamnagar (all above in Jamnager District) and

(d) Gujarat Agriculture University, Junagadh campus, cattle breeding farm (on growing calves).

DISCUSSION

Feed back data received from field centres with milking cows are given in tables 3, 4 & 5.

TABLE 3

Fish Silage Experiment Data - Vatsalya Dairy Farm, Jam Khambhalia

Sr. No.	Name of the centre	No. of milking cow taken up	Average yield of milk per day for the last 15 days before feeding silage for cows		Average yield of milk per day 30 days of 10 per cent liquid fish silage in feed.		Average increase per day for cows			Average fat content in milk before fish silage given (%)	Average fat content in milk after fish silage given (%)
			Morning (litres)	Evening	Morning (litres)	Evening	Morning	Evening	Total		
1.	Jam-Khambhalia	*Experimental*									
		Cow no. one	3	3	3.250	3.432	0.268	0.432	0.682	4.5	5.0
	Two cows										
		Cow no. two	4	4	4.316	4.300	0.316	0.300	0.616	4.5	5.0
		Control									
		One cow	5	5	5.0	4.983	0'0	0.017	0.017	5.0	5.0
		Average % of increase in yield in expt. cows : 11.68%									
		Average % of increase in yield in fat in expt. Cows : 11.11									

TABLE 4

Fish silage Data - Navsargan Rural Development Foundation, Ravalsar

1.	Ravalsar	*Experimental*									
		Cow no. one	2.794	2.188	2.981	2 325	0.187	0.37	—	+ 6.50	—
	Two cows										
		Cow no. two	1.623	1.311	1.636	1.181	0 013	0.30		— 3.98	—
		Control									
		Cow no. one	1,123	1 023	0.873	0 766	—0.267	—0.515		—23.99	—
	Two cows										
		Cow no. two	0.777	0.559	0.711	0 526	—0.033	—0.099	—	— 7.41	—

TABLE 5

Statement showing the increase of milk production and fat content during feeding of liquid fish silage

Place of experiment : INS Valsura, Dairy farm

Name of Buffalow : KATNA

Percentage of silage given : 5%

Date	A. M.			P. M.			Remarks
	Qty. of milk (L)	Fat	Sp. Gravity	Qty. of milk (L)	Fat	Sp. Gravity	
01-2-87 to 08-2-87	2.9	6.8	1.026	2 3	6.6	1.025	This is preprimary expt. only and requires broad based trials and feed back.
09-2-87 to 15-2-87	3.1	6.9	1.027	2.4	6.8	1.026	
16-2-87 to 22-2-87	3.2	7.2	1.028	2.5	7.0	1.027	
23-2-87 to 28-2-87	3.2	7.2	1.028	2.5	7.0	1.027	

Total increase in milk production 10%; Increase in fat content 4.5%

TABLE 5 Continued

Place of Experiment : INS Valsura Dairy farm
Name of Buffalow : RITA
Percentage of silage given : 10%

Date	A. M.			P. M.			Remarks
	Qty. of milk	Fat	Sp. Gravity	Qty of milk	Fat	Sp. Gravity	
01-2-87 to 08-2-87	2.1	6.9	1.026	2.2	7.0	1.025	This is preprimary expt. only and requires broad based trials.
09-2-87 to 15-2-87	2.2	7.0	1.027	2.3	7.1	1.026	
16-2-87 to 22-2-87	2.5	5.1	1.027	2.6	7.1	1.026	
23-2-87 to 28-2-87	2.5	7.3	1.027	2.6	7.3	1.026	

Total increase in milk production — 18.6%; Increase in fat content — 5.0%

Place of experiment : INS Valsura dairy farm
Name of Buffalow : ASHA
Percentage of silage given - 10%

Date	A. M.			P. M.			Remarks
	Qty of Milk	Fat	Sp. Gravity	Qty. of milk	Fat	Sp. Gravity	
01-2-87 to 08-2-87	1.9	8.1	1.026	1.6	8.0	1.025	This is preprimary expt. only and requires broad based trials.
09-2-87 to 15-2-87	2.2	8.3	1.027	1.9	8.3	1.026	
16-2-87 to 22-2-87	2-3	8.4	1.028	2.0	8.4	1.026	
23-2-87 to 28-2-87	2-3	8.4	1.028	2.0	8.4	1.027	

Total increase in milk production — 22.8%; Increase in fat content — 4.3%

Place of experiment : INS Valsura dairy farm
Name of Buffalow : NILAM
Percentage of silage given : 10%

Date	A. M.			P. M.			Remarks
	Qty. of milk	Fat	Sp. Gravity	Qty. of milk	Fat	Sp. Gravity	
01-2-87 to 08-2-87	2.7	7.1	1.026	2.2	7.0	1.025	This is preprimary expt. only and requires broad based trials.
09-2-87 to 15-2-87	2.8	7.3	1.027	2.3	7.3	1.026	
16-2-87 to 22-2-87	2.0	7.5	1.028	2.5	7.5	1.028	
23-2-87 to 28-2-87	3.0	7.5	1.028	2.5	7.5	1.028	

— Total increase in milk production — 12.2%
— Increase in fat content — 6.4%
— Overall increase in milk production and fat content by feeding 10% fish silage is 17.9% and 5.2% respectively.

These indicate that :

(a) At 5% fish silage mixed with rations the cattle gave about 10% more milk and about 11.5% in increase in fat content in experimental group in comparison to control.

(b) At 10% mixture with rations the increase in milk yield in the experimental group was as much as 18 to 20%.

(c) The fat content increase varied between 5 and 11%.

Junagadh cattle breeding farm has also shown encouraging growth potential of cows but definite conclusions will be obtained on full growth cycle observations.

During the experiments and observations, it has been noted that for economic productions of silage :

(1) Raw material should be cheap and fresh,

(2) Quality and quantity of chemical preservative should be optimum.

(3) Ensilage producing centres can be preferably located in the coastal areas near landing sites and surrounding dairy areas with easy transportation facilities.

(4) For proper storage and shelflife and to avoid corrosion and toxicity HDPE drums, plastic carbouys etc. are preferable to metal containers. This being a liquid product it entails long distance transportations overheads. Hence dry product experiments with various animal feeds are indicated and are on hand.

CONCLUSIONS

(1) The process needs cows, cost and trash fish materials easily and locally available.

(2) The product can be useful and coast effective in areas with cattle farms near to landing centres.

(3) The process has been simplified to a level where only one trained technical staff is required. The rest would be on daily wages and can be relieved when there is no work this will reduce further costs.

Further field trials on larger scale will be on hand. The product trial on poultries and piggeries as well as on growing cattles has indicated increased hatchability.

Such product preparation and popularisation can lead to :

(a) Increased constructive utilization of trash fish,

(b) better remuneration to fishermen and

(c) more yields and profit to farmers at low costs and simple technology.

Flow chart for preparation of fish silage

Fresh raw material (Small trash fish)
↓
Washing with tap water and weighing
↓
Mixing with bone seperater or mixing machine
↓
Mixing with organic acid (formic acid)
↓
3 5% of raw material
↓
Keep it in polythene or plastic tub
↓
Everyday mix it well with wooden stick for one week
↓
After one week it becomes slury type liquid and viscous
↓
Filtering with sieve to remove scales skin, bone and other materials
↓
Storing in suitable container like plastic carbouys, polythene jerry cans etc.
↓
Transportation to cattle farm
↓
Utilize as a cattle feed, adding into daily feed 4 ro 10%.

PROXIMATE COMPOSITION, CALCIUM AND PHOSPHORUS CONTENTS OF FIVE VARIETIES OF DEEP SEA FISHES OF ANDHRA COAST

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ABSTRACT

Five varieties of deep sea fishes *Psenes Indicus, Decapterus dayi, Priacanthus* sp. *Centrolophus niger* and deep sea pink prawn *(Solenocera hextii)* were collected from the deep-sea fishing vessels of Fishery Survey of India from Visakhapatnam base. These were analysed for their proximate composition, calcium and phosphorus contents in the edible muscle portions. Sensory evaluation of the edible muscle of these fishes was carried out and found to be tasty and acceptable. The fat content is very high in these deep-sea fishes and they deserve consideration while developing suitable processing techniques.

INTRODUCTION

In order to ensure proper utilisation of the newer varieties of fish, information on their proximate composition is an essential pre-requisite and the current work is a step in that direction. *Psenes indicus, Decapterus dayi, Priacanthus sp., Cantrolophus niger* and *Solenocera hextii* were used for this study. These fish were collected from the deep sea fishing vessels of Fishery Survey of India, Visakhapatnam Base. The material had been stored on board in frozen condition at about -18°C. The frozen fish and prawns were taken from the vessels and packed in ice in thermocole insulated boxes and brought to Kakinada by train and used for analysis. The fishes were thawed, cleaned, gutted and beheaded. In case of prawn, the head was removed and the shell was peeled off and deveined. The edible muscle portions were separated and analysed for moisture, total protein, fat and ash content following AOAC methods (1975). Calcium was analysed from the ash content following AOAC (1965) method. Phosphorus was also determined from ash content using Fiske and Subba Row method (1925). Sensory evaluation of the edible muscle was carried out by boiling the edible muscle pieces in 2% salt solution, in tap water for 10 minutes and tasted by a panel of Judges.

RESULTS AND DISCUSSIONS

From taste panel observations, it was seen that all the fishes were tasty and liked by all the members.

The proximate analysis, calcium and phosphorus contents of different fish samples are given in Table- 1. From the protein contents, it is very clear that all the above fishes contain good amount of protein. The calcium content is comparatively high in deep-sea prawn. Inorganic phosphorus content and calcium content are more in *Decapterus dayi* when compared to other fishes under study. All the fishes (except prawn) contain a high percentage of fat. This high fat content in fishes may pose certain problems in adopting different processing techniques.

The fleshy fishes *Psenes Indicus, Priacanthus* sp. and *Centrolophus niger* can easily be comparable with other conventional fleshy food fishes. An effective method of preservation of these fishes is icing which permits distribution over considerable distance or the provision of short term buffer stock at any point on the way to consumer. *Decapterus dayi*, which is a bony fish with high fat content, can be easily and hygienically processed to smoked product. All these fishes may not give good salt dried products, because of their high fat content. As

TABLE – 1. *Proximate composition, calcium and phosphorus contents of deep-sea fishes (edible protions)*

Sl. No.	Species	Moisture %	Ash %	Fat %	Protein (T. NX6.25)	Calcium mg/100 g muscle	Phosphorus mg/100 g muscle
1.	*Psenes indicus*	74.5	1.453	4.4	20.125	236 6	257.6
2.	*Decapterus dayi*	75.7	1.65	5.1	17.35	270.4	385.5
3.	*Priacanthus* sp.	75.8	1.431	2.06	19.375	267.5	350.0
4.	*Centrolophus niger*	74.0	0.832	8.996	15.88	77.5	250.46
5.	*Solenocera hextii*	78.1	1.562	1.367	16.74	459.4	196.85

smoked and dried products from small prawns are already popular locally, this small deep-sea prawn can easily be utilised in a similar way besides their utilisation in fresh condition. Thus these new resources from deep sea can reasonably be expected to go a long way in filling the gaps of our country's animal protein requirements.

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