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PART 3

FINFISH CULTURE

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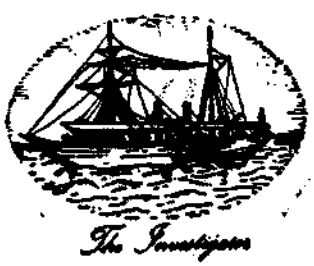

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PROCEEDINGS OF THE SYMPOSIUM ON COASTAL AQUACULTURE

PART 3 : FINFISH CULTURE

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PRESENT STATUS OF COASTAL AQUACULTURE IN BRAZIL

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ABSTRACT

Coastal aquaculture in Brazil is concentrated on the rearing of finfishes (mullets, snooks and mojarras), crustaceans and molluscs.

Most of the papers reviewed give only preliminary results. However, good results are being achieved with the polyculture of the mullet *Mugil curema*, associated with the snook *Centropomus undecimalis* and mojarras *Diapterus olisthostomus*, *D. brasilianus* and *D. rhombeus*, yielding about 1,300 kg/ha/year with artificial feeding. Similar type of culture with the mullet *M. liza* and the snook *C. undecimalis* yielded about 1,500 kg/ha/year.

The stockings of the fishponds are made with young fishes. The hypophysation method, which was started in Brazil, is not yet being used in coastal aquaculture.

Culture of shrimps *Penaeus brasiliensis*, *P. paulensis* and *P. monodon* is in progress.

Good concentrations of mussels *Perna perna* and *Mytella falcata* and oysters *Crassostrea brasiliana* and *C. rhizophorae* are found in some areas, but there is no commercial culture. The Pacific oyster *Crassostrea gigas* was recently introduced in southern Brazil.

INTRODUCTION

THE ESTIMATED number of inhabitants is more than 110 millions in Brazil. It is natural that such population cannot survive by ingesting only animal protein of bovine origin, which is not cheap. In this way great part of the population needs other sources of animal protein, mainly of fishes, crustaceans and molluscs either harvested from wild and / or raised through aquaculture.

BRIEF HISTORICAL ASPECTS

Fish culture in Brazil was started in 1882, with the introduction of carp *Cyprinus carpio* in Rio de Janeiro. In Sao Paulo State it was started in 1893, but officially only in 1904 (Nomura, 1976), with the same species.

In November 12, 1932, the government created the 'Comissao Técnica de Pisicultura do Nordeste' (Northeastern Fish-culture Technical Commission). Its first Director Dr. Rudolph von Ihering and two collaborators managed to induce fish to spawn by hypophysation (Ihering, 1937). This method that was soon adopted mainly in the United States and Russia.

During his work in northeastern Brazil, Ihering had the opportunity of observing the rearing of estuarine fishes at Pernambuco State. In 1932, the yield of the local fishponds was estimated in 1,400 kg/ha/year (Ihering, 1932), but later on Schubart (1939) found only 670 kg/ha/year. At that time one could find 284 fishponds at Recife, capital of Pernambuco State. Twenty-one species of fishes were pre-

sent, but only some had commercial value: snook *Centropomus undecimalis*, mullets *Mugil liza* and *M. curema* and mojarra *Diapterus rhombeus*.

Nomura (1977) presented a brief review of the cultivation of some marine and some brackishwater fishes, marine and freshwater shrimps and molluscs in Brazil. A review on mullets and snooks was also presented by Nomura (1978 b).

In this paper the main coastal resources which have potential for aquaculture will be reviewed by species.

Fishes

Mullets (Mugilidae)

Two species are common at northeastern fishponds: *Mugil liza* (formerly known as *M. brasiliensis*, according to Trewavas (1950). Braga (1978) made a morphological comparison of the species found along the Brazilian coast.

At present the main fishponds are located at Santa Cruz Channel and Igaracau River, at Itamaracá, Pernambuco State. During summer, the degree of salinity becomes higher, being a handicap to the development of fishes. Critical months go from December to February, due to quick water evaporation. The species reared are eurybaline, but the environment becomes hyperhaline, with salinity varying from 43.82 to 47.41‰, according to Silva *et al.* (1969). During winter months there is a flow of freshwater from the rivers, which causes a decrease in salinity, temperature, transparency of water and dissolved oxygen, thus increasing its nutritional values.

Age, maturity and parasites of *Mugil liza* and *M. curema* were studied by Schubart (1936). At the third year of life the first one reaches 39 to 49 cm in length, while the second one, 37 to 41 cm in the same period of time. The first one spawns at the fourth year of life, and the second one, at the second year. Fecundity of *M. curema* reaches 300,000 eggs. A specimen of *M. liza* reaches 78 cm and 4 kg, while *M. curema* of 41 cm reaches 710 g. Through scale reading, Schubart (1936) found that *M. liza* reaches 16-20 cm during the first year of life, 26 cm at the second, 32 cm at the third, and 49 cm at the fourth, while *M. curema* reaches 29 cm at the second year, 37 cm at the third, and 41 cm the fourth year. Through analysis of length frequency distribution curves, Moura, *et al.* (1972) found 15.5 cm and 41 g for the first year of life of *M. curema*, 28 cm and 233 g for the second, and 37.5 cm and 549 g for the third year.

From March 1970 to April 1971, experiments on the rearing of mullets in four fixed nets and two floatings ones, were made by Silva and Moura (1972). Monthly growth increment varied from 0.36 to 2.13 cm.

Two fishponds — one measuring 2,000 and the other 2,100 m² — were used for rearing *M. curema* (Albuquerque *et al.*, 1978). One of them received chicken manure, at the rate of 120 kg/month, and the other, bovine manure at the rate of 124 kg/month. The experiment was conducted during 11 months. In the first fishpond the mullets reached 22.2 cm total length and 107 g mean weight. The yield was 367.10 kg/ha/year and the survival rate, 78.25%. In the second fishpond, the fishes reached 20.55 cm and 84.44 g. The yield was 263.7 kg/ha/year and the survival rate, 71.4%. Better results were achieved with chicken manure.

Silva (1975) reared *M. curema* in some fishponds at Itamaracá. One of them received 1,140 fingerlings, while another one received 1,400. The latter was fed with complementary amount of food. A sample of 20 to 50 fishes was taken monthly, to be measured and weighed. After one year the total number of fishes was counted. The production of the first fishpond was higher than that of the

second. Stomach contents of those fishes showed 19 genera of diatomaceae, 1 chlorophyceae, 3 cyanophyceae, 1 euglenophyceae, crustaceans, foraminifera, rotifers, larvae of molluscs and sponges. Supplementary ration made out of 5.0% meal flour, 5.0% fish-flour, 40.0% castor-oil tart, 35.0% cotton tart, 15.0% dried pulp of brewery, 1,100 to 1,200 cc of water for each 6 kg of the components, was used, in the total of 442 kg during the experiment. It was offered 3 times a week, at the proportion of 5 to 10% of the biomass, in the second fishpond. After 12 months, only 127 fishes rested in the first pond, showing a survival rate of 11.1%, while in the second one, only 142, with a survival rate of 10.9%. It is supposed that high mortality was due to predation, or bad adaptation of the fingerlings in the ponds. Fingerlings used measured 3 cm and weighed 3-4 g in the beginning of the experiment, reaching 25 cm and 130-160 g after one year.

Another experiment was carried out by Okada and Rocha (1978). They used three fishponds, stocked with mullets fry for periods varying from 365 to 463 days. Weight increase varied from 0.18 to 0.47 g/fish/day, while the survival rate varied from 14.50 to 44.66% and the yield, 124.4 to 413.6 kg/ha/year. In one of the fishponds there was also *M. liza* which yielded 42.3% of the total. No special food was used.

Polyculture was adopted in some experimental fishponds by Cavalcanti (1977) and Rocha and Okada (1978). The first author showed that *M. liza* reaches 1 kg in one year and that *M. curema* grows slower. Survival rates of 70 to 80% were achieved with the combination of *M. curema* and *Centropomus undecimalis*, and 95% with *M. liza* and *C. undecimalis*. Without artificial feeding or fertilization, the combination between *M. curema*, *C. undecimalis*, *Diapterus olisthostomus*, *D. rhombeus* and *D. brasilianus*, varied from 400 to 800 kg/ha/year, while for *M. liza* and *C. undecimalis* reached 1,050 kg/ha/year and for *M. curema*, *M. liza* and the three species of *Diapterus*, 1,100 kg/ha/year. With fertilization the yield varied from 700 to 900 kg/ha/year for *M. curema*, *C. undecimalis* and the three species of *Diapterus*, while the same combination with artificial feeding varied from 800 to 1,300 kg/ha/year and for *M. liza* and *C. undecimalis*, 1,500 kg/ha/year.

In two experiments carried out by Rocha and Okada (1978), survival rate was 100% for *M. liza* in both trials; 86% and 100% for snook and 100% for *M. curema*. Growth rate in weight varied from 1.06 to 1.20 g/fish/day for *M. liza*; 0.43 to 0.93 g/fish/day for *C. undecimalis* and 0.27 g/fish/day for *M. curema*. The fishes used only natural food.

Two other experiments were carried out by Okada *et al.* (1978). One of the pond was stocked with 2 *M. curema* per m^2, 1 *C. undecimalis* per 10 m^2, and the other one with 2 *M. curema* per m^2 and 1 *Diapterus brasilianus* per 10 m^2. In both experiments a complement of rice was added. In one year the weight increase of *M. curema* varied from 0.136 to 0.186 g/fish/day, corresponding to a biomass increase of 1,922 and 2,776 g/ha/day. Weight increase of *C. undecimalis* was 0.324 g/fish/day, corresponding to a biomass increase of 100 g/ha/day. For *Diapterus brasilianus* the increase in weight was 0.197 g/fish/day, corresponding to a biomass increase of 212.5 g/ha/day. Survival rate of *M. curema* was 70.72 and 74.62%, while for *C. undecimalis* was only 30.83% and for *D. brasilianus*, 100%.

Maia *et al.* (1978) conducted two experiments: polyculture of *M. liza* and *M. curema* in one fishpond, and *M. liza* and *C. undecimalis* in another. The experiments lasted one year and the food used was soy-bean bran, wheat bran, castor-oil bran, dried pulp of beer yeast and fish-flour. *M. liza*, in both experiments, showed an increment of 1.13 and 1.39 g/fish/day, *M. curema*, 0.23 g and *C. undeci-*

malis, 0.42 g. Survival rate for *M. liza* was 75.2 and 93.6%, while for *M. curema* was 75.5% and for *C. undecimalis* 100%. In the first polyculture, the yield of *M. liza* was equivalent to 1608.6 g/ha/day and for *M. curema* 1,415.2 g/ha/day. For *C. undecimalis*, the yield was only 210 g/ha/day, while for *M. liza* was 2,872.7 g/ha/day. Food conversion was 4.4 and 5.8 respectively.

In nature, mullets feed on algae, mainly diatomaceae and cyanophyceae. The diatomaceae are : *Amphora*, *Navicula*, *Nitszchia*, *Pleurosigma*, *Coscinodiscus*, *Cyclotella* and *Melosira* ; cyanophyceae : *Anabaena*, *Chroococcus*, *Oscillatoria* and *Merismopedia*, according to Vasconcelos Filho and Souza Jr. (1978).

Females of *M. curema* are more abundant during September upto December, spawning from March to August (Couto and Nascimento, 1978).

All the former experiments were carried out at Pernambuco State.

At Alagoas State, experiments were made by Barros *et al.* (1978) with *M. liza*, *M. trichodon* and *M. curema*. Three fishponds were used. One of them was stocked with 1.4 fish/m², measuring 11.0 cm mean length and 15.5 g mean weight. In four months they reached 16.1 cm and 48.4 g, which means an increase of 1.4 cm/month. Later on the density was changed to 3 fish/m², with fry. Another fishpond received 6 fish/m² and a third one, 10 fish/m². *M. liza* of the second fishpond reached 2.25 cm/month in four months and the third one, 2.5 cm/month in two months. *M. trichodon* and *M. curema* reached 0.5 cm/month in one year observation. From 20 cm on, the increase was almost assintoptic. Both species attain smaller length than *M. liza*.

From July 1977 to May 1978, Barros and Silva (1978) observed that the fry of the three above species of mullets are common at Mundaú lagoon. Their lengths varied from 2 to 5 cm, which are ideal for stocking at the fishponds.

At Rio Grande do Norte State, experiments were carried out with *M. curema* by Cruz (1978) and Cruz and Araújo (1978). Tanks used measured 700 m² and 200 m², stocked respectively with 500 and 400 fry. Chicken food was used in one of them and in the other bovine manure. Some tanks were maintained in natural conditions. The fertilization was made monthly, using 70 kg of manure in the proportion of 100 g/m². The experiments lasted from 12 to 15 months. Feeding and fertilization were conducted from the fourth month on. Quantity of food, offered twice a week, was around 4% of the biomass. Monthly increment was 14.7 mm with food ; 13.5 mm with fertilization ; 11.3 mm in natural conditions and 8.1 mm in natural conditions plus periphyton.

According to Ramanathan *et al.* (1978), natural food of *M. curema* consists mainly of unicellular, filamentous green algae, diatoms, detritus, small pieces of soft vegetable matter, sand particles and the associated microbenthos.

Hypophysation method was not used in the fishponds. The stockings at the fishponds were made with youngs measuring 10 to 15 cm, captured along the seashores.

Snooks (Centropomidae)

The first attempt to rear snook *Centropomus undecimalis* was made by Magalhães (1931). He kept 17 specimens in an aquarium of 4,000 litres capacity, from September 15, 1930 to June 15, 1931, at Sao Paulo State. In the same aquarium he kept several *Astyanax* sp., a small Characidae fish, which at night were swallowed by the snooks. Snooks are brackish-water species, which tolerate freshwater.

Rearing of snooks was recommended by Carvalho (1943). Its natual food are made out of small fishes, such as sardines and anchovies and shrimps, insects and aquatic larvae.

At Pernambuco State, Silva and Vasconcelos Filho (1972) analysed the stomach contents of *C. undecimalis* and *C. parallelus*. Both feed on fishes and crustaceans and rarely on plants. The first species showed preference for fishes (44%), while the second one for crustaceans (55%).

Silva (1977) studied the growth of *C. undecimalis* in a confined environment.

According to Porto and Vasconcelos Filho (1978) both species feed on fishes (Atherinidae, Gobiidae and Gerridae) and crustaceans (Penaeidae).

Snooks and mullets are also caught at the fishponds of Soubara, Bahia State. Such ponds yielded about 206 kg/ha/year in 1952 (Menezes, 1956).

Mojarras (Gerridae)

The three species common at the fishponds located in Pernambuco State, were previously mentioned in association with mullets.

CRUSTACEANS

Shrimps

At Natal, Rio Grande do Norte State, a project on shrimp culture is being carried out since April 15, 1973, with the species *Penaeus brasiliensis*. They have 29 ponds, with depths varying from 50 cm to 2 m. First mature females were captured on March 28, 1974 and kept in a well aerated tank of 500 litres capacity. One of the females was transferred to an aquarium, containing filtered salt water, with 35‰ salinity and 25°C temperature. EDTA was added in the proportion of 0,01 per g/l. The aquarium was kept in the dark and spawning occurred at 7 p.m. of March 29. Eggs were transferred to a hatchery tank. When the larvae reached the third nauplius stage on March 31, they were fed with diatomaceae *Skeletonema costatum*. At protozoa phase II they received *Tetraselmis* sp. At mysis stage they were fed with *Artemia salina*. After post-larvae phase the youngs were put into the ponds (Souza and Monte, 1974).

In 1977, two types of tanks were used for larval stages (Nomura, 1978a): (1) tanks measuring 5 m × 5 m with 2 m height (Japanese system); (2) cylindrical tanks with 2,400 litres capacity (American method). For post-larvae, juvenile and adult stages there are: (1) 1,000 m² ponds for post-larvae from 1 to 30 days, densities varying from 100, 150, 200 upto 250 prawns per square metre, artificially fed; (2) 10,000 to 40,000 square metres ponds for juvenile and adult stages, with variable densities, according to the method: (a) extensive—3 to 5 prawns per m², artificially fed; (*b*) semi-intensive—5 to 10 prawns per m², artificially fed and supplemented with artificial food in small quantities; (*c*) intensive—10 to 20 prawns per m², artificially fed and supplemented with artificial ration, in the proportion of 5% of its biomass.

The shrimp *Penaeus brasiliensis* reaches 25 g in 8 months.

Due to the increase in the number of shrimp larvae, there is an interest on algae culture as food source for those organisms. Rego (1978) was able to produce large quantities of *Tetraselmis chuii* to serve as food for *P. brasiliensis*.

In a shrimp culture, it is necessary to produce economic food. The diatomaceae *Skeletonema costatum* and the green flagellate *Tetraselmis chuii* were replaced by *Saccharomyces cerevisiae* during the zoea stage of *P. brasiliensis*. Three experiments carried out by Guimaraes (1978) showed that during nauplius and post-larval stages survival rate was higher than 90% when *Saccharomyces cerevisiae* was served together with nauplius of *Artemia salina*.

The reproduction of another species, *Penaeus schmitti*, was also achieved at that State.

In the same State, *Penaeus monodon*, native from the Phillippines, was introduced (Verani *et al.*, 1978). Experimental culture was made in a 100 square metre pond, with 1 m depth and sandy bottom. The experiment is still in progress. This species reaches 100 g in 8 months, four times more than *P. brasiliensis*, in the same period.

At Rio de Janeiro State, mature females of *P. brasiliensis* and *P. paulensis* were caught during commercial activities in December 1975. Four spawnings occurred, from which 90,000 larvae were obtained. Most part was thrown at Sepetiba Bay and small part for feeding and growth studies at the laboratory (Nomura, 1978 a).

At Cananéia, Sao Paulo State, both species were reared upto juvenile phase by Iwai (Nomura, 1978 a). He replaced *Skeletonema* sp. by *Phaeodactylum tricornutum* with success.

At Florianópolis, Santa Catarina State, mature females of *P. paulensis* were caught on October 20, 1973. They were kept in an aquarium of 80 litres capacity. For each 10 litres of salt water, 0.1 g of EDTA was added. Temperature was maintained at 24°C and the salinity at 30‰. During the first, second and third nights, the females spawned. At zoea stage they were fed with plankton, together with nauplius of *Artemia salina* at zoea III phase. Once a day crab eggs were added during post-larval stage (Nomura, 1978 a).

MOLLUSCS

Mussels

At Mundaú lagoon, Alagos State, there is a mussel known as 'sururu', *Mytella falcata*, which lives in muddy bottom (Nomura, 1977). Larvae show up in September, floating on the water, searching places for fixation (Magalhães, 1942). Mean number of individuals per m³ is about 14,000 with mean salinity of 7‰. Barros and Macedo (1967) managed to rear larvae at the laboratory.

Salinity plays a very important role upon the life of that mussel. An experiment conducted by Barros and Macedo (1967) during 40 days, with 60 mussels, showed that at salinity 0‰, mortality during a week was 51.7%; at 1‰, 60.0%; at 2‰, 20.0%; at 3‰, 5.0%; at 4‰, 0.0%; at 35‰, 13.4%; at 36‰, 56.8%. Lethal concentrations were below 2 and above 35‰; best salinity was between 5 and 15‰.

The mussel spawns all year round, more intensively in February, May, September and November. Mean density of larvae per square metre reaches 14,266. Commercial size is attained in four months. In two months the males reach 18.1 mm length and 139.7 mg weight, while the females, 17.4 mm and 148.7 mg.

The productivity at Mundaú lagoon reached 12 tonnes per ha/year, but recent statistics shows a lower yield (Table 1).

TABLE 1. *Production of the mussel sururu*, Mytella falcata (1960-1966)

Year	Tonnes
1960	3,907
1961	3,199
1962	2,808
1963	1,671
1964	2,271
1965	723
1966	478*
Total	15,057

Source: SUDEPE (* January-July).

Recently a new ground of 'sururu' was found at São Luís, Maranhão State. It is

estimated that the stock of adults reached 25,000 tonnes. Scientists are searching for good places to start the culture of that mollusc (Nomura, 1978 a).

At Cabo Frio, Rio de Janeiro State, the mussel *Perna perna* is very common. An analysis of the stomach contents of 250 mussels showed abundance of diatomaceae and foraminifera ; turbellarian and polychaete larvae were also found (Fernandes *et al.*, 1978).

In that region an experiment of mussel culture was carried out by Rafael (1978 a). He used bamboo sticks (*Bambusia vulgaris*) under the form of raft measuring 6×4 m, with a diameter of 10 cm. Those collectors were placed in July. After 3 to 4 months, when the mussels attain 3 cm length, they were taken out and kept in polyethelene nets. A quantity of 120 to 140 of those nets were suspended in fattening rafts. After 5 to 7 months the mussels reached about 7 cm. Rafael showed that the largest concentration of mussel larvae was 16,316 per m³ and occurred in August 1973, in plankton collections at Cabo Frio. The salinity varied from 34 to 36‰.

At Ubatuba, Sao Paulo State, an experimental culture of *Perna perna* was conducted by Ishibashi (Nomura, 1978 a). In an area measuring 50 cm², the number of mussels reached 56, size varying from 33 to 42 cm and the weight, from 4 to 8 g. Mean annual temperature of the water as 24°C, varying from 21.2 to 28.4°C. A nylon rope measuring 15 m was used in the experiment. Larvae were observed from July to September. Later on they were suspended at 1 m depth, in plastic nets. It was seen that growth reached 5 mm per month. In 6 months they measured 45.8 mm and weighed 9.5 g and one year later, 62.4 mm and 20.2 g. Survival rate was 100% and the only predator noted was *Thais haemastoma*.

In a laboratory near Ubatuba, Salomao and Magalhaes (1978) subjected 400 mussels to different salinities. They were caught in water with 34‰ salinity and transferred to 4, 9, 14, 19, 24, 29, 39, 44 and 49‰. In each experiment a total of 10 mussels were kept in aquaria with 10 litres of sea-water, 24° ± 1°C temperature. The water was changed daily. The mussels were observed at intervals of six hours, during 102 hours. The species survives at 19 to 44‰ salinities, being euryhaline. At 4, 9 and 49‰ salinities, they loose their capacity of elaborating the byssus and therefore unable to fix on a substratum.

In natural beds located at Santa Catarina State, production was the following (Table 2) :

TABLE 2. *Production of the mussel* Perna perna *in natural beds* (1974-1976)

Years	Tonnes
1974	1,485
1975	933
1976	467*
Total	2,885

Source : SUDEPE (*First semester)

Oysters

At Bahia State, an experimental culture of the mangrove oyster *Crassostrea rhizophorae*, was started in 1972 by Santos (1978). Larvae fixation occur all year round, but with maximum peaks between April and August (winter). Best salinity was observed in zones between tides. Larvae measuring up to 10 mm showed a daily increment of 0.34 mm ; from 10 to 35 mm, increment of 0.26 mm and from 30 to 70 mm, increment of 0.05 mm. Spat collectors were made with bamboo (stick culture), exposed at 1.8 m above the zero level. For fattening stage, tray culture was used.

In the analysis of 1,152 oysters, only 0.52% of hermaphrodites was found; upto 90% of individuals measuring 2 cm were males and changes of sex occurred with oysters measuring 2 to 4 cm (Nascimento *et al.*, 1978). Gametes are eliminated during the rainy season (Nascimento *et al.*, 1978). The species is not strictly protandrous; about 10% develop as females, without passing through a male phase.

A small crab, *Pinnotheres ostreum*, is very common in oysters measuring from 6 to 8 cm. It was seen that percentage of flesh in relation to oyster's total weight is significantly lower in infested animal when compared with normal ones, showing that the crab acts as predator (Nascimento and Pereira, 1978). The oyster is also attacked by trematodes *Bucephalus* and the protozoa *Nematopsis* (Nascimento, 1978).

The same species is being observed at Pernambuco State. Larvae fixation occur all year round, with maximum at the end of September and beginning of October. Spawning occurs in September, when salinity reaches 28‰ at the surface and the temperature is around 30°C. Predominance of females was noted from September to April, and males from May to July (Nascimento and Travassos, 1978). Maximum mean fixation density was 292 and minimum 73.

The Pacific oyster, *Crassostrea gigas*, was introduced at Cabo Frio, Rio de Janeiro State. The spats measuring 3 to 4 mm came from Anglesey, England. At the beginning, after acclimatization, the spats were kept in wooden boxes measuring 60 × 60 × 10 cm, covered with nylon, with 2 mm aperture in the upper and lower sides. Those boxes were suspended in rafts measuring 6 × 4 m, with 10 cm diameter bamboo and blocks of styro-foam, in a place with 6 m depth. Each box received 200 spats and was kept at 1.50 m from the surface. In eight months the oysters attained the commercial size of 75 mm (Costa, 1978).

An attempt to rear *Ostrea arborcum* was made in September 1960 at Santos, São Paulo State (Lima and Vazzoler, 1963). Three level shelves were made and on it, colonial bricks for larvae fixation were placed. They were put in three environments: salt water at tide line; brackishwater at tide line and at bottom. The first environment made the oysters reach 2.0 to 8.0 cm in one year; on the second one, 1.5 to 12.0 cm, and on the third one, 3.0 to 20.5 cm. Fixations upto 700 larvae were observed in an area of 2,000 cm², but good number was fixed as 10, to allow space for the development of the oysters.

The region of Cananéia, São Paulo State, is ideal for oyster-culture (Wakamatsu, 1975). This author made experimental culture from November 1969 to September 1972. Phytoplankton is abundant in that region: *Coscinodiscus*, *Chaetoceros*, *Skeletonema*, *Asterionella* and *Rhizosolenia*. Salinity varied from 10 to 30‰, while temperature ranged from 20 to 30°C. In his experiments, Wakamatsu observed that oysters reach 4 to 7 cm in one year.

A technique for the cultivation of *Crassostrea brasiliana* was developed at Cananéia, to assist in the re-stocking of the exhausted natural beds (Akaboshi and Bastos, 1974). Ten *Pecten* shells were used as collectors. Spats were obtained with collectors made from 100 large oyster shells and placed on bamboo frames. For selection, the collectors were kept in the intertidal zone for a period of four months and eventually transferred to growing lines vertically suspended from buoys or rafts.

Akaboshi and Pereira (1978) continued the experiments. Test collectors made out of 3 to 5 *Pecten* shells, perforated by a wire, were kept at 2-3 m and 7-8 m depth, during three to four days. At the surface, oyster larvae fixation was low and high at the bottom.

Production of oysters from natural beds in Brazil is given in Table 3.

TABLE 3. *Production of oysters* Crassostrea brasiliana *in natural beds* (1972-1975)

Years	Tonnes
1972	266
1973	422
1974	459
1975	238
Total	1,385

Source : SUDEPE.

CONCLUSIONS AND RECOMMENDATIONS

Coastal aquaculture in Brazil consists mainly on the cultivation of mullets *Mugil liza* and *M. curema*, snooks *Centropomus undecimalis* and *C. parallelus* and mojarras *Diapterus olisthostomus*, *D. rhombeus* and *D. brasilianus*. The fishponds at Pernambuco State are the older ones, but the stockings are made out only with small fishes measuring 10 to 15 cm length, captured along the seashores.

It is recommended that similar fishponds should be built in other northeastern regions as well as in the south, and that fry should be obtained through hypophysation method, now used in Israel and Taiwan successfully with mullets (Bardach *et al.*, 1972). The same is true for snooks.

There is no doubt that culture of *M. curema*, associated with *C. undecimalis* and mojarras, is the best method, yielding up to 1,300 kg/ha/year with artificial feeding. Same type of culture with *M. liza* and *C. undecimalis* yielded 1,500 kg/ha/year, which is very high.

It is necessary that scientists engaged in the culture of mullets and snooks in various regions should exchange information more frequently and even working together when necessary to avoid duplication of efforts.

Studies on the biology of snooks and mojarras should be encouraged, because little is known on the subject.

As to crustaceans, best results are being achieved at Rio Grande do Norte State, whose scientists were trained by well-known North-American specialists; its laboratories are well equipped.

The stocks of the mussel *Mytella falcata* must be preserved at Mundaù lagoon, Alagoas State. It was once considered the most productive hectare of Brazil: 12 tonnes/ha/year (Nomura, 1978 a), but its present yield is very low, due mainly to industrial pollution.

Culture of the mussel *Perna perna* and the oyster *Crassostrea brasiliana* is in its very beginning. Commercial culture should be tried by government clerks or private persons, in order to contribute with high and quick production of animal protein to the population.

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

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ABSTRACT

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

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

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

INTRODUCTION

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

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

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

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

Traditional Culture of Marine Fishes

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

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

Research on the Culture of Marine Fishes

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

Culture of fishes in salt pans

Experiments were conducted to culture the milkfish *Chanos chanos* and the mullet *Liza macrolepis* in salt pans at Tuticorin. Four ponds of an area of 23×15 m each with a

depth of 0.6×1.0 m were utilised for this purpose. The ponds were provided with wooden sluices for regulation of tidal flow. In the ponds, surface temperature ranged from 24 to 31°C, salinity from 34 to 37‰, dissolved oxygen from 3 to 5 ml/l and pH varied around 8.0. Plankton volume was poor, zooplankton being dominant. Studies indicated distinct differences in the hydrobiological factors of small ponds and larger ponds, the former being generally more productive than the latter.

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

Culture of fishes in pens

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

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

TABLE 1. *Details of polyculture experiments at Tuticorin*

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

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

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

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

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

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

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

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

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

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

At Mandapam, the grey mullet *V. seheli* was stocked in association with *C. chanos* at the stocking rate of 500 each/81 m² (62,000/ha) in a pen made up of palmyra leaf stalks and erected in the coastal waters of Palk Bay. The average size and weight at the time of stocking were 35.2 mm (0.5 g) for *V. seheli* and 66.4 mm (6.2 g) for *C. chanos*. In the pen, the average size and weight increase recorded for *V. seheli* were 22.6 mm (9.6 g) in 30 days, 51.1 mm (14.5 g) in 60 days and 73.8 mm (18.5 g) in 90 days. On the other hand, *C. chanos* showed an average size and weight increase of 25 mm (4.3 g), 46.8 (8.0 g), 81.9 mm (27.9 g) and 120.3 mm (48.4 g) in 30, 60, 90 and 120 days respectively. Thus, the average monthly growth increments for *V. seheli* and *C. chanos* were 24.6 mm (6.2 g) and 30.1 mm (12.1 g) respectively.

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

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

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

Pond culture

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

Monoculture

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

Polyculture

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

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

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

Seed resources at Mandapam

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

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

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

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

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

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

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

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

Cage Culture

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

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

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

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

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

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

The results of the above experiments indicated that, of all the species cultured, *E. tauvina* registered good growth per month and the yield had been 2-5 times in 6 months. The survival rate was 73%. Therefore, this species appears to be ideal for cage culture in coastal waters. However, during the present investi-

gation, juveniles of this species could not be collected in large numbers for extensive culture.

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

Running water culture

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

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

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

In order to conserve fresh water, an experiment was designed to culture eels in recycled water. An outdoor cement tank (6 × 3 × 1 m) with natural bottom was constructed. By sluice gate arrangement, the bottom water was drained by gravitational flow and passed through gravel, stones, charcoal and sand filters. The filtered water was allowed to settle in a settling tank. The clear water from the settling tank was made to overflow into an oxidation pond from where the water was pumped up into a small overhead tank and fed into culture tank by pipe line arrangement. Thus, the recycled water was re-used again and again after filtration and oxidation. Once a week, about one-third of the total quantity of the water in the culture tanks was replenished with fresh water. The eels were fed in a shaded area by suspending a tray

with the feed, so that the tray just touches the surface of water. The eels crawl over to the tray from all sides, take in mouth fulls of the feed and slip back into the water. The process is repeated till the eels are satiated and return no more to the tray, although enough feed may be present in the tray. This method ensures maximum utilization of feed and absolutely no waste by dissipation into water. The water could also be maintained uncontaminated from left over parts of food for longer periods of time. The feed is made into a paste composed of minced fish (silverbellies), rice bran and oil cake in 2 : 1 : 1 proportion with 0.2% multivitamin. The eels were fed daily once with a ration ranging between 5 to 10% of their body weight. The results showed that the total weight had increased from 9 to 47.7 kg in about 5 months (August '78 to January '79) and average weight from 43 to 232.8 gms indicating an increase of 430% of the initial weight. The net production rate works out to 2.15 kg/sq. m in five months. The gross food conversion ratio was 1 : 4 and the survival rate 98.56%.

Coastal Fish Farm Development

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

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

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

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

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

study the effect of wave action inside the pond due to rough weather and whether the turf grass would survive in the sea water.

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

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

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

Problems in the Culture of Marine Fishes

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

Marine fish culture experiments so far had been restricted to only a few species like the mullets and milkfish, but recently, studies have been extended to other groups like groupers, rabbitfishes and the Indian sandwhiting. There is need to identify more species with faster growth rates for culture under suitable conditions. Experiments are now being conducted in several situations using artificial feeds like the conventional feeds (combination of rice bran, oil cake and fish meal) as well as

pelleted feeds, dry and wet feeds using locally available raw materials. This development has to go a long way to standardise artificial feeds keeping in view the nutritional requirements of various species and the economics of preparation of such feeds.

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

Constraints Identified During Recent Research in Culture of Marine Fishes

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

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

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

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

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

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

Prospects

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

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

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STATUS AND PROSPECTS OF FISH FARMING IN GOA

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ABSTRACT

In Goa, aquaculture is being practised from time immemorial. The methods of fish culture used are traditional and involve composite culture of wild stocks. Despite the ignorance of modern methods of aquaculture, the fish farmers of Goa seem to know many relevant facts empirically from their experience.

Brackish water ponds are used to serve several purposes. Some of the ponds are used for fish culture exclusively; some for salt pan-cum-fish culture, while others are used for paddy-cum-prawn culture.

Relevant information on the indigenous methods of cultivating common species, their annual yield and economics of aquaculture are discussed in the paper with reference to future prospects of fish farming in Goa.

INTRODUCTION

THE UNION TERRITORY of Goa (between Latitude 14°54′ and 15°48′N and Longitude 73°41′ and 74°20′E) lies along the west coast of India. It has a total area of about 3,611 sq. kms. It is bounded on the north by Maharashtra and on the east and south by the Karnataka State. The continental shelf area off Goa measuring about 9,984 sq. kms upto 200 m depth, is reportedly rich (Rao and Dorairaj, 1968) in living resources and the average annual marine fish landing is about 24.000 tonnes (1965-78). The population of Goa is about 0.9 million and fish forms an important part of food for about 90% of the population. Due to high variability of marine fish catches a good demand for any type of seafood exists in Goa. The scarcity of fish necessitates the exploration of other avenues of fish production and the foremost of this is the coastal aquaculture.

The coastal aquaculture, in a traditional way has been practised in Goa from times immemorial, but its present state is poorly known and, hence, it was felt necessary to summarise the relevant information for knowing the 'state-of-art' and for working out the feasibility of coastal and brackishwater fish farming in Goa. The present survey was carried out between May 1977 and June 1978.

Grateful thanks to Dr. S. Z. Qasim, Director, National Institute of Oceanography for taking personal interest in this survey and also for giving useful comments on the manuscript.

SCOPE AND AREA

The coastline of Goa is about 104 km long. The estuarine and freshwater wetlands are 250 sq. km. The Goa Coast (Fig. 1) is full of creeks, estuaries and backwaters formed by seven rivers, *viz.*, Teracol, Chapora, Mandovi, Zuari, Sal, Talpona and Galgibag. A number of brackishwater fish farms, locally known as 'agar' are used in a traditional way, for fish and shrimp culture. The total area of the

brackishwater ponds is estimated to be about 200 hectares. Individual pond varies from 0.16 to 4.5 ha, in area. Such ponds are mainly confined to Bardez, Tiswadi and Salcete Taluks (Table 1). Besides, the existing ponds, there are vast areas of mangrove swamps, disused paddy fields and salt pans, which can be utilised for fish farming.

Methods of Fish Culture in Goa

Traditional methods involving composite culture of wild stocks are in vogue. Despite the complete ignorance of scientific methods of fish farming, the fish farmers seem to know many relevant facts, especially by practical experience.

The brackishwater ponds are used to serve different purposes. Some of the ponds are exclusively used for fish culture; others for salt pan-cum-fish culture (locally known as 'mitache agar') while some others are used for paddy-cum-fish culture, known as 'khazan' land fish culture.

Permanent fish farms

These farms (Pl. I A) of varying dimensions are generally situated close to the estuary or adjoining the tributary of a river. They are characterised by dense mangrove vegetation in the surrounding area. Such ponds are bounded by mud embankments and strengthened with lateritic boulders (Pl. I B). The flow of water, in and out, of the pond is regulated by sluice gates, fitted with wooden planks (Pl. I C).

Stocking of the farm is undertaken in the months of May-June. Sluice gates are kept open, thus allowing the free exchange of water which largely depends upon the tidal conditions. Tidal inflow allows the entry of fish and prawn larvae into the pond. The larvae continue to grow and by September-October they make attempts to move out of the pond. At this time, the water level in the pond is regulated by allowing the exchange of water only during the spring and neap tides. To prevent the escape of fish and prawn from the pond, fine mesh nets are used in the sluice gate. Small branches of trees are also planted in the

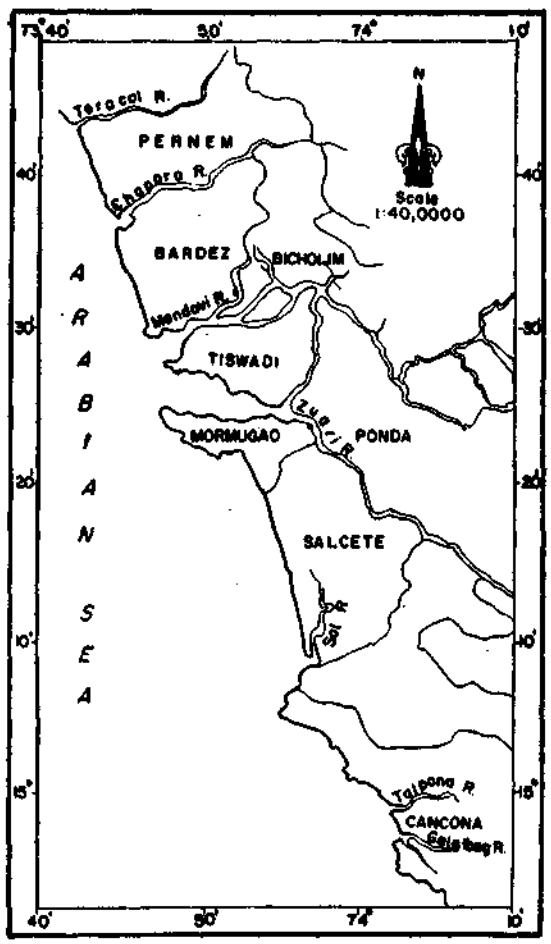

Fig. 1. Map of Goa showing Taluks and Rivers.

pond for providing shelter to fish. These twigs also help in preventing poaching. The harvesting is undertaken from February to April and is mainly done by nets fixed at the sluice gate, but at times, drag nets or cast nets are also used. Permanent fish ponds are few in number (Table 1) and are mostly located in Salcete Taluk (Fig. 1).

Salt Agar

Such ponds serve a dual purpose of both salt and fish production (Pl. I D). During the monsoon season (June-September), the salt pans are inundated with brackishwater by regulating the inflow of water through the sluice gate. By the end of August, the sluice gate is closed and the fish is allowed to grow inside the pond till December, when the pond is completely drained out in preparation for salt production. The harvesting of fish is done within 3-4 days, by nets fixed at the sluice gate. On one of the sides of the pond, a wide but shallow (about 0.5 m depth) channel (Pl. I E) is dug for maintaining fish larvae, which serve as stock for the next season.

The ponds are completely sun-dried and small rectangular pans are prepared. The water during spring tides is then taken in for the extraction of salt from February to May. The crystallization of salt cubes largely depend upon weather conditions, dry weather being more favourable. In such farms, the fish production is considered as a secondary crop and hence, more attention is paid to salt production.

'Khazan' Lands

Similar to salt 'agars', 'khazan' lands also serve a dual purpose of fish and paddy cultivation. A preliminary account of khazan land fisheries of Goa, has been given by Gopinath and Dani (1973).

TABLE 1. *Some details of fish farming in different parts of Goa*

Taluk	Location of farms	Number of farms	Area (m^2)	Annual fish production (kg)	Annual Salt production (kg)	Number of persons employed	
						Part time	Full time
Canacona	Mashe, Painginim and Galgibag	5	5,000	150	..	8	..
Salcete	Betul, Assolna, Durga, Panchwadi, etc.	50	1,23,000	5,500	44,000	46	18
Tiswadi	Santan to Siridao; Sant Inez to Merces; Ribandar to Panaji; Chorao Island, etc.	101	3,80,100	13,700	81,300	115	30
Bardez	Nerul, Orda, Verem, Arpora, Candolim, Siolim, etc.	56	2,19,000	4,700	1,12,500	100	20
Pernem	Kerim, Mandrem, Morjim, Malpem, etc.	11	800	50	..	15	2

These are low lying wet lands, along the tidal marshes and are protected from inundation by embankment (locally known as 'bandh') of mud and lateritic boulders. Inflow of water is regulated through a sluice gate, called as 'manas'.

Paddy cultivation is undertaken only during the monsoon season and after the harvesting in October, these fields are used for fish and shrimp cultivation. Thus, fish farming may be either :

(*a*) Secondary crop of fish after harvesting of paddy.

Or

(*b*) Continuous fish culture all the year round.

In such wet lands, fish and shrimp seeds are allowed to enter, by regulating the flow of brackishwater through sluice gates. The young fish and sbrimp grow along with the paddy. In the region, where paddy is grown, deep dykes (Pl. I F) are dug in which fish can remain when the paddy field is to be drained during the harvesting.

Paddy-cum-fish culture in Goa, has declined to a large extent, because of the prevailing statutory regulations, which restrict the intake of saline water into the fields for fish cultivation. Also for such ' khazan ' lands, a special salt-resistant variety of paddy kown as 'korgut' is used. The high yielding varieties of paddy do not seem to grow well in such environment.

Common Cultivated Species

Different varieties of fish and shrimp larvae enter the pond in the monsoon season along with the tidal inflow. The prawns are mostly *Metapenaeus monoceros*, *Penaeus monodon* (locally known as ' Waghi') and *P. indicus*. Important species of fish are mullets (*Mugil cephalus* and *M. parsia*—locally known as ('Sevtali'), milkfish (*Chanos chanos*—locally known as ' Gholshi '), pearlspot (*Etroplus suratensis*—locally known as 'Kalundra') and bhekti (*Lates calcarifer*—locally known as ' Chanyak '). Species of lesser importance are ' Tamboshi ' (*Lutianus* sp.), ' Kharchani' (*Gerres* sp.) and ' Banoshi ' (*Thenus* sp.). Large numbers of predatory species, like *Therapon jarbua*, grow in the farm. Similarly, ' bhekti ' also a highly carnivorous species is detrimental, especially to shrimps. These predators are generally removed by angling or netting.

The species composition is almost similar in all the three categories of fish farms, but in ' khazan' type of fish farming, prawns are dominant.

Harvesting—Season and Methods

Time of harvesting varies with the type of fish farming. In permanent fish farms, harvesting is generally undertaken from February-May. Prawn fishing is generally done at night, by using a cast net and a lantern. Fishing lasts for about 4-8 days during the full moon and new moon phases. It also depends on the local demand for fish. Drag nets are also used. This type of net is pulled all along the pond by 5-6 persons. For night fishing, sometimes gillnets are used in addition to cast nets.

A conical shaped net is fixed at the main sluice gate for the capture of fish and prawn, when the water gets drained with the ebb flow.

The harvesting of fish from salt ' agars' is generally done in December. The water is either drained or pumped out and the fish is trapped either by cast nets or drag nets.

Though the paddy-cum-fish culture has been less popular these days, the fish growing in the network of channels traversing the ' khazan ' lands, are caught by fixing the conical nets at the sluice gate. The nets are fixed mainly during the night and during the receding tide. Total quantity of fish caught at one time varies from 1-25 kg.

Total Yield

The estimates of fish and salt production are based on the information collected from the local operators engaged in fish farming and extraction of salt. It seems that about 50 tonnes of fish is harvested from different fish farms and sluice gate systems in Goa. Incidentally, this is only about 0.1% of the total marine fish landing in Goa. However, it should be noted that most of the production figures given by individual fish farmers are underestimates, as most of them are rather reluctant to disclose the actual figures.

TABLE 2. *Cost benefit analysis of fish farming alone in Goa (Case Study)*

Area of farm	:	3 hectares
Number of fishing days	:	80
Quantity of fish caught/day	:	40 kg
Total catch (40 × 80)	:	3,200 kg
Cost of catch (at Rs. 7 per kg.)	:	Rs. 22,400

Expenditure		Rs.
(*a*) Labour		
(i) Part-time (6/day at Rs. 10 for 80 days)	..	4,800.00
(ii) Full-time (1 at Rs. 250 per month for 12 months)	..	3,000.00
(*b*) Other expenses– including maintenance, unforeseen, nets, etc.	..	1,000.00
(*c*) Annual lease charges	..	2,100.00
Total	..	10,900.00
Returns		
(i) Gross Profit (Cost of catch—Expenditure)	..	11,500.00
(ii) Profit per hectare	..	3,833.00
Rate of returns		
(i) Cost of production	..	10,900.00
(ii) Value of produce	..	22,400.00
(iii) Gross profit	..	11,500.00
(iv) Profit margin	..	100%

TABLE 3. *Cost benefit analysis of salt-cum-fish farming in Goa*

Area of farm	:	10.5 hectares
Number of fishing days	:	4-6
Quantity of fish caught/day	:	700 kg
Total catch	:	3,500 kg
Cost of catch (at Rs. 5 per kg)	:	Rs. 17,500
Income from salt (12,000 bags at Rs. 4 per bag)	:	Rs. 48,000
Total income Rs. 17,500 + Rs. 48,000)	:	Rs. 65,500

Expenditure		Rs.
(*a*) Labour charges		
(i) Part-time (50% of total income from salt)	..	24,000.00
(ii) Full-time (2 at Rs. 250 per month for 12 months)	..	6,000.00
(*b*) Other expenses—including maintenance, pump, charges, unforeseen, nets, etc.	..	2,000.00
(*c*) Annual lease charges (25% of total salt income)	..	12,000.00
Total		44,000.00
Returns		
(i) Gross Profit (Total income—Total expenditure)	..	21,500.00
(ii) Profit per hectare	..	2,150.00
Rate of returns		
(i) Cost of production	..	44,000.00
(ii) Value of Produce	..	65,500.00
(iii) Gross Profit	..	21,500.00
(iv) Profit margin	..	47.7%

The total salt production is estimated to be about 2,13,000 bags (1 bag=50 kg). The brackishwater ponds are owned by landlords and are given on short lease to an interested party. In the case of salt agar, ⅓ of the total salt produced is given to the land owner, in lieu of fees for the lease. In the case of fish ponds, the terms of lease generally depend on the size and production of the pond. A fish pond of 1 ha fetches about Rs. 200-300 per annum from the lease.

Economics of Fish Farming

The cost-benefit analysis for a productive fish farm and salt agar, has been attempted and shown in Table 2 and 3 respectively.

It can be seen (Table 2) that both direct and indirect cost of a fish farm of 3 ha are relatively high (Rs. 3633/ha), but in spite of traditional methods of fish farming, the rate of returns is also fairly high (100%). Therefore, by adopting proper management techniques (hatcheries, nurseries, fattening ponds, compounded diet, etc.), there is a good scope for improving the yield and thus increasing the profitability.

As seen from Table 3, the cost of production in a salt pan-cum-fish farming, is high and consequently the profit margin is rather low (47.7%). Thus, though undertaken by traditional methods, the fish pond farming is more profitable than the 'agar' farming. At present, more than 400 persons are engaged in fish farming in Goa, and since it is done as a family business, it becomes quite economical.

Problems and Prospects

Fish farming in Goa is being practised on non-scientific lines at present. No special attention is being paid for improving the stock of the cultivable species and hence the success or failure entirely depends on the availability of larvae from the natural sources. No proper measures are being undertaken for controlling predation by carnivores and infection by different vectors is quite common. Poaching is another serious problem and for small fish farmers, it is not possible to make a full-time watch and ward arrangement. Such problems are forcing many of the traditional fish farmers of Goa to shift to salt production, where the problems are not so acute and the profit is steady.

In a recent case study of fish farming in Goa (Matondkar, 1978), the high productivity potential of fish farming has been demonstrated. The scope for the expansion of coastal aquaculture in Goa appears to be quite good, as there are vast stretches of low lying wet lands adjoining the estuaries and mangroves. There are also a number of sheltered bays and coves, which can be put to proper use. These areas when brought under scientific management can produce substantial quantities of animal proteins besides providing the much needed vocational opportunities to a large number of coastal population.

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BRACKISHWATER FISHERIES IN ANDHRA PRADESH

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ABSTRACT

Andhra Pradesh on the east coast of India with a coast line of about 900 km has about two lakh hectares of brackishwater areas. Considerable quantities of fish and exportable varieties of prawn are being harvested from backwaters, low lying areas that get inundated during high tides and other impoundments, although no scientific culture is practiced in these water bodies. With the global and national awareness for aquaculture, particularly for prawns, brackishwater culture technology developed within the state coupled with technology borrowed from other Institutes, conversion of brackish water areas for aquaculture is going on commercial lines. Aquaculture in brackishwater has been accepted as a paying profession and industry.

INTRODUCTION

ANDHRA PRADESH on the east coast of India has a coast line of about 900 kms, spreading over the 9 coastal districts from Itchapuram in Srikakulam District in the North to Pulicat Lake in Nellore District in South. Major rivers like the Godavari and the Krishna and a number of minor rivers and rivulets besides innumerable drains and irrigation systems empty into the Bay of Bengal. The Godavari and Krishna Estuaries with rich mangroves, the lagoons and backwaters of Srikakulam and central delta area of East Godavari District, Pulicat brackishwater lake and the innumerable drains called ' Upputerus ' are well known for their rich brackishwater fisheries. The extensive marshy mangrove of the Koringa reserve forest of the Godavari estuaries spreads over an area of about 25,000 ha. The mangrove swamp on Krishna estuary has an area of 27,500 ha. The total extent of saline swamps in Andhra Coast is estimated at about 2.0 lakh hectares (Report of NCA 1976). In Kakinada Bay the tides are semidiurnal, the maximum spring tides being 1.8 m and lowest tides 0.18 m (Bhavanarayana, 1975). Hydrobiological and faunistic survey of Godavari estuarine systems carried out by the Zoology Department, Andhra University has brought out interesting data (Final Report, 1965). The chief commercial species of prawns of Godavari Estuary are *P. indicus*, *P. monodon*, *Metapenaeus monoceros*, *M. affinis*, *M. dobsoni* and *M. brevicornis*. Prawns occur practically throughout the year (Ganapati and Subramaniam, 1966).

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Traditional Culture

The traditional system of 'Brackishwater fish culture' consists of allowing the young fish and prawns entering these waters to grow for sometime to be fished thereafter. The seeds of fishes like *Chanos chanos*, mullets, *Megalops*, *Elops*, *Lates* as well as prawns are found extensively in the estuaries, backwaters and swamps of Andhra Coast (Chandraiah, 1972). Of these, the cultivable species like milk fish and mullets used to be collected from brackishwaters, transported and stocked in fresh water tanks for culture during 1940s to 1960s all along the coast. Tummalapenta and Oolempalem in Nellore District for mullets, Kalingapatnam in Srikakulam District, Gangavaram in Visakhapatnam District, Mulapet in East Godavari District etc., for *Chanos* were well known localities in this respect (Nagaraja Rao, 1977). The survey of brackish water areas, swamps and impounded waters by a team of workers including the author, along the coast revealed that the cultivable species of mullets, milkfish, *Lates*, *Megalops*, the tiger prawn and the Indian prawn which get stranded in the impoundments grow to good size. Specimens measuring upto 17.0 cm of Indian prawn and 23.0 cm tiger prawn are recorded, besides fishes of marketable size.

Scientific Approach in Recent Years

The Andhra Pradesh Fisheries Department has constructed an Estuarine Fish Farm at Kakinada in 1962 by converting a swampy mangrove area. This Farm has subsequently been developed by Central Institute of Fisheries Education as their Brackishwater Fish Culture Field Training Centre.

Systematic culture practices have been taken up at this Farm. Surveys for finding out fish and prawn seed resources have been conducted all along the Kakinada (Coramandel) Coast. It was established that considerable quantities of seed of cultivable varieties of prawns like *P. monodon*, *P. indicus*, *M. monoceros* and *M. dobsoni* as well as fry of *Chanos chanos*, mullets including *Mugil cephalus* and small quantities of *Scatophagus argus*, *Megalops cyprinoides*, *Eleutheronema tetradactylum* and *Elops saurus* are available. Their occurrence and seasonal abundance have been reported (Dwivedi and Reddi, 1976). The availability of the young ones at different collection grounds in lunar periods has also been reported (Reddi, 1977 b).

The experiments carried out at the farm in polyculture of *Chanos chanos*, *Mugil cephalus*, other mullets and prawns, particularly *P. monodon* and *P. indicus* have shown a record production of 2,220 kgs (1,960 kgs of fish and 260 kgs of prawn) per hectare per annum (Dwivedi and Reddi, 1976) (Table 2). Different species of fish and prawn have grown from fry size at the farm. *Chanos* grew to 37.5 cm (380 g), 54.5 cm (1.7 kg) and 71 cm (3.0 kg) at the end of 1st, 2nd and 3rd year respectively. The grey mullet *M. cephalus* grew to 37.6 cm (550 g) in the first year and to 57.8 cm (3.0 kg) in two years and nine months. The fish has attained sexual maturity at the end of second year. *Lates calcarifer* grew to 30.5 cm (500 g) in the first year and to 75 cm (6.1 kg) in three and half years. This fish attained sexual maturity during the third year. Of the exportable varieties of prawn seeds stocked in ponds at 2.0 to 3.0 cm size, *P. monodon* grew to 25.0 cm (150 g) in 8 months, while *P. indicus* grew to 22.0 cm (100 g) in one year (Dwivedi and Reddi, 1977). A few specimens of *P. monodon* in the ponds attained a size of 26.8 cm (200 g) in 10 months (Reddi, 1973, 1977).

Various problems encountered during the culture were eventually solved. The main-

tenance of water level in ponds was achieved by using sand filled polythene bags as bunds across the channels (Reddi and Choudhury, 1975). The entry of predators was prevented by placing basket traps at the entrance of feeder canals to the ponds. Crabs were netted out using a special bait (Reddi *et al.*, 1972, 1973, 1974). The fish and prawn seed from Kakinada were successfully transported by train and road to Bombay, Goa, Cochin and Madras and by air to Andamans.

The Andhra Pradesh Fisheries Corporation eventually plans to convert 50,000 ha of brackishwater area into fish farms in the State (Sanjeeva Rao, 1978). Brackishwater Farming has already been taken up in Visakhapatnam and Kakinada with the assistance under Small Farmers Development Agency. A few private individuals in Krishna District, West Godavari and Nellore District have also constructed some ponds in private lands where culture of fish and prawn has already been initiated.

Prawn and Fish Culture in Salt Pans

It is estimated that there are 10,000 ha of salt pans (8,000 ha licensed and 2,000 ha unlicenced areas) lying all along the Andhra Coast from Poondi and Naupada in the North to Tada in the South. The first stage reservoirs could be utilised for fish and prawn culture for a major part of the year without detriment to salt production by making suitable adjustments. Most of the salt pan reservoirs could be utilised in the lean season when salt is not manufactured.

It is a common experience that considerable fish and prawn are being harvested from the first stage reservoirs of the salt pans, where the salinity does not generally increase beyond 35‰. Some of the well managed reservoirs of salt works are being sold in auction for fish and prawn for considerable amounts. The culture of brackishwater fish and prawn taken up in Sri Krishna Salt Works in Visakhapatnam during 1977-78 has shown the technical feasibility and economic viability. During the 4 months culture period from December 1977 to March 1978 the fry stocked have grown to 15.0-20.0 cm, 17.0-18.0 cm, 25.0 cm, 20.0 cm and 28.0 cm in the case of *P. monodon*, *P. indicus*, *C. chanos*, *M. cephalus* and *Lates* respectively. The District Administration has granted assistance to fishermen and other weaker sections for taking up brackishwater farming in salt pan areas besides converting new grounds into fish ponds.

The successful prawn and fish farming in salt pans at Patharlagadda by utilising underground saline water (Rao and Raghavulu, 1979) opens a new avenue particularly to small and marginal farmers in brackishwater farming.

Cropping Pattern and Plan of Harvest

It is proposed to have two to three crops for prawns and one or two for fish in a year. Prawn seeds are available almost round the year, and those of the cultivable varieties of fishes in two seasons. As the Andhra Coast was hit by severe cyclones in 1977 and 1979, the months of May and November are now considered as cyclone prone months. In view of this, the ponds could be harvested just before these months, so that there is no loss or only minimum loss of the harvest.

Conclusion

Brackishwater farming has been accepted as a paying profession and viable industry in Andhra Pradesh. With the acceptance of the concept of rural development in India as a means for generating employment potential, for producing food and for earning foreign exchange, brackishwater farming is taken up seriously in Andhra Pradesh alongwith the other regions of the country.

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FINFISH SEED RESOURCES OF VELLAR ESTUARY

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ABSTRACT

The estuaries, backwaters and mangroves act as nursery grounds for a variety of finfish and shellfish and hence they are the ideal grounds for the collection of fish seeds for aquacultural practices. A study was conducted for a period of one year from June 1976 to May 1977 from two stations on the seasonal abundance, distribution pattern and potentiality of the cultivable finfish seed resources of Vellar Estuary (Lat. 11°29′ N ; Long 79°46′ E). The observations revealed that this natural nursery is one of the richest grounds for the fry and fingerlings of the principal cultivable fishes *viz.* mullets *Mugil cephalus*, *Liza dussumieri* and *L. macrolepis* and milkfish *Chanos chanos*. Juveniles of mullets occurred throughout the year in large quantities. Fry of *C. chanos* was abundant during the month of May, but its occurrence was notable from March to June and September to November. Seeds of pearl-spot *Etroplus suratensis* were available in appreciable number from October to January. During northeast monsoon and the post-monsoon months meagre numbers of juveniles of giant-perch *Lates calcarifer* were noticed. Stray incidence of fry of ten-pounder *Elops saurus* was recorded only during the months of September and October. A brief account on the juveniles of leiognathids, clupeoids, carangids and sciaenids has also been incorporated.

INTRODUCTION

IN INDIA the harvest of fishes can be further enhanced to a greater extent by culture practices of suitable cultivable species of finfish and shellfish. One of the pre-requisites to augment the fish production through the unutilised or underutilised areas of about 2 million ha stated to be suitable along the Indian Coast (Jhingran and Natarajan, 1973) is the availability of fish seed in required quantities. Along the east coast of India a number of perennial rivers empty their run-off and give rise to a number of estuaries, backwaters, mangroves, coastal swamps, lagoons, deltaic marshes and tidal flats and inlets which act as nursery grounds for a variety of young ones of finfish and shellfish *per se* the ideal seed collection grounds. A thorough knowledge on the availability of fish seed in an estuarine ecosystem is essential as it is directly related to the successful implementation of fish farming practices of both brackish and marine waters. The present investigation was therefore undertaken to obtain information on the finfish seed resources of Vellar Estuary (Lat. 11°29′ N ; long. 79°46′ E), Porto Novo (Fig. 1).

We are thankful to Dr. R. Natarajan, Director, C.A.S. in Marine Biology, Porto Novo for suggestion and encouragement, to Dr. K. Ayyakkannu for his help in obtaining material and to the U.G.C., New Delhi for the financial support.

HYDROBIOLOGICAL CONDITIONS OF THE VELLAR ESTUARY

Vellar Estuary is formed by the river Vellar before joining with the Bay of Bengal at Porto Novo along the Coramandel Coast. The river mouth is open, having connection with the sea

throughout the year. The area of the estuary has been calculated as 262 ha (Venkatesan, 1969). The tides are semidiurnal type with an amplitude of 1-1.5 m. The width of the estuary is about 200 m and the mean depth is about 2.5 m. Based on vertical gradient of salinity, Vellar Estuary is demarcated into marine, gradient, tidal and freshwater zones (Ramamoorthi, 1954). The estuarine sediment is muddy mixed with sand and shell fragments and is rich in organic matter harbouring dense population of bacteria and other organisms such as polychaetes, copepods and nematodes.

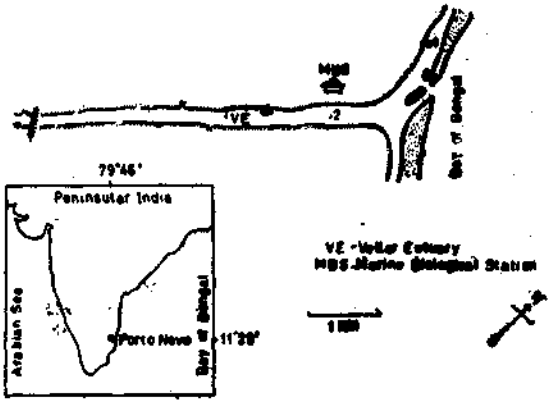

Fig. 1. Map of the Vellar Estuary showing the location of the stations.

Salinity plays a major role in the distribution of floral and faunal elements of this estuary (Chandran *et al.*, 1978). The average monthly salinity of the surface water from June 1976-May 1977 during high and low tides have been provided in Fig. 2. The value of primary production (440 mg C/m³/hr) and biomass of heterotrophic bacterial population (470×10^4 cells/ml), phytoplankton (182.3×10^7 cells/m³) and zooplankton (8.6×10^6 organisms/m³) estimated by Thangaraj *et al.* (1978) show that the Vellar Estuary is highly fertile.

Species of seaweeds *Chaetomorpha* sp., *Enteromorpha clathrata*, *E. compressa*, *Gracilaria* sp., *Halophila ovata*, *Pedina* sp. and *Acanthophora spicifera* are common in Vellar Estuary.

Rich fishery of finfishes, prawns, crabs and edible molluscs is prevalent throughout the year. The dominant finfish groups are teiognathids, clupeoids, mullets, carangids, flatfishes, catfishes, glass perchlets, sciaenids, milkfish, eels, giantperch and grunters.

Material and Methods

Weekly collections were made from two stations selected in the marine zone (station 1) and gradient zone (station 2) of Vellar Estuary (Fig. 1) for a period of 1 year from June 1976 to

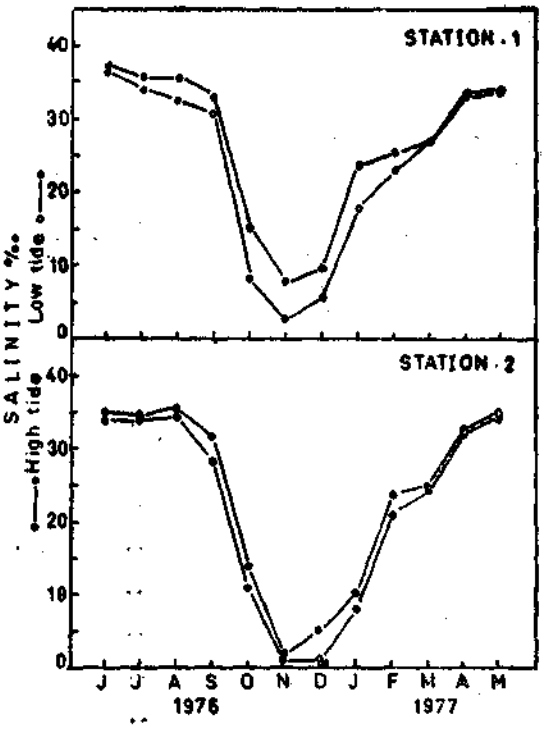

Fig. 2. Average monthly salinity during June 1976 - May 1977.

May 1977 by using a shore seine of the mesh size 4 mm covering an area of 25.7 m²/haul. Four hauls, two in high tide and two in low tide were made. The total number of hauls

during high tides and low tides in a month, was treated separately and the average number of seeds per haul was computed for comparison. Fry and fingerlings belonging to the primary cultivable species of fishes such as mullets *Mugil cephalus*, *Liza dussumieri* and *L. macrolepis*, milkfish *Chanos chanos*, pearl-spot *Etroplus suratensis*, giantperch *Lates calcarifer* and ten-pounder *Elops saurus* were sorted out for their numerical abundance. The number of juveniles of other commercially important fish groups such as leiognathids clupeoids, carangids and sciaenids occurred along with the cultivable groups of fishes were also considered for estimating the annual seed production of this estuary. The terms fry, fingerlings and juveniles are used as cited by Jhingran (1975).

Seed Resources

Table 1 shows the average monthly abundance of finfish seeds in Vellar Estuary. Number of seeds per haul was more throughout the year during high tide collections from both the stations (station 1 and 2). January recorded maximum availability of seeds (327/haul) of finfish in station 1 and (222/haul) in station 2 during the high tide. During low tide also the maximum value was observed during January. The minimum number of seeds was obtained in the month of August during low tide and high tide from both the stations studied. Rest of the months recorded notable fluctuations in abundance.

Mullets

Mullets contribute a good fishery throughout the year in Vellar Estuary. Reddy (1977) has recorded 15 species of mullets from Porto Novo waters representing 7 genera namely *Mugil*, *Osteomugil*, *Valamugil*, *Rhinomugil*, *Rajamugil*, *Liza* and *Ellochelon*. The major contribution is by the species *M. cephalus*, *L. dussumieri* and *L. macrolepis*. Fry (20-40 mm) and fingerlings (50-80 mm) of mullets could be collected in most part of the year but the abundance varies during different months (Fig. 3).

Table 1. *Average number of finfish seeds/haul in the Vellar Estuary during* 1976-1977

Month & Year	Station 1		Station 2	
	High Tide	Low Tide	High Tide	Low Tide
June 1976 ..	127	64	94	33
July ..	122	54	73	33
August ..	75	52	71	28
September ..	182	93	99	41
October ..	152	92	115	50
November ..	152	85	86	41
December ..	No Collection			
January 1977 ..	327	165	222	81
February ..	246	133	180	70
March ..	136	77	126	75
April ..	145	100	90	55
May ..	160	69	123	51

Station 1 recorded higher number of seed all the time than station 2 and the highest number (76/haul) was collected in the month of January. The lowest value (4/haul) was from station 1 during November and from station 2, during October. The availability

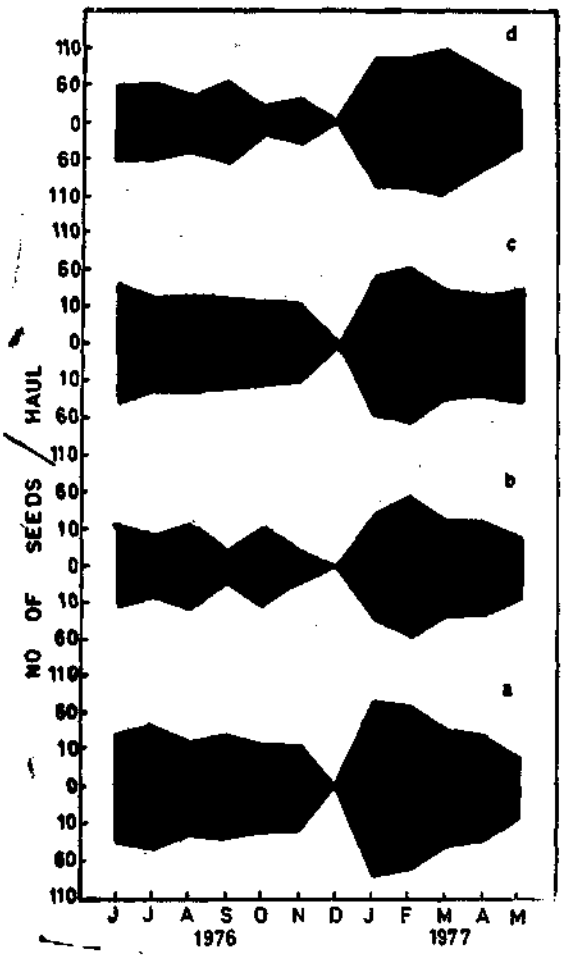

Fig. 3. Period of occurrence and abundance of mullet seeds in the Vellar Estuary.

(*a*) Station 1 high tide. (*b*) Station 1 low tide.
(*c*) Station 2 high tide. (*d*) Station 2 low tide.

of mullet seed was high during January and February at station 2. Throughout the period of investigation high tide collections showed maximum availability than the collections during low tide. The best time for the collection of mullet seed is during the high tide when the sea water incurses into the estuary.

Milkfish

The period of occurrence of *Chanos* fry and fingerlings in Vellar Estuary starts during March and terminates at June (first season) and from September to November (second season). The numerical abundance was high (36/haul) during the high tide from station 1 in the month of May.

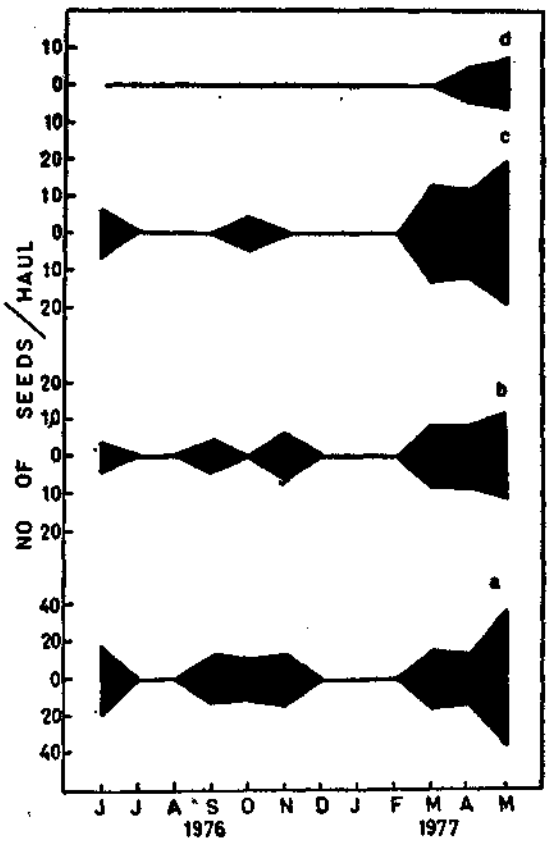

Fig. 4. Period of occurrence and abundance of milkfish seeds in the Vellar Estuary.

(*a*) Station 1 high tide. (*b*) Station 1 low tide.
(*c*) Station 2 high tide. (*d*) Station 2 low tide.

Comparatively, station 1 had more number of milkfish seed. The seed was more abundant during the high tide than low tide period. At station 2, seed was not encountered during

low tide excepting the months of April and May (Fig. 4).

Pearlspot

Etroplus suratensis occurring in brackish water can be easily acclimatized to freshwater (Tampi, 1974). The occurrence of fry (15-40 mm) and fingerlings (45-80 mm) was recorded from October to February in Vellar Estuary. In station 1, this species was totally absent during February but occurred in less numbers in station 2 only during high tides. There was not much difference in numerical abundance of seed observed in various months and tides (Fig. 5).

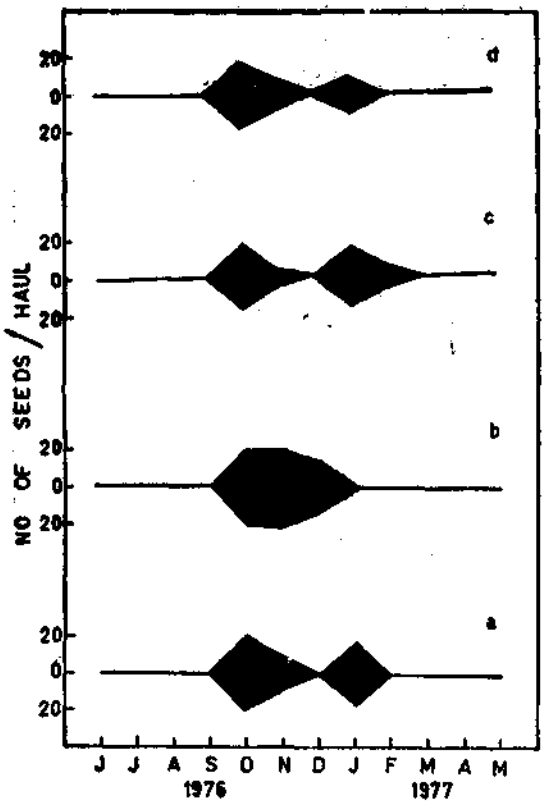

Fig. 5. Period of occurrence and abundance of pearl-spot seeds in the Vellar Estuary.

(*a*) Station 1 high tide. (*b*) Station 1 low tide.
(*c*) Station 2 high tide. (*d*) Station 2 low tide.

Giant perch

The giant-perch *Lates calcarifer* forms a minor fishery of this estuary. The occurrence of fingerlings was moderately high in number during November and low during the months of October, January and February. Collections made in the rest of the period lacked this species (Fig. 6).

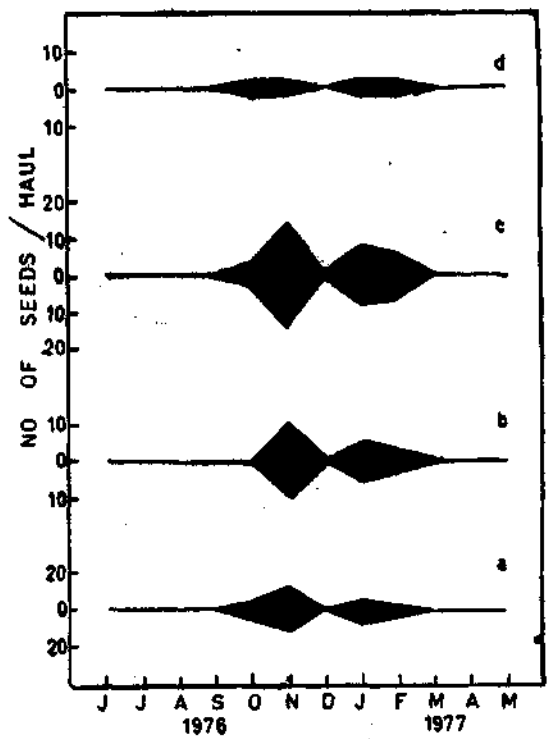

Fig. 6. Period of occurrence and abundance of giant-perch seeds in the Vellar Estuary.

(*a*) Station 1 high tide.
(*b*) Station 1 low tide.
(*c*) Station 2 high tide.
(*d*) Station 2 low tide.

Ten-pounder

Fry of *Elops saurus* (20-25 mm) occurred only during the months of September and October in meagre numbers. In most part of the period of study, fry and fingerlings were not encountered (Fig. 7).

TABLE 2. *Seasonal abundance of juveniles of miscellaneous groups of fishes in the Vellar Estuary during* 1976-77 (*average numbers/haul*)

Station 1	Leiognathids		Clupeoids		Carangids		Sciaenids	
	High Tide	Low Tide	High Tide	Low Tide	High Tide	Low Tide	High Tide	Low Tide
June 1976 ..	41	28	30	16	5	—	3	2
July ..	38	31	28	8	16	7	—	—
August ..	29	21	18	11	4	3	2	1
September ..	98	68	23	10	9	4	4	3
October ..	48	39	25	17	13	8	3	3
November ..	55	23	34	25	9	3	5	4
December ..	No Collection							
January 1977 ..	138	89	65	22	24	12	2	
February ..	86	81	69	39	19	6	—	—
March ..	42	29	39	18	3	—	1	—
April ..	57	34	41	29	8	7	2	1
May ..	77	22	27	19	12	8	—	1

TABLE 3. *Seasonal abundance of juveniles of miscellaneous groups of fishes in the Vellar Estuary during* 1976-1977 (*average numbers/haul*)

Station 2	Leiognathids		Clupeoids		Carangids		Sciaenids	
	High Tide	Low Tide	High Tide	Low Tide	High Tide	Low Tide	High Tide	Low Tide
June 1976 .	28	1[illegible]	22	10	—	—	—	—
July ..	29	1[illegible]	16	5	6	2	—	—
August ..	14	8	28	12	4	—	1	—
September ..	48	2[illegible]	16	6	3	1	3	1
October ..	39	14	13	5	8	5	4	2
November ..	31	16	18	9	3	—	5	—
December ..	No Collection							
January 1977 ..	76	22	53	16	14	7	3	—
February ..	55	27	39	13	11	4	1	—
March ..	33	21	44	25	3	1	1	—
April ..	24	20	27	15	—	—	—	—
May ..	36	19	29	18	5	—	—	—

Miscellaneous groups

Juveniles of the commercially important fishes of the families Leiognathidae, Clupeidae, Engraulidae, Carangidae and Sciaenidae were found to occur in large quantities during the present investigation. Pre-monsoon, monsoon and post-monsoon months recorded higher number of young ones of these groups. The leiognathids are represented by 14 species in Porto Novo waters, but only a few species support the fishery in the estuary. They are *Leiognathus splendens*, *L. equulus*, *Leiognathus* sp., *Secutor insidiator* and *S. ruconius*.

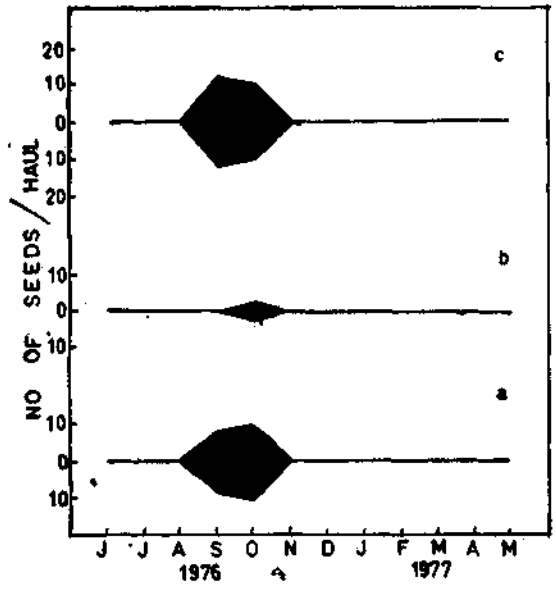

Fig. 7. Period of occurrence and abundance of ten-pounder seeds in the Vellar Estuary.

(*a*) Station 1 high tide.
(*b*) Station 1 low tide.
(*c*) Station 2 high tide.

Juveniles of *L. splendens* are abundant throughout the year. Other fish seeds like *Caranx* spp., *Carangoides malabaricus*, *Nibea soldado* and *Daysciaena albida* also encounter in appreciable numbers. The commonest clupeoids are *Stolephorus* spp., *Hilsa ilisha*, *Raconda russeliana*, *Coilia dussumieri*, *Thryssa* spp. and *Sardinella* spp. (Table 2 and 3).

RELATIVE ABUNDANCE OF FINFISH SEEDS

The annual percentage composition of fish seeds belonging to different groups available from both the stations during high tide and low tide is given in Table 4. From the data available it is evident that station 1 supports more number of cultivable finfish seeds, particularly mullets. The abundance of mullet fry and fingerlings in station 1 may be due to the higher organic matter derived from the trash fish and prawn peelings dumped in the nearby places from the commercial trawlers and prawn peeling centres. The reason for the occurrence of more number of *Chanos* fry in station 1 may be due to the presence of rich algal flora which supplement the fry in feeding. The distribution pattern of young ones of *E. suratensis*, *L. calcarifer* and *E. saurus* is almost similar in both the stations. Fry and fingerlings of all cultivable species were more during high tides than low tides. Juveniles of leiognathids ranked first in both the stations all the times. Clupeoids occupied second position in station 1 but in station 2 mullets out numbered them. Carangids closely followed by milkfish were in fourth and fifth places respectively in station 1. But in station 2 during low tides pearl-spot represented

TABLE 4. *Percentage composition of finfish seeds in the Vellar Estuary during* 1976-1977

Fish group	Station 1		Station 2	
	High Tide	Low Tide	High Tide	Low Tide
Leiognathids ..	38.54	42.17	32.29	35.30
Clupeoids ..	21.87	21.75	23.85	24.03
Mullets ..	20.50	19.72	25.95	26.88
Carangids ..	6.69	5.89	4.46	3.58
Milk fish ..	6.47	4.17	4.22	1.79
Pearl spot ..	2.41	2.74	3.44	6.45
Giant perch ..	1.32	1.83	2.66	1.43
Sciaenids ..	1.21	1.53	1.41	0.54
Ten pounder ..	0.99	0.20	1.72	..

with more number of seeds than carangids and milkfish. The contribution towards the total production of seeds was meagre by giant-perch, sciaenids and ten-pounder.

Scope for Finfish Farming in Porto Novo Region

Vellar Estuary supports a rich potential of seeds of cultivable fishes. But there is no well organised commercial harvest of seeds for cultural practices. The full utilization of available natural seed resources for farming in confined areas will benefit not only the entrepreneurs economically but also the consumer nutritionally. The practice of seed collection may also provide job for a number of people of this area. There are good infrastructural facilities to transport the seeds immediately to farming sites without any delay for stocking. Since Porto Novo region consists of fertile backwater and luxuriant mangrover forests the culture practices can be successfully implemented in the adjoining low lying area also. The cost of labour is also cheaper and the seed potential is highly sufficient to start with the farming of finfishes in this region.

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OBSERVATIONS ON THE SEASONAL ABUNDANCE OF LARVAE AND JUVENILES OF SOME PERCOID FISHES ENTERING INTO LAKE PULICAT

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ABSTRACT

Based on shooting net collections made at the mouth of Pulicat Lake over a period of three years, the seasonal abundance of larvae and juveniles of some percoid fishes *viz. Stllago sihama, Gerres* spp., *Therapon jarbua, Ambassis gymnocephalus, Lutianus* sp., *Lelognathus* sp. and *Siganus javus* has been studied. Of the large variety of fish larvae that get recruited into the lake, percoid fishes form 30 to 50%. Their entry into the lake was generally more during the first half of the year, peaks being in January and May. The effect of tide, diurnal changes and lunar variation on their recruitment has been discussed. Influence of temperature and salinity on their abundance also has been studied. Importance of recruitment studies in predicting the commercial catches and augmenting the seed supply for culture ventures is emphasised.

INTRODUCTION

WITH the increasing interest in brackishwater fish culture, a quantitative assessment of the stocking material in an area and knowledge on their availability in relation to space, time, tide and lunar phases are essential. Keeping this in view, investigations have been done on the availability and abundance, acclimation and transport of fish and prawn seed from Pulicat Lake. Detailed description of the morphometry of the Lake Pulicat, fish and fisheries and ecological characteristics have been discussed by many workers (Chacko *et al.*, 1953 ; Narasimha Rao, 1971 ; Krishnamurthy and Rao, 1970 ; Raman *et al.*, 1975).

Subrahmanyam and Rao (1968) and Prabhakara Rao (1970, 1971) have studied the seasonal abundance of prawn and fish larvae in the Pulicat Lake. Gopinathan *et al.* (1974) and Kaliyamurthy *et al.* (MS) have examined the availability of prawn and fish larvae in the lake in relation to environmental characteristics ; while Rao and Kaliyamurthy (1974) discussed the abundance and distribution of juveniles of beloniform fishes in the lake.

Ramamohana Rao *et al.* (MS) gave a detailed account on the ingress of larvae of some clupeid fishes into Lake Pulicat. The present paper deals with the seasonal ingress of larvae of some percoid fishes in relation to time, tide and lunar phases.

The authors are highly indebted to Dr. V. G. Jhingran, former Director for the keen interest evinced in the study and to Dr. A. V. Natarajan, Director, Central Inland Fisheries Research Institute for the kind encouragement. They are grateful to Shri B. B. Pakrasi for critically going through the manuscript and suggesting improvements.

MATERIAL AND METHODS

Collections were made both at low and high tides of day and night on all spring tides (full moon and new moon days) by operating a Midnapore type shooting net (Jhingran, 1965) at

the lake mouth. The collections were made uniformly for one hour on all occasions and the larvae collected were segregated and identified upto species wherever possible and expressed as number/hour/net. As a result of construction of dams over the rivers which are sources of freshwater influx into the lake and due to failure of monsoon, the lake mouth remained closed for periods varying from 3 to 6 months from 1972 to 1974. Hence the collections could be made only during the periods when the lake mouth was open and the data presented pertain only to such periods. The abundance of perch larvae in relation to tide, diurnal variations and lunar phases were discussed from the data collected during 1972, whereas for the purpose of describing the seasonal abundance data collected during all the three years were used.

In the present communication 7 important percoid fishes that were recorded from the lake are taken for study.

OBSERVATIONS

A. *Seasonal abundance*

The seasonal abundance of larvae of all the seven percoid fishes in the lake during the years 1972 to '74 is depicted in Fig. 1.

Ambassis gymnocephalus

The tiny post-larvae of *Ambassis gymnocephalus* (usually 5 to 8 mm size) were always seen in good quantities in the shooting net collections throughout the period of investigation. This species was more abundant in the collections of 1972 than in '73 and '74. April to June was found to be the best period when the post-larvae of this species were observed in large quantities.

Therapon jarbua

Post-larvae of *Therapon jarbua* also were available throughout the period, peak being in April-June.

Sillago sihama

Post-larvae and juveniles of *Sillago sihama* were available throughout in the collections of 1972 and 1974 whereas they were recorded only during January-March and May in the year 1973. But, considering the total number collected, the year 1973 was found to rank first. They were generally seen in good quantities during March-April except in the year 1973 when the peak was in January.

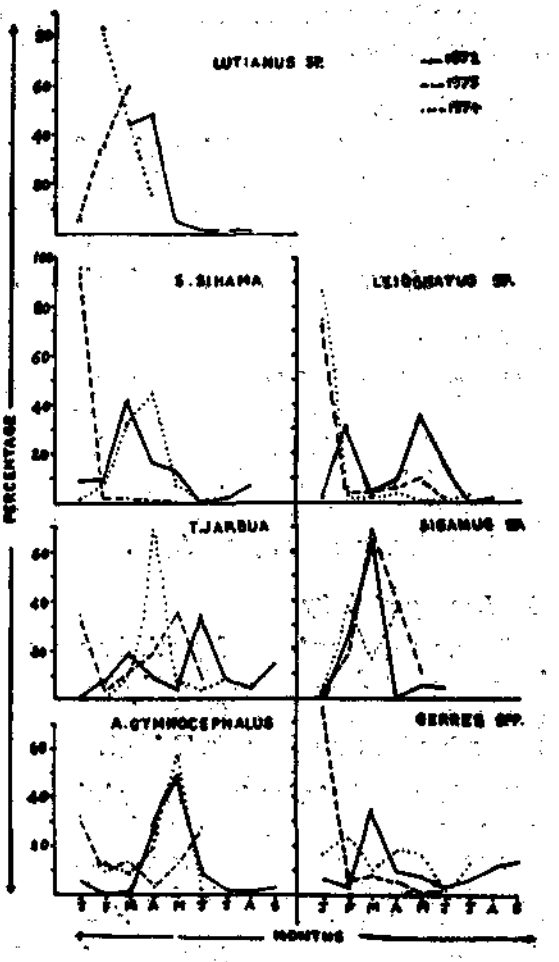

Fig. 1. Seasonal abundance of perch larvae (percentage) during the years 1972-'74.

Gerres spp.

Recruitment of this species was very good throughout the period in all the years maxi-

mum being in the year 1972. They were generally seen in large numbers during January (1973), February (1974) and March (1972).

Siganus sp.

Recruitment of this species was continuous upto June in the year 1972. During the later two years it was present only for a few months (January to March and May in 1973 and January to April and July in 1974). Peak occurrence was however in March (1972 and 1973) and April (1974).

Leiognathus sp.

The small post-larvae and juveniles of silverbellies were always recorded in the collections throughout the period of investigation. Two peaks of occurrence were noticed one during January-February and the other in April-May.

Lutianus sp.

The post-larvae of *Lutianus* sp. were poorly represented in the collections. They were recorded during March to June and August in 1972, peak being in March. In the remaining two years they were present only in a few numbers during January to April.

B. *Lunar periodicity*

The average numbers of perch larvae collected during full moon and new moon days (irrespective of tides) from January to September 1972 are shown in Table 1.

Post-larvae of *Ambassis gymnocephalus* were generally present in more numbers during new moon days except in the collections of January, March and May, while those of *Therapon jarbua* were more in numbers in full moon collections during July-September, the overall maxima being on new moon days. *Sillago sihama* did not show any clear variation in relation to lunar periodicity, the number of larvae collected being more or less uniform on full moon and new moon days the latter however showing an edge over the former. As far as *Gerres* spp. is concerned out of the 9 months of collections, full moon collections dominated in 4 months, while those of new moon recorded numerical superiority during the remaining period and in the total numbers collected. The post-larvae of *Siganus* sp. were totally absent in the full moon collections and those of *Leiognathus* sp. were more numerically in new moon collections except in March, April and September. *Lutianus* sp. though very few in numbers were always more in the new moon collections. When the total number of larvae collected during full moon and new moon are taken into account, the new moon collections showed numerical superiority over full moon collections in all the cases.

C. *Tidal periodicity*

The average numbers of perch larvae collected during low tide and high tide during the period January-September '72 were separately compiled (Table 2) with a view to studying the variations in respect of tide. From the table it could be seen that except in one instance (*Ambassis gymnocephalus* in April) the collections of all the species were numerically more during high tide.

D. *Diurnal variations*

The collections made on all spring tides were segregated as day and night collections with a view to identifying the best time for collections in respect to dial changes. The average numbers of larvae collected during day and night from Jan. to Sept. '72 are shown in Table 3.

Post-larvae of *A. gymnocephalus*, *T. jarbua*, *S. sihama* and *Gerres* spp were more in the day collections while *Siganus* sp., *Leiognathus* sp. and *Lutianus* sp., were more in night collections. When the total number of all the groups together is considered the collections made during day showed numerical superiority over night collections.

TABLE 1. *Average numbers of perch larvae collected during full moon and new moon from January to September 1972*

Month	*A. gymnocephalus*		*T. jarbua*		*S. sihama*		*Gerres* spp.		*Siganus* sp.		*Leiognathus* sp.		*Lutianus* sp.	
	F.M.	N.M.	F.M.	N.M.	F.M.	N.M.	F.M.	N.M.	F.M.	N.M.	F.M.	N.M.	F.M.	N.M.
January	84.0	42.0	0.3	0.5	2.0	2.0	25.0	7.0	—	0.3	0.3	5.0	—	—
February	1.0	1.3	2.3	12.3	0.3	4.3	9.0	11.3	—	18.3	0.3	110.3	—	—
March	23.4	10.0	1.3	38.0	10.7	9.0	21.0	151.0	—	47.3	16.3	0.7	7.0	10.3
April	28.0	605.2	—	17.8	2.5	5.0	0.8	49.5	—	0.2	17.3	13.5	—	18.8
May	596.3	536.0	1.3	7.0	4.3	2.0	25.8	15.5	—	3.8	4.3	123.5	0.5	1.5
June	1.0	300.8	—	70.5	—	0.5	0.3	18.0	—	3.8	0.5	54.5	—	0.5
July	12.3	54.8	16.8	1.8	0.3	1.0	28.0	2.3	—	—	—	3.0	—	—
August	18.8	21.3	5.8	4.0	0.5	2.5	24.5	35.5	—	—	0.3	6.3	—	0.3
September	39.0	40.5	28.0	2.5	—	—	41.0	29.0	—	—	6.0	—	—	—

E. *Abundance in relation to salinity and temperature*

The total number of perch larvae collected during different months in 1972 along with the corresponding salinity and surface water temperature values at lake-mouth are shown in Fig. 2.

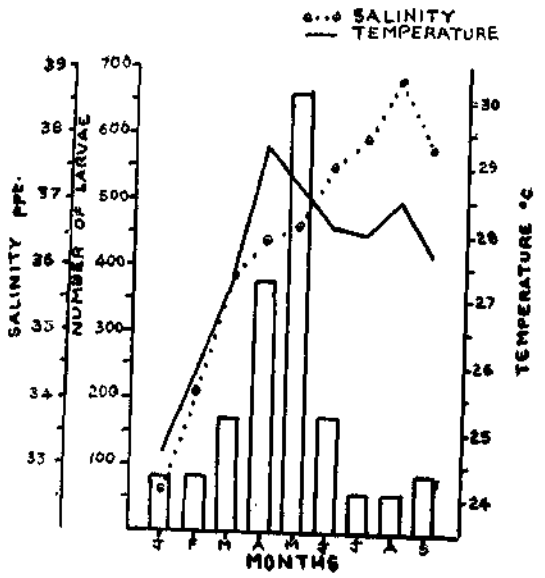

Fig. 2. Number of perch larvae collected during 1972 with correspondent salinity and surface water temperature values.

Larval abundance showed a major peak in May and a minor one in September. The salinity values showed a gradual increase from January to August and a slight fall during September and the water temperature values showed two peaks, one during April and the other in August. The peak occurrence of larvae coincided with high temperatures (29.3 and 28.7°C in April and May) and moderately high saline conditions (36.4 and 36.6‰ in April and May). During the period of high salinity (beyond 37.5‰) an inverse relationship between larval abundance and salinity could be seen.

F. *Larval abundance in relation to commercial fishery*

The total number of perch larvae collected during the years 1972-'74 and the commercial landings of perches for the years 1974-'76 are shown in Table 4. The larval abundance was at its maximum during '72 followed by '73 and '74. Considering the fact that the young ones may require about 2 years to enter the exploitable segment of fish populations, the larval index of a particular year was compared with the commercial landings of the third year. Thus the landings of 1974 were more than the later two years perhaps indicating that it may be possible to predict the catches based on larval collections. In the present study this correlation could be seen to a limited extent, but not strictly in a proportionate way.

Discussion

It has already been pointed out by the authors in an earlier communication (Ramamohana Rao *et al.*, MS) that due to the closure of Lake mouth for varying periods from 1972 to '74 the larval ingress was considerably affected. Recruitment during 1972 was comparatively better than the other two years.

Of the important groups that contribute to the lake's fishery, perches generally rank third or fourth accounting for nearly 7 to 10% of the total catches. When the total number of larvae collected was considered, perch larvae formed 33.9%, 51.4% and 63.0% in 1972, '73 and '74 respectively.

From Fig. 2 it is evident that excepting *Lutianus* sp. and *Siganus* sp., all the perches were continuously available in the collections with minor variations in the peaks. In general the collections of perches were better during March-June period.

From the study on lunar periodicity, it was observed that new moon collections showed numerical superiority over that of full moon collections. The authors in their earlier communication (Ramamohana Rao *et al.*, MS) have found that in case of clupeid larvae also the collections of new moon were better than

TABLE 2. *Average numbers of perch larvae collected during low tide and high tide from January to September* 1972

Month	*A. gymnocephalus*		*T. jarbua*		*S. sihama*		*Gerres* spp.		*Siganus* sp.		*Leiognathus* sp.		*Lutianus* sp.	
	L.T.	H.T.	L.T.	H.T.	L.T.	H.T.	L.T.	H.T.	L.T.	H.T.	L.T.	H.T.	L.T.	H.T.
January	26.0	100.0	—	0.8	1.0	3.0	2.0	30.0	—	0.3	0.5	4.8	—	—
February	0.3	2.0	—	14.3	—	4.6	0.3	20.0	0.3	18.0	—	110.6	—	—
March	4.7	28.7	1.0	38.3	6.0	13.7	19.7	152.3	0.7	46.6	3.3	13.7	3.0	14.3
April	564.8	68.5	0.3	17.5	0.3	7.3	0.8	49.5	—	0.2	1.3	29.3	—	18.8
May	2.8	1129.5	2.5	5.8	0.5	5.8	0.3	42.0	—	3.8	1.3	126.5	1.0	1.0
June	0.3	201.6	—	70.5	—	0.5	—	18.3	—	3.8	0.3	54.8	—	0.5
July	0.8	66.3	—	18.5	0.3	1.0	—	30.3	—	—	—	3.0	—	—
August	0.3	39.8	—	9.8	—	3.0	—	60.0	—	—	0.3	6.3	0.3	—
September	—	79.5	—	30.5	—	—	—	70.0	—	—	—	6.0	—	—

TABLE 3. *Average numbers of perch larvae collected during day (D) and night (N) from January to September* 1972

Month	*A. gymnocephalus*		*T. jarbua*		*S. sihama*		*Gerres* spp.		*Siganus* sp.		*Leiognathus* sp.		*Lutianus* sp.	
	D	N	D	N	D	N	D	N	D	N	D	N	D	N
January	90.0	36.0	—	0.8	1.0	3.0	8.0	24.0	—	0.3	3.5	1.8	—	—
February	1.0	1.6	5.0	9.7	0.6	4.0	3.0	17.3	1.7	15.6	25.6	85.0	—	—
March	11.4	22.0	2.7	36.7	11.0	8.7	60.0	112.0	0.3	47.0	6.3	10.7	0.5	16.8
April	38.8	594.3	18.0	17.5	5.3	2.3	45.8	4.5	—	0.2	13.5	17.3	0.5	18.3
May	1086.5	45.7	2.3	6.0	4.8	1.5	15.8	26.5	1.0	2.8	10.5	117.3	0.8	1.3
June	190.0	11.8	66.3	4.3	0.3	0.3	12.0	6.3	2.0	1.8	28.0	27.0	0.5	—
July	64.8	2.3	16.5	2.0	0.5	0.8	30.3	—	—	—	0.8	2.2	—	—
August	22.8	17.3	4.3	5.5	1.5	1.5	26.5	33.5	—	—	0.5	6.0	—	0.3
Septembe	71.6	8.0	5.0	25.5	—	—	49.5	20.5	—	—	6.0	—	—	—

full moon. Chacko and Mahadevan (1956) and Prabhakara Rao (1971) also have observed a similar trend in case of chanos post-larvae. When the tide and time are considered, it was found that the collections made during day time at high tide are generally better though in a few instances the night collections were slightly more (Table 3). This is in conformity with the observations made on clupeid larvae by Ramamohana Rao *et al.* (MS). When the tables on lunar variations and diurnal variations (Tables 1, 3) are examined together the behaviour of *Siganus* sp., *Leiognathus* sp. and *Lutianus* sp. stands out in contrast with the general trend of other genera. They were distinctly abundant during the dark periods *viz.* new moon and nights, indicating that they are shunning light. Balan (1963) has observed very good catches of *L. bindus* during foggy nights and also during dark phase of the moon when shoals reveal their presence by luminiscence in the surface and sub-surface waters. In the case of *L. jonesi* and *L. brevicornis*, Venkataraman and Badrudeen (1974) have noted that the proportion of the smaller ones was greater in night catches than in the day catches and vice versa in the case of larger ones. They have also inferred from the data that the silverbellies stay at the bottom during day time and a good proportion of them migrates to the surface and sub-surface waters at night. This again points to the probability of their avoiding light. It is also worth mentioning in this context that specimens of *Siganus oramin* when kept in aquaria try to hide near the corners avoiding light. Similarly it has been commonly observed that among the oyster trays set one above the other in boxes fixed in the lake, more numbers of perches such as *Lutianus* sp., *Siganus* sp., *Epinephelus* sp., *Scatophagus argus* etc. are found in the lower most trays which are obviously cut off from light. However, this has to be confirmed with further detailed studies on the behaviour of juveniles and adults of these genera.

The average number of larvae collected during different months along with the salinity and temperature values when plotted (Fig. 2) showed that the peak occurrence of larvae coincided with high temperatures (29.3 and 28.7°C) and moderately high salinity values (36.4 and 36.6 ‰) in April and May. When the salinity crossed 37.5‰, the larval ingress appeared to be poor, perhaps indicating an inverse relationship beyond this point. Prabhakara Rao (1971) also has observed inverse relationship between salinity and occurrence of chanos fry beyond a certain limit. While correlating the abundance of clupeid larvae with salinity Ramamohana Rao *et al.* (MS) have mentioned that 'when the salinity rises nearer to the upper limits of tolerance the larval abundance is not much in evidence'. These were in general agreement with the present observations. The observations that larval ingress was associated with high temperature also is in corroboration with the studies made by Prabhakara Rao (1971) on *Chanos* larvae and Ramamohana Rao *et al.* (MS) on clupeid larvae.

The possibility of predicting future catches based on larval index was mentioned by Subrahmanyam and Rao (1968), Prabhakara Rao (1971) and Ramamohana Rao *et al.* (MS). While Subrahmanyam and Rao (1968) and Rao (1970) have used the larval data of a given year to predict the catches of the subsequent year, the authors in their earlier communication on clupeid larvae (Ramamohana Rao *et al.*, MS) have mentioned that the larval index of a particular year reflects the trend of commercial catches only in the third year giving allowance of nearly 2 years for the young ones to enter the commercial fishery. This trend, as far as clupeid larvae were concerned was clearly seen, but in case of perches it was not so well pronounced. From Table 4 it can be seen that the total number of larvae were more in '72 than the other two years. Similarly the perch landings of '74 were more than the subsequent

TABLE 4. *Total Number of perch larvae collected during 1972-74 and commercial landings of perches during 1974-76*

Year	No. of larvae	Year	Landings (tonnes)
1972 ..	1767	1974	83.285
1973 ..	594	1975	67.337
1974 ..	871	1976	44.092

years. The low catches in '76 in spite of at slight increase in the larval index in '74 might be explained as due to the influence of several other factors than recruitment in the earlier years. For instance, the severe drought conditions prevailed in the region during 1975 have caused mass mortality of a large variety of fishes in the lake, thereby bringing down the landing figures of 1976 (Raman *et al.*, 1981).

From the experience of workers from various countries it is now well known that many of the perches are amenable to culture. It has also been found possible to transport the young ones without much mortality for stocking purposes. Hence the observations set forth in the present communication will be of immense use when culture practices are taken up on a large scale.

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OBSERVATIONS ON THE LARVAE AND JUVENILES OF *SILLAGO SIHAMA* FROM THE PULICAT LAKE

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ABSTRACT

A description of the larval and juvenile stages (8.2 to 69 mm) of *Sillago sihama* is given. The seed availability in the Pulicat Lake, their collection, acclimation and transportation are presented. Fry of *S. sihama* preferred live diets like microcrustacea, tubificid worms and larvae of mosquito and chironomids in the laboratory. Better growth and conversion were obtained when fed with tubificid worms in freshwater at lower stocking densities.

INTRODUCTION

SILLAGO SIHAMA is a commercially important food fish of the Pulicat Lake. It contributes to the extent of 34% to the perch production of the lake. Because of its good taste and restorative properties it commands higher price. In recent times this species has been considered for culture in freshwater and saltwater areas (Ramamurthy and Dhulkhed, 1975; James *et al.*, 1976; Kartha, 1978; Kaliyamurthy, 1979).

Knowledge of the diagnostic features of the seed of any cultivable species is essential for greater success in aquaculture. Information available on the eggs and larvae of *Sillago* is mainly due to the works of Gopinath (1946), Chacko (1950) and Uchida *et al.* (1958). In this paper some developmental stages of *S. sihama* is presented based on the material collected from the Pulicat Lake.

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MATERIAL AND METHODS

Larvae and juveniles were collected with a velon screen drag net and 0.5 m diameter organdi cloth tow net. This study is based on the specimens preserved in 5% formalin. Alizarine preparations were made to study the ossification of bones and for vertebral count. Various morphometric dimensions were measured using a calibrated ocular micrometer. Regressions of body proportions were computed for all variables and graphically represented.

OBSERVATIONS AND DISCUSSION

Description

A selected series of developmental stages are described and only salient diagnostic features are illustrated with the aid of a camera lucida.

8.2 *mm stage* (Fig. 1a) : This is the smallest size in the present collections. Body is elongated and laterally compressed. Depth of head is greater (1.3 mm) than that of the body (1.1 mm). Lower jaw is slightly longer and mouth is upturned. Minute teeth are present on both jaws. Head is 4.3 in total length and other

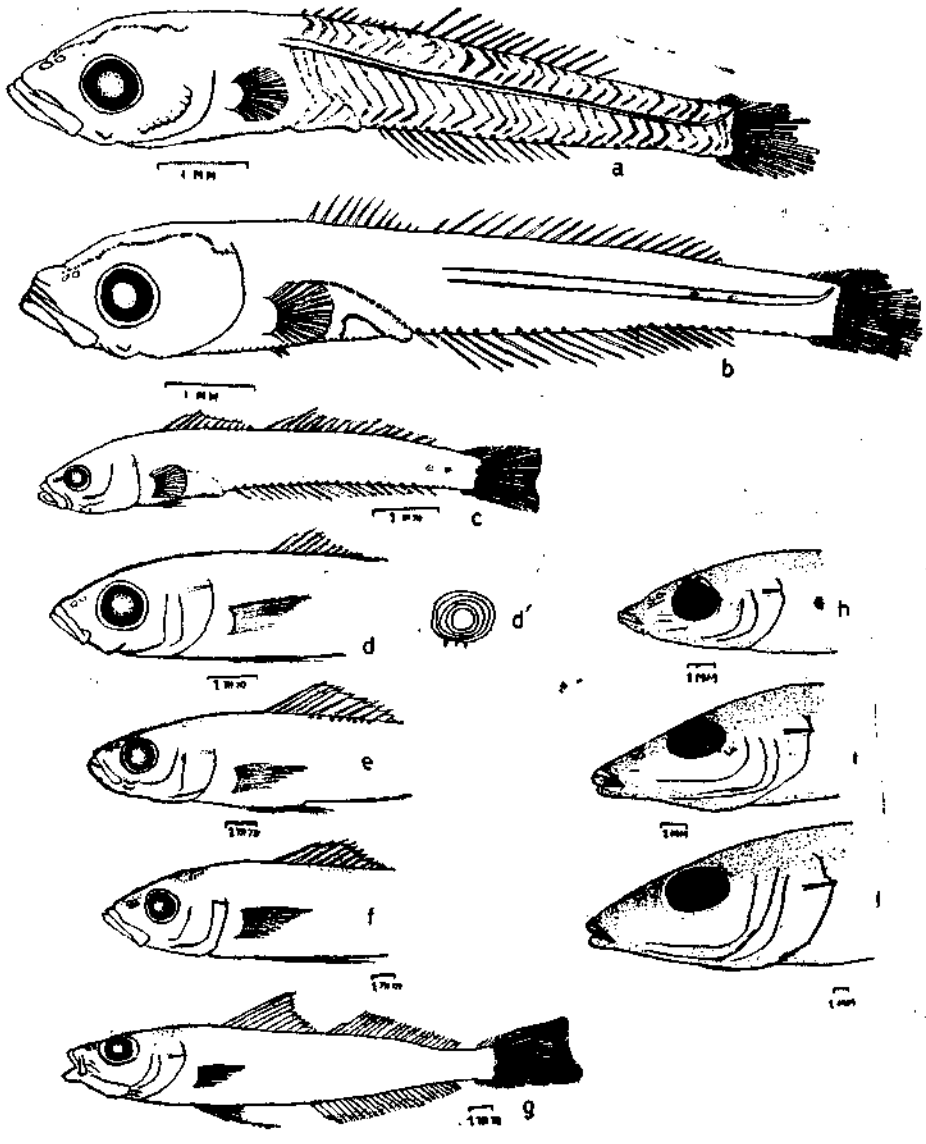

Fig. 1 a, b. Larvae of *Sillago sihama*, a- 8.2 mm ; b- 9.5 mm total lengths ; c-g. Young stages of *S. sihama* c- 13.3 mm ; d- 15.7 mm ; e- 18.0 mm ; f- 20.4 mm and g- 24.4 mm and h-j. Head region of juveniles of *S. sihama*. h- 35 mm ; i- 45.7 mm and j- 69 mm.

body proportions are given in Table 1. Pectorals are rounded. Spines on the dorsal fin are weak and about nine are discernible. In the second dorsal, one weak spine and thirteen rays are countable. Ventral fins are not visible. Anal fin is with thirteen rays and one spine. Caudal has about seventeen rays which are not clearly segmented or branched. About 20-22 postanal and 13-14 preanal myotomes are visible and are arranged in a zigzag pattern. A pigment spot is present at the base of each anal ray and this dotted line extends

beyond the rays to the end of caudal peduncle. A few chromatophores were seen at the base of caudal fin rays and on the sides of the caudal peduncle. A streak of chromatophores is seen at the midventral side of the body from pharynx to near anus.

9.5 *mm stage* (Fig. 1b) : First dorsal is with eleven spines, the last few are very small. Second dorsal has 18 rays and anal 20. As in the previous stage the pectorals are rounded. Ventrals make their appearance as small pointed buds. Minute teeth are noticed on both jaws. Caudal has 17 faintly segmented rays of which the middle ones are branched. The streak of chromatophores seen on the mid ventral side of the body becomes more or less a continuous line.

13.3 *mm stage* (Fig. 1c) : Ventral fins are developing. Pectorals are rounded and about 18 rays could be counted. First dorsal spine is shorter than the second. At the base of each anal ray one pigmented dot is seen and also a few at the ventral side of the caudal peduncle. Caudal fin has 17 rays. The characteristic opercular spine makes its appearance as a small notch at the posterior margin of the opercle. A pigmented line is seen at the ventral side of the body from near pharynx to anus. Head is 4.3 in total length (Table 1).

15.7 *mm stage* (Fig. 1d) : Ventral fin is well formed and the first ray is elongated reaching near anus. The opercular spine is clearly visible. Pectorals become pointed and longer. Lower jaw is slightly longer. Scales are visible on the body. Each scale is 0.3 mm in diameter with 4-5 circuli and three ctenii (Fig. 1 d). Height of the body becomes greater than head (Table 1).

18.0 *mm stage* (Fig. 1e) : All the spines of the first dorsal fin are lengthened. Pectorals are pointed. Caudal fin is well formed and lunate in shape with 17 segmented rays of which the middle 14 are branched. Some chromatophores appear on the snout and head. A few pigmented dots are seen at the base of the dorsal spines and rays. Seven gill-rakers are present on the lower arm, one in the angle and three on the upper arm. The gill-rakers are long and smooth.

20.4 *mm stage* (Fig. 1f) : General body shape is more like that of an adult. Snout is slightly pointed. More chromatophores appear on the head and snout. A few pigmented spots appear at the base of spines and rays of the dorsal and anal fins. Dorsal fins are pigmented. Gill rakers (7+1+3) are unarmed.

TABLE 1. *Body proportions of* Sillago sihama *at different sizes (number of times in total length)*

Character	Text Fig. Numbers									
	1a	1b	1c	1d	1e	1f	1g	1h	1i	1j
Total length (mm) ..	8.2	9.5	13.3	15.7	18.0	20.4	24.4	35.0	45.7	69.0
Body length ..	1.12	1.13	1.33	1.18	1.16	1.15	1.15	1.18	1.18	1.06
Head length ..	4.3	4.5	4.4	4.3	4.4	4.5	4.2	4.4	3.9	4.0
Head height ..	6.3	6.8	..	7.1	7.0	7.2	6.6	7.9	8.5	8.6
Body height ..	7.4	7.3	6.2	7.5	6.5	6.1	6.5	8.2	7.9	6.9
Snout length ..	13.4	16.0	16.2	17.1	15.7	..	15.7	12.6	10.3	9.8
Eye diameter ..	13.6	15.0	14.9	14.8	14.1	14.3	13.7	16.4	14.6	13.8
Caudal peduncle ..	13.6	16.0	13.9	14.8	14.8	14.3	14.4	16.9	18.4	17.3

24.4 *mm stage* (Fig. 1g) : Body is slightly rounded and all the fins are with full compliments of spines and rays. Fin membranes of dorsals and anal are dotted with pigmented spots. Tip of the caudal fin is darker. More chromatophores appear on the head and snout. Gill rakers are well developed and spines appear on them.

35 *mm stage* (Fig. 1h) : More pigmentation is observed on the upper half of the body. The outer edges of the scales are darker. Lateral line is clearly visible. Below the lateral line about seven groups of pigmented blotches are seen in a row. Snout becomes more pointed and longer. Eye becomes slightly oblong and body more deep near the origin of the first dorsal (Table 1).

45.7 *mm stage* (Fig. 1i) : Above the lateral line body becomes more dark and lower side pale creamy in colour. A silvery band appears along the sides of the body. Snout becomes further pointed and longer. Mouth projects downward. Eye is oblong. At this stage it resembles an adult in general appearance. Length of head is 3.9 in total length (Table 1). Caudal peduncle becomes more slender.

69 *mm stage* (Fig. 1j) : Head length is 4.0, its height 8.6 and body height 6.9 in total length (Table 1). Head and body assume adult form. Body becomes more deeper and rounded near the origin of first dorsal. All the fins get the adult colouration. Upper jaw is slightly longer than the lower.

Changes in the body form : Four selected parameters namely eye diameter (A), body height (B), snout length (C) and head length (D) were taken into account to study the changes in the morphometric features. All these characters showed linear relationship with total length of the fish. For each mm increase in total length eye diameter showed an increase of 0.096 mm, body height 0.124 mm, snout length 0.11 mm and head length 0.263 mm (Fig. 2). The corresponding equations for these relationships are given below.

$$A \ldots\ldots\ y = -0.463 + 0.096\,x$$
$$B \ldots\ldots\ y = -0.682 + 0.124\,x$$
$$C \ldots\ldots\ y = -0.764 + 0.110\,x$$
$$D \ldots\ldots\ y = -0.604 + 0.263\,x$$

Within the size range studied, the head length was greater in higher length groups than in lower groups (Table 1). Eye becomes slightly oblong as the fry grew in size. In bigger fishes Day (1878) had reported that eye diameter becomes smaller as the length of the fish increases.

Feeding habits

Young ones in the size range of 13-37 mm were found to have fed exclusively on planktonic organisms like copepods and occasionally on tintinnids. Earlier observations on the food of fry of this fish (below 40 mm) in the Pulicat Lake (Krishnamurthy, 1969) also showed that they preferred mainly copepods and occasionally mysids, prawn larvae and other crustaceans. At this stage the mouth is upturned and the lower jaw is longer (Fig. 3 a-c). From 45 mm stage onwards (Fig. 3 d-f) the snout becomes pointed and long as mentioned earlier. The upper jaw becomes longer and the mouth opens downward. At this size range they switch over to benthic feeding habit. Fingerlings (41-100 mm) have been reported to feed chiefly on polychaetes, though copepods, mysids and other planktonic organisms were also consumed in negligible quantities (Krishnamurthy, 1969). In the laboratory the fingerlings showed preference to tubificid worms over other live diets like microcrustacea, larvae of mosquito and chironomids and earth worms.

Seed resources

Fry and fingerlings of this species are available in good quantities in the Pulicat Lake almost throughout the year with a peak in January to April period (Rao *et al.*, MS). This may be due to its prolonged breeding habit (Krishnamurthy and Kaliyamurthy, MS). In the Chilka Lake also it has an extended

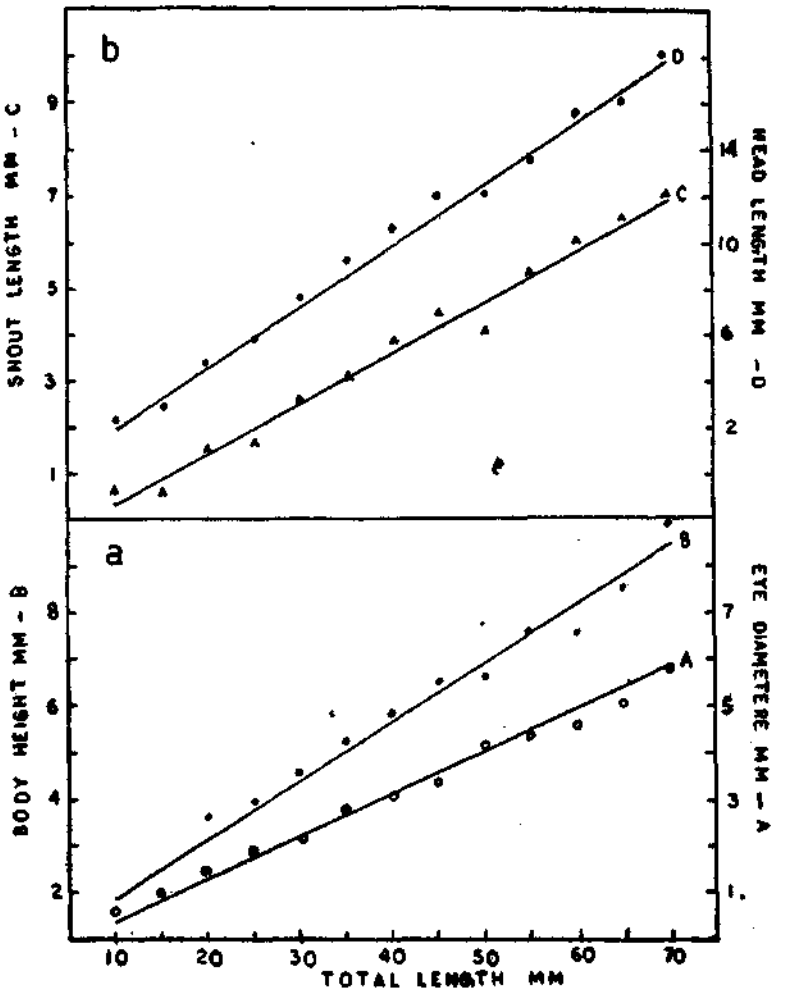

Fig. 2 a. Regressions of eye diameter and body height on total length of *S. sihama* and b, snout length and head length of total length.

breeding season and the seed is available from October to June (Jones and Sujansinghani, 1954; Kowtal, 1976). Round the year availability with a peak in June has been reported from the South Kanara Coast (Ramamurthy and Dhulkhed, 1975). In the Gangolly Estuary seed is available during January-February period (James *et al.*, 1976).

Collection

Post-larvae and fry can be collected by fixing a Midnapore type of spawn collection net (Jhingran, 1975) against the tidal current near the mouth of the Pulicat Lake. For advanced fry and fingerlings, velon screen drag net and small meshed *konda valai* are used in sandy marginal areas and ditches exposed during low tides. James *et al.* (1976) have reported that scaring the fish with a scare line and production of sound in the bag of the net are effective methods of seed collection.

Transportation

Fry and fingerlings are transported in open

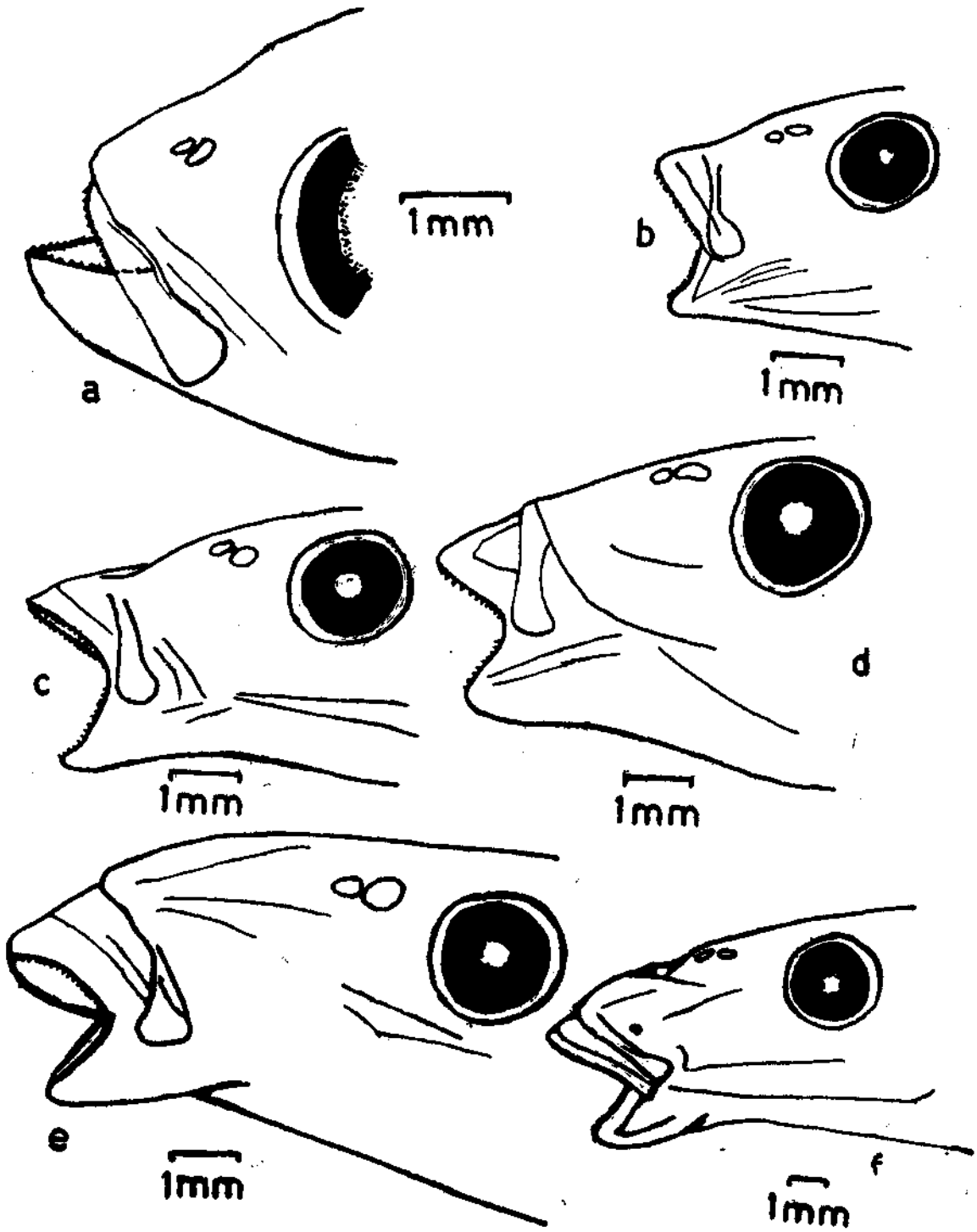

Fig. 3 a-f Mouth structure of larvae and juveniles of *S. sihama* : a. 13.3 mm ; b. 31 mm ; c. 37 mm ; d. 45 mm ; e. 57 mm and f. 69 mm in total lengths.

plastic buckets, earthen pots and plastic bags in fish carriers without oxygen packing for shorter distances by road lasting upto 3 hours. Ramamurthy and Dhulkhed (1975) have transported 400 fry in two fish cans of 35 ltr. capacity over a distance of 100 km in 3½ hours without much mortality. Transportation of 30 fry in 6 ltr. of water in oxygen filled plastic bags was found successful (James *et al.*, 1976).

Acclimation

Sudden transfer of young ones from brackishwater to freshwater or 50% brackishwater led to heavy mortality (James *et al.*, 1976). Gradual lowering of salinity spread over a period of one week appears to be the best method of acclimation (James *et al.*, 1976; Kaliyamurthy, 1979). By this way fry and fingerlings have been acclimated to freshwater and reared for several months in plastic pools.

Culture

Under yard conditions better growth (9.5 mm/month) and 100‰ survival were obtained when fry were cultured in freshwater than in 20 and 30‰ saltwater. Similarly better growth was obtained at very low stocking densities than in crowded conditions. Fry and juveniles showed preference to tubificid worms which gave best growth, conversion (8.4-10) and survival. Juveniles of this species were found to be cultivable either singly or in combination with other species in cages fixed in the Pulicat Lake. In a small brackishwater pond (0.05 ha) at the stocking density of 2,000/ha, the growth of the fingerlings was 9.0 mm/month. In Mangalore area *Sillago* was reported to grow to 200 mm in seven months (Kartha, 1978).

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STUDIES ON DIURNAL VARIATIONS IN THE OCCURRENCE OF GREY MULLET SEED AT MANDAPAM

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ABSTRACT

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

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

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

INTRODUCTION

AQUACULTURE received considerable attention throughout the World in recent years because fish production cannot be increased by depending on capture fisheries only. Finfish, crustaceans and molluscs are now cultured in several countries, some of them very extensively and others on moderate or small scale. Of about 20 species of finfishes cultured at present, the fishes of the family Mugilidae are cultured mostly on small scale and in a few cases on large scale in several countries, especially in south-east Asia. Although efforts are being made on the artificial propagation of mullets in a number of countries, the fry or fingerlings used in culture are still collected from natural waters. In India, attempts have hitherto been made to culture *Mugil cephalus*, *L. tade* and *L. dussumieri* and more recently, experiments were initiated by the Central Marine Fisheries Research Institute at Mandapam Camp and Cochin, both on artificial propagation and culture of various species of mullets, especially *M. cephalus*, *Liza vaigiensis*, *L. parsia* and *Valamugil seheli*. Since large scale culture of mullets still depends on naturally available stocks of seed, it was found necessary to assess the mullet seed resources in the area. From earlier observations, it is known that young ones of mullets and of other commercially important species and prawns are abundant in the Pillaimadam lagoon and adjacent coastal areas (Tampi, 1959; Luther, 1967). However, details of occurrence of various species,

their seasonal abundance and diurnal variations are not known. Therefore, a detailed study of the diurnal variations in the occurrence of mullet seed had been undertaken and the results are presented in this paper.

Material and Methods

For this study, collections of mullet seed were made in the sea, tidal stream and lagoon area at Theedai along the Palk Bay side, 3-6 days after the new and full moon periods from August 1978 to July 1979 and 2-3 days before the new and full moon periods from August to October 1979 in addition to the regular collections made once in a fortnight from August 1978 to April 1979. For the purpose of collections, each diurnal period of 24 hours was divided into four equal periods of 6 hours duration. Collections were made one hour before and after the high and low tides reached their maxima. The gear employed was a drag net made of nylon mosquito netting of the size 8 m in length and 2.5 m in breadth, with a cod-end like portion measuring 3 m in length. Each haul covered a distance of 10 m. Samples were analysed quantitatively and qualitatively. Data on salinity, oxygen and temperature were also collected.

Observations

During the month of August 1978 seed of the mullet *Liza vaigiensis* ranging from 30-85 mm were obtained, along with few numbers of those of *L. macrolepis*, of the size range 50-105 mm. Good numbers of *L. vaigiensis* were obtained during the new moon period late in the night and early in the morning. In September, the collection was very poor in the new moon period but in the full moon period, good numbers of *L. macrolepis* of the size range 50-98 mm were obtained in the early morning (high tide). During October, more seed of *L. vaigiensis* of the size 17-80 mm were obtained during full moon period. In November, a good concentration of mullet seed of the species *L. vaigiensis* was noticed both in the new moon and full moon period, having a size range of 10-65 mm. They were abundant in the early morning and night during the new moon period and in the evening during the full moon period. In December, occurrence of seed was very poor and also the collection was very difficult both in the tidal stream as well as along the shore due to the rough condition of the sea.

During January 1979 large number of seed of *L. vaigiensis* (18-80) and *L. macrolepis* (17-55 mm) occurred. The abundance of the seed was more during early morning and night hours in the full moon period. During the month of February also, good number of seed of *L. vaigiensis* and *L. macrolepis* were collected from the tidal stream in the early morning and evening in the new moon period and *L. vaigiensis* alone in the night on full moon period. During the month, the sizes varied from 14-82 mm and 15-55 mm for *L. vaigiensis* and *L. macrolepis* respectively. In March, the seed of *L. vaigiensis* were obtained in good numbers in the evening in the new moon period and early morning in the full moon period. The size range of seed obtained during the month was 15-72 mm. On the other hand, in April better collections were obtained in the early morning in both new moon and full moon periods though small numbers were obtained in the noon and evening. During May, good numbers of seed of *L. vaigiensis* of the size range 12-90 mm were collected in the early morning of new moon and full moon periods. Particularly in the full moon period, the other three collections were also better. During the month, a small number of seed of *V. seheli* of the size range 33-41 mm were also obtained in the new moon period. The seed of *L. vaigiensis*, *L. macrolepis* and *V. seheli* were obtained in large numbers in June. Their occurrence was more in the receding high tide in the early morning in both the

periods. The size ranges obtained for the species during the month were 15-90 mm, 31-105 mm and 32-91 mm for *L. vaigiensis*, *L. macrolepis* and *V. seheli* respectively. The seed of *L. vaigiensis* were distributed equally in both new and full moon periods. On the other hand, seed of *L. macrolepis* and *V. seheli* were obtained in large numbers only during the full moon period. In July, good collections of seed of *L. vaigiensis* were obtained especially during the early morning (high tide) and night in the full moon period. Seed of *L. macrolepis* and *V. seheli* were also obtained in few numbers during the month. The size ranges of seed obtained were 15-82 mm, 35-107 mm and 34-95 mm for *L. vaigiensis*, *L. macrolepis* and *V. seheli* respectively.

From August 1979 onwards, the collections were made 2-3 days before the new and full moon periods and also an hour before the peak high and low tides, in order to see whether there is any variation in their occurrence. In August, *L. vaigiensis* ranged in size between 32-82 mm; *L. macrolepis*, 50-105 mm and *V. seheli*, 59-92 mm. In September, the size ranges were 12-75 mm, 103-105 mm and 42-48 mm for *L. vaigiensis*, *L. macrolepis* and *V. seheli* respectively; in October, the sizes of the three species were 15-81 mm, 73-107 mm and 45-95 mm in the same order. During September more seed were obtained in the new moon period whereas in October 1979, more seed were obtained in the full moon period. In general, the collections were not encouraging from August to October 1979. From these observations it could be inferred that the occurrence of seed was more during 3-6 days after the new moon and full moon than 2-3 days before the new and full moon periods. It was also inferred that one hour period before the highest high tide and lowest low tide is not suitable for seed collection.

Along with mullets, other species of fishes such as *Therapon* sp., 20-30 mm; *Hemirhamphus* sp., 17-123 mm; *Chanos chanos*, 40-125 mm; *Allanetta* sp., 12-85 mm; *Sillago sihama*, 12-80 mm; *Tachysurus thalassinus*, 27-81 mm; *Nematalosa nasus*, 20-90 mm; *Leiognathus brevirostris*, 30-40 mm; gobids 30-40 mm; *belonids*, 80-102 mm; *Gerres* sp., 14-84 mm; *Megalops cyprinoides*, 19-55 mm; *Plotosus* sp., 21-65 mm and prawns represented by *Penaeus indicus*, 25-30 mm and *Metapenaeus burkenrodi*, 30-50 mm were also found to occur. Young ones of *Sillago sihama* occurred during October 1978, June, August, September and October 1979 with peak abundance during August, September and October 1979 in the full moon period with peak occurrence in April, the night collection during the month being composed exclusively of *C. chanos* in the tidal stream and lagoon. *Allanetta* sp., occurred throughout the period with peak abundance in August and September 1979 both in the full and new moon periods. However, its occurrence was restricted to coastal waters only, few of them entering the tidal stream. *M. cyprinoides* was recorded during the months of June, September and October 1979 with peak abundance in October 1979 with equal distribution in both the new and full moon periods. Young ones of *N. nasus* occurred in August 1978, June, July, August, September and October 1979 with peak abundance in October 1979, both during new and full moon periods. *T. thalassinus* was obtained in fewer numbers in the tidal stream during April, June, July, August and September 1979. But in the full moon period in October 1979 good numbers were obtained in the noon (high tide). Their occurrence was restricted in the muddy areas only. During day time, schools of cat fish seed were observed in surface water. *Gerres* sp. occurred in all the months with peak abundance during June and August 1979. Among prawns, *M. burkenrodi* seed were obtained in most of the months with peak abundance during August 1978, June and October 1979 during the new moon period. Good numbers could be collected in the early morning hours and at night. They were more abundant in the tidal stream

and lagoon than in coastal waters. Their numbers gradually decreased during day time. The month-wise, species-wise data for the new and full moon periods and also for the periods between new and full moon periods are given in Tables 1 to 6.

Discussion

In West Bengal, drag nets or dip nets are used for capturing mullet seed. In Taiwan, two types of gear are used to catch the mullet fingerlings, a small floating drag net in deeper water, and a small beach seine in shallow water (Chen, 1976). In the present studies, a standard drag net made of nylon mosquito netting was used throughout the period. Sarojini (1958) and Luther (1967) stated that collections of mullet fry were richest during the period 4-6 days after the full and new moon period. Results of the present investigation are also in agreement with their view and in addition, it was also noticed that an hour before the high tide reaches its peak, good number of fry entered the tidal stream and also congregated near the shore line. Even then, collections were possible at the receding high tide only. Jhingran (1975) stated that mullet seed can best be collected from shallow pits, dug up in the intertidal zone. The receding tide invariably leaves behind a large crop of mullet fry in the pits. In almost all seed collection studies high tide collections were better than those made during low tides (Bhanot, 1971).

Observations during August, September and October 1979 revealed that abundance of mullet seed was more during 3-6 days after the full and new moon period than 2-3 days before and also that one hour before the peak high and low tide is not suitable for seed collection. It was observed during the present studies, the mullet seed which entered the area at high tide remain in the tidal stream and lagoon at low tide, making the collections easier at low tide. This observation is in agreement with the earlier findings of Pillay (1949) who stated that the high water brings in numerous fry ranging from three quarters of an inch to 2 inches size and when the tide recedes, a good number of them remain in the burrow pits and pools.

It was also noticed in the present investigation that abundance of mullet seed depends on the peak breeding season of the particular species. The seed of *V. seheli* appeared in large numbers during June, July and August 1979. Adults of the species in advanced stages of maturity appeared in the commercial catch from April onwards in this area. In the case of *L. vaigiensis*, the seed occurred in good numbers over a prolonged period from May to September 1979. This may be a result of the prolonged spawning of the species with peak spawning immediately prior to May. The observations also indicate that the growth rate of this species appears to be slower when compared to other species of grey mullets. Similarly, the seed of *L. macrolepis* occurred in good numbers throughout the year except in few months, showing that the spawning season of this species is also prolonged.

Luther (1968) found that the seed of *L. vaigiensis* occur in the coastal and adjacent areas of the Palk Bay and Gulf of Mannar during November-February. But the present studies revealed that the seed of the above species were obtained throughout the years; with peak abundance during August and November 1978 and June and July 1979. Tampi (1959) stated that although the occurrence of mullet is a regular feature throughout the year, there is a noticeable abundance from December to March and again in June and July. The present observations revealed that one or the other species appeared in the collections throughout the year. From the observations made on the commercial catches in the area, it was found that the adults of

TABLE 1. *Month-wise occurrence (number/haul) of seed of* L. vaigiensis *during new and full moon periods*

Month and year		3-6 days after the full moon and new moon periods												2-3 days before the full and new moon periods			
		Aug. 1978	Sep. 1978	Oct. 1978	Nov. 1978	Dec. 1978	Jan. 1979	Feb. 1979	March 1979	April 1979	May 1979	June 1979	July 1979	Aug. 1979	Sep. 1979	Oct. 1979	Total
New Moon																	
Size range (mm)	..	30-85	21-62	50-58	14-65	33-65	23-80	14-82	15-72	28-72	20-90	21-90	15-82	35-68	12-75	23-81	12-90
High tide (EM)	..	343	13	—	150	5	15	62	3	41	74	150	42	1	67	36	1001
Low tide (N)	..	26	4	—	4	—	4	22	15	16	6	19	20	1	—	19	156
High tide (E)	..	—	—	—	—	—	15	65	69	3	3	24	23	5	4	—	211
Low tide (Nt)	..	197	3	3	126	—	23	—	36	1	—	19	20	3	—	—	314
Full Moon																	
Size range (mm)	..	31-81	28-82	17-80	10-35	36-51	18-57	25-57	21-68	26-75	12-75	15-77	26-75	32-82	16-74	15-73	10-82
High tide (EM)	..	78	—	161	6	1	57	18	52	70	131	134	135	16	—	5	864
Low tide (N)	..	58	2	3	7	—	14	—	13	35	33	34	45	14	1	36	295
High tide (E)	..	15	—	—	99	3	30	2	—	—	58	61	9	5	12	50	344
Low tide (Nt)	..	22	5	24	—	—	45	56	—	10	31	—	200	5	—	56	454
Total	..	739	27	191	392	9	203	225	188	176	335	441	494	47	87	202	3756

EM : Early morning ; N : Noon ; E : Evening ; Nt : Night.

TABLE 2. *Month-wise occurrence (number/haul) of seed of* L. macrolepis *during new and full moon periods*

Month and year		3-6 days after the full and new moon periods											2-3 days before the full and new moon periods			
		Aug. 1978	Sept. 1978	Oct. 1978	Nov. 1978	Dec. 1978	Jan. 1979	Feb. 1979	March 1979	April 1979	May 1979	June 1979	July 1979	Aug. 1979	Sep. 1979	Oct. 1979	Total
New Moon																	
Size range (mm)	..	50-105	60-102	92	—	—	—	15-55	34-103	75-84	105	81-105	35-76	50-105	103-105	73-105	
High tide (EM)	..	52	18	—	—	—	—	58	3	1	1	4	—	2	1	2	142
Low tide (N)	..	—	12	1	—	—	—	—	7	—	—	1	7	—	1	2	31
High tide (E)	..	—	8	—	—	—	—	46	9	—	—	—	2	—	—	—	65
Low tide (Nt)	.	—	—	—	—	—	—	—	8	—	—	2	—	—	—	—	10
Full moon																	
Size range (mm)	..	93-103	50-98	—	—	—	17-55	—	51-64	73-90	—	31-98	65-107	105	—	102-107	
High tide (EM)	..	4	46	—	—	—	63	—	3	3	—	72	7	—	—	5	203
Low tide (N)	..	4	2	—	—	—	26	—	—	—	—	25	4	—	—	—	61
High tide (E)	..	—	—	—	—	—	25	—	—	—	—	—	—	1	—	—	26
Low tide (Nt)	..	—	—	—	—	—	56	—	—	—	—	26	10	—	—	—	92
Total	..	60	86	1	—	—	170	104	30	4	1	130	30	3	2	9	630

EM : Early morning ; N : Noon ; E : Evening ; Nt : Night.

TABLE 3. *Month-wise occurrence (number/haul) of seed of* V. seheli *during new and full moon periods*

Month and year		3-6 days after the full and new moon periods												2-3 days before the full and new moon periods			
		Aug. 1978	Sep. 1978	Oct. 1978	Nov. 1978	Dec. 1978	Jan. 1979	Feb. 1979	March 1979	April 1979	May 1979	June 1979	July 1979	Aug. 1979	Sep. 1979	Oct. 1979	Total
New Moon																	
Size range (mm)	..	—	—	—	41	—	15-44	—	—	—	33-41	32-59	55-95	-90	42-48	—	
High tide (EM)	..	—	—	—	—	—	3	—	—	—	4	7	24	2	9	—	49
Low tide (N)	..	—	—	—	1	—	3	—	—	—	1	—	20	—	—	—	25
High tide (E)	..	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	2
Low tide (Nt)	..	—	—	—	—	—	—	—	—	—	—	—	9	—	5	—	14
Full Moon																	
Size range (mm)	..	40-42	—	—	-36	38-41	—	—	—	—	—	32-91	34-80	55-92	42-	45-95	
High tide (EM)	..	—	—	—	—	1	—	—	—	—	—	22	43	22	—	10	98
Low tide (N)	..	—	—	—	—	—	—	—	—	—	—	10	3	—	—	—	13
High tide (E)	..	—	—	—	1	3	—	—	—	—	—	3	—	—	1	—	8
Low tide (Nt)	..	6	—	—	—	—	—	—	—	—	—	—	7	10	—	—	23
Total	..	6	—	—	2	4	6	—	—	—	7	42	106	34	15	10	232

EM : Early morning ; N : Noon ; E : Evening ; Nt : Night.

TABLE 4. *Pooled data on the occurrence (number/haul) of seed of* L. vaigiensis, L. macrolepis *and* V. seheli *during new and full moon periods*

Nature of the tide		*Liza vaigiensis*			*L. macrolepis*			*V. seheli*			All the species combined		Grand total
		NM*	FM	Total	NM	FM	Total	NM	FM	Total	New moon	Full moon	
High tide (EM)	..	1001	864	1865	142	203	345	49	98	147	1192	1165	2357
		(55.70)	(44.15)	(49.65)	(57.25)	(53.14)	(54.76)	(54.44)	(69.02)	(63.36)	(55.78)	(46.96)	(51.04)
Low tide (N)	..	156	295	451	31	61	92	25	13	38	212	369	581
		(8.65)	(15.08)	(12.01)	(12.50)	(15.98)	(14.60)	(27.78)	(9.15)	(16.38)	(9.92)	(14.87)	(12.58)
High tide (E)	..	211	344	555	65	26	91	2	8	10	278	378	656
		(11.71)	(17.57)	(14.78)	(26.21)	(6.81)	(14.45)	(2.22)	(5.63)	(4.31)	(13.01)	(15.24)	(14.21)
Low tide (Nt)	..	431	454	885	10	92	102	14	23	37	455	569	1024
		(23.94)	(23.20)	(23.56)	(4.04)	(24.07)	(16.19)	(15.56)	(16.20)	(15.95)	(21.29)	(22.93)	(22.17)
Total	..	1799	1957	3756	248	382	630	90	142	232	2137	2481	4618

* NM : New moon ; FM : Full moon.

EM : Early morning ; N : Noon ; E : Evening ; Nt : Night.

TABLE 5. *Occurrence (number/haul) of seed of* L. vaigiensis, L. macrolepis *and* V. seheli *between full and new moon periods*

Name of the species	Aug. 1978	Sep. 1978	Oct. 1978	Nov. 1978	Dec. 1978	Jan. 1979	Feb. 1979	March 1979	April 1979	Total
L. vaigiensis										
Size range (mm) ..	20-77	38-73	38-80	12-88	18-68	17-88	17-68	18-81	25-75	
High tide (EM) ..	356	18	63	168	3	108	168	58	107	1030
Low tide (N) ..	16	4	13	13	—	35	11	3	11	106
High tide (E) ..	22	3	13	—	3	37	9	9	18	202
Low tide (Nt) ..	296	21	50	176	—	21	51	116	20	731
Total ..	690	46	139	357	6	201	239	186	156	2078
L. macrolepis										
Size range (mm) ..	—	—	63-93	—	—	61-90	23-63	36-98	70-93	
High tide (EM) ..	—	—	6	—	—	49	39	6	1	101
Low tide (N) ..	—	—	3	—	—	13	—	4	2	22
High tide (E) ..	—	—	3	—	—	22	—	1	—	26
Low tide (Nt) ..	—	—	37	—	—	36	24	6	—	103
Total ..	—	—	49	—	—	120	63	17	3	252
V. seheli										
Size range (mm) ..	—	—	—	15-32	—	16-28	—	—	—	—
High tide (EM) ..	—	—	—	3	—	3	—	—	—	6
Low tide (N) ..	—	—	—	1	—	—	—	—	—	1
High tide (E) ..	—	—	—	—	—	—	—	—	—	—
Low tide (Nt) ..	—	—	—	8	—	1	—	—	—	9
Total ..	—	—	—	12	—	4	—	—	—	16

EM : Early morning ; N : Noon ; E : Evening ; Nt : Night.

TABLE 6. *Occurrence (number/haul) of other fish seed during new and full moon periods*

Name of species	Aug. 1978	Sep. 1978	Oct. 1978	Nov. 1978	Dec. 1978	Jan. 1979	Feb. 1979	March 1979	April 1979	May 1979	June 1979	July 1979	Aug. 1979	Sep. 1979	Oct. 1979
Sillago sihama ..	28-58+ (52)*	—	15-41 (49)	20-80 (14)	—	—	—	—	—	15-36 (78)	38-77 (7)	—	12-38 (25)	12-35 (49)	14-39 (358)
Allanetta sp. ..	15-81 (251)	21-60 (52)	13-48 (62)	16-72 (35)	—	12-56 (10)	26-68 (43)	16-32 (18)	—	32-75 (60)	30-80 (120)	30-85 (75)	15-70 (558)	12-60 (165)	16-24 (150)
Gerres sp. ..	21-35 (141)	19-38 (148)	—	16-28 (4)	—	15-32 (5)	21-48 (7)	19-45 (13)	—	21-67 (4)	26-73 (311)	33-84 (223)	26-63 (179)	15-74 (24)	14-75 (73)
Tachysurus thalassinus ..	31-68 (6)	—	48-76 (18)	—	61-74 (7)	—	—	—	65-68 (15)	—	67-77 (4)	27-55 (5)	65-74 (8)	68-75 (6)	65-81 (10)
Megalops cyprinoides ..	—	—	—	—	—	—	—	—	—	—	48-55 (6)	—	—	30-35 (36)	19-55 (543)
Hemirhamphus sp. ..	122 (1)	—	—	—	—	—	—	—	—	—	89-114 (47)	53-20 (27)	80-120 (3)	87-90 (2)	17-123 (225)
Nematalosa nasus ..	—	—	20-99 (6)	—	—	—	—	—	—	60-90 (6)	42-60 (38)	50-83 (27)	53-65 (5)	—	—
Chanos chanos ..	112 (1)	—	—	—	—	—	—	—	40-80 (200)	70-110 (21)	120-125 (3)	—	—	—	—
Plotosus sp. ..	—	—	—	—	—	—	—	—	—	—	—	35-65 (45)	—	—	21-31 (38)
Therapon sp. ..	24-27 (5)	—	22-30 (11)	21-29 (6)	20-30 (5)	20-28 (3)	—	—	25-29 (3)	—	23-30 (6)	21-29 (2)	25-30 (3)	23-27 (5)	20-29 (9)
P. indicus ..	—	—	—	—	—	25-30 (16)	—	—	—	—	—	—	—	—	—
M. burkenrodi ..	30-42 (251)	—	33-40 (42)	30-35 (35)	—	30-33 (35)	—	—	30-35 (106)	31-48 (615)	30-50 (850)	32-45 (150)	34-50 (73)	30-50 (19)	36-44 (1147)

+ Size range (mm); * Total number; — No occurrence.

V. seheli were caught between Pillaimadam to Thonithurai area along the Palk Bay near Mandapam. Consequently, the diurnal studies and regular seed collections revealed that the seed of this species were also obtained in large numbers in the same area.

During the present investigations, large number of mullet seed were obtained during the months of August and November 1978 and January, February, May, June and July 1979. Their distribution was more or less equal in both new and full moon periods. It was also found that the tidal stream and the lagoon are suitable areas for mullet seed collection at the time of receding high tide. Moreover, the seed which enter these areas at high tide remain there till the next high tide, providing opportunity for intensive collections. Early morning and night hours were found to be the most suitable times for obtaining large collections. Collections were also possible at low tide during day time. The present investigation also revealed that the variations in the occurrence of mullet seed in this region are not related to lunar periodicity but are influenced by the tides since the regular seed collection also showed good numbers of mullet seed in all the months. Prabhakara Rao (1972) stated *C. chanos*, *Elops saurus* and mullet fry exhibit diurnal periodicity in abundance. The present studies also indicate that there are diurnal variations in the occurrence of mullet seed as better collections were obtained during the early morning and late night hours than during day time. There were no significant variation in their distribution between new moon and full moon periods. During the present studies, it was observed that seed of *Mugil cephalus* were not obtained throughout the period.

Along with mullet seed, seed of large number of other commercially important fishes and prawns were also obtained in most of the months. Of these, the occurrence of seed of *C. chanos*, *S. sihama*, *T. thalassinus* and prawns is noteworthy. The seed of these fishes and prawns could be made use of for large scale culture in the area.

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OBSERVATIONS ON GROWTH, SURVIVAL AND PRODUCTION OF GREY MULLETS *MUGIL CEPHALUS* (LINNAEUS), *LIZA PARSIA* (HAMILTON) AND *LIZA TADE* (FORSSKAL) IN A COASTAL LOW SALINE POLYCULTURE POND

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ABSTRACT

Three species of Indian grey mullets *Mugil cephalus* (Linnaeus), *Liza parsia* (Hamilton) and *Liza tade* (Forsskal) were cultured with fresh water carps, milkfishes and prawns in a 0.25 ha coastal low saline pond at a combined stocking density of 5,300/ha, at the Bakkhali fish farm in lower Sunderbans. The percentage of mullets in the total stocking was 17.43. During a culture period of 374 days *M. cephalus*, *L. parsia* and *L. tade* registered a daily growth of 0.6 mm/1.313 g, 0.2 mm/0.069 g and 0.4 mm/0.298 g respectively. The survival rate of the mullets was 80.8% and the total survival of the fishes and prawns was 64.36%. The net production of 141.544 kg/ha/374 days contributed by mullets. accounted for 10.8% in the total net production of 1,306.94 kg/ha/374 days. The growth and survival of the grey mullets have been discussed in relation to the physico-chemical and biological parameters of the culture pond.

INTRODUCTION

MULLETS are euryhaline in nature and are widely distributed in seas and estuaries of the tropics and subtropics. As a most suitable group for large scale fish farming in brackish-water impoundments (Gopalakrishnan and Ghosh, 1976), mullets have been increasingly used in systems of monoculture, mixed culture and polyculture. Among the 26 species of Indian grey mullets (Day, 1878) only *Mugil cephalus* (Linnaeus), *Liza tade* (Forsskal), *Liza parsia* (Hamilton), *Mugil cunnesius* (Day) and *Rhinomugil corsula* (Hamilton) have been recorded from the Hooghly-Matlah estuarine system (Pillay, 1954).

Carps have been cultured along with grey mullets in brackishwater ponds in Hong Kong (Lin, 1940). According to Hora and Nair (1944) mullets grow faster in freshwaters. Grey mullets form an important constituent in multiculture stocking practices in freshwater ponds in China (Lin, 1955), Israel (Yashouv, 1972 ; Pruginin *et al.*, 1975) and India (Job and Chacko, 1947 ; Pillay, 1949 ; Chakrabarty *et al.*, 1976).

Culture of carps in association with grey mullets in low saline ponds is in vogue in deltaic Sunderbans of West Bengal. Jhingran *et al.* (1970) pointed out the possibility of polyculture of freshwater carps, brackish-water fishes and prawns in coastal low saline ponds and experiments on this line were carried out by Pakrasi *et al.* (1975). The present study deals with the performance and

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contribution of three species of Indian grey mullets *Mugil cephalus*, *Liza parsia* and *Liza tade* from a coastal low saline polyculture pond.

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Material and Methods

Polyculture of freshwater carps, brackishwater fishes and prawns was carried out in a 0.25 ha low saline pond at the Bakkhali fish farm of the Central Inland Fisheries Research Institute, situated in Henry's Island in lower Sunderbans. The seed of *Catla catla*, *Labeo rohita* and *Cirrhina mrigala* were procured locally and that of *Hypophthalmichthys molitrix* was obtained from the Pond Culture Division, Cuttack, C.I.F.R.I. They were reared in nursery ponds of 0.02 ha each for stocking in the culture pond. The stocking material of mullets *M. cephalus*, *L. parsia* and *L. tade*, milkfish *Chanos chanos* and tiger prawn *Penaeus monodon* were collected from creeks by operating Midnapore-type spawn collection net and also from intertidal pits using hapa nets. The seed of brackishwater fishes were acclimated in brackishwater ponds for a fortnight and then transferred into 0.06 ha low saline rearing ponds.

The stocking pond was prepared in the month of September 1977 by applying mohua oil cake at the rate of 200 ppm to eradicate all the unwanted fishes and other organisms. On 12-10-1977 the pond was stocked at the rate of 5,300/ha with freshwater carps, brackishwater fishes and prawns in the ratio of 78 : 20 : 2. The stocking density of mullets alone was 924/ha. The percentage of mullets in the total stocking was 17.43. The pond was manured with raw cow dung at the rate of 5,000 kg/ha and fertilized with urea and superphosphate at the rate of 480 kg/ha each alternately at fortnightly intervals.

Supplementary feeding with mustard oil cake : rice bran : wheat powder (1 : 1 : 1) was done at the rate of 3% of the total biomass. Monthly sampling was made to assess the growth of the stocked species. Plankton analysis was carried out at fortnightly intervals. Water analysis of the culture pond was done on weekly intervals using standard methods (A.P.H.A., 1965). The pond was harvested on 22-10-1978.

Results

The growth, survival and production of the three species of grey mullets are presented in Table 1.

The pond was stocked with Indian and exotic carps (@ 4,134/ha), mullets (@ 924/ha), milkfishes (@ 136/ha) and prawns (@ 106/ha). The respective species-wise break-up of stocking density of *M. cephalus*, *L. parsia* and *L. tade* were 172/ha, 548/ha and 204/ha. The average length and weight of the mullets at the time of stocking were, *M. cephalus*—135.5 mm/23.2 g, *L. parsia*—101.7 mm/9.0 g and *L. tade*—69.0 mm/8.0 g. In 374 days of culture *M. cephalus*, *L. parsia* and *L. tade* have attained an average size of 362.8 mm/514.4 g, 163.9 mm/34.9 g and 233.4 mm/119.6 g respectively and their respective growth increments were observed as 227.3 mm/491.2 g, 62.2 mm/25.9 g and 164.4 mm/116.6 g. A daily growth of 0.6 mm/1.313 g for *M. cephalus*, 0.2 mm/0.069 g for *L. parsia* and 0.4 mm/0.298 g for *L. tade* was obtained during the culture period.

The survival rate of the mullets was 80.8% and the species-wise survival rates were, *M. cephalus*—100%, *L. parsia*—86.9% and *L. tade*—55.5%. The total survival percentage of the fishes and prawns was 64.36%. Mullets

TABLE 1. *Growth, production and survival of grey mullets from* 12-10-1977 *to* 22-10-1978

Species	Stocking density (no/ha)	Initial size		Final size		Growth increment		Growth per day		Production (kg/ha/374 days)		
		Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Gross	Net	Survival (%)
M. cephalus	172	135.5	23.2	362.8	514.4	227.3	491.2	0.6	1.313	106.620	102.628	100
L. parsia	204	101.7	9.0	163.9	34.9	62.2	25.9	0.2	0.069	8.856	7.20	86.9
L. tade	548	69.0	8.0	233.4	119.6	164.4	11.6	0.4	0.298	36.280	31.896	55.5

have contributed 10.8% in the total net production of 1,306.936 kg/ha/374 days and the total gross production being 1,390.436 kg/ha/374 days. The gross and net production of mullets obtained were 151.756 kg/ha/374 days and 141.544 kg/ha/374 days respectively. The individual contribution of the three species of mullets is given in Table 1.

The depth of the pond was observed to vary between 110 to 133 cm during the culture period. Water temperature, turbidity, pH, DO and salinity of the pond water fluctuated between 23.0 to 34.0°C, 110 to 210 mm, 8.0 to 9.0, 6.0 to 9.6 ml/l and 0.72 to 2.55‰. The phyto—and zooplankton concentration varied from 150 to 300 units/litre of water and 950 to 1,859 units/litre of water. *Anabeena, Nitzschia, Spirulina, Ankistrodesmus, Chlorella* and *Gyrosigma* among phytoplankton and *Brachionus*, Calanoid and Cycloid copepods, Nauplii larvae and *Moina* among zooplankton were commonly observed.

Discussion

The results indicate the feasibility of mullet culture under favourable salinities in association with carps in coastal low saline ponds. The grow h of mullets was promising and that of *M. cephalus* was exceptionally encouraging. Bograd (1955) has stated that *M. cephalus* is by far the best species to use as a supplemental fish in carp ponds because of its superiority in growth rate.

In this culture experiment, *M. cephalus* has attained an average size of 362.8 mm/514.4 g in 374 days. In brackishwater ponds at Narakkal, *M. cephalus* has attained 405 mm in one year (Alikunhi, 1957). Pillay (1949) has reported that *M. cephalus* normally grow to 400 mm in one year when cultured with carps. Pruginin *et al.* (1975) showed that *M. cephalus* attain a weight of 500 g or more in one year culture and in nursery ponds the fishes reach the weight of 200 g. *M. cephalus* was observed to grow to a length of 300 mm and weight of 260 g in twelve months in brackishwater ponds (2‰ salinity) fertilized with superphosphate (Bishara, 1978). In a freshwater pond when cultured with carps *M. cephalus* attained the size of 343 mm/496 g in 15 months (Chakrabarty *et al.*, 1976). In Chilka Lake this species was reported to reach 307 mm in one year (Jhingran and Natarajan, 1969). In Chinese ponds the species reach the weight of 300 g in one year (Hora and Pillay, 1962). Pakrasi *et al.* (1975) have reported a growth of 426.6 mm/873.8 g for *M. cephalus* in 11 months in low saline ponds. In the present study a survival of 100% was obtained for this species as that reported by Pakrasi *et al.* (1975). However, in their subsequent experiment Pakrasi *et al.* (1975) obtained only 75.86% survival for this species.

L. parsia showed slower growth compared to *M. cephalus*. Pillay (1949) has observed a growth of 120 to 150 mm for *L. parsia* in one year when cultured together with carps. Hora and Pillay (1962) reported that in 12 months *L. parsia* attained 150 to 190 mm. According to Sarojini (1957) *L. parsia* attain 95 mm in 12 months. A monthly increment of 8 mm was reported by Thakur (1970) for *L. parsia* in Hooghly Estuary. According to Pakrasi *et al.* (1975) *L. parsia* recorded the growth of 196.1 mm/111.2 g in 11 months in a low saline pond at Bakkhali. In the present study *L. parsia* attained the size of 163.9 mm/34.9 g in 374 days and showed a survival of 86.9%. In two experiments Pakrasi *et al.* (1975) obtained 50.19% and 22.73% survival for *L. parsia*.

L. tade exhibited faster growth next to *M. cephalus*. This fish reached 240 to 250 mm in one year (Hora and Pillay, 1962). Pillay (1949) has reported that *L. tade* attains 150 to 225 mm in 12 months in freshwater ponds in combination with carps. According to

Pakrasi *et al.* (1975), *L. tade* has grown to 286.2 mm/191.0 g in 11 months. In 374 days of culture, in the present experiment, *L. tade* attained 233.4 mm/119.6 g. The fishes have registered a survival of 55.55% while that reported by Pakrasi *et al.* (1975) in two experiments were 52% and 71.7%. The mullets have recorded 80.8% survival in this investigation which is far better than that of 33.52% and 52.34% reported by Pakrasi *et al.* (1975).

It is evident from the results that mullets contributed 10.8% to the total production. The net mullet production was 141.544 kg/ha/374 days. From two similar polyculture experiments, Pakrasi *et al.* (1975) obtained net mullet productions of 217.74 kg/ha/yr and 209.76 kg/ha/yr.

The pond remained turbid for most of the culture period. As a result the plankton production was found to be very low irrespective of fertilization. During summer months, when the pond water level decreased there were practically low concentration of fish food organisms. Although supplementary feeding was practiced, the slow growth rate of the mullets was attributed to the low concentration of natural food. However, the results of the present experiment indicated the possibility of mullet culture in combination with carps on a commercial scale. It has also shed light on the higher survival and encouraging growth rate of mullets when stocked in low saline coastal ponds in association with freshwater carps and other compatible euryhaline fishes and prawns.

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POSSIBILITIES OF AQUACULTURE OF SILVER POMFRET *PAMPUS ARGENTEUS* (EUPHRASEN) ALONG THE BALASORE COAST

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ABSTRACT

Balasore Coast in the north-eastern part of Bay of Bengal is characterised by a vast stretch of intertidal zone. The silver pomfrets spawn in the offshore regions of the coast and early juveniles occur in plenty throughout the foreshore areas. This potential resource of fish seed and the topography of sea coast open up new vistas for planned coastal aquaculture of silver pomfrets. The nature of the bottom would facilitate easy construction of stocking ponds in the intertidal flat with inlets to the sea. Supplementary feeding is not necessary as the coastal waters are highly productive and rich in zooplankton. It is estimated that with a stocking density of 12,500 fish per hectare, the harvest would record 2,000 kg after the second year.

INTRODUCTION

IN INDIAN waters pomfrets which are highly esteemed as table fish and fetch high unit value, are represented by three species, *viz.* Silver pomfret (*Pampus argenteus* Euphrasen), Chinese pomfret (*Pampus chinensis* Euphrasen) and Black pomfret (*Formio niger* Bloch). The average annual landing of pomfrets from India is nearly 20,000 tonnes, constituting nearly 2.0 per cent of the total marine catch. In spite of their commercial importance very little attempt has so far been made for augmenting their production through coastal aquaculture. The present paper deals with the possibilities of farming silver pomfrets at the edge of the sea along Balasore Coast.

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MATERIAL

The present investigation is based on observations on hydrography, inshore plankton, fishery and biology of silver pomfrets from Balasore Coast during 1972 to 1974. Climatological data were collected from the Meteorological Department, Poona. Data collected during the International Indian Ocean Expedition (1960-65) have been a valuable aid during the present study.

PHYSICO-CLIMATIC FEATURES OF BALASORE COAST

Balasore Coast forms the northeastern part of Orissa State bordering Bay of Bengal (Fig. 1). It is located between Lat. 20°43'N and 21° 59'N. The intertidal zone along Balasore coast is extremely wide and during ebb tide water recedes to a distance of 2 to 3 kilometres exposing an extensive flat. The coast experiences semi-diurnal tide with an average tidal range of 2.5 metres.

The climate is decidedly tropical being largely governed by the monsoons. The northeast monsoon is established in November and persists till February. March and April are the

transitional months with weak southwest monsoons. By May, the southwest monsoon becomes fully established and persists till October. Of the two monsoons the southwest monsoon is stronger and blows with a maximum speed of beaufort 7 or even more. The coast is invariably hit by cyclonic storms,

HYDROGRAPHY

Hydrography of the northern part of Bay of Bengal is largely influenced by the river system opening into it. Rivers large and small, like Subarnarekha, Panchpara, Budhabalang, Kansbans and Dhamra empty into the Bay along Balasore Coast. The mouths of Ganga

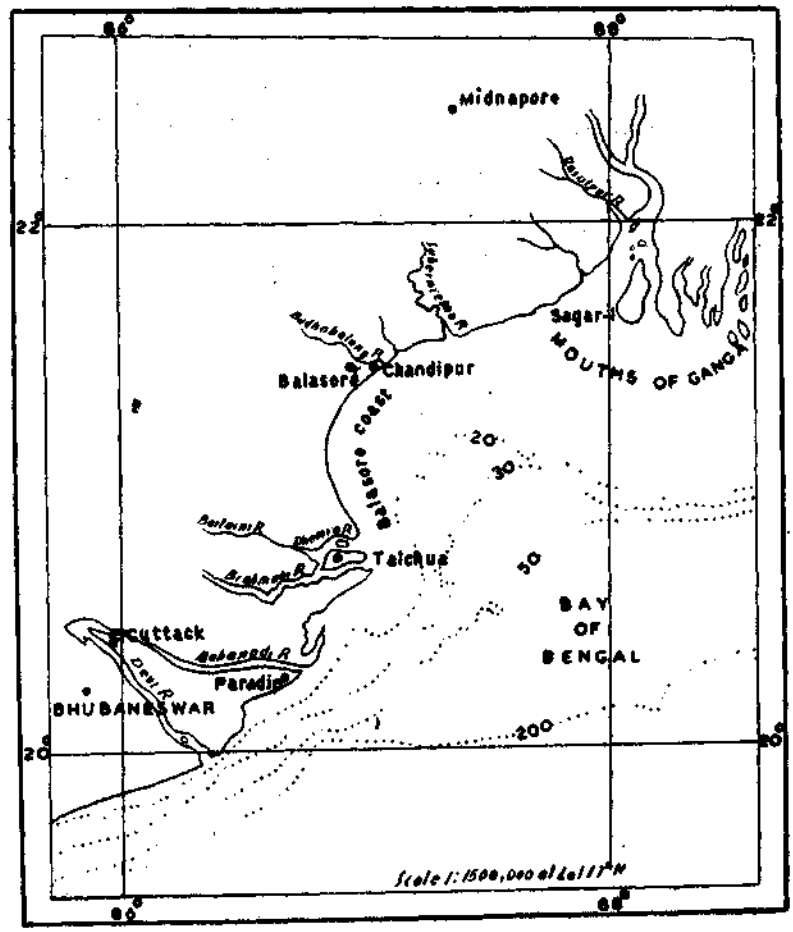

Fig. 1. Map showing Balasore Coast.

the incidence being high during the transitional months of April and October-November. The annual rain fall recorded at Balasore varies from 1,134 mm (in 1974) to 2,481 mm (in 1971) the bulk of precipitation coming from Southwest monsoon.

also discharge huge quantities of freshwater to the north of the coast. The annual range of salinity varies between 22.0 to 33.0‰, whereas the temperature fluctuates between 24.8°C to 29.5°C off Balasore. The heavy influx of nutrient laden freshwater, has

made the coast highly productive. Highest productivity (exceeding 500 mgC/m3/d) has been recorded from the Orissa Coast in the Bay of Bengal during the International Indian Ocean Expedition (Krey and Babenerd, 1976) and high density of copepod (9,000—27,000 per haul) has been observed in the offshore region (Kasturirangan *et al.*, 1970). The inshore waters are also rich in phytoplankton as well as zooplankton (Prasad, 1968; Pati, 1977).

Resources of Fish Feed

One of the basic requisites for any successful aquaculture programme is the availability of fish-seed in large scale and the coastal waters of Balasore poses no difficulty in this respect. The coast is noted for its pomfret fishery and silver pomfret contributes to nearly 23% of the gillnet catch (Roy and Roy, 1974). The coastal water is the spawning ground of pomfrets (Pati, 1978) and spawners are available in the offshore waters from late February to the end of August. The early juveniles ranging in size from 2.5 cm (standard length) onwards are available in plenty in the barrier nets (*Malo-jalo* or *Bedha jalo*) set up in the foreshore areas. This is a contrivance for enclosing adult fish and fry during high tide and trapping them as the tide recedes. The net is a characteristic feature of the intertidal zone of north Orissa and West Bengal Coast and is extensively used along the seashore of Balasore and Midnapore districts. The early juveniles of silver pomfret (Fig. 2) can be collected with scoop nets and transferred directly to the stocking tanks.

Besides direct collection of fry from natural sources, procurement can also be effected through artificial fertilization. Mito and Senta (1967) have successfully raised larva of silver pomfret measuring 4.10 mm in total length from Seto Inland Sea through artificial fertilization. Such larvae can be reared in nursery tanks with appropriate planktonic food and can be utilised for seed.

Fig. 2. Early juveniles of Silver pomfret from Balasore Coast.

Aquaculture Ponds

The intertidal zone along Balasore Coast is made of alluvial sand and is firm enough for the parking of light vehicles. This peculiar topography would enable the construction of aquaculture ponds directly on the intertidal flat with inlet to the sea provided with sluices (Fig. 3). Each pond would be surrounded by raised embankments or concrete bunds with gates guarded by wire netting to allow inundation during high tide. An additional

enclosure has to be set above the embankments to prevent escape of fish from the stocking tank during spring tides and cyclonic surges. Between two rows of culture tanks, a gap has to be provided for collection of fry during receding tide from barrier nets. This would function in the same principle used in the indigenous method. A deeper tank would be necessary on the seaward side for the overwintering of silver pomfrets. Where creeks

Annual Harvest

Silver pomfret grows to a size of about 12.5 cm (standard length) after the first year and weigh nearly 100 gms. At the end of the second year the fish attains a size of 18.0 cm and a weight of 200 gms. The male matures after reaching a size of 13.0 cm and females mature at a size of 16.0 cm standard length. Thus, both males and females mature after the first year (Pati, 1978) and attain marketable

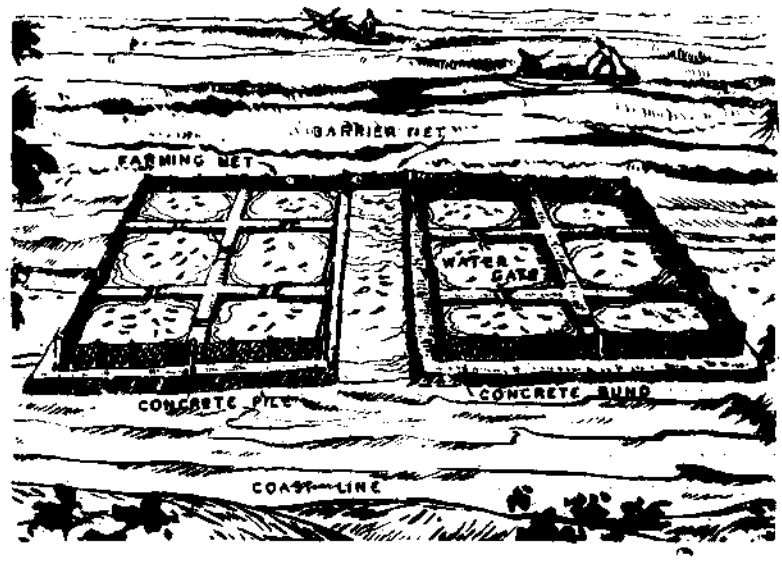

Fig. 3. Diagrammatic layout of the aquaculture ponds in the intertidal zone.

are available, the same may be modified for stocking purpose with inlets to the sea.

The pattern of tide being semidiurnal, the influx of sea water rich in phyto and zooplankton into the ponds would occur twice a day and supplementary diet would not be necessary. Even if the tanks are 2.5 metres deep, the fishes would be exposed to a water column of nearly 5.0 metres during high tides. Silver pomfret is carnivorous, feeding chiefly on zooplankton and occasionally on phytoplankton (Pati, 1978). Copepods are the favourite food organism of this fish and the coastal waters are rich in these zooplankters.

size at the end of second year. Therefore, stocking of alternate series of ponds during successive years would be necessary to ensure harvest from at least fifty per cent of the ponds each year. One hectare of aquaculture pond can be stocked with 12,500 early juveniles and with 80 percent survival, the harvest at the end of second year would yield 2,000kg of silver pomfrets. This stocking rate has been followed by Tang (1970) in milkfish for coastal culture in Taiwan.

Discussion

Coastal aquacuture is still in its infancy in India and farming the edge of the sea has

not yet gained momentum in the country. The subcontinent with its vast coast line extending over 5,650 kms has great potentialities for coastal aquaculture. Farming of selected commercial species in the coastal belt would not only augment production, but also improve the economic conditions of the country. Since tidal inundation is the main source of water supply in coastal aquaculture, adequate information regarding tidal amplitude and cyclonic surges are necessary for proper management. For construction of aquaculture ponds appropriate design for elevation, foundation and sluice have to be worked out in detail. In addition, the material for fencing like nylon nets, steel webbing and bubble fence are some of the problems which specialist engineers have to solve.

Pillay and Shaw (1949) were able to rear young pomfrets in fresh water in cemented tanks at Kodinar (Gujarat) for a short duration. Pati (1978) was able to acclimatise young ones of silver pomfret and chinese pomfret in brackishwater aquaria with negligible mortality. Available data indicate that Balasore Coast with its vast intertidal zone and abundant seed resources is an ideal site for pomfret culture. The fry can be directly procured from the foreshore area, or can be raised through artificial fertilization. Supplementary feeding would not be necessary as the coastal water is rich in zooplankton. These fishes mature after the second year and ripe specimens from nature can be utilized for artificial fertilization and raising of fish seed on a large scale. The coastal waters being the spawning ground of pomfrets, captivity may not even inhibit spawning in the stocking tanks. But for achieving this end further experimentation and investigation would be necessary.

The initial investment would be for the construction of aquaculture ponds and enclosures, while the management would entail recurring expenses. As the marketable size is attained after the second year, stocking should be properly planned to get regular supply during each year. With a stocking rate of 12,500 per hectare, the production after the second year would be of the order 2,000 kg which is highly promising. As the fish fetches high price and has export potentialities, coastal aquaculture of the species can equally be tried with success in other parts of the subcontinent, where fry are available.

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ON THE DEVELOPMENTAL STAGES OF *SCATOPHAGUS ARGUS* (LINNAEUS) (SCATOPHAGIDAE : PISCES)

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ABSTRACT

Larvae of *Scatophagus argus* have been collected from Vellar Estuary, Porto Novo (lat. 11°29'N; long. 79° 46'E) and reared in the laboratory. Description of different stages is given. Seasonal occurrence of the larvae in the estuary was recorded for a period of one year (December 1977 to November 1978) in relation to salinity and temperature. The feeding habits of the larvae have been observed both from natural and under controlled conditions. The results show that *S. argus* is sturdy and suitable for aquaculture practices.

INTRODUCTION

THE SPOTTED SCATS *Scatophagus argus* (Linnaeus), a euryhaline species found distributed in estuaries, backwaters and rivers are very common in Porto Novo waters and preferably consumed by the local people. Hora (1924), Weber and de Beaufort (1936), Panikkar and Nair (1945), Bal and Pradhan (1946, 1947, 1951) and Nair (1952) reported on the larvae of *S. argus*. Venkataramanujam and Ramamoorthi (1974) and Venkataramanujam (1975) reported the postlarvae from Porto Novo. The present attempt on the developmental stages of this species based on laboratory rearing and larvae collected from plankton adds some more information. Feeding habits of larvae, their seasonal occurrence in Vellar Estuary and salinity and temperature tolerance are also reported.

Our thanks are due to Dr. R. Natarajan, Director and Professor, Centre of Advanced Study in Marine Biology, Parangipettai for his keen interest and encouragement. We are grateful to the University Grants Commission, New Delhi for financial support.

MATERIAL AND METHODS

The postlarvae were collected from the Vellar Estuary by plankton net made of bolting silk No. 10 and also by scoop net and reared in the laboratory for further development. Drawings were made by using camera lucida with specimens preserved in 5% formalin. The terms post-larvae and juvenile are used according to Jones (1950).

To study the food preference selective food items were provided and the results were compared with the gut contents of the larvae obtained from plankton collection. Juveniles and adults were also subjected for gut content analysis.

DESCRIPTION OF LARVAE

3.0 *mm stage* (Fig. 1a)

The body is almost oval in shape, mouth is terminal. Preanal myotomes are not clear ; countable postanal myotomes are 12 in number. The dorsal and anal fin flaps are seen without spines or rays and are continuous with the caudal which has a few rays. Eyes are

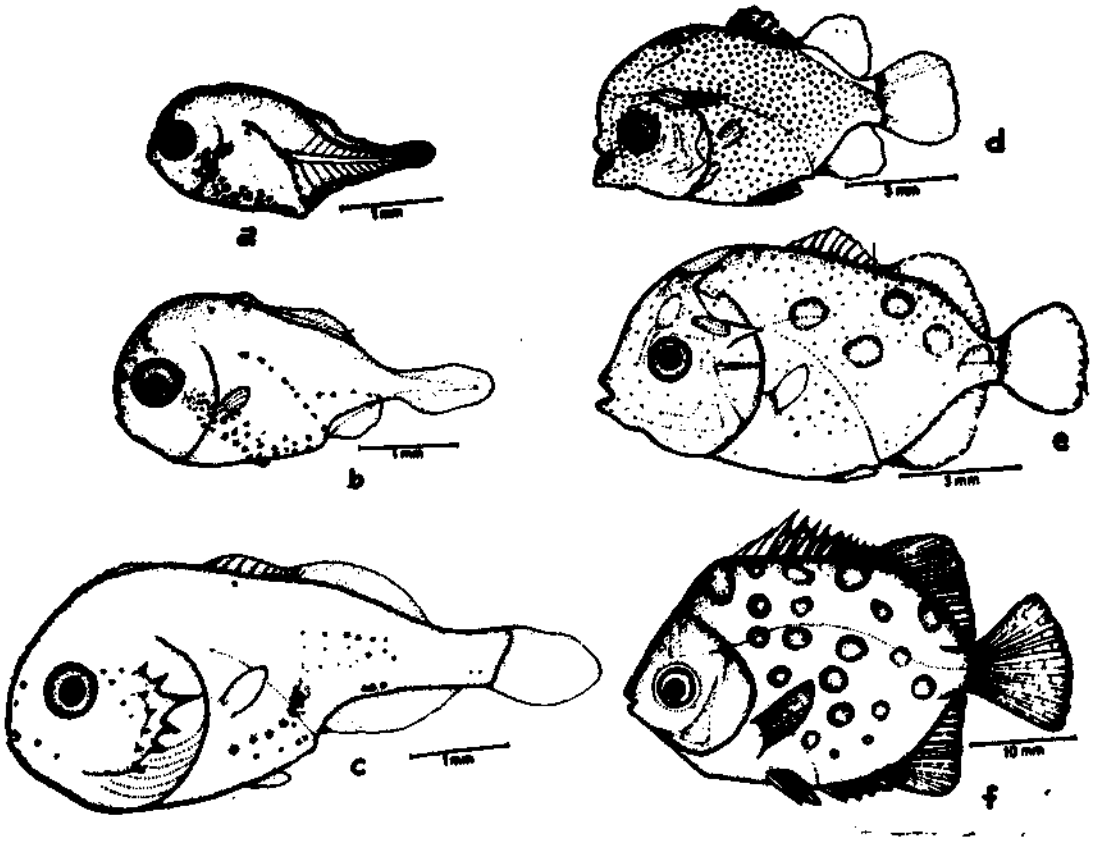

Fig. 1. Postlarvae and juvenile of *Scatophagus argus* (Linnaeus): a. 3.0 mm, b. 4.0 mm, c. 6.0 mm, d. 10.5 mm, e. 13.0 mm post-larval and f. 43.5 mm juvenile stages.

pigmented as in the adult. Some scattered stellate black chromatophores begin to appear below the eyes extending upto the anus ventrally. Another row of same type of chromatophores begins to appear just above the anus leading to the dorsal side of the body as a curve. Few black stellate chromatophores lie just above the eyes. The pectoral fin is like a flap ; no pelvic fins.

4.0 *mm stage* (Fig. 1b)

The body is broader. The dorsal has spines and rays. The anal has rays but not countable. The caudal is straight with numerous rays. The pigments are clear as in the previous stage, but few more chromatophores present just below the dorsal spines and just above the anal. The pelvic fin is feebly developed. The rays of the pectoral fin are not clear.

6.0 *mm stage* (Fig. 1c)

The arrangement of the chromatophores is different than the previous stages as follows : anterior region of the eye with two stellate black chromatophores and a few stellate chromatophores on the posterior side ; on the lower jaw two chromatophores ; a group of stellate chromatophores on the stomach ;

below the dorsal spine one ; the middle region of the body with scattered dots and stellate chromatophores; three stellate chromatophores just above the anal and near the caudal latero-ventrally two punctate pigments.

Six branchiostegal rays are prominent. Two rows of opercular spines (4 inner and 6 outer) appeared in this stage. One of the spines in the outer row is much elongated. Just anterior to the dorsal fin a row of twelve prominent serrations are present on the head. The rays of pectoral and other fins are clear.

10.5 *mm stage* (Fig. 1d)

Body is compressed. Head is large and protected by bony plates and a strong suprascapular spine. Except the single suprascapular spine, all the other opercular spines of the previous stage disappear. A strong bony structure is prominent in the place of serrations of the previous stage. The spines of dorsal and spines and rays of pelvic are reddish black in colour. All the other fins are transparent and free from chromatophores. Chromatophores uniformly spread all over the body except base of the anal and dorsal rays. Very minute teeth are seen.

13.0 *mm stage* (Fig. 1e)

There is not much change from the 10.5 mm stage. But along with the uniformly pigmented spots there are five groups of chromatophores on the upper part of the body, being fore runners of the black patches of the adult. Teeth are highly prominent.

43.5 *mm juvenile* (Fig. 1f)

The black patches of chromatophores spread all over the body as in adult. Size of the head gets reduced and the body depth increases. Bony plates of the head and supra-scapular spine completely disappear.

Food and Feeding

In the laboratory, the larvae were fed with phyto and zooplankton. The food items preferred were : phytoplankton *Nitzschia* sp., *Thalassiothrix* sp., *Navicula* sp., *Chaetoceros* sp. and *Asterionella* sp. and zooplankton *Acartia* sp., *Oithona* sp. and *Temora* sp. Apart from these items, the larvae readily accepted nauplii of brine shrimp and fish meat. The gut of juveniles and adults had plant matters such as *Halophylla* spp., *Enteromorpha* spp., *Cladophora* sp. and *Chaetomorpha* sp. Comparison of the gut contents of the larvae from the natural environment and larvae reared in the laboratory showed that the larvae in natural condition feed on only phytoplankton while in laboratory they feed on phyto and zooplankton and even fish meat. This result reveals that the species can change its feeding habits according to the availability of food materials. The larvae thrive well in laboratory condition without food for more than one week and without changing and aerating the water for longer period.

Remarks

The postlarvae of *S. argus* could be collected from the Vellar Estuary during November to January and April to July when salinity and temperature range between 1.02 and 35.00‰ and 25.5 and 34°C respectively. This shows that *S. argus* can tolerate a wide fluctuation of salinity and temperature. Schools of the postlarvae are seen in surface waters at the early morning hours. During midday they take shelter under shady places like boat sides. Unlike other postlarvae of fishes this can be easily collected by a scoop net. The larvae always move on the surface water.

The mortality rate is high when the larvae are of 3-6 mm size but less after 10 mm.

The seed of *S. argus* is available not only in the estuarine environs but also in nearby

backwaters, mangroves and even to some extent in freshwater tidal pools of Porto Novo region. The flexibility of feeding habits, wide fluctuation of salinity tolerance, easy availability of seed and its sturdiness show its prospects for brackishwater culture. But still great deal of works remain to be done ; for example, time of spawning, rate of fecundity, identity of egg, artificial fertilisation, biochemical components etc. Thus it seems that the actual prospects of its culture is still in the hand of future workers.

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PRELIMINARY EXPERIMENTS ON THE CULTURE OF GREY MULLETS AT MANDAPAM

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ABSTRACT

The paper deals with experiments on the culture of grey mullets *Valamugil seheli*, *Liza vaigiensis* and *Liza macrolepis* in monoculture and polyculture systems in seawater ponds and a pen erected in coastal waters at Mandapam.

In a monoculture experiment, *L. vaigiensis* (35 to 77 mm) was stocked at the rate of 1,125/225 m² (= 50,000/ha). In polyculture experiments, mullets (*V. seheli*, 25 to 40 mm and *L. macrolepis*, 35 to 80 mm), *Chanos chanos* (45 to 80 mm) and prawns (*Penaeus indicus*, 22 to 52 mm) were stocked at the rate of 100 and 600, 1000 and 300/450 m² (= 2,000 and 13,000 ; 22,000 and 7,000/ha) respectively in one pond and mullets (*V. seheli*, 29 to 44 mm), *C. chanos* (31 to 59 mm) and *Sillago sihama* (24 to 48 mm) at the rate of 750 nos. each (=17,000/ha) in another pond. Mullets (*V. seheli*, 30 to 43 mm) and *C. chanos* (65 to 71.5 mm) were also stocked in a pen (81 sq. m) erected in coastal waters of the Palk Bay at the rate of 500 nos. each (= 62,000/ha). The stocks were fed with artificial feed composed of equal proportions of rice bran and groundnut oil cake in the form of a paste. The results of the above experiments are discussed in the paper.

Attempts were also made to collect, transport and maintain the adults for the purpose of artificial propagation by hypophysation.

INTRODUCTION

CULTURE of grey mullets (family Mugilidae) is gaining rapid popularity. Though milkfish is the principal species farmed in estuaries and coastal areas, mullets are more acceptable as food fishes than the milkfish in many Asian countries.

Mullets are cultured in both freshwater and brackishwater ponds in many countries of the Indo-Pacific region. While in most countries, culture of mullets is on a small scale, they are extensively cultured in Taiwan and Hong Kong. The species cultured in various countries include *Mugil cephalus*, *Liza tade* and *L. dussumieri*. In Taiwan, mullets are cultured mostly in combination with other fish species. Lin (1940) reported on the culture of carps together with grey mullets in brackishwater ponds in Hong Kong. The culture of grey mullets together with Indian major carps, exotic carps, the milkfish and the prawn in coastal tanks of West Bengal was reported by Pakrasi *et al.* (1975). Fry and fingerlings are collected from nature, acclimatized and stocked in ponds. Experiments to breed mullets under controlled conditions have been conducted in many countries and the first success in rearing larvae (hatched from eggs produced by induced spawning) to fry and fingerlings ready for stocking was obtained in 1968-'69 in Taiwan.

In view of the importance of mullets as food fishes in the country, a comprehensive study on the breeding and culture of mullets was initiated at Mandapam Camp and Cochin.

The results of the experiments on culture of mullets in salt water ponds so far conducted at Mandapam are presented in this paper.

Material and Methods

For culture experiments fry and fingerlings of mullets, milkfish, sandwhiting and prawns were collected from Thonithurai, Theedai and Pillaimadam areas (Palk Bay). In Taiwan two kinds of gear are employed to catch the mullet fingerl ngs. A small floating drag net is used in deeper water and a small beach seine is used in shallow water (Chen, 1976). In the present studies, a drag net made out of nylon mosquito net cloth was used. The seed were transported in fibreglass tanks and plastic buckets to the culture ponds successfully with little mortality. Before stocking the seed in the ponds, measurements and weights were taken for each species by taking sub-samples. Regular measurements and weights were taken at 30 days interval. From these data, the average sizes and weights were calculated for different periods. The size of the pond selected for monoculture was 225 m^2 and for polyculture 450 m^2. A pen of the size 81 m^2 made out of palmyra leaf stalks was also erected in coastal waters of Palk Bay for growing mullets. The culture experiments were carried out from April to October 1979. Seawater was pumped daily twice into the culture ponds for maintaining the water level of about a metre in depth.

For experiments in transportation, maintenance and artificial propagation, adults of *L. macrolepis* were collected from the stakenet catch (*Kalamkatti valai*) at Manoli Island (Gulf of Mannar) and *V. seheli* and *M. cephalus* from the seine-net catches (*Siraiyan valai*) near Pillaimadam (Palk Bay). The description and operation of the stakenet (*Kalamkatti valai*) are similar to the stakenet (*Bher Jal*) described by T. V. R. Pillay (1954). Sebastian and Nair (1975) stated that ripe spawners of mullets were transported in plastic buckets. In Taiwan, the mullet breeders are placed in dark coloured plastic bags filled with sea water and oxygen and transported (Chen, 1976). During the present studies, adult mullets were transported by means of a one metre-square transportation cage made out of nylon netting and PVC frame, as well as in fibreglass tanks of the dimensions 75x50x50 cms, to the experimental site successfully. In the case of fibreglass tanks, water was changed frequently. Upto 10 adults could be transported at a time without mortality. Fish were kept in the breeding hapas fixed in the sea or released into the broodstock pond into which sea water was pumped in daily and were maintained in healthy condition. In Taiwan, feeds given in freshwater polyculture ponds where mullet are present consist mainly of rice bran and peanut and or soybean meal (Chen, 1970). The fish stock in all the experiments were fed with groundnut oil cake and rice bran in equal proportions in the form of a paste. Injected fish were kept in hapas of 2 x 1 x 1 m in size and made of synthetic fibre mosquito netting (Sebastian and Nair, 1975). During the present studies, experiments were conducted in the breeding hapas. Acetone dried cat fish (*Tachysurus* sp.) pituitary glands were used for hormone injections. The doses were calculated in mg of gland/kg body weight of the fish. The hormone injection was tried even with the fish which was in the primary oocyte stage to see whether any progress in the oocyte development occurred. Soon after the injection, the fish were kept in the breeding hapas.

Observations

Monoculture

In the monoculture experiment, the grey mullet *L. vaigiensis*, the seed of which is available in plenty around this area was stocked in the sea water pond at the stocking density of 1,125/225 m^2 (50,000/ha). At the time of

stocking the size ranged from 35 to 77 mm with an average size and weight of 58 mm and 3.3. g. Measurements were taken at an interval of 30 days to minimise mortality due to handling. The average size increased to 65.4 mm (5.5 g), 78.3 mm (7.9g), 77.2 mm (8.1g), 78.6 mm (8.3 g), 80.2 mm (8.5 g) and 82.5 mm (9.2 g) during 30, 60, 90, 120, 150 and 180 days period respectively. Thus, an average growth increment of 7.4 mm (2.2 g),20.3 mm (4.6 g), 19.2 mm (4.8 g), 20.6 mm (5.0 g), 22.2 mm (5.2 g) and 24.5 mm (5.9 g) for 30, 60, 90, 120, 150 and 180 days was obtained for the species. An overall monthly average growth of 4.1 mm (0.98 g) was recorded.

Polyculture

In Experiment No. I, grey mullets *L. macrolepis* and *V. seheli* were stocked in association with *C. chanos* and *P. indicus* at the stocking rate of 600, 100, 1,000 and 300/450 m^2 (13,000, 2,000, 22,000 and 7,000/ha for *L. macrolepis*, *V. seheli*, *C. chanos* and *P. indicus* respectively). The average size and weight shown by each species at the time of stocking were 60.5 mm (5.4 g) for *L. macrolepis*, 32.6 mm (1.0 g) for *V. seheli*, 61.4 mm (2.6 g) for *C. chanos* and 34 mm (0.3 g) for *P. indicus*. The average size and weight increase shown by each species in 60, 90, 120 and 150 days period were 43.7 mm (4.6 g), 54.5 mm (7.6 g), 58.2 mm (13.6 g) and 67.1 mm (24.6 g) for *L. macrolepis*; 23.8 mm (7.4 g), 35.2 mm (9.4 g), 62.2 mm (13.4 g) and 83.9 mm (24.6 g) for *C. chanos*; 29.8 mm (1.1 g), 42.1 mm (1.6 g), 44.5 mm (2.7 g) and 47.2 mm (3.1 g) for *P. indicus* respectively. The seed of *V. seheli* was added to the stock during May only, because of the non-availability of the fry in April. The average size and weight increase recorded for the above species were 19.9 mm (3.5 g), 44 mm (9g), 65.9 mm (14.0 g) and 76.6 mm (29.0 g) during 30, 60, 90 and 120 days respectively. Thus, an average monthly growth rate of 13.4 mm (4.9 g), 16.8 mm (4.9 g), 9.4 mm (0.6 g) and 19.2 mm (7.3 g) was recorded for *L. macrolepis*, *C. chanos*, *P. indicus* and *V. seheli* respectively. The results indicate that *C. chanos* showed better growth, followed by *V. seheli*.

In the Experiment II, *V. seheli* (29-44mm) was stocked with *C. chanos* (31-59 mm) and *Sillago sihama* (24-48 mm) at the stocking rate of 750/450 m^2 each (17,000/ha). The average size and weight at the stocking time for *V. seheli*, *C. chanos* and *S. sihama* were 33.9 mm (0.4 g), 45.6 mm (1.1 g) and 31.0 mm (0.2 g) respectively. After 30, 60, 90 and 120 days, the average size and weight increase shown by these species were 25.4 mm (5.1 g), 37.1 mm (5.8 g), 53.1 mm (8.8 g) and 63.3 mm (12.3 g) for *V. seheli*; 35.6 mm (5.9 g), 61.5 mm (11.7 g), 72.9 mm (17.0 g) and 82 mm (20.5 g) for *C. chanos* and 22.1 mm (2.8 g), 34.6 mm (3.8 g), 38 mm (5.4 g) and 45.8 mm (7.8 g) for *S. sihama*. Thus, the average monthly growth increments for the species were found to be 15.8 mm (3.1 g) by *V. seheli*, 20.5 mm (5.1 g) for *C. chanos* and 11.4 mm (1.9 g) by *S. sihama* respectively. In this experiment, *C. chanos* showed better growth than in the first experiment, whereas *V. seheli* showed good growth in the first experiment. Perhaps it may be due to the stocking density which was lesser for *V. seheli* in Experiment No. I and for *C. chanos* in Experiment No. II.

Pen culture

In Experiment III, the grey mullet *V. seheli* was stocked in the pen in association with *C. chanos* at the stocking rate of 500 each/81 m^2 (62,000/ha). The average size and weight at the time of stocking were 35.2 mm (0.5 g) for *V. seheli* and 66.4 mm (6.2 g) for *C. chanos*. In the pen, the average size and weight increase recorded for *V. seheli* were 22.6 mm (9.6 g) in 30 days, 51.1 mm (14.5 g) in 60 days and 73.8 mm (18.5 g) in 90 days. On the other hand, *C. chanos* showed an average size and weight increase of 25 mm (4.3 g), 46.8 mm (8.0 g), 81.9 mm (27.9 g) and 120.3 mm (48.4 g)

in 30, 60, 90 and 120 days respectively. Thus, the average monthly growth increments for *V. seheli* and *C. chanos* were 24.6 mm (6.2 g) and 30.1 mm (12.1 g) respectively.

The overall picture in the above mentioned experiments indicated that the growth rate of mullet has been better in the pen in coastal waters when compared to that obtained in the ponds, although Bardach *et al.* (1972) mentioned that most Indian mullet ponds are fertile enough to provide for fairly rapid growth. Similarly, *C. chanos* also showed good growth in the pen than in the ponds. The results are summarised in Tables 1 and 2.

TABLE 1. *Monoculture of the grey mullets* L. vaigiensis *at Mandapam*

Months	Size range (mm)	Mean size (mm) and mean weight (g)	Growth increment in size (mm) and weight (g)
April ..	35-77	58 (3.3)	..
May ..	40-91	65.4 (5.5)	7.4 (2.2)
June ..	61-105	78.3 (7.9)	20.3 (4.6)
July ..	50-106	77.2 (8.1)	19.2 (4.8)
August ..	50-105	78.6 (8.3)	20.6 (5.0)
September ..	60-106	80.2 (8.5)	22.2 (5.2)
October ..	60-109	82.5 (9.2)	24.5 (5.9)

During the above experiment, apart from the natural food available in the ponds, artificial food, namely rice bran and groundnut oil cake were given in equal proportions in the form of a paste. It was observed that mullets accepted the supplementary feed readily. The surface temperature ranged between 27 to 34°C in all the ponds. The salinity and oxygen values ranged between 33 to 35.6‰ and 4.18 to 5.16 ml/l respectively. Simultaneously, data were also collected from the sea which indicated that there were no significant differences between the values from ponds and sea.

Transportation and maintenance of adults for artificial propagation

During the present studies, adults of *L. macrolepis* were transported from Manoli island to the experimental site (about 6 kms) in fibre glass tanks whereas the other species, *V. seheli* and *M. cephalus* were transported from Pillaimadam area in fibreglass tanks as well as in the transportation cage mentioned earlier. It was found that the later method gave better results in transporting live adults without injuries. The transported fish were kept in hapas and in the pond into which sea water was pumped daily. Those kept in the pond were found to be healthy and no mortality occurred. Similarly, keeping not more than two fish in a hapa in coastal waters showed good survival. Another problem faced in the hapa was that, if the hapas were allowed to remain in the sea for more than a week, undesirable dense filamentous algal growth was found inside the hapas hindering the free movement of the fish. Therefore, keeping the fish in the pond for experimental work appears to be a better method than keeping them in hapas in coastal waters.

Oocyte development

During the present investigations adult mullets were collected from June to September 1979. Neither gravid females nor milting males of *M. cephalus* were encountered during the period of observation. In the case of *V. seheli* and *L. macrolepis* females were available in good number but those in the advanced stages were very few. A total of 12 specimens of *V. seheli*, 3 of *L. macrolepis* and 2 of *M. cephalus* were administered with pituitary hormone to see the progress of maturity. The dosage given for one *V. seheli* varied from 0.15 mg to 5 mg, for *L. macrolepis* it was 0.1 mg and for *M. cephalus* 0.15 mg of gland/kg body weight. However, the fish died within 48 hours after the first injection. There was no further development of oocytes.

TABLE 2. *Polyculture experiments on grey mullets at Mandapam Camp*

Species	Stocking rate/ha	Size range at stocking (mm)	Mean size (mm) and weight (g)	Mean size (mm), weight (g)* and growth during various periods										Average monthly growth rate in size (mm) and weight (g)
				30 days		60 days		90 days		120 days		150 days		
				1	2	1	2	1	2	1	2	1	2	
Experiment No. 1														
L. macrolepis	13,000	35-80	60.5 (5.4)	—	—	104.2 (10)	43.7 (4.6)	115 (13)	54.5 (7.6)	118.7 (19)	58.2 (13.6)	127.6 (30)	67.1 (24.6)	13.4 (4.9)
C. chanos	22,000	45-80	61.4 (2.6)	—	—	84.2 (10)	23.8 (7.4)	96.6 (12)	35.2 .9.4)	123.6 (16)	62.2 (3.4)	145.3 (27.2)	83.9 (24.6)	16.8 (4.9)
P. indicus	7,000	22-52	34.0 (0.3)	—	—	63.8 (1.4)	29.8 (1.1)	76.1 (1.5)	42.1 (1.6)	78.5 (3)	44.5 (2.7)	81.2 (3.4)	47.2 (3.1)	9.4 (0.6)
V. seheli	2,000	25-40	32.6 (1.0)	52.5 (4.5)	19.9 (3.5)	76.6 (10)	44.0 (5.0)	98.5 (15)	65.9 (14.0)	109.2 (30)	76.6 (29.0)	—	—	19.2 (7.3)
Experiment No. II														
V. seheli	17,000	29-44	33.9 (0.4)	59.3 (5.5)	25.4 (5.1)	71 (6.2)	37.1 (5.8)	87 (9.2)	53.1 (8.8)	97.2 (12.7)	63.3 (12.3)	—	—	15.8 (3.1)
C. chanos	17,000	31-59	45.6 (1.1)	81.2 (7.0)	35.6 (5.9)	107.1 (12.75)	61.5 (11.7)	118.5 (18.1)	72.9 (17.0)	127.6 (21.6)	82.0 (20.5)	—	—	20.5 (5.1)
S. sihama	17,000	24-48	31.0 (0.2)	53.1 (3.0)	22.1 (2.8)	65.6 (4)	34.6 (3.8)	69 (5.6)	38 (5.4)	76.8 (8.0)	45.8 (7.8)	—	—	11.4 (1.9)
Experiment No. III Pen culture at sea														
V. seheli	62,000	30-43	35.2 (0.5)	57.8 (10.1)	22.6 (9.6)	86.3 (15)	51.1 (14.5)	109 (19)	73.8 (18.5)	—	—	—	—	24.6 (6.2)
C. chanos	62,000	65-71.5	66.4 (6.2)	91.4 (10.5)	25.0 (4.3)	113.2 (14.25)	46.8 (8.0)	148.3 (34.1)	81.9 (27.9)	186.74 (54.64)	120.3 (48.4)	—	—	30.1 (12.1)

1. Indicates mean size (mm) and weight (g).
2. Indicates growth in size (mm) and weight (g).

* All weights indicated in parentheses.

Remarks

There is virtually no monoculture of the grey mullet *M. cephalus* in Taiwan. They are nearly always reared in the same pond with Chinese carps and other freshwater fishes (Chen, 1976). Luther (1967) stated that most of mullet species show good growth in culture ponds than in the natural environment. During the present studies on monoculture, *L. vaigiensis* was tried since this species had so far not been tried and since seed of the species was abundant in the area. But the results indicated very slow growth rate for the species. Hence, it may be stated that this species is not at all suitable for culture.

In the polyculture Experiment I, the growth of *V. seheli* was encouraging. It had shown an average growth of 19.2 mm (7.3 g)/ month, which was higher than that of *C. chanos* (16.8 mm/month). On the other hand, in Experiment II, though mullet showed good growth, the overall monthly average size and weight shown by *C. chanos* were higher. As was in the case of mullet in Experiment I, the stocking density for *C. chanos* in this experiment was lower. Perhaps this could be the reason for its higher growth rate. Comparatively, the average growth of 24.6 mm (6.2 g) shown by *V. seheli* in the pen was more than its growth in the ponds. This may be due to the availability of food in natural environment in addition to the supplementary feed given. Since the experiments are continuing the mortality rate could not be calculated.

It was observed that rarely, both sexes of the same species in prime condition were available (Radhakrishnan *et al.*, 1976). According to Ching-Ming Kuo *et al.* (1974), the growth of the oocyte is accelerated readily from 500 μ by daily injection of pituitary gonadotropin. During the present experiment, most of the fish (*V. seheli*) had the ova diameter ranging from 0.1 to 0.24 mm and few *L. macrolepis* had ova diameter upto 0.4 mm only. The results of the present experiments revealed that acceleration of oocyte development was not readily achieved in fish having the oocyte diameter below 0.5 mm.

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OBSERVATIONS ON THE EFFECT OF SUPPLEMENTARY FEED ON GROWTH AND SURVIVAL OF GREY MULLET *LIZA PARSIA* (HAMILTON) FRY IN BRACKISHWATER NURSERY PONDS AT KAKDWIP

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ABSTRACT

Results of a statistically designed experiment conducted to study the effect of fertilization and supplementary feeding on the growth and survival of *Liza parsia* (Hamilton) fry (15-25 mm) during nursery rearing are reported. The experiment was conducted in six 0.02 ha brackishwater nursery ponds for a period of 50 days at a constant stocking density of 1 lakh/ha. Three treatments of feeding (*a*) control (natural food), (*b*) rice bran, (*c*) prawn meal and rice bran (1 : 2), each with two replicates were tried in the experiment. All the experimental ponds were treated with both urea and superphosphate (1 : 1) and poultry dropping at 20 kg/ha/fortnight and 40 kg/ha/fortnight respectively.

Maximum average weight increment of 5.244 g was obtained by applying prawn meal and rice bran containing 27.7% protein which is significantly higher than that of other treatments ($P<0.05$). No significant difference in survival was observed within treatment ($P<0.05$). However, treatment C demonstrated maximum average survival of 83.67%. So considering both growth and survival, prawn meal and rice bran is recommended as a supplementary feed during nursery rearing of *L. parsia*. Growth rate observed under different treatments in relation to the physico-chemical and biological factors are discussed.

INTRODUCTION

THE CULTURE of grey mullets along with other compatible species of fish and prawn in brackishwater impoundments is an age old practice in deltaic West Bengal. In recent years, greater emphasis is being laid on scientific brackishwater aquaculture in India, to improve the protein sources as well as employment opportunities in rural areas. In any selective culture, a constant supply of nursery reared healthy fingerlings is the most essential prerequisite. Since, stocking densities are higher in scientific culture systems, natural food alone will not be sufficient for the growth of fish and prawn. Hence studies in formulating suitable feed for fishes and prawn is more important, which will eventually lead to better production. Various reports are available on the food and feeding habits of mullets in Indian waters (Bapat and Bal, 1952 ; Chidambaram and Kuriyan, 1952 ; Pillay, 1950, 1953 ; Sarojini, 1951, 1954). In recent years studies on the acceptance and efficiency of various supplementary feeds were tested for different species of mullets (Ghosh *et al.*, 1975 ; Prasadam *et al.*, 1976 ; Bishara, 1978 ; Roy *et al.*, 1979). Das *et al.* (1979) studied the growth and survival of *Liza parsia*, under different stocking densities without any supplementary feeding. In the present communication, results of a statistically designed experiment conducted in brackishwater nursery ponds to evaluate the efficiency of prawn meal and rice bran (1 : 2) and rice bran alone in comparison to natural food were presented.

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Material and Methods

The experiment was conducted on the principle of randomised complete block design with two replicates for each treatment in six identical sized brackishwater nursery ponds each of 0.02 ha. The three different treatments, feed used, their nutritive value and proportion are presented in Table 1.

Table 1. *Summary of food items used in the different treatments, their cost and nutritive value*

Treatment	Feed Applied	Cost per kg in rupees	Proximate composition (%)				Fertilizer
			Protein	Carbo-hydrate	Fat	Ash	
A	Control	—	—	—	—	—	Inorganic and organic fertilizer applied at uniform rate.
B	Rice bran	1.40	13.4	74.1	2.5	10.4	Do.
C	Prawn meal and rice bran (1 : 2)	1.60	27.7	56.4	2.7	13.2	Do.

The ponds were dewatered and sundried for about a week, then filled with fresh tidal water from the feeder canal of the farm. Before initiation of the experiment, ponds were fertilised with inorganic fertilizer, urea and superphosphate (1 : 1) and poultry manure as organic fertilizer at the rate of 20 kg/ha/fortnight and 40 kg/ha/fortnight. The ponds did not have any direct connection with the feeder canal and water exchange was done through siphoning.

The fry of *L. parsia* (15—25 mm) were stocked in February 1979 in all six nursery ponds at a uniform stocking density of 1 lakh/ha. The collection of fry were made by scoop netting using hapa, from the intertidal pits adjacent to Muriganga Estuary. The fry were conditioned to the lentic environment for a period of 24 hours in small cages fixed in the nursery ponds. Stocking of fry was done a week after the initial manuring and filling of the ponds. Subsequent repetition of doses of fertilizers were made at fortnightly interval.

Fifty numbers of samples of fry were randomly taken for length and weight measurement, the average length and weight and initial number of stocking materials from each pond were recorded. Experiment was conducted during the months of February—April 1979, for a period of 50 days. Supplementary feeds were supplied at 10% of body weight of the experimental population and the ration was given daily during the evening. Feeding rates were adjusted on the basis of estimated biomass in different experimental pond based on fortnightly sampling. Physico-chemical samples were collected weekly and analysed as per standard method for the examination of water and waste water A. P. H.A. (1965). Plankton samples were collected fortnightly by filtering 50 litres of water through bolting silk net from all the experimental ponds for qualitative and quantitative analysis. At the completion of the experiment the population were removed by repeated netting and dewater-

ing the pond to assess the final growth and survival of *L. parsia*.

Results

Summary of average initial size, average increment in length/weight and average percentage survival for different treatments are furnished in Table 2.

To determine whether the treatments differed significantly an analysis of variance was carried out on average weight increment for six experimental units (Table 3). The mean increment in weight for treatments differed significantly at ($P<0.05$). From Table 3 it will be seen that treatment C differed significantly from other treatments indicating the best mean increment in weight of 5.244 g. which is greater than the increment in weight of other treatments but the treatments A and B do not differ significantly between themselves. The differences were evaluated by critical differences test at 5% level of confidence, Standard error of differences of two treatment mean is 0.4280 and critical difference being 1.8416.

Similarly to determine whether treatments differed significantly an analysis of variance was carried out on percentage survival of six experimental ponds (Table 4). The results demonstrated that there is no significant difference in percentage survival. However, maximum average survival of 83.67% was observed with treatment C, followed by treatment B (78.50%) and A (68.75%).

The range of physico-chemical factors of the different treatments during the month February—April 1979, are given in Table 5. The range of physico-chemical factors in different treatments were almost same during the period of observation.

The quantity of plankton (no/litre) available in different treatment ponds were : zooplankton 1059—2002 (A); 1410—2950 (B); 1352—2742 (C); and phytoplankton 650—1125 (A); 800—1400 (B); 600—3200 (C). Among phytoplankton common genera represented were *Lyngbya* sp., *Oscillatoria* sp., *Navicula* sp., *Gyrosigma* sp., *Coscinodiscus* sp. and *Synedra* sp., *Diaptomus* sp., *Cyclops* sp. and their nauplii, Mysid sp. and *Brachionus* sp. were the frequently encountered zooplankters.

Discussion

Reports on the feeding habits of mullets are varied and inconsistent. Bapat and Bal (1952) observed that copepods constitute the main food of *L. parsia* in Bombay waters. Three species of typically estuarine and marine mullets *viz.*, *L. parsia*, *L. tade* and *Mugil speigleri* of Bengal were reported to be bottom feeders and that decayed organic matter, fresh and decaying algae and diatoms formed their food (Sarojini, 1954; Pillay, 1953). Chidambaram and Kuriyan (1952) concluded that mullets of Gulf of Mannar are primarily plankton feeders, with occasional browsing habit in the full grown mullet. Ghosh *et al.* (1972) studied the food preference of *L. parsia* in laboratory experiments and concluded that the fry, though primarily a diatom feeder changes over to zooplankton feeding immediately after entering into a lentic environment where diatoms are scarce. Ghosh *et al.* (1975) observed that the normal plankton production in brackishwater ponds was not sufficient for the growth of *L. parsia* fry, unless they are stocked at a very low rate. Das *et al.* (1979) in their experiment on nursery rearing of *L.parsia* under different stocking densities, without artificial feeding observed best survival where the zooplankton density was maximum.

Studies on artificial diet for mullets are scarce. Yashouv and Benshachar (1967) tried pelleted protein rich diets fortified with vitamins and minerals for *Mugil capito*. Rangaswamy (1979) obtained best growth of *L. parsia* fry

TABLE 2. *Summary of average initial length/weight, average increment in length/weight and average percentage survival under different treatment during the 50 days experiment*

Treatment	Average initial length (mm)	Mean increase in length (mm)	Average initial weight (g)	Mean increase in weight (g)	Mean survival (%)
A	20.70	31.76	0.117	1.658	68.75
B	19.97	42.66	0.122	3.047	78.80
C	19.30	54.87	0.106	5.244	83.67

TABLE 3. *Summary of analysis of variance with weight increment in gm of* Liza parsia

Source of variation	D.F.	Sum square	Mean square	F	Comments
Replicates	1	0.2745	0.2745	1.4984	Not significant
Treatment	2	13.1022	6.5511	35.9593	Highly significant
Error	2	0.3665	0.1832	—	—
Total (corrected for mean)	5	13.7432	—	—	—

TABLE 4. *Summary of analysis of variance with % survival data (Arcsin transformed) of* L. parsia

Source of variation	D.F.	Sum square	Mean square	F	Comments
Replicates	1	0.3300	0.3300	0.0198	Not significant
Treatment	2	109.7545	54.8772	3.2959	Do.
Error	2	33.3005	16.6502	—	—
Total (corrected for mean)	5	143.3850	—	—	—

TABLE 5. *Range of physico-chemical factors of ponds under control and different treatments during the month of February to April* 1979

Treatment	Water depth (cm)	Water temperature (°C)	Salinity (ppt)	D.O. (ppm)	pH	Turbidity (mm)	Alkalinity (ppm)
A	44.5—57.0	24.9—27.1	8.67—14.03	5.7—8.0	8.5—8.8	90—150	125—129
B	49.5—60.5	24.7—27.1	9.50—14.80	5.2—8.4	8.3—8.7	140—180	120—134
C	45.0—59.8	24.9—26.5	8.13—13.33	6.2—9.6	8.1—8.8	142—155	101—120

with Bengal gram, prawn head and sago at 2 : 2 : 1 ratio. Rathakrishna (1979) tried brackishwater macrophytes as supplemental feed for mullet fry. Details of the efficiency of the diet used by Rangaswamy (1979) and Radhakrishna (1979) are not available for comparative purposes. In the present study, two locally available ingredients were tested and it was observed that the growth rate obtained with treatment C (prawn meal and rice bran 1 : 2) were significantly higher ($P < 0.05$) than treatment B (rice bran) and A (control). The growth increment and survival under different treatments were 5.244 g/83.67% (C), 3.047 g/78.80% (B) and 1.658 g/68.75% (A) respectively. The crude protein contents of the feed used under treatment B was 13.4% and C 27.7%.

Experiments on nursery rearing of *L.parsia* at a stocking density of 12,500 per hectare with fertilization and supplementary feeding (at 16% of body weight of stocking material) w th a proper management method demonstrated a growth of increment of 65 mg/day and a survival of 82% (Anon, 1975). In the present study at a stocking density of 1 lakh/ha with fertilization and supplementary feeding (at 10% of body weight of stocking material) and periodic replenishment of impounded water with the fresh tidal water, an enhanced daily growth rate of 105 mg/day with survival of 83.67% was observed, which is higher and satisfactory compared to that obtained in the earlier experiment (Anon, 1975).

The results of the present study show that prawn meal : rice bran at 1 : 2 ratio is a suitable feed during the nursery rearing of *L. parsia* fry. Generally it can be concluded that 25 to 30% crude protein in the diet is suitable for *L. parsia*. Further experiment with other locally available cheap ingredients are in progress, so as to develop a still cheaper diet.

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EXPERIMENT FOR OPTIMISATION OF FEEDING RATE AND FEEDING INTENSITY DURING NURSERY REARING OF *LIZA PARSIA* (HAMILTON)

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ABSTRACT

Efficient feeding programme in nursery management is an essential requirement for better survival and growth. In order to ascertain the rate of feeding per day of *Liza parsia* and the instalments for application a 3^2 factorial experiment was conducted in the laboratory on the principle of randomised complete block. The two factors each with three levels, rate of feeding (6%, 12% and 18% of body weight) and instalment of feeding (one, two and three instalment/day) were considered for the present study.

Statistical analysis of the results showed that the difference between the feeding rates were significant at 1% level and feed given at the rate of 12% of body weight had significantly increased the weight. The difference between the number of instalments was not found significant. However, survival rate was equally well and significantly different in 6% and 12% level of feeding.

INTRODUCTION

MULLETS comprise one of the most important group of fishes that contribute to the fisheries in estuaries, backwaters and inshore areas. They are cultured widely in brackishwater impoundments in various parts of India. Since stocking densities are quite high in nursery ponds, the available natural food is insufficient. Hence, supplementary feeding becomes necessary. The use of supplementary feed is not extensive in brackishwater systems as in freshwater fish culture. The fluctuating salinity and other physico-chemical factors affects the natural food production. Pillay (1950), Sarojini (1957), Chidambaram and Kuriyan (1952) have realised the necessity of supplementary feeding in mullet farming. Very recently, works have been done by different workers in India on the development of suitable, supplementary feed for mullet *Liza parsia* (Hamilton) (Ghosh *et al.*, 1972, 1975; Das *et al.*, 1979; Rangaswamy, 1979; Rangaswamy and Raman, 1979). But, so far, no study has been done to find out the effect of feeding rate and feeding intensity on the growth and survival of *Liza parsia*. Hence, an attempt has been made in this paper to optimize the feeding and intensity of feeding for *L. parsia*, during rate of nursery rearing.

The authors are grateful to Dr. V. G. Jhingran, former Director, Central Inland Fisheries Research Institute, Barrackpore for his keen interest in the work.

MATERIAL AND METHODS

Fry of *L. parsia* (23-27 mm) were collected from intertidal pits adjacent to Muriganga Estuary by scooping with hapa nets. Collected fry were then kept for 3 days in plastic pools containing estuarine water for acclimatising them to captive condition, before the start of the experiment.

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A 3^2 factorial experiment on the principle of randomised complete block design with two replicates were conducted during 1974. The feeding rates were in three levels, *viz.*, 6%, 12% and 18% of body weight of the stocked fry. The feeding intensities were in 3 levels—once in a day, twice in a day and thrice in a day. The experiment was conducted in 18 glass jars of 15-20 litres capacity, in 3 blocks. The glass jars were filled with 10 litres of filtered estuarine water. Healthy fry were stocked at 3 nos./litre. Individual length and group weight were recorded before stocking. Water was changed every day. Finely ground, rice polish was used as the supplementary feed. As per the design of the experiment feeds were provided at 6 A. M., 12 P. M. and 6 P. M.

Dead fry were removed every day and rates adjusted depending on the living fishes. At the end of 14 days, the fry were counted and individual length and weight were recorded.

For critical analysis of the data, F-test of analysis of variance, least significant difference test for pairwise multiple comparison between means were used.

Results

Table 1 represents the average initial weight, final weight and survival rate of *L. parsia* fry during 21 days experimental period.

Analysis of variance was carried out with the increase in weight and the result is presented in Table 2. Making use of F-test it is found that the treatment mean is significantly different at 1% level. The main effect of rate of feeding (A) is highly significant at 1% level. But the main effect of intensity of feeding (B) and the main effect of interaction (AB) are found to be non-significant at 5% level. The standard error of difference between any two feeding rate means is $\pm$ 14.80 mg. The least significant difference is 32.25 mg.

To determine whether the survival rate in different treatments varies significantly, the data obtained were transformed by Arcsin transformation and analysis of variance was carried out with the transformed data. From the analysis (Table 3) it was observed that the main effect of treatment A is significantly different ($P < .01$) and the main effect of treatment B and the interaction AB are not significant. From the LSD test it was observed that the survival rates in both 6% and 12% level of feeding rate were significantly different than 18% level.

Discussion

Seed of *Liza parsia* is available in plenty in Sunderbans and invariably forms one of the major component in the culture fisheries. In high density cultures, the natural food available in the pond, is insufficient for the growth of *Liza parsia* (Ghosh *et al.*, 1975). Hence supplementary feeding becomes essential for better growth. Providing protein rich diet definitely increases the growth rate as studied by Ghosh *et al.* (1975) in pond conditions. Understanding of optimal rate and intensity of feeding will help to reduce the wastage of feed and the pollutional effect arising out of it. No study in this regard has been conducted so far, hence no comparable data are available. This laboratory experiment, with a view to optimise the rate and frequency of feeding, is a preliminary attempt, so as to get a basic knowledge before trying them in pond conditions. In the present case growth observed is not satisfactory compared to that of Ghosh *et al.* (1975) in pond condition. This may be due to high stocking density of 3 nos./litre (3000 nos./m^3 or 30,000,000 nos./ha). But since this is uniform in all the treatments it doesn't interfere with the results.

From the present observations, it can be generally concluded that feeding at 12% of

TABLE 1. *Details of mean initial weight, mean increase in weight and mean survival rate of* Liza parsia *under* 3^2 *factorial experiment (Mean of two replicates)*

Factor		Initial weight (mg)	Increase in weight (mg)	Survival rate (%)
Feeding intensity (No. of times feed given)	Feeding rate (% body weight)			
Once	6	142.8	76.3	88.7
	12	142.8	139.5	68.7
	18	142.8	68.5	37.5
	6	142.8	53.0	77.5
Twice	12	142.8	139.5	61.2
	18	142.8	67.5	31.2
	6	142.8	81.5	78.7
Thrice	12	142.8	140.1	72.5
	18	142.8	50.4	33.7

TABLE 2. *Analysis of variance table for testing gain in weight of* L. parsia *under* 3^2 *factorial experiment*

Sources of variation	Degrees of freedom	Sum of square	Mean square	F	New F
Replicate	1	2,048.00	2,048.00	2.5433	3.1164
Feeding rate (A)	2	18,148.00	9,074.00	11.2685	13.8077*
Intensity of feeding (B)	2	388.00	194.00	0.2409	0.2952
Interaction (AB)	4	1,444.00	361.00	0.4483	
Error	8	6,442.00	805.25		
New Error**	12	7,886.00	657.17		
Total	17	28,470.00			

* Highly significant 1% level.
** New Error = Error + Interaction.

TABLE 3. *Analysis of variance table for testing mean survival rate*

Sources	Degrees of freedom	Sum of square	Mean square	F	New F
Replicate	1	103.00	103.00		
Treatment					
Rate of feeding (A)	2	2,681.22	1,340.61	11.8418	16.3969*
Intensity of feeding (B)	2	17.72	8.86	0.0782	
Interaction (AB)	4	75.45	18.86	0.1666	
Error	8	905.70	113.21		
New Error**	12	981.15	81.76		
Total		3,783.09			

* Highly significant at 1% level.
** New Error = Error + Interaction (AB).

body weight of the stocked fry will be the optimum rate with whatever frequency suitable, since frequency of feeding has little influence over the growth and survival of *L. parsia* fry.

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EVALUATION OF SUPPLEMENTARY FEEDING ON THE GROWTH AND SURVIVAL OF GREY MULLET *LIZA TADE* (FORSSKAL) FRY

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ABSTRACT

Results of a laboratory experiment on the effect of supplementary feeds on the growth and survival of *Liza tade* (Forssal) fry are presented in this communication. The experiment was conducted in glass jars of 10-20 l capacity on the principle of randomised complete block design with four replicates for each of the following treatments : (A) natural food (zooplankton), (B) fish meal, (C) fish meal and rice bran (1 : 1), (D) rice bran, (E) mustard oil cake and rice bran (1 : 1). The analysed crude protein contents of feeds B, C, D and E were 50.0%, 31.5%, 13.0% and 23.8% respectively.

Each experimental jar was stocked with five numbers of fry (15-18 mm/60-100 g) at a stocking density of 1 no./l and was aerated for 8 hours/day. Supplementary feed was applied at the rate of 5-10% of the biomass. The fry in control jars were fed *ad libitum*. In an experimental period of twenty-one days, the fry from treatments A and B registered the maximum average weight increments of 213 mg and 219 mg respectively, which were significantly different ($P<0.01$) from that of treatments C, D and E. Fishes from treatments A, C and D showed a percentage survival of 100, 95 and 100 respectively which were significantly higher ($P<0.01$) than that of the other treatments (B and E). Rate of growth and survival of *L. tade* fry are discussed.

INTRODUCTION

GENERALLY aquatic species with high market value are cultured intensively using artificial and expensive facilities and feeds and mullets fit in this category. Among mullets *Liza tade* has been accepted as the most important cultivable species in brackishwater aquaculture in Sunderbans. Under intensive aquaculture practices, where large number of individuals are stocked in a restricted space, nutritional deficiencies may arise due to inadequate supply of natural food resulting in poor survival and growth. Hence, supplementary feeding, appears to be the only other alternative to provide sufficient quantity of food in order to achieve better survival and growth. Pillay (1953) studied the food and feeding habits of *L. tade*. Roy and Chakrabarti (1979) made a preliminary study on the effect of supplementary feed on growth and survival of *L. tade*. Halder and Roy (1979) studied the effect of aeration and density on the growth and survival of *L. tade*.

The objective of the present investigation was to test the locally available cheap feeds for *L. tade* fry during nursery rearing, under laboratory conditions, before testing them in pond conditions.

The author is indebted to Mr. D. D. Halder, Officer-in-Charge, Kakdwip Research Centre for constant encouragement and providing necessary facilities in conducting the study. He is grateful to Mr. P. Ravichandran for going through the manuscript and suggesting improvement. Thanks are due to Mr. P. M.

Sherif, for bio-chemical analysis of feeds and D. Sanfui for rendering help in analysis of physico-chemical parameters.

Material and Methods

Liza tade fry (15-18 mm/60-100 mg) were collected from intertidal pits nearer Kakdwip Research Centre by scooping with hapa nets. Before starting the experiment the fry were acclimatised to confined environment by keeping them in a plastic pool for about a week.

At the start of the experiment, estuarine water was stored in a big plastic pool and the same water was used during the experiment. *L. tade* were reared in glass jars (10-20 litre capacity) containing 5 litres of water. Each glass jar was stocked with 5 numbers of fry and aeration arrangement to all the experimental units through polyvenyl chloride airpipe system (consisting mostly of *Diaptomus* sp., Mysids, *Cyclops* sp. and *Brachionus* sp.) was also tested along with other formulated feeds. Fish meal tested in the present study was prepared in the laboratory from the locally available fish, Bombay duck (*Harpodon nehereus*). Feeds were provided in fine powder form. Live zooplankton, collected from brackish-water ponds were provided daily to the experimental animals on *ad libitum* basis. Details of feeds/treatments used in the experiment with nutritive value and cost are presented in Table 1. In a statistically designed experiment, it was established that stocking of *L. tade* fry at 1 no/l with aeration of 8 hours/day is the best combination for good growth and survival (Halder and Roy, 1979). In a previous unpublished experiment it was observed that feeding at 5-10% body weight of *L. tade* fry were sufficient for optimum growth and survival. So, in the present experiment a density of 1 no/l, aeration for 8 hrs/day was made for 8 hours/day. At the start and close of the experiment individual length and group weight of fry for the experimental units were recorded. Only cheaper and locally available items of feed such as fish meal, rice bran, wheat powder and mustard oil cake were selected and used in the experiment either individually or mixed with one or more ingredients. Natural fish food, zooplankton and a feeding rate of 5-10% of body weight of animals were uniformly used for all the experimental units. Feeding rates were adjusted with the surviving fishes throughout the experiment period. The feeding experiment was conducted for a period of 21 days during August-September 1978. Fishes were fed daily in the afternoon. Accumulated faecal matter and dirt were removed daily by

Table 1. *Summary of feeds used in* L. tade *feeding experiment with cost and analysed nutritive values*

Feeds	Treatments	Cost per kg in Rs.	Proximate composition			
			Protein %	Fat %	Ash %	Carbo-hydrate %
Zooplankton	A	—	—	—	—	—
Fish meal	B	2.50	50.0	3.5	12.4	34.1
Fish meal and rice bran (1 : 1)	C	1.75	31.5	3.0	11.4	54.1
Rice bran	D	1.00	13.0	2.5	10.4	74.1
Mustard oil cake and rice bran (1 : 1)	E	1.25	23.8	5.0	10.5	60.6

siphoning. The quantity of water removed during cleaning were replaced with fresh and filtered estuarine water. Water temperature in all the experimental units were recorded daily. Dissolved oxygen and salinity were recorded weekly.

There were five feeds/treatments arranged in a randomised complete block design with four blocks. Thus there were a total of four glass jars receiving the same feed for each of the five treatments. Analysis of variance, co-variance and least significant difference test were used to evaluate the differences among treatment means (Ostle, 1966).

Results

Ranges of temperature, dissolved oxygen and salinity during the period of observation were 27—29°C, 5.0—7.2 ml/l and 3.75—3.80 ppt respectively. Variation of physico-chemical factors between experimental units were found to be nonsignificant.

Results of observations like initial average length/weight, average increment in length/weight, daily average increment and percentage survival are presented in Table 2.

It was observed that initial average weight of *L. tade* in the experimental units ranged from 60—100 mg. In order to study whether differences among final weight reflect feed effect rather than varying initial weight, analysis of co-variance in randomised complete block design was performed under usual assumptions of independence, normality, homogenous variances (Table 3). Now let us denote initial weight as X and increment in weight as Y. $H_0 : B = O$ was tested i.e. the assumed hypothesis that the regression co-efficient of increment in weight on varying initial weight is equal to zero was tested. To test the validity of hypothesis, variance ratio test was performed as $F = \frac{(-658.5)^2}{1275.8} / 1130 = 0.3007$ with 1 and 11 degrees of freedom. Since the calculated value of $F = 0.3007$ is less than the tabulated value of $F_{0.95\ (1,\ 11)} = 4.84$ so the hypothesis was accepted which proves that varying initial weight has no effect on increment in weight.

Table 2. *Summary of initial average length/weight, increment in average length/weight, daily increment in length/weight and percentage survival*

Treatments	Initial average length/weight (mm/mg)	Increment in average length/weight (mm/mg)	Daily average increment* in length/weight (mm/mg)	Survival %
A ..	16.25/81.25	7.55/213.00[a]	0.36/10.14	100[a]
B ..	15.87/67.25	7.34/219.00[a]	0.35/10.43	90[a]
C ..	16.05/78.75	5.64/115.00[b]	0.27/5.84	95[a]
D ..	16.35/94.00	4.40/54.75[c]	0.21/2.61	100[a]
E ..	16.15/83.75	3.03/28.50[c]	0.14/1.36	76[c]

* Figures with the same superscript are not significantly different from each other at the P=<0.01 level.

Analysis of variance was done with weight increment data for all twenty experimental units to find out statistical difference among treatment means and presented in Table 4. The result demonstrated that the weight increment for treatments differed significantly at 1% level. The differences in weight increment between any two treatment means were evaluated by least significant difference (L.S.D.)

test. Standard error (S.E.) of difference between any two treatment means and L.S.D. values are ± 23.07 mg and 50.27 mg respectively. A perusal of Table 2 will indicate that group of treatments A and B demonstrated best increment in weight which are significantly higher than that of treatment C which is still significantly higher than those of group of treatments D and E. But the difference in weight increment between treatments within the groups is not statistically significant.

Similarly analysis of variance was carried out with percentage survival data for all the experimental units and presented in Table 5. The results demonstrated that percentage survival for treatments differ significantly at 1% level of significance. S.E. and L.S.D. values are ± 4.4% and 9.6% respectively. From Table 2 it can be seen that percentage survival for group of treatments A, C and D are significantly higher than that of treatment B which is again higher than that of treatment E. But there is no significant difference in percentage survival among treatments A, C and D.

TABLE 3. *Analysis of co-variance for testing effect of initial weight (X) on gain in weight (Y)*

Source of variation	Degrees of freedom	Sum of squares and product			Deviations about regression		
		Σx^2	Σxy	Σy^2	$\Sigma y^2-(\Sigma xy)^2/\Sigma x^2$	D.F.	Mean square
Replicates	3	137.2	—277.0	691.8	—	—	—
Treatments/Feeds	2	1483.0	—9706.5	123687.2	—	—	—
Experimental error	12	1275.8	—658.5	12769.9	12430.0	11	1130.0

TABLE 4. *Analysis of variance for testing the significant difference in weight increment among the treatments*

Source of variation	Degrees of freedom	Sum square	Mean square	F-ratio observed
Mean	1	317772.05	—	—
Replicates	3	691.75	230.58	0.22
Treatments	4	123687.15	30921.79	29.06*
Experimental error	12	12770.05	1064.17	—
Total	20	454921.00		

* Significant at $P \leq 0.01$ level.

DISCUSSION

In search of an economical and biologically viable feed for the fry of *L. tade*, fish meal prepared from Bombay duck, as protein source was used, because of its local availability. Bombay duck contributes 26.2% of total landings from the Hooghly-Matlah Estuary (Anon, 1975).

Results of an earlier laboratory experiment indicated maximum daily increment (0.22 mm)

and survival (32%) when *L. tade* fry fed with fish meal containing 30.8% of protein (Roy and Chakrabarti, 1979). In the present study with aeration for 8 hrs/day fish meal containing 50.0% of protein demonstrated daily increment (0.35 mm) and survival (90%). The possible reason for better growth and survival in the present study may be attributed to the use of better quality of fish meal and or extension of aeration facilities which helped in supplying oxygen and expelling metabolites from the experimental units.

It can be observed from Table 2 that mean increment of *L. tade*, when fed with fish meal (219 mg) do not vary statistically from planktonic feed (213 mg). Most notable observations are that full survival was observed in case of both the feeds *viz.*, planktonic food (A) and rice bran (D). Rice bran has registered a very poor increment of 54.75 mg. Considering both growth and survival, planktonic feed can be considered to be the best food during nursery rearing of *L. tade*,

TABLE 5. *Summary of analysis of variance with percentage survival data*

Sources of variation	Degrees of freedom	Sum square	Mean square	F-ratio observed
Mean	1	170201.25	—	—
Replicates	3	253.75	84.58	2.18
Treatments	4	1555.00	388.75	10.03*
Experimental error	12	465.00	38.75	
Total	20	172475.00		

* Significant at $P = 0.01$ level.

From feeding experiments in ponds, stocking at 36,250/ha of *L. tade* fry, daily average weight increment was observed to range from 32.8-42.3 mg (Roy and Chakrabarti, MS). In the present experiment stocking at 1 no/l, daily average weight increment was observed to range from 1.36-10.43 mg by applying supplementary feed. The poor growth in the laboratory experiments may be due to the stunted growth, generally observed in high stocking density and limited space experiments.

if sufficiently available in the pond. But the plankton concentrations in well prepared and fertilised ponds were found to be always insufficient for high density culture (Ghosh *et al.*, 1975). In such a situation, supplementary feeding with protein rich fish meal (as the one tried in this experiment) would lead to better growth and survival of *L. tade* fry during nursery rearing.

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STUDIES ON THE EFFECT OF SUPPLEMENTARY FEEDS AND FERTILISATION ON THE GROWTH AND SURVIVAL OF GREY MULLET *LIZA TADE* (FORSSKAL) FRY IN BRACKISHWATER NURSERY PONDS

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ABSTRACT

Two sets of experiments on the nursery rearing of *Liza tade* fry were conducted to study the effect of supplementary feeding alone and fertilisation and supplementary feeding, in 0.02 ha brackishwater ponds, at an uniform stocking density of 36,250/ha and feeding at 6% body weight of fry for a period of 74 and 113 days respectively.

Feed materials such as fish meal, rice bran, wheat powder and mustard oil cake in different combinations were used in the experiments.

The crude protein content of the tested feeds varied between 16.52 to 20.23%.

The daily growth increment and the percentage survival of mullets in all the treated ponds were higher by 1.76-5.17 times and 1.33-7.99 times respectively, over that of 18.6 mg per day and 10.34% obtained in the control experiment without fertilisation and feeding. Enhancement of natural food production through fertilisation and supplementary feeding led to better growth rate compared to supplementary feeding alone, fertilisation alone and without feed and fertilisation. Fertilisation and feeding with fish meal and rice bran showed a maximum growth rate (96.2 mg/day) and moderate percentage survival (33.24%), but treatment using wheat powder also in addition to the above registered and moderate growth (51.9 mg/day) and highest survival (82.62%).

The growth rate and survival of *L. tade* under different treatment conditions have been discussed in relation to the physico-chemical and biological factors of the culture ponds.

INTRODUCTION

IN RECENT years, greater emphasis is being laid in brackishwater aquaculture to improve the protein sources and employment opportunities in rural areas. Grey mullets form one of the major component of brackishwater farming all over the world. Among the grey mullets available in India, *Mugil cephalus*, *Liza tade*, *L. trosehelli*, *L. macrolepis* and *L. parsia* are the cultivable species. *M.cephalus* one of the fastest growing mullet is not available in sufficient quantities in Sunderbans and hence *L. tade* forms an important cultivable species in brackishwater fish farming in Sunderbans.

Under intensive aquaculture practices, where large number of individuals are stocked in a restricted space, nutritional deficiencies may arise due to inadequate supply of natural food resulting poor survival and growth. Hence, the need to find out a combination of efficacious supplementary feed and fertiliser conducive for faster growth for this particular species is highly essential.

Various reports are available on the food and feeding habits of grey mullets (Bapat and Bal, 1952; Chidambaram and Kuriyan, 1952; Pillay, 1950, 1953; Ghosh *et al.*, 1972). Experiments have been conducted to develop suitable artificial feed for mullets (Yashouv

and Ben-Shachar, 1967; Ghosh *et al.*, 1975; Prasadam and Gopinathan, 1976; Roy and Chakrabarti, 1979). Bishara (1978) studied the growth of *M. cephalus* in Egypt by pond fertilisation and feeding. Recently Roy *et al.* (1979) made some preliminary studies on suitable supplementary feeds for the advanced fry of *L. tade* in brackishwater ponds at Kakdwip. But so far no studies have been made on the effect of supplementary feed as well as fertiliser on the growth and survival during nursery stage of *L. tade*.

This paper is an attempt to study the effect of supplementary feeding with and without fertilisation on the growth and survival of *L. tade* fry in brackishwater nursery ponds.

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Material and Methods

Experiments were conducted in four identical sized brackishwater ponds of 0.02 ha. Two sets of experiments were conducted during September-November 1977 and October 1978 to February 1979 for 74 days and 113 days respectively. The details of various treatments, feed used and their proximate composition are presented in Table 1.

Table 1. *Summary of fertiliser and food items used in different ponds under L. tade feeding experiments with their nutritive value*

Experiment number with duration	Fertiliser applied	Feed applied	Feed numbers/ treatments	Proximate Composition of the feed			
				Protein %	Fat %	Ash %	Carbo-hydrates %
	Nil	Nil (control)	A	—	—	—	—
1	Nil	Fish meal & rice bran (1 : 3)	B	17.45	2.75	19.83	59.97
Sept.-Nov. 1977 (74 days)	Nil	Fish meal, rice bran & wheat powder (1 : 2 : 2)	C	16.52	2.30	15.14	66.04
	Nil	Fish meal & wheat powder (1 : 2)	D	18.87	2.17	18.29	60.67
	Urea & super-phosphate (1 : 1)	Nil (control)	E	—	—	—	—
2	Do.	Fish meal & rice bran (1 : 3)	F	17.45	2.75	19.83	59.97
Oct. 1978-Feb. 1979 (113 days)	Do.	Fish meal, rice bran and wheat powder (1 : 2 : 2)	G	16.52	2.30	15.14	66.04
	Do.	Mustard oilcake and rice bran (1 : 2)	H	20.23	4.17	10.47	65.13

Ponds were prepared by draining the water and sundrying. The bottom of the ponds were observed to be slushy with grey and dark soil covered with detritus. Fertilisation, whenever mentioned, was done with urea and superphosphate (1 : 1) with an initial dose of 100 kg/ha followed with monthly dose of 50 kg/ha.

Water was filled in the ponds through siphoning, from the adjacent feeder canal and regular exchange of tidal water was done. Care was taken to prevent the entry of unwanted fish and prawn in the experimental ponds. *Liza tade* fry collected by hapa net from the pits from around the farm were acclimatised to lentic environment in brackish-water nursery ponds for a minimum period of one week. The experimental ponds were then stocked with *L. tade* fry at an uniform stocking density of 36,250/ha. Adequate number of samples of fry were taken for length and weight measurements. Feeds were supplied at 6% body weight of fry during the week days only and the daily ration was given during evening. Feeding rates were adjusted on the basis of estimated biomass in different experimental ponds based on monthly sampling.

Monthly water analysis for pH, dissolved oxygen, salinity, temperature, fortnightly water depth and turbidity were recorded throughout the experimental period. Monthly plankton samples were collected from all the experimental ponds by filtering 50 litres of pond water through bolting silk plankton net for quantitative and qualitative analysis.

TABLE 2. *Summary of stock, harvest, survival and growth increment of* L. tade *of the experimental ponds under different treatments*

Experiment No.	Ponds under treatment	Stock		Harvest		Survival %	Average daily increment mm/g
		Average size mm/g	No. stocked	Average size mm/g	No. harvested		
1	A	39.27 / 1.37	725	63.95 / 2.75	75	10.34	0.33/18.6
	B	Do.	725	71.28 / 4.50	100	13.79	0.43/42.3
	C	Do	725	69.34 / 3.80	360	49.65	0.41/32.8
	D	Do.	725	69.98 / 4.00	360	49.65	0.41/35.5
2	E	24.08 / 0.125	725	72.28 / 4.00	165	22.76	0.43/34.3
	F	Do.	Do.	92.70 / 11.00	241	33.24	0.61/96.2
	G	Do.	Do.	77.78 / 6.00	599	82.62	0.47/51.9
	H	Do.	Do.	74.60 / 6.00	536	73.93	0.45/51.9

At the end of the experiment *L. tade* fingerlings were removed by successive drag nettings and complete dewatering of all the experimental ponds to assess the survival and growth.

RESULTS

Details of average stocking size, density, average final size, percentage survival and daily growth increment of *L. tade* of different experimental ponds under various treatments are presented in Table 2.

Observations on the range of physico-chemical factors of the ponds under different treatments are furnished in Table 3.

It can be observed from Table 4 that plankton concentration in the fertilised ponds (E-H) are significantly higher than those in the unfertilised ponds (A-D).

TABLE 3. *Range of physico-chemical parameters of the ponds under different treatments of* L. tade *feeding experiment*

Experiment No.	Treatment	Salinity (ppt)	Temperature (°C)	D.O. (ml/l)	pH	Turbidity (mm)	Water depth (cm)
1	A	2.91-4.0	29-34.0	8.4-9.2	8.0-8.4	230-275	59-83
	B	3.64-5.44	28.8-34.0	8.8-12.0	8.2-8.4	200-310	56-74
	C	3.27-5.54	28.8-34.0	9.2-9.6	8.0-8.2	180-210	49-53.5
	D	3.27-4.72	29.0-34.2	8.0-10.0	8.0-8.2	200-310	78-88
2	E	1.47-10.49	22.4-31.8	7.6-10.4	8.4-9.6	140-200	50-71
	F	1.83-9.00	22.2-31.6	6.2-10.0	8.4-9.0	130-210	47-70
	G	1.47-11.64	23.4-32.0	7.6-8.4	8.4-9.6	140-180	47-72
	H	1.42-10.30	23.4-32.4	7.2-10.0	8.4-9.0	140-160	47-72

The range of physico-chemical factors between ponds under each of experiments (1 and 2) were almost same. But the range of factors like temperature and salinity were observed to be different between experiments (1 and 2) which is inherent because Experiment 2 was conducted till the 1st week of February *i.e.* during winter season when salinity used to be higher. But interestingly, the average salinity and temperature between the ponds were not differing significantly, since during January and February only the highest value of salinity and lowest value of temperature was observed.

Observations on the range of zoo and phytoplankton concentration of all the experimental ponds under different treatments are presented in Table 4.

Among phytoplankton *Lyngbya* sp., *Oscillatoria* sp., *Cymbella* sp., *Nitzschia* sp. and *Navicula* sp. were mainly encountered in the samples. *Diaptomus* sp., *Cyclops* sp., *Mysids* and *Brachiomus* sp. were frequently encountered zooplankters.

TABLE 4. *Summary of plankton concentration (no/l) in the ponds under different treatments used in* L. tade *feeding experiment*

Experiment No.	Treatment	Plankton	
		Phyto	Zoo
1	A	70- 95	50- 80
	B	100-160	110-200
	C	95-165	80-250
	D	75-120	130-180
2	E	400-520	280-340
	F	495-575	400-510
	G	550-675	290-460
	H	530-720	270-550

DISCUSSION

Pillay (1953) studied in detail the food habits of *M. tade* collected from Matlah Estuary and reported that the fish is an iliophage; decayed organic matters, filamentous algae and diatoms being the principal food items. It has been

observed that the natural fish food produced in brackishwater ponds are not sufficient unless they are stocked at a very low rate (Ghosh *et al.*, 1972). It is well known that when the density of fish population in pond increase over a certain level, the scarcity of natural food affects fish growth and suryival and in such a situation supplementary feeds are required for faster growth and satisfactory survival. In Israel, pelleted protein rich diets consisting of fish meal, blood meal, eggs, liver and soyabean fortified with vitamins and minerals were used in experiments with *Mugil capito* (Yashouv and Ben-Shachar, 1967). Most of the feeds used in the above experiments are either too costly or uneconomical and not locally available. In India studies on the development of supplementary feeds for brackishwater fishes especially *L. tade* are still at initial stages. In view of the above facts, in the present study only locally available cheap items of supplementary feeds were selected and tested.

A perusal of Table 2 will indicate that daily weight increment and percentage survival of *L. tade* in all the treated ponds (B to H) were higher by 1.76—5.17 times and 1.33—7.99 times respectively, over that of 18.6 mg/day and 10.34% obtained in the control experimental pond without fertilisation and feeding. From Table 4 it can be observed that the plankton concentration in the ponds treated with urea and superphosphate are significantly higher than those not treated with fertiliser. Enhancement of natural food production through fertilisation and supplementary feeding led to better growth rate of *L. tade* compared to supplementary feeding alone, fertilisation alone and without feed and fertilisation. No statistically significant relationship was observed between growth rate of *L. tade* with each of the varying physico-chemical factors.

Fertilisation and feeding with fish meal and rice bran (1 : 2) demonstrated a maximum growth rate (96.2 mg/day) and moderate percentage survival (33.24%), but treatment using wheat powder also in addition to the above registered a moderate growth (51.9 mg/day) and highest survival (82.62%).

Bishara (1978) reported that the best and cheapest method of increasing the growth of *M. cephalus* fry in the pond was to fertilise with superphosphate. In 180 days nursery rearing of *M. cephalus* fry at a stocking density of about 9,090/ha, daily weight increment of 138.8 mg was obtained (Bishara, 1978). In the present study, *L. tade*, a comparatively slow growing species stocked at about four times higher, the daily weight increment with feed and fertilisation ranged between 51.9—96.2 mg which are found to be satisfactory.

Hence, it can be concluded that fish meal, rice bran and wheat powder (1 : 2 : 2) which contains 16.52% of protein can be used along with fertilisation with urea and superphosphate (1 : 1) for successful nursery rearing of *L. tade*.

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ISOPOD PARASITES OF FISH OF PULICAT LAKE

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ABSTRACT

Of the 50 species of food fishes examined for larger parasites, 9 are infested by four species of isopod parasites of which, *Nerocila pulicatensis* and *Cymothoa krishnai* are new to science. The rest, *Nerocila trivittata* Bleeker and *Anilocra longicauda* Schioedte and Meinert are new records for Pulicat Lake. While *N. pulicatensis*, *N. trivittata* and *A. longicauda* are restricted to one or two hosts, *C. krishnai* exhibits a wide variety of host distribution.

INTRODUCTION

PULICAT LAKE (lat. 13.24°N-13.47°N ; long. 80.02°E-80.16°E) is a large brackishwater lake with an area of nearly 280 sq. kilometres. It is situated on the east coast of peninsular India, opening into the Bay of Bengal at Pulicat Village which is about 56 kilometres north of Madras city. It is the second largest brackish-water body in India and has very rich but poorly studied fauna. There is no information on the fish-parasites of this lake and infact parasites of estuarine fish in India have not been systematically studied. During the course of our studies on the fish-parasites from the Pulicat Lake, four species of isopod parasites have been found to infest several species of food-fishes. Of these, *Nerocila pulicatensis* and *Cymothoa krishnai* are new to science. The remaining two species, *Nerocila trivittata* Bleeker infesting *Arius nenga* and *Anilocra longicauda* Schioedte and Meinert infesting *Polynemus tetradactylus* are new records for the Pulicat Lake. While *Nerocila pulicatensis*, *Nerocila trivittata* and *Anilocra longicauda* are restricted to just one or two hosts, *Cymothoa krishnai* exhibits a wide host distribution among the fish of the Pulicat Lake, infesting as many as eight different host fishes.

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Family : *Cymothoidae*

Genus : *Nerocila* Leach

Nerocila pulicatensis sp. nov.

(Plate I A, B and Fig. 1 a-j)

Material

Seven females were collected from the body surface of four specimens of *Plotosus canius* Hamilton Buchanan, and one from the buccal cavity of *Mystus gulio* Hamilton Buchanan. The hosts were caught at the Karimanal shores of the Pulicat Lake.

Female : Body oblong-ovate and relaxed (Plate I A). Cephalon subquadrate, wider than long, anterior margin rounded, posterior

PLATE I

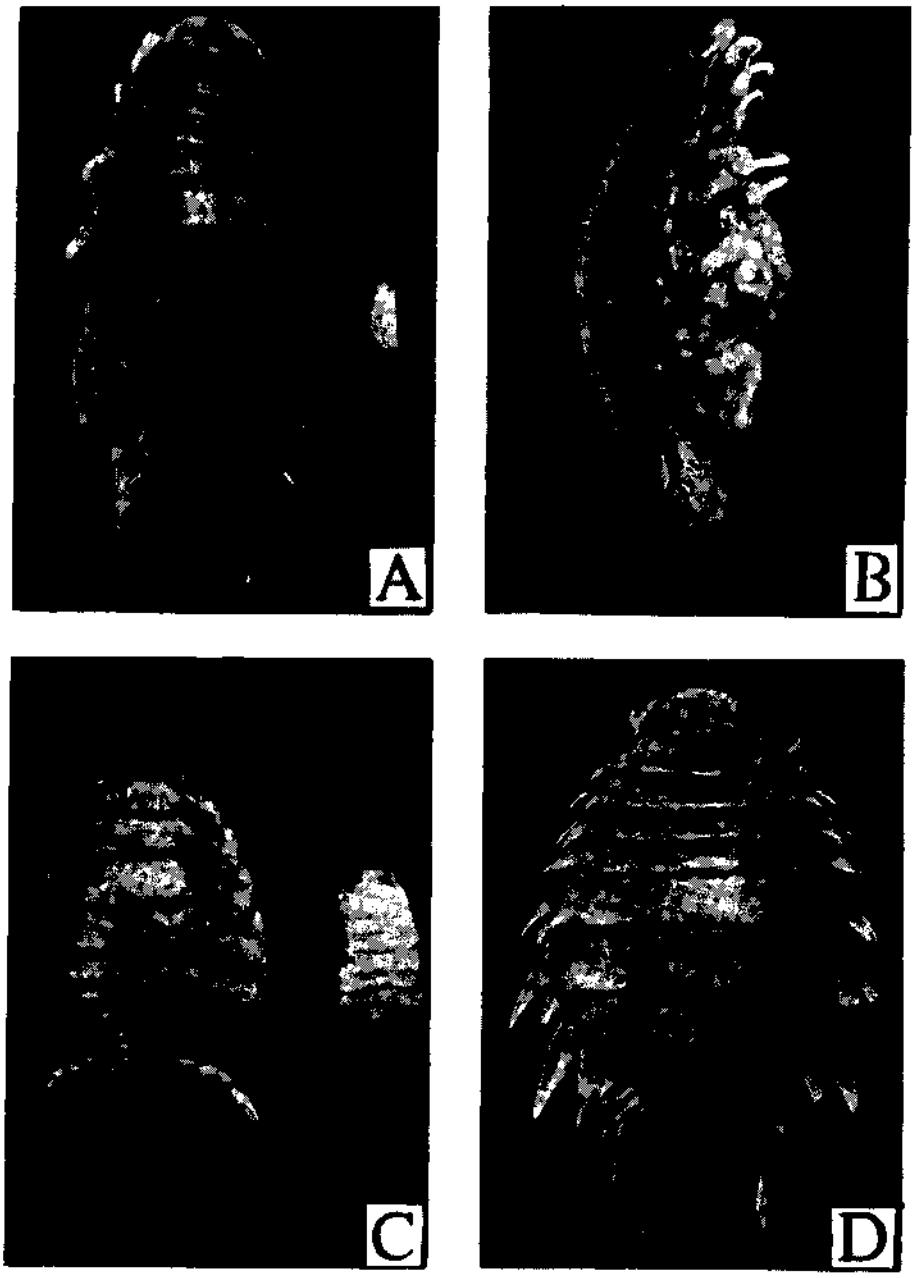

PLATE I. A and B. *Nerocila pulicatensis* sp. nov.: A. Female and juvenile; B. Lateral view showing marsupium; C. Female and male *Cymothoa krishnai* sp. nov. and D. Female *Nerocila trivittata*.

margin trisinuate. Eyes small and situated in the postero-lateral angles of the head.

First peraeonite longer than any of the three following segments, last segment longer than any of the preceding segments and about equal in length to the first segment. Thorax broadest at the fifth peraeonite. Postero-lateral angles of only the last three segments produced, postero-lateral angles of the seventh segment extending upto the second pleonite. The epimera of all the segments with the exception of the first distinctly separated from the segments. First two epimerites have their posterior extremities rounded, extremities of the last four acutely pointed. The epimera do not extend beyond the posterior margins of the segments, excepting the last.

First antenna (Fig. 1 b) eight segmented extending upto the seventh joint of the second antenna. Second antenna (Fig. 1 c) ten segmented extending upto the end of the first peraeonite.

Incisor and molar of the mandible (Fig. 1 d) well differentiated, palp three segmented, first segment stout and subequal to the second, third slender with a few apical setae and two knob like apical processes.

Maxilliped (Fig. 1 g) two jointed, distal segment with four hooks. First maxilla (Fig. 1 f) with four hooks. Distal portion of second maxilla (Fig. 1 e) bilobed, inner lobe with one hook and outer with two hooks.

Legs (Fig. 1 h, i) prehensile, gradually increasing in length and terminating in curved dactyli. Seventh leg (Fig. 1 j) situated well apart from the sixth, its dactylus small.

Pleon with five free segments of subequal length. Lateral angles well marked. Epimera of first two pleonites prolonged. Pleotelson as broad as long, somewhat quadrate with the post-lateral angles obtusely rounded. Posterior margin fringed with hairs. Uropods long (Fig. 1j), outer ramus slender, narrow and long reaching a little beyond the tip of the telson. Endopod distally expanded with serrated margins and shorter than the exopod.

Colouration : Body cream coloured with three dark longitudinal bands, median band extending from the tip of cephalon to the tip of telson, lateral bands thick extending from the first peraeonite down to the peduncle of the uropod and its rami.

Total length : 18.0 to 28.0 mm

Dimensions (in mm for an average sized specimen) :

Length of cephalon :	1.5
Width at fifth peraeonite :	8.0
Length of telson :	4.0

Juvenile : The marsupium of one female contained 22 juveniles of 3.5 to 4.0 mm length range.

Body compact (Fig. 1 a), cephalon broad and long. Eyes distinct and large occupying half the portion of the cephalon posteriorly. Peraeon and pleon well differentiated. Peraeonites without postero-lateral prolongations. Pleonites free with distinct epimerites. Rami of the uropod with long setae. Pleotelson broad at the base and rounded at the free end.

Discussion

The present isopod belongs to the genus *Nerocila* Leach by virtue of its following characters. Obovate body, sub-quadrate cephalon with trisinuate posterior margin, eyes in the postero-lateral angles of the head, first and the last peraeonites of equal length, peraeonites with their postero-lateral angles produced, epimera of the segments well separated, ten segmented second antenna, two jointed maxilliped, seventh leg located well apart from the sixth leg, a broad pleotelson and long uropods.

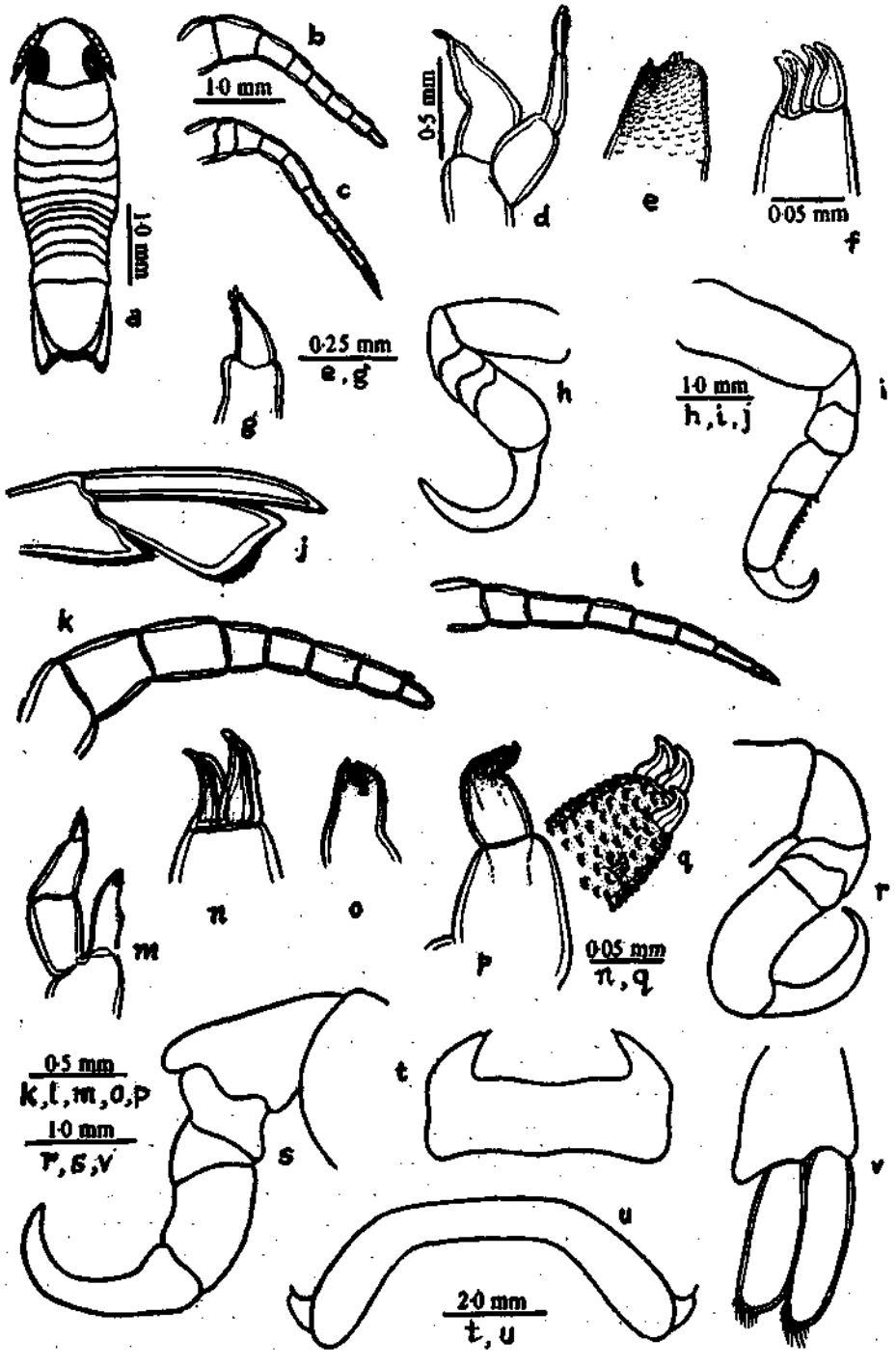

Fig. 1. a-j. *Neroctla pulicatensis* sp. nov.: a. Juvenile, b. First antenna, c. Second antenna, d. Mandible, e. Second maxilla, f. First maxilla, g. Maxilliped, h. First leg, i. Seventh leg, j. Uropods, k-v. *Cymothoa krishnai* sp. nov.: k. First antenna, l. Second antenna, m. Mandible, n. First maxilla, o. Second maxilla, p. Maxilliped, q. Distal segment of maxilliped, r. First leg, s. Seventh leg, t. First peraeonite, u. Seventh peraeonite and v. Uropod.

Among the species of *Nerocila*, *N. latiuscula* Dana, comes very close to the present species by virtue of its general body shape. A closer examination of the two however reveals a number of differences. The present species differs from *N. latiuscula*, in the shape of its peraeonites. In the former, the postero-lateral angles of only the last three segments are produced. Those of the seventh segment extend upto the second pleonite. Further, the epimera of all the segments with the exception of the first, are distinctly separated from the segments. The posterior extremities of the first two epimerites are rounded, those of the last four are acutely pointed. Third segment of the mandibular palp is slender with a few apical setae and two knob like processes. The distal part of the second maxilla is bilobed, the inner lobe of which bears one hook and the outer two hooks. All these aforesaid features are quite characteristic of the present species. They separate it not only from *N. latiuscula*, but also from the rest of the known species, in which all the peraeonites have well produced postero-lateral angles.

The characteristic bands on the body and the presence of hairs on the free borders of the telson even in the adult stage, are the two additional features of this new species, not found in any of the known species of *Nerocila*.

Nerocila trivittata Bleeker

Nerocila trivittata Bleeker, 1857, p. 9,
Nerocila serra Sch & Mein, 1881 (a), p. 17, pl. i.
Nerocila serra Nierstrasz, 1915, p. 74.
Nerocila serra Barnard, 1925, p. 392.
Nerocila trivittata Nierstrasz, 1931, p. 124,
Nerocila trivittata Pillai, 1958, p. 113, pl. IV, figs. 1-2. (Plate 1, fig. D)

Material

One adult female collected from the buccal cavity of *Arius nenga* Bleeker, caught from Musamani Lock area of the Pulicat Lake.

Colouration : Body cream coloured with three faint longitudinal bands, median band extending from the tip of the cephalon to the tip of the telson ; lateral bands less conspicuous anteriorly, becoming deeper on the pleon, peduncle of uropod and its outer ramus.

Total length : 18.0 mm.

Remarks : This species agrees in all respects with the specimen described by Pillai (1958) and is a new record for the Pulicat Lake.

Genus : *Anilocra* Leach

Anilocra longicauda Schioedte and Meinert

Anilocra longicauda Sch & Mein, 1881 (b), p. 113, pl. VII, figs 7-8.
Anilocra cauvicauda Richardson, 1910, p. 18. Fig. 17.
Anilocra cauvicauda Hale, 1926, p. 210. Figs. 7 a-i.
Anilocra longicauda Monod, 1934, p. 12. pls. XX, XXI, XXV A-C.
Anilocra longicauda Pillai, 1958, p. 134, pl. VI, Figs. 17-19 & pl. VII, Figs. 39-48.

Material

Two adult females were found attached to the nape region of *Polynemus tetradactylus* Shaw, caught near the mouth of the Pulicat Lake.

Colouration : Specimens are olive green above and reddish below.

Dimensions (in mm of the largest specimen) :

Total length	29.0
Length of cephalon	2.5
Breadth of fifth peraeonite	7.5
Length of telson	7.0

Remarks : This is the first record of this species from Pulicat Lake.

Genus : *Cymothoa* Fabricius

Cymothoa krishnai sp. nov.

(Plate I C and Fig. 1 k-v)

Material

Thirteen females and five males were collected from seventeen individuals of eight different

species of fish caught from different localities on the Pulicat Lake.

Female : Body short but stout, obovate and slightly asymmetrical. Cephalon triangular, with a blunt front, constricted at the antennal area and slightly bent inwards. Posterior border of cephalon convex, with the postero-lateral angles prominent ; cephalon sunk in the first peraeonite. Eyes very faint.

Antennae partially exposed, first antenna (Fig. 1 k) stout and eight segmented ; second antenna (Fig. 1 l) also eight segmented but slender, terminal segment with short setules.

Mandible (Fig. 1 m) with a three jointed stout palp, terminal segment small with a few apical setules. Incisor and molar less differentiated.

Maxilliped (Fig. 1 p, q) three segmented, distal segment small with four blunt spines.

First maxilla (Fig. 1 n) with the usual four hooks. Distal portion of second maxilla (Fig. 1 o) bilobed, inner lobe with one and the outer lobe with two apical hooks.

Peraeonites one to four of sub-equal length ; first peraeonite (Fig. 1 t) narrow and long, anterolateral parts produced and acute, posterior margin convex. Second to fifth peraeonites gradually broadening, their posterior margins convex, that of the fifth less convex. Peraeon broadest at the fifth peraeonite. Sixth and seventh short and narrower than fifth, with their posterior margins concave, seventh peraeonite (Fig. 1 u) with deeply concave posterior margin, its postero-lateral parts extending upto the last pleonite. Coxal plates not extending to the posterior border of peraeonites.

Legs (Fig. 1 r, s) prehensile, gradually increasing in length and terminating in curved dactyli. Seventh leg (Fig. 1 s) longest with its second segment long and inwardly produced into a blunt process.

Pleon triangular, immersed in peraeon with a broad median ridge ; pleonites of subequal length but increasing in breadth posteriorly. Telson broader than pleon and about twice as broad as long, its posterior margin straight. Peduncle of uropods (Fig. 1 v) inwardly produced ; uropods shorter than telson, outer ramus slender and slightly longer than the inner ramus, both rami with a few plumose apical setules.

Colouration : Body uniformly coloured with dark brown pigment on the dorsal side of cephalon, peraeon, pleon and proximal portion of telson.

Total length : 12.0 to 32.0 mm

Male : Body oblong (Plate I C), sides sub-parallel. Cephalon triangular and sunk in the first peraeonite. Eyes large and conspicuous. First peraeonite long, antero-lateral angles produced. Peraeonites two to three of subequal length and equal to fifth ; fourth peraeonite long, its posterior margin straight. Sixth peraeonite short, its posterior margin concave. Peraeon broadest at sixth segment. Seventh shorter than sixth, its posterior margin arched. Coxal plates prominent. Pleon narrow and sunk in the peraeon. Telson as broad as long and broader than pleon. Uropods short with apical setules.

Discussion

This species resembles *Cymothoa indica* Sch. & Mein, but differs markedly in the nature of its appendages and in the general shape of the body. In *C. indica* the body is oblong with sides sub-parallel. In the present species, the body is obovate ; anteriorly the body is very narrow and posteriorly broadening to attain its maximum width at the fifth peraeonite.

The acute antero-lateral angles of the first peraeonite, the deeply arched seventh peraeonite and the inwardly produced second segment of the seventh peraeopod (Fig. 1 s, t, u) are the other

features which distinguish this species from *Cymothoa indica*.

C. indica Sch. & Mein, first described from Bangkok, Thailand has been recorded by Chilton (1924), from Chilka Lake where it is stated to infest the mouth of *Gobius giuris*, causing deformation of the host's tongue. Subsequently, Panikkar and Aiyar (1937) have recorded *C. indica* on *Etroplus maculatus, E. suratensis* and *Glossogobius giuris* from the Adyar Estuary. Evangeline (1963) has further reported the occurrence of this parasite, in the Adyar fish farm, from a variety of hosts, *viz., Etroplus suratensis, Tilapia mossambica, Macrones gulio, Gobius giuris, Polynemus tetradactylus, Pomadasys hasta* and *Sphyraena obtusata*. It is thus clear that *C. indica* exhibits a wide geographic and host distribution.

Similarly *C. krishnai* sp. nov. has been noticed to be frequently occurring in several different species of fish of the Pulicat Lake, *viz, Polynemus tetradactylus, Lutjanus johnii, Lutianus argentimaculatus, Mystus gulio, Arius nenga, Nematalosa nasus* and *Chanos chanos*, besides *Platycephalus insidiatrix*.

C. indica has been reported to infest the buccal region and the gill chamber of the host, but *C. krishnai* has been noticed to infest several regions like the chin, nape and pectoral fin base and the buccal cavity. It has never been observed to inhabit the gill chamber of the host.

This species is named in honour of Dr. N. Krishna Pillai, Trivandrum, S. India.

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CASE REPORTS OF DISEASES OF SOME MARINE TELEOSTS, IN AND AROUND VISAKHAPATNAM HARBOUR

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ABSTRACT

During the course of routine haematological and biological studies on fishes obtained from Visakhapatnam Harbour and trawl catches from outside the harbour, abnormalities in some fishes have been observed.

Deviations from normal composition of blood cells were not uncommon under conditions of disease or physiological stress due to environmental perturbations. In the case of some aberrant specimens of *Elops saurus*, low total RBC count (1.24 million/mm³), reduced haemoglobin content (4.85 gm/100 ml) and change in the ratio of total WBC to RBC count from the normal 0.081 to 0.189 indicated anaemic condition of the fish. In both *Elops saurus* and *Gerres filamentosus* high percentage of immature cells was also observed associated with anaemia in the former and physiological stress in the latter.

Gonadial infection by the microsporidian *Nosema* sp. was observed in the case of *Nemipterus mesoprion* obtained from trawl catches. The infection resulted in the formation of gonadial tumours and consequent dwarfing of the ovaries and testes. Gonadial tumours were observed in 10 out of 190 specimens examined.

Epidermal tumours were observed in the head region of a marine teleost *Johnius* (*Johnieops*) *aneus* obtained from the trawl catches.

Physico-chemical and biological agents related to industrial and domestic wastes that are getting discharged into the Visakhapatnam Harbour may be considered as possible cause for the diseases warranting consideration in the location of fish farms for coastal aquaculture.

INTRODUCTION

THE PRESENT study concerns reports of the occurrence of tumours in *Johnius* (*Johnieops*) *aneus* (Srinivasa Rao and Janardhana Rao, 1979) and *Nemipterus mesoprion* caught off Visakhapatnam ; and irregularities in the blood composition of *Gerres filamentosus* (Usha Rani and Srinivasa Rao, 1979 a), *Elops saurus* (Usha Rani and Srinivasa Rao, 1979 b) and *Mugil cephalus* from the harbour waters. These abnormalities were observed during the routine examination of fish for biological and haematological studies. The causative factor for the tumours in *N. mesoprion* is known to be a protozoan parasite *Nosema* sp. The other abnormalities are attributed to the effects of pollution in the Visakhapatnam Harbour. The present study brings to light the adverse effects of pollutants of Visakhapatnam Harbour on the resident and coastal marine fishes and fishes of the harbour waters.

THE NATURE AND CAUSES OF FISH DISEASES

Ganapathi and Raman (1973) described the extent of pollution in Visakhapatnam Harbour. The pollution was due to the effluents from several sources like the Caltex Oil Refinery, the Coramandel Fertilisers, the Hindustan

Polymers and the Ore Handling Project. Their observations showed low oxygen values, widely fluctuating chlorinity and high concentrations of nutrient salts such as nitrates and phosphates besides the presence of heavy metallic ions namely copper, iron, lead, nickel, chromium, arsenic and also fluorides, phosphorus and oils from the industrial effluents. Some of these substances were in concentrations well above the normal tolerance level of marine organisms. Recently De Souza and Naqvi (1979) studied the concentration levels of various metals in different body tissues of *Mugil cephalus* from Visakhapatnam Harbour. They found heavy concentrations of iron, manganese, zinc and lead in the harbour waters as well as body tissues of the fish.

Epidermal tumours

Srinivasa Rao and Janardhana Rao (1979) described the occurrence of epidermal tumours in *Johnius* (*Johnieops*) *aneus* from the waters off Visakhapatnam. The catch was obtained from trawler operating outside the breakwater of Visakhapatnam Harbour on 21-11-1978. It was possible that the fish was exposed to the noxious influence of the waters from Visakhapatnam Harbour (pH values were as low as 6.0 ; extending upto 6 km from the effluent points—personal communication from A. V. Raman) at a time when the effect of pollution was severe and the susceptibility of the fish high.

Skin tumours are not uncommon among marine fish exposed to polluted waters. Oishi *et al.* (1976) mentioned about the high frequency of epidermal tumours of flatfish in the coastal waters of Hokkaido, Japan. The percentages of tumourous fish were 8.29 in inlets and 0.34 in areas facing a strait. A blood-red parasite *Philometra* was associated with the infection. Stich *et al.* (1976) reported that tumour prevalence reached 58% in young English sole and 100% in young Pacific cod populations from the waters off British Columbia. They suggested the possibility of a link between plaice papillomas and discharges from human activities, whereas no such correlation could be observed with cod tumours. The possible involvement of viruses and chemical contaminants was not excluded.

Gonadial tumours

Gonadial tumours were observed in 10 out of 190 (5%) of specimens of *Nemipterus mesoprion* collected during 26-12-1978 to 24-2-1979 off Visakhapatnam, while 90 other specimens collected outside the period were without any tumours. The tumours in varying degrees of development were full of the microsporidian parasite *Nosema* sp. Eight of the infected fish were males and the remaining two were females. In advanced stages of infection there were multiple tumours. The affected fish were in the size range of 10.9 to 13.9 cm and exhibited signs of retarded growth.

Narasimhamurty and Kalavati (1972) reported the occurrence of two new species of microsporidian parasites (*Pleistophora sauridae* and *Nosema sauridae*) from the visceral muscles of *Saurida tumbil*. They also noticed *N. nemipteri* from the gill filaments of *Nemipterus japonicus* (personal communication) caught in the trawl nets from the near shore waters of Visakhapatnam. Their observations also support the prevalence of *Nosema* sp. infecting some marine fishes off Visakhapatnam.

McVicar (1975) stated that he was not aware of any published information dealing directly with microsporidian infection in marine fish. He observed infection of *Glugea* (*Nosema*) *stephani* among plaice, *Pleuronectes platessa* under cultivation and viewed the observation with some concern as the infection could become fatal. He achieved experimental oral transmission of the parasite and showed that the parasite becomes virulent with rise in temperature, when the fish did not possess any innate resistance.

Sneiszko (1974) reviewed the effects of environmental stress on outbreaks of infectious diseases of fishes and showed that parasites get hold of the host under conditions of environmental stress. Mawdesley-Thomas (1972) also stated that disease is an interaction between the host, the pathogen and the environment.

Gonadial infection by *Nosema* sp. has not been reported earlier. It got deleterious effects on the fecundity and normal growth of the fish. Since the infection was not observed after the period 26-12-1978 to 24-2-1979, it is quite possible that the particular batch of fish were exposed to environmental stress in the vicinity of the Visakhapatnam Harbour when they were young and contracted the infection. McVicar (1975) also showed that more than half of the heavily infected fish were recorded in the first 6 months of sampling. It is also worth mentioning in this connection that the peak period of the *N. mesoprion* fishery at Visakhapatnam was during the period when infection was at its maximum.

Abnormalities in the blood composition of some harbour water fishes

Differential counts and cytomorphology of blood cells were studied (Usha Rani and Srinivasa Rao, 1979 a) in *Gerres filamentosus* from Visakhapatnam Harbour. They noticed abnormal features like presence of hasophilic normoblasts along with other immature cell types like haemoblasts, polychromatocytes, prolymphocytes and progranulocytes. These cell types were observed in March samples, when the conditions in the harbour showed a marked rise in surface temperature (as high as 36°C) within the shallow creeks adjoining the north arm of the harbour from where the fish were collected. Detailed hydrographical and biological observations (A. V. Raman, personal communication) indicated that dissolved oxygen fluctuated diurnally in the harbour waters and that the accumulated organic matter imposed additional stress on the fishes, particularly during summer months (March-June) when the rate of decomposition due to bacterial action was high. The highly polluted and hypoxic conditions resulted in the appearance of immature blood cells indicating inflammation or infection in the fish due to stress. However, the fish did not show any symptoms of disease.

Usha Rani and Srinivasa Rao (1979 b) reported anaemia in *Elops saurus* collected from the harbour waters. The anaemic fish obtained in samples during August 1977 showed low RBC count, increase in the WBC along with slight increase in MCH (mean corpuscular haemoglobin). Anisocytosis (dissimilar erythrocytes) was also observed. The leucocyte composition also showed significant deviations. The anaemic fish had granuloblasts and small haemoblasts. Other prominent changes observed were increase of neutrophils and decrease of thrombocytes and a slight increase in erythroblasts. Presence of immature cells along with reduced RBC, haemoglobin and haematocrit indicated anaemia due to some infection which was not apparent in the form of any lesion.

In addition, anaemia observed in two specimens of *Mugil cephalus*, one of which had an intestinal tumour. In the tumoured fish RBC count, WBC count, haemoglobin content and haematocrit values exhibited a greater decrease. However, there was no variations in MCH between healthy and the diseased fish.

Discussion

The stress conditions in the aquatic environment are such that they lower the innate resistance of the fish during unfavourable conditions (Sneiszko, 1974). The situated gets aggravated in the local harbour under unfavourable conditions when the dissolved oxygen is low or free carbon dioxide is high. Ganapati and Raman (1973) reported mass mortalities of fish in the Visakhapatnam Harbour due to

asphyxiation arising out of a complex of unfavourable conditions. These mortalities were observed in the early hours of the day, when dissolved oxygen under the influence of a high phytoplankton production gets depleted. In the presence of sublethal amounts of toxic substances, which otherwise remain innocuous during day time, the hypoxic conditions produce a synergistic effect overwhelming the fish populations. Larsson *et al.* (1976) stated 'Elimination of aquatic animals by small, insidious physiological or behavioural changes can be regarded as more serious than a massive kill since the latter is likely to be observed and corrected.' Effects of the sublethal concentrations of toxic substances in and around local harbour waters as revealed by the infections, tumours and changes in the blood composition of fishes warrant, therefore, careful consideration.

Hypoxic conditions may also arise in the brackishwater fish farms which are subjected to excessive fertilization for the production of rich phytoplankton as live feed for the fry and adult fish. In mariculture, intensive fish farming is inevitable to make it economically viable. These fish farms are necessarily located near big cities or towns where there is demand for quality fish. Such areas are also subjected to various degrees of pollution due to proximity of industrial and domestic effluents. In addition, the fish farmer should also anticipate toxic endogenous concentrations of ammonia and try to keep the waters at a stable pH level to reduce the adverse effects. Otherwise, due to the limited horizontal movement of water caused by tidal action, as in the harbour waters, even sublethal levels of toxic substances like ammonia and other toxic metabolites might result in the mass mortalities of fish. These facts have to be borne in mind in the future expansion programmes of intensive brackishwater culture along the coast.

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ACUTE TOXICITY OF PETROLEUM HYDROCARBONS TO THE ESTUARINE FISH *THERAPON JARBUA* (FORSSKAL) AND THE ESTUARINE CLAM *KATELYSIA OPIMA* (GMELIN)

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ABSTRACT

The acute toxicity values (LC_{50}) of 6 petroleum hydrocarbons, namely cyclohexane, benzene, toluene, phenol, xylene and naphthalene, were determined for the crescent perch *Therapon jarbua* (Forsskal) and the inflated clam *Katelysia opima* (Gmelin), both estuarine animals, during static bioassay studies. The fish appears to be more sensitive than the clam to all the 6 hydrocarbons. The bi-aromatic hydrocarbon, naphthalene, was seen to be the most toxic petroleum-associated hydrocarbon for both the test species. The greatest resistance was shown by both the fish and the clam to the cyclic hydrocarbon, cyclohexane. The monoaromatic hydrocarbon, benzene and its derivatives, phenol, toluene and xylene, give acute toxicity values which are intermediate between those calculated for naphthalene and cyclohexane. The possible causes of the differences in the toxicity of the tested hydrocarbons and in the susceptibility of the 2 animal species to these hydrocarbons are discussed.

A short note is added on the histopathology of some tissues like the gill, intestine and liver from the fish exposed to the lethal concentration of naphthalene for 4 days.

INTRODUCTION

THE GROWING problem of oil contamination of the world's water masses has attracted attention of many aquatic biologists and consequently, the literature is replete with reports on the toxicity of various oils, crude as well as refined, to aquatic organisms. However, the complexity of the chemical compositions of these oils, which may vary due to various factors like source of the oil and the weathering and degrading processes that occur in the natural aquatic environment, make the study of the individual oil components equally significant. These studies may offer some explanation for the differences in the effects of various oils on different aquatic organisms.

A few workers like Shelford (1917), Meyerhoff (1975) and Benville and Korn (1977) have reported on acute toxicity of different petroleum hydrocarbons to different fishes. An excellent account of the acute toxicity values of many petroleum hydrocarbons, among other organic pollutants, has been given by Verschueren (1977).

During the course of the present investigation, experiments were conducted to determine acute toxicity of some petroleum hydrocarbons to 2 estuarine organisms, namely the crescent perch *Therapon jarbua* (Forsskal) and the inflated clam *Katelysia opima* (Gmelin). The 5 lower aromatic hydrocarbons (benzene, toluene, phenol, xylene and naphthalene) were selected because of their relatively greater toxicity as reported by Anderson *et al.* (1974) and Moore and Dwyer (1974). The cyclic hydrocarbon, cyclohexane was selected for comparison. Histological effects on gills,

intestine and liver caused by the acute exposure to naphthalene were also studied.

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Material and Methods

The fish specimens were collected from the Versova Creek, while the clams were obtained from Dahisar, both around Bombay, Maharashtra. The fishes were acclimatized to the laboratory conditions for 8 weeks prior to the bioassays. The acclimatization period for the clams was 2 weeks. During this period, the organisms were maintained, at room temperature and under natural light and dark cycles in large aquaria in sea water of appropriate salinity (31.5‰ for the fish and 29.0‰ for the bivalve). The fish were daily fed a diet consisting of live *Tubifex* and groundnut cake. *K. opima* were not fed during the 2 week acclimatization period owing to the observation that they thrived well in the sea water, presumably feeding on plankton present in the water. In both the species, some of the stocks were discarded because they exhibited high mortality rates during this period.

Following their successful acclimatization, animals were randomly selected for the bioassays, though care was taken to choose only healthy animals of a relatively uniform size (Fish — 1.025 ± 0.040gms ; bivalve — 4.300 ± 0.150 gms). The static bioassay procedure prescribed by the American Public Health Association (1971) was followed to determine the acute toxicity values (LC_{50}) of the hydrocarbons. In most cases, the LC_{50} values were obtained by experimenting with increasingly narrower ranges of the hydrocarbon concentrations, whereas in others the values were calculated by log-probit analyses.

During another experiment, a group of the fish was subjected to a lethal concentration (LC_{50} for 96 hours) of naphthalene for 4 days. The surviving fish were dissected to remove gills, intestine and liver which were fixed overnight in Bouin's fixative. The procedures described by Thompson (1966) for subsequent paraffin embedding and staining with hematoxylin and eosin were followed. Sections of the same tissues from unexposed fish were also prepared and comparison of the histological observations was made.

Results and Discussion

The LC_{50} values of the 6 hydrocarbons in case of *T. jarbua* are presented in Table 1. The data indicate that the fish is most sensitive to naphthalene. This hydrocarbon is followed, in the decreasing order of toxicity, by phenol, benzene, xylene, toluene and cyclohexane. Comparison of the LC_{50} values shows that naphthalene is about 2 times as toxic as phenol, 4 times as toxic as benzene and xylene, 6 times as toxic as toluene and about 30 times as toxic as cyclohexane during the initial 24 hours of exposure. However, these ratios are reduced when the experimental exposure period is extended to 96 hours.

Table 1. *Acute Toxicity* (LC_{50} *Values in ppm*) *of Hydrocarbons to* Therapon jarbua

Hydrocarbon	Exposure Period			
	24 hrs	48 hrs	72 hrs	96 hrs
Cyclohexane ..	660	635	625	610
Benzene ..	96	94	88	84
Toluene ..	142	136	131	128
Phenol ..	49	44	41	40
Xylene ..	102	95	92	89
Naphthalene ..	22.5	20	18	15.5

Compared to the fish, the clam *K. opima*, appears to be much less sensitive to all the

6 hydrocarbons (Table 2). But like the fish, *K. opima* was also observed to be most susceptible to naphthalene, whereas the highest resistance was shown for cyclohexane. The order of toxicity of the hydrocarbons to the clam is the same as in case of *T. jarbua*, but the ratios of the acute toxicity values of naphthalene to those of the remaining 5 hydrocarbons are not as high.

TABLE 2. *Acute Toxicity (LC_{50} Values in ppm) of the Hydrocarbons for the clam* Katelysia opima

Hydrocarbon	Exposure Period			
	24 hrs	48 hrs	72 hrs	96 hrs
Cyclohexane ..	1,525	1,475	1,470	1,420
Benzene ..	225	205	195	190
Toluene ..	250	245	235	225
Phenol ..	138	128	122	117
Xylene ..	240	220	205	190
Naphthalene ..	74	68	64	57

This remarkable difference in the degree of sensitivity of the more susceptible fish species on one hand and the hardier bivalve on the other can be easily explained. Whereas the fish is unable to avoid contact with the dissolved hydrocarbons which can easily enter the body tissue through gills, the clams possess an excellent armour in the form of the thick calcareous shells. The clams were observed to close these valves tightly when they were introduced into the hydrocarbon contaminated water. The entry of the water-borne hydrocarbons into the clam tissues through the respiratory currents was thus very effectively curtailed during the initial stages of exposure. Similar closure of valves in *K. opima* when the water conditions are unfavourable has also been reported by Ranade (1964). This view is also supported by the experiments carried out by Clarke *et al.* (1974) and Anderson (1975). Their studies have provided evidence to show that clams accumulate in their tissue smaller concentrations of petroleum hydrocarbons than do the shrimps and mussels. The shrimps and mussels are more sensitive to attack by the pollutants, for the former lack the completely enclosing armour while the latter do not have any means of closing the byssal openings.

As regards the clams another interesting observation was made during the present investigation. Significantly high mortality rates were noticed in those groups of clams which had been exposed for 4 days to hydrocarbon concentrations that were lower than their LC_{50} levels, within 15 days of transferring them to clean water. Rice *et al.* (1977) have discussed the significance of delayed mortality, a term describing occurrence of deaths after termination of the exposure period, which may be seen in animals such as molluscs. Keck *et al.* (1978) have also recorded cases of delayed mortality in bivalves exposed to oil.

Regarding the comparative toxicities of the 6 hydrocarbons in case of both the test species, the evidence clearly indicates that the aromatic hydrocarbons are more toxic than cyclohexane which is a cyclic hydrocarbon. Indeed, the LC_{50} values of cyclohexane for both the organisms are so high that it can be considered to be non-toxic. Wallen *et al.* (1957) have also observed that cyclohexane is considerably less toxic than the aromatic hydrocarbons.

The more soluble, lower boiling aromatic hydrocarbons have also been implicated as the most toxic components of oil, as is apparent from the work of Anderson *et al.* (1974), Moore and Dwyer (1974) and Corner *et al.* (1976). According to Nelson-Smith (1972) the wide range of the degree of toxicity of various crude oils reported by Ottway (1971) may also be related to the proportion of lower aromatics in these oils. It is possible that due to greater solubility and lesser degradability of these aromatic hydrocarbons, they are more persistent and hence, may be absorbed and accumulated to a greater extent. This may result in the

lower aromatic hydrocarbons being the most toxic of the petroleum components.

Among the lower aromatics tested during the present study, naphthalene is the most toxic. This may also be due to the difference in accumulation of these hydrocarbons in the animal tissues. Anderson (1975) has shown that regardless of the species of the test animal, the exposure time or the concentration of dissolved oils, naphthalene and its derivatives are predominantly and rapidly accumulated by the animal tissues. Further evidence in support may be derived from the work of Rouball *et al.* (1977). They have suggested that the aromatic hydrocarbons are absorbed and accumulated by the key organs of fish in relation to the number of benzenoid rings in the hydrocarbon molecules. Among the 5 aromatic hydrocarbons whose toxicity was assessed during the present study, naphthalene is the only compound with 2 benzenoid rings. It is therefore possible that the animals are most susceptible to naphthalene due to the rapid and more extensive invasion of the tissues by naphthalene.

Most of the work on aquatic oil pollution carried out to date has been directed towards determining the toxic levels of oils and the constituent hydrocarbons and the extent of their uptake by the aquatic animals. Very little attention has been given to studies of their effects on the structure and function of the animal tissues. An attempt is therefore made in this study to assess the histopathological changes in some important tissues from *T. jarbua* exposed to the acute lethal concentration of naphthalene which, as described earlier, is the most toxic hydrocarbon.

All the fish surviving the exposure showed extensive gill hyperplasia. The lesions were seen to cover large areas. Large haemorrhagic sites were also observed, particularly towards the base of the gill filaments. Similar effects were observed by DiMichele and Taylor (1978) in *Fundulus heteroclitus* exposed to lethal concentrations of naphthalene. But such effect, if detected in fish collected from the field, cannot be imputed to this hydrocarbon alone. Gardner (1975) has shown that hyperplasia of gill epithelium in fish may be induced by many pollutants. Furthermore, parasitic infections of gills can also evoke a similar response in fish. Gill hyperplasia appears to be stimulated by almost any irritant that comes in contact with the gill surface.

The intestinal mucosa was also severely affected. Extensive necrosis and sloughing of the mucosa was recorded in all the exposed fish. DiMichele and Taylor (1978) detected such effects only in mummichogs exposed to very high concentration. In their experiments, sublethal concentrations failed to affect the intestine during an exposure period of 15 days. The lesser degree of damage to the intestinal tissues as compared to the gills may be ascribed to the fact that the pollutant has little access to the intestines, whereas gills continue to be in contact with the dissolved pollutants.

Lesions were also found in liver of fish exposed to naphthalene. Large areas of the liver were extensively damaged. According to DiMichele and Taylor (1978) naphthalene poisoning causes blood stasis that results in ischemia of tissues like liver, pancreas and brain. However, as liver is the major active site of metabolism of foreign substances including the polluting hydrocarbons, it is possible that the absorbed naphthalene is increasingly routed to the liver. The subsequent accumulation of naphthalene in liver may directly affect the tissue and cause liver necrosis. Disturbances of the membrane structure in fish by naphthalene has been reported by Sabo and Stegeman (1977).

In conclusion, it can be stated that the petroleum hydrocarbons exhibit more severe effects on fish than on the molluscs. In the natural waters, particularly in areas continuously receiving large quantities of effluents from petroleum refineries and other industries, the effects may be still more damaging. Even

individual spills in small, closed areas may exert a remarkable effect, as is evident from the histopathological investigation. Damage of gills by these acute exposures may reduce the oxygen supply to the tissues, resulting in physiological disturbances. Deviations in physiological processes due to naphthalene have been indicated by our other investigations (Dange, 1979). Culture efforts in such localities would be highly uneconomical, not only because of the unpalatability of the fish as a result of the kerosene-like taint, but also because of retarded growth due to the adverse effects on the metabolic activities of the organisms.

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TOXICITY OF TOLUENE : EFFECT OF AMINOTRANSFERASES IN DIFFERENT TISSUES OF *TILAPIA MOSSAMBICA* (PETERS) ADAPTED TO SEA WATER

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ABSTRACT

Effects of 10 weeks' exposure to 2 sublethal concentrations (25 ppm and 50 ppm) of toluene, a major water soluble and toxic component of various crude oils, on the protein metabolism, as reflected by changes in the activities of aspartate aminotransferase or AAT (EC 2.6.1.1.) and alanine aminotransferase or AlAT (EC 2.6.1.2.) in the gill, kidney, intestine, brain, liver, skeletal muscle, cardiac muscle, ovary and testes of the euryhaline cichlid fish *Tilapia mossambica* (Peters) adapted to 50% sea water, have been investigated. The activities of both the enzymes were seen to be significantly elevated in all the selected tissues of the fish following exposure to either concentration of the polluting hydrocarbon. The changes in liver, brain and muscles were most significant It was further observed that in nearly all the exposed fish, the activity of AlAT was stimulated to a greater extent than that of AAT. The elevated aminotransferase activities indicate increased protein metabolism which was evident in the reduction in the soluble protein and free amino acid contents in the tissues of toluene-treated fish. These changes are probably related with impaired carbohydrate metabolism in the stressed fish. It is suggested that the changes may possibly be due to a stress-induced increase in the circulating levels of the glucocorticoid hormone, cortisol.

INTRODUCTION

IN FISH toxicological studies, involving observations on changes in enzyme activities in different tissues, the aminotransferases have been largely ignored. Moreover, whatever few reports are available deal only with the symptomatic aspects of these changes (Bell, 1968; Lane and Soura, 1970; Kristoffersson *et al.*, 1974), whereas very little attention has been given to the physiological significance of such alterations.

The purpose of the study reported here was to investigate effects of sublethal concentrations of toluene, a relatively abundant component of the water-soluble fractions of petroleum and petroleum products, on the activities of aspartate aminotransferase (AAT) (EC 2.6.1.1) and alanine aminotransferase (AlAT) (EC 2.6.1.2) from various tissues of *Tilapia mossambica* (Peters). Effects on the soluble proteins and total free amino acids from liver and skeletal muscle were also studied.

Though basically a freshwater fish *T. mossambica* has a wide range of salinity tolerance and is known to inhabit estuarine waters. Since the problem of oil pollution is more rampant in the seas, it was originally decided to use fish which were naturally adapted to sea water. But such locally available fish were deemed unfit for the present study, as the area from which they are collected, namely Thane Creek, is very highly polluted and it was believed that this previous exposure to a variety of pollutants would interfere with the effects of the test pollutant. Therefore, fish obtained from a pollution-free freshwater body were adapted to sea water in the laboratory prior to their treatment with toluene.

One of the authors (ADD) is grateful to the C.S.I.R., New Delhi for the award of the Junior Research Fellowship.

Material and Methods

The fish needed for the experiment were collected from Shivaji Lake, Thane, Maharashtra and transferred to the laboratory where they were held in large stocking aquaria containing weathered, well aerated tap water for 6 weeks. The fish were then gradually adapted to 50% sea water by first acclimatizing them to 10%, 20%, 30% and 40% sea water, successively. They were maintained for one week at each concentration before subjecting them to the next higher concentration. The acclimatization period in 50% sea water was extended to 4 weeks.

Following the adaptation to sea water, the fish were divided into 3 groups. Fish from a very narrow size range (average wt. 12 ± 1.5g) were selected since the enzyme activities in this fish have been reported to vary according to size (Mansuri and Pandya, 1977).

The experiments were carried out in 35 l aquaria containing 50% sea water. The quality of water was maintained at conditions prescribed by the American Public Health Association (1971). The temperature was 28.9 ± 0.7°C; dissolved oxygen was 8.3 ± 0.3 ml/l; pH was 7.5 ± 0.2; and salinity was 16.7 ± 0.5‰. The acclimatization period was continued for one more week in the experimental aquaria.

Subsequently, the fish were exposed to the two sublethal concentrations of toluene (25 ppm and 50 ppm) for a period of 10 weeks. These concentrations were selected on the basis of preliminary experiments in the laboratory. During the static exposure system adopted for the present study, the test solutions were changed daily in order to maintain somewhat constant levels of the hydrocarbon in water, although unfortunately it was not possible to avoid some loss of toluene by evaporation and also due to action of some hydrocarbon degrading bacteria (*Pseudomonas* sp.) which were identified from samples of the test water.

During the acclimatization and exposure periods, the fish were fed daily to satiation on live *Tubifex*. The diet was supplemented once a week with groundnut cake.

At the end of the exposure period, the fish were killed by decapitation and the selected tissues were immediately excised. The tissues were homogenized with 10 volumes of distilled water in a teflon tipped, power driven glass homogenizer for 5 minutes, followed by centrifugation at 10,000 rpm for 15 minutes.

The clear supernatents were used as enzyme source during the assays.

The activity of the aminotransferases was determined according to the method of Reitman and Frankel (1957) and is expressed as units of enzyme activity/hr/mg tissue. The unit is defined as the amount of enzyme which catalyses the turnover of 1 μ mole of substrate per minute under the assay conditions.

The proteins were estimated by the method of Lowry *et al.* (1951). Crystalline bovine serum albumin was used as the standard. The method described by Rosen (1957) was followed for determination of the total free amino acids.

The changes in the enzyme activities and protein and free amino acids in the toluene-tested fish as compared to the control fish were tested for statistical significance at $P<0.01$ and $P<0.001$ according to Student's 't'—test (Spiegel, 1961).

Results and Discussion

The evidence obtained during the present investigation reveals that the activities of AAT and AlAT from all the selected tissues were

elevated in both the toluene-treated fish, though this change was more extensive and statistically more significant in the tissues of the fish exposed to the higher concentration (50 ppm) of toluene (Tables 1 and 2).

The mode of action of the pollutants and the exact relationship between the pollutants and the changes in enzyme activities have not been satisfactorily established. But perusal of relevant literature gives indication that this

TABLE 1. *Effect of toluene on AAT activity from different tissues of* T. mossambica

(Values are mean ± S.D. Values in parentheses indicate the change in enzyme activity as compared with the control. Activity is expressed as units of AAT activity/hr/mg tissue)

Tissue	Control	Expt I (25 ppm)	Expt II (50 ppm)
Gill ..	1.99 ± 0.20	2.42 ± 0.16* (+ 21.61%)	2.58 ± 0.17† (+ 29.65%)
Kidney ..	1.94 ± 0.12	2.35 ± 0.19* (+ 21.13%)	2.56 ± 0.19† (+ 31.96%)
Intestine ..	1.68 ± 0.18	1.93 ± 0.21 (+ 14.88%)	2.11 ± 0.12* (+ 25.60%)
Brain ..	2.27 ± 0.16	2.69 ± 0.15† (+ 18.50%)	2.82 ± 0.18† (+ 24.23%)
Liver ..	2.17 ± 0.18	2.91 ± 0.23† (+ 34.10%)	2.90 ± 0.09† (+ 33.64%)
Skeletal Muscle ..	1.90 ± 0.13	2.49 ± 0.15† (+ 31.05%)	2.55 ± 0.18† (+ 34.21%)
Cardiac Muscle	2.34 ± 0.19	2.98 ± 0.11† (+ 27.35%)	3.16 ± 0.14† (+ 35.04%)
Ovary ..	1.46 ± 0.10	1.71 ± 0.19 (+ 17.12%)	1.80 ± 0.15* (+ 23.29%)
Testes ..	1.72 ± 0.16	2.07 ± 0.18* (+20.35%)	2.03 ± 0.11* (+ 18.02%)

*: $P < 0.01$; †: $P < 0.001$

Comparable data on effect of pollutants on fish aminotransferases are scanty. But during a second set of experiments, naphthalene, another important toxic hydrocarbon, was also observed to effectively enhance activities of these enzymes in *T. mossambica* (Dange, 1979). A few other workers like Bell (1968), Lane and Scura (1970) and Kristoffersson *et al.* (1974) have also recorded increased activities these enzymes in tissues of fish exposed to different pollutants.

increase in the aminotransferase activity is the result of a rise in serum concentrations of glucocorticosteriod hormones like cortisol due to exposure of fish to pollutants. Grant and Mehrle (1973), Donaldson and Dye (1975) and DiMichele and Taylor (1978) have reported that on exposure to environmental pollution fish respond with increased levels of serum cortisol. When injected into fish, cortisol is known to stimulate aminotransferase activities

in tissues like liver (Storer, 1967; Chan and Woo, 1978).

By extending these observations to the present study, it is possible to suggest that the stress caused by the presence of sublethal concentration of toluene in surrounding water induces an increase in production of cortisol which stimulates the enzyme activities in *T. mossambica*. In this context, it should be noted that according to results obtained by Storer (1967) and Chan and Woo (1978), AlAT is more sensitive than AAT to cortisol treatment. Therefore, the observation that the elevation in activity of AlAT is greater than that calculated for AAT in most tissues of the exposed fish perhaps reflects this natural difference in the sensitivity of the two enzymes.

Further significance of the changes observed following treatment of *T. mossambica* with toluene lies in the controversy over the relationship between the activity of these enzymes and protein metabolism. This controversy arises out of conflicting evidence recorded by different workers, which has been reviewed by Meister (1955). The present study corroborates the view suggesting catabolic action of aminotransferases during protein metabolism. This conclusion is based on the fact that the increase in aminotransferase activity was accompanied by reduction in the proteins and total free amino acids in liver and skeletal muscle (Table 3).

The decrease in protein and amino acid contents indicates that large scale proteolysis in fish tissues is initiated by toluene, probably in order to meet the increased metabolic demands of life under stressful conditions. It is likely that the proteins are extensively catabolised to compensate for abnormal carbohydrate metabolism. Such faulty and excessive depletion in glycogen stores occurred when *T. mossambica* were exposed to sublethal concentrations of naphthalene (Dange, 1979). This lends support to the view that aminotransferases have a rate limiting role in gluconeogenesis. The amino acids on which the two aminotransferases act have been included by Krebs (1943) among glycogenic amino acids, which can be oxidized to produce the corresponding keto acids of the TCA cycle. It is therefore contended that in toluene-treated *T. mossambica* the proteins were broken down and the resulting amino acids were routed to TCA cycle as a consequence of an impaired carbohydrate metabolism.

The results of the present study attain further significance when effects of an osmotic stress in fish experimentally adapted to sea water are considered. Vasantha (1964) holds the view that the increase in amino acid levels in tissues of such fish has a regulatory influence on the tissue chloride content. Data on other aquatic organisms supporting this theory has also been presented by Lockwood (1962). It is probably due to this adaptive variation that the values for amino acid content of liver and skeletal muscle from the sea water adapted fishes are greater than those reported for the freshwater fish (Dange, 1979). But the results of the experiment reported here show that exposure of sea water adapted *T. mossambica* to toluene caused a remarkable reduction in amino acids. Apparently, the two stresses are antagonistic in their effects on the amino acids. While the osmotic stress tends to increase the free amino acids in the tissues, the stress of exposure leads to their removal from the tissues. Since only a decrease in the amino acid content of liver and skeletal muscle was noticed during the present study, it seems that the stress of toluene exposure is more severe than the stress of a hyperosmotic environment. Therefore, a possibility exists that prior exposure of fish to pollutants reduces its ability to withstand wide fluctuations in salinity. Further investigations to establish occurrence of such a phenomenon would be of great importance during aquaculture studies, as the species considered suitable for coastal aquaculture should necessarily be able to tolerate the natural variations in salinity of the coastal waters.

TABLE 2. *Effect of toluene exposure on AlAT activity in few tissues of* T. mossambica

(Values are mean ± S.D. Values in parentheses denote the per cent change in the enzyme activity. Activity is expressed as units of enzyme activity/hr/mg tissue)

Tissue	Control	Expt I (25 ppm)	Expt II (50 ppm)
Gill ..	3.09 ± 0.31	3.87 ± 0.19† (+ 25.24%)	4.12 ± 0.30† (+ 33.33%)
Kidney ..	3.30 ± 0.38	4.22 ± 0.27† (+ 27.88%)	4.39 ± 0.41† (+ 33.03%)
Intestine ..	2.61 ± 0.19	3.16 ± 0.24* (+ 21.07%)	3.23 ± 0.31* (+ 23.75%)
Brain ..	3.89 ± 0.32	4.95 ± 0.26† (+ 27.25%)	5.14 ± 0.40† (+ 32.13%)
Liver	3.52 ± 0.26	4.79 ± 0.44† (+ 36.08%)	4.91 ± 0.34† (+ 39.49%)
Skeletal Muscle ..	3.14 ± 0.29	4.05 ± 0.28† (+ 28.98%)	4.32 ± 0.40† (+ 37.58%)
Cardiac Muscle ..	3.78 ± 0.43	4.97 ± 0.38† (+ 31.48%)	5.40 ± 0.39† (+ 42.86%)
Ovary ..	2.64 ± 0.26	3.04 ± 0.28 (+ 15.15%)	3.34 ± 0.18* (+ 26.52%)
Testes ..	2.80 ± 0.39	3.46 ± 0.31) (+ 23.57%)	3.57 ± 0.25* (+ 27.50%)

*: $P < 0.01$; †: $P < 0.001$.

TABLE 3. *Soluble protein and free amino acid (FAA) content (mg/g wt) from liver and skeletal muscle of* T. mossambica *after toluene exposure*

(Values are mean ± S.D. Change from the control levels is indicated by the values in parentheses)

	Control	Expt I (25 ppm)	Expt II (50 ppm)
Liver Proteins ..	191.56 ± 6.47	161.62 ± 8.51† (— 15.63%)	149.57 ± 7.36† (— 21.92%)
Muscle Proteins ..	108.92 ± 4.31	93.89 ± 5.49† (— 13.80%)	85.23 ± 5.84† (— 21.75%)
Liver FAA ..	34.28 ± 3.29	28.31 ± 2.11* (— 17.42%)	23.77 ± 1.73† (— 30.66%)
Muscle FAA ..	51.19 ± 2.16	44.68 ± 1.82† (— 12.72%)	40.39 ± 2.05† (— 21.75%)

*: $P < 0.01$; †: $P < 0.001$.

The results thus demonstrate that water pollution has an adverse effect on the nutritive value of aquatic organisms in that, the rapid and extensive protein breakdown results in a drastic reduction in body proteins. Since one of the major objects for conducting aquaculture studies is to make available increased quantities of fish proteins for human consumption, further research to verify such relationship is necessary.

Moreover, the changes in the enzyme activities in reproductive tissues (both the ovary and testes), as in the remaining tissues, point to the possibility of an adverse effect of pollution on the reproductive capacity of the organisms. The reduction in the fecundity values of *T. mossambica* exposed to sublethal concentrations of naphthalene and toluene (Dange, 1979) may have resulted from such abnormal metabolic activities in the ovaries. Similar deviations in the other tissues may lead to deterioration of the animal's health and further affect the ability of the animal to reproduce. The data thus clearly indicate that pollution, even in small quantities, may interfere with the normal metabolism and growth of the animals and subsequently make management of aquaculture projects difficult.

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STUDIES ON CHITINASE ACTIVITY AND CHITINOCLASTIC BACTERIA IN SEDIMENTS, FISHES AND PRAWNS

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ABSTRACT

The role of chitinoclastic bacteria as causative agents of certain shell diseases of shrimp, crab, lobster and crayfish is well documented. Besides, their activity is indispensible for the degradation of chitin in aquatic systems. Hence, a preliminary survey was conducted to assess the distribution of chitinoclastic bacteria and the chitinase activity in the sediments of Vembanad Lake and in selected aquatic animals. Twenty sediment samples were analysed for the total and chitinoclastic bacterial populations. All the samples showed the presence of chitinoclasts but their populations fluctuated widely from one sample to another (1×10^3 to 13.1×10^5/gm). Chitinoclastic bacterial populations were also estimated in the digestive tracts of selected fish and prawns. No detectable chitinase activity could be recorded in all the sediment samples tested. However, the enzyme activity was more pronounced in the alimentary tract of the animals examined. The possible ecological significances of the chitinoclastic bacteria are discussed.

INTRODUCTION

CHITIN forms the major structural and skeletal component of many invertebrate species and is one of the most abundant biodegradable polymers in the marine and estuarine environments. The biodegradation of chitin is brought about by a series of enzymes (chitinases and chitobiases) which are known to be secreted extracellularly by a variety of organisms including members of bacteria, fungi and actinomycetes (Jeuniaux, 1961 ; Okutani, 1966 ; Hood and Meyers, 1973 ; Micha *et al.*, 1973 ; Jeuniaux and Cornelius, 1978). A number of reports are available on the rates of chitin degradation under laboratory conditions (Seki and Taga, 1963 a, b ; Seki, 1965 a, b ; Chan, 1970), *in situ* marine and estuarine environments (Hood, 1973 ; Hood and Meyers, 1977) and in guts of several species of marine fish (Seki and Taga, 1963a ; Seki, 1965 a, b ; Goodrich and Morita, 1977 a, b). Among the micro-organisms capable of degrading chitin, bacteria are known to be the most common (Hood and Meyers, 1973 ; Timmis *et al.*, 1974) and they have been isolated from sediments, waters and chitin-containing organisms in the marine environment (Jones, 1958 ; Lear, 1963 ; Seki and Taga, 1963 a, b, c, d, 1965 a, b ; Chan, 1970 ; Kaneko and Colwell, 1975).

The role of chitinoclasts as the causative agents of certain diseases of aquatic animals has been well documented (Sindermann, 1974) and these chitinoclasts may be directly involved as primary pathogens (Rosen, 1970 ; Cook and Lofton, 1973 ; Young and Pearce, 1975 ; Baross *et al.*, 1978) or indirectly induce disease syndrome by toxin production (Krantz *et al.*, 1969 ; Tubiash *et al.*, 1970 ; Vanderzant *et al.*, 1970 ; Evelyn, 1971). These data clearly indicate the importance and diversity of chitinoclastic bacteria in the marine and estuarine environments. It is needless to emphasise the importance of crustacean culture in nearshore waters. In such intensive cultivation of aquatic

species, the quality of water and actual food conversion rates are the two essential considerations to achieve economic success. Most often the microbiological component of a given system plays a major role beneficially or adversely.

No information is available on the nature and concentration of chitinoclastic bacteria either in the sediments of Vembanad Lake or associated with aquatic animals of commercial importance. Unless the extent of chitinase activity in different niches is assessed properly, it will be difficult to ascertain the exact rate of chitin degradation. Hence a survey was conducted to quantify the chitinoclastic bacteria and chitinase activity in sediments and in digestive tracts of selected species of prawns and fish and the results are reported here.

We thank Prof. C. V. Kurian, Head of the Department of Marine Sciences for his interest in the work and suggestions. We also thank Dr. R. Damodaran, Reader, Department of Marine Sciences for his help in collection of some of the sediment samples.

Material and Methods

Sampling

Collections were made within the Vembanad Lake. Totally twenty stations were selected in such a way so as to represent the entire lake between Azhikode in north of Cochin and Alleppey in south (Fig. 1). The stations varied in their physico-chemical and biological properties. Sediment samples were collected with the aid of a Van Veen grab. The central portions of the grab samples were aseptically removed and placed in sterilized containers. The samples were kept below ambient temperature in portable ice chests and transported to the laboratory for microbiological analyses within 12 hours of collection. Prawn and fish samples were collected afresh for digestive tract analysis near Vypeen area and placed in sterile polythene bags. They were brought to the laboratory in an ice box within 2 hours of collection.

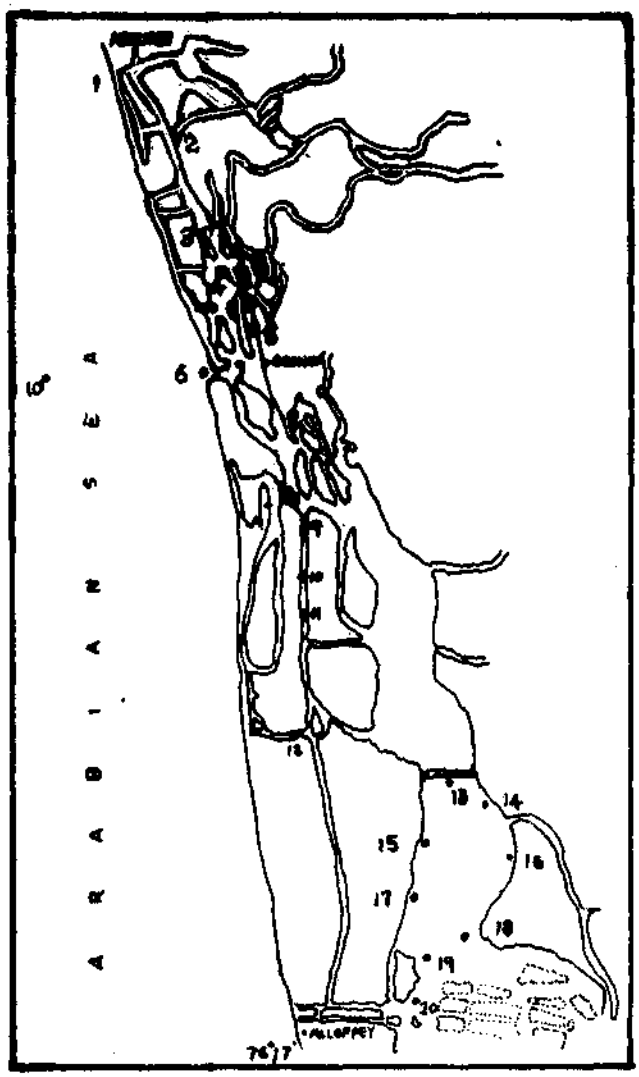

Fig. 1. Map showing the locations of sampling stations.

Preparation of Chitin and Chitin agar medium

Purified chitin was prepared from the exoskeleton of prawns using the procedure of Skermann (1967). The neutralized reprecipitated chitin was suspended in a minimal seawater salts solution (MSWS) of Goodrich and Morita (1977a) which contained most

major ions of seawater (g/l : NaCl, 24.0 ; Mg SO_4. $7H_2O$, 7.0; Mg Cl_2.6 H_2O, 5.3 ; KCl, 0.7; pH 7.5) or in tap water. The chitin suspension (0.25 g/ml) was autoclaved for 20 min. and stored at room temperature (28 ± 2°C). The chitin suspension was added to a basal medium (Yeast extract, 0.5 g : peptone, 1.0 g ; Agar, 15.0 g ; 50% MSWS or tapwater, 1.0 l ; pH, 7.5) so as to have a final concentration of chitin in the medium as 1.5%. The media were sterilized and stored at room temperature till use.

Preparation of samples

For bacteriological analysis, the sediment samples were serially diluted using sterile water blanks. The blanks were prepared either with 50% MSWS or tapwater and used depending on the place of sample collection. In the case of prawns and fish, the digestive tract was removed aseptically and the contents were squeezed into sterile water blanks and serially diluted.

For chitinase assay, the sediment samples were diluted 1 : 100 (W/V) in 50% MSWS or tap water and the gut contents of animals were transferred to sterile test tubes and diluted 1 : 10 (W/V) in 50% MSWS. These preparations were used as enzymes in enzyme assays.

Enumeration of chitinoclastic bacteria

One millilitre of the appropriate dilution of sediment/gut contents was placed in a sterile petridish and 20 ml of melted and cooled chitin agar medium was poured, mixed thoroughly and allowed to solidify. The plates were inverted and incubated at room temperature (28 ± 2°C) for a maximum period of 10 days : colonies which exhibited clearing zones around them indicating chitin utilization were counted. For total bacterial population colonies with and without clearing zones were counted. The bacterial populations were expressed per gm on dry weight basis.

Chitinase assay

A modified procedure of Jeuniaux (1966) as employed by Goodrich and Morita (1977a) was followed to determine levels of chitinase activity in various samples. For sediments, the assay mixture consisted of chitin suspension (5 mg/ml)—1.0 ml ; citric acid (0.6M), dibasic sodium phosphate (1.2M) buffer (pH 5.1)—1.0 ml ; sample (enzyme)—0.1-2.0 ml ; MSWS or tapwater—to make up a total volume of 4.0 ml. 0.5 ml of toluene was added to each flask (50 ml) containing the assay mixture to prevent bacterial action during the assay. For controls, the volume of chitin suspension was substituted with equal volume of water. Duplicate flasks were incubated in a waterbath at 35°C for 24 hours with occasional shaking. At the end of the incubation period, the contents of the flasks were centrifuged at 15,000 g for 15 min and the end product, N-acetyl-D-glucosamine (NAG) level in the supernatant solution was estimated.

For assaying the chitinase activity of the gut contents, the procedure and composition of the assay mixture were essentially the same as that used for sediments except incubation time which was only 2 hours. The colorimetric procedure employed for the determination of NAG has already been described (Goodrich and Morita, 1977a). Since a Hitachi Double beam recording Spectrophotometer (Model-200) was used in the present investigation, the NAG concentrations in various test solutions could be directly read as μg NAG. To determine the dry weight of each sample, one ml of each sediment and gut sample was added to a pre-weighed boat made of aluminium foil and dried in a oven to constant weight. The results were expressed as μg NAG produced/g dry weight/hr.

Results

In the present investigation, twenty sediment samples and gut contents of four species of prawns and seven species of fish were examined for the chitinoclastic bacterial population and

TABLE 1. *Chitinoclastic bacterial population and chitinase activity in sediments*

Station No.	Name of the stations	Nature of sediment	Total Bacteria (No./g.)	Chitinoclasts %	Chitinase activity (μgNAG/g)
1	Munambam	Clay	94×10^5	13.94	ND*
2	Cherai	Clay	75×10^5	1.33	NT**
3	Kadakkara	Clay	129×10^4	2.25	NT
4	Narakkal	Clay	72×10^5	1.66	ND
5	Vaduthala	Clay	61×10^5	2.12	ND
6	Barmouth	Clay	95×10^5	5.27	ND
7	Vypeen	Sandy Clay	15×10^4	9.33	ND
8	Aroor	Clay	88×10^4	1.73	NT
9	Arookutty	Clay	116×10^4	4.29	ND
10	Panavally	Clay	84×10^5	3.26	ND
11	Thycattussery	Clay	134×10^5	11.25	ND
12	Nedumbrakkad	Silty Clay	72×10^4	3.12	ND
13	Southern side of Thanneermukkam bund	Clay	156×10^5	8.16	NT
14	Vechoor	Clay	128×10^5	10.33	ND
15	Muhamma	Clay	132×10^5	11.35	ND
16	Karyil	Sand	113×10^3	1.13	ND
17	Manachery	Clay	96×10^5	4.13	ND
18	Muthencone	Clay	127×10^5	7.51	NT
19	Ariad	Clay	152×10^4	2.11	ND
20	Thattampally	Clay	116×10^5	1.56	ND

* ND — Not detected. ** NT — Not tested.

TABLE 2. *Chitinoclastic bacterial population and chitinase activity in the digestive tract of fish and prawns*

Specimen	No.* sampled	Weight (g) and Length (cm) of the specimens		Total Bacterial Population (No./g)	Chitinoclasts %	Chitinase activity (μg NAG/g/hr.)
Sciaena sussli ..	1	13.0 ;	8.8	312×10^6	89.75	251.00
S. albida	1	14.0 ;	9.2	320×10^6	62.50	98.00
Leiognathus brevirostris	2	10.0 ;	7.0	60.8×10^6	92.10	56.25
		10.0 ;	7.0			
L. equulus ..	2	10.0 ;	6.5	340×10^6	97.00	84.61
		8.0 ;	6.0			
Megalaspis cordyla ..	1	70.0 ;	17.0	202×10^6	98.00	705.88
Chironemus tala ..	2	25.0 ;	14.0	200×10^6	20.20	240.00
		13.0 ;	11.5			
Tylosurus strongylurus ..	1	52.0 ;	26.0	115×10^6	15.21	70.06
		3.33 ;	8.0			
Penaeus indicus ..	3	5.38 ;	9.3	7.5×10^6	66.67	123.52
		5.45 ;	9.3			
Metapenaeus monoceras ..	2	5.33 ;	8.0	6×10^6	8.33	72.34
		1.85 ;	6.0			
		1.63 ;	6.0			
M. dobsoni	3	1.90 ;	6.2	5.1×10^6	9.80	66.43
		1.93 ;	6.0			
Macrobrachium rosenbergii ..	2	135.0 ;	19.0	38×10^6	17.39	118.51
		56.0 ;	11.0			

* samples pooled before assay.

chitinase activity and the results are given in Tables 1 and 2. All the sediment samples were found to harbour chitinoclastic population (Table 1) and it ranged from 1×10^3 to 13.1×10^5/g (1.13% to 13.94% of total bacterial population). The sediment collected at station 16 was sandy in nature and harboured the least population of chitinoclasts. The population fluctuated widely from station to station. The gut contents of all the fish and prawns examined harboured chitinoclastic bacterial population (Table 2). Among the fishes, *Leiognathus brevirostris*, *L. equulus* and *Megalaspis cordyla* harboured maximum percentage of chitinoclastic bacterial population. In the case of prawns, with the exception of *Penaeus indicus*, generally low levels of chitinoclastic bacterial population were recorded. All species assayed exhibited some level of chitinase activity associated with the gut contents (Table 2). Maximum activity (705.88 μg NAG/g/hr) was recorded in *Megalaspis cordyla*. There was no direct relationship between the chitinoclastic bacterial population and chitinase activity. The sediments exhibited no detectable levels of chitinase activity. Various combinations of the enzyme assay mixture were tried and still no chitinase activity could be detected in sediments tested.

Discussion

The fact that all the sediment samples and animals examined yielded chitinoclastic populations suggests that marine environment is a very potential source of chitinoclastic bacteria. The percentage of chitinoclasts recorded in sediments currently seems to be much higher than some of the earlier reports and in general sediments harbour a higher chitinoclastic population than the overlying water (ZoBell and Rittenberg, 1938; Seki and Taga, 1963 a; Chan, 1970). From the present investigation it is clear that clayey sediments normally harbour higher percentage of chitinoclasts possibly because of higher organic matter content. After a detailed study, Hood (1973) concluded that distribution of chitinoclastic bacteria in a given environment appeared to be related to (i) organic matter content (ii) chitin deposition and (iii) to a limited extent, temperature. The factors like salinity, depth seem to have only marginal effects on the distribution. Since other environmental factors were not analysed in the present study it will be premature to relate the distribution of chitinoclastic bacteria to any one or more parameters.

When compared to sediments, the digestive tract of animals seems to be a better place for chitinoclastic bacteria. In some fish as much as 98% of the total bacterial population was found to be chitinoclastic. Generally higher percentages of chitinoclasts were recorded in guts of fish than in that of prawns. This is contradictory to the earlier report that 85% of the bacteria in the digestive tract of the shrimp were able to elaborate chitinase (Hood and Meyers, 1973). The low percentage occurrence of chitinoclasts observed in prawns may possibly be attributed to the composition of food *i.e.* the food may contain a low level of chitinous material. The higher percentage occurrence of chitinoclastic bacteria in the digestive tract of aquatic animals is attributed to the chitinous food material (Goodrich and Morita, 1977 b). In addition to this, the fact that chitinase activity could be detected only in the gut samples of animals and not in sediments confirms the earlier findings of Goodrich and Morita (1977 a). Eventhough they failed to detect the chitinase activity in the nearshore sediments, they were able to observe the activity in the offshore sediments at 400 m deep. These observations suggest that major portion of chitin degradation may occur in tne digestive tracts of animals (both vertebrates and invertebrates) at least in nearshore environments. A chitinase system in the digestive tract may be advantageous to penaeids since a portion of the prawns' diet is usually composed of chitinous material. More-

over, glucosamine, the end product of chitin breakdown has been shown to be a growth factor for prawns (Kitabayashi *et al.*, 1971) and acetyl glucosamine has been shown to be involved in biosynthesis of crustacean exoskeleton (Stevenson, 1972).

Many strains of chitinoclastic bacteria were isolated in the present study. A detailed report on the taxonomy of chitinoclastic bacteria will be published elsewhere but can be summarised briefly here. Members of the genera, *Vibrio* and *Aeromonas* were found to be the majority of the chitinoclasts. In addition to few strains of *Micrococcus*, *Bacillus* and *Pseudomonas* capable of degrading chitin were also isolated.

Estimation of chitinase activity in different samples would be useful to assess the rate of chitin degradation in a given environment. Goodrich and Morita (1977a) after estimating the chitinase activity associated with a marine fish (*Enophrys bison*) reported that a population of 1×10^5 would be able to decompose as much as 16 metric tons of chitin annually, using a conversion factor suggested by Jeuniaux (1966). Such techniques would be useful to monitor the chitin turnover in a given ecosystem with reference to human activity and pollution.

From the present investigation and earlier reports it is possible to predict that major portion of chitin degradation may undergo in the digestive tract of aquatic animals and the digestive tract seems to offer a relatively stable environment for microbial chitin degradation when compared to sediments and water.

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STUDIES ON THE PRESERVATION OF CULTURED *CHANOS CHANOS* BY ICING AND FREEZING

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ABSTRACT

Ice storage shelf-life of milkfish (*Chanos chanos*) was studied with daily replenishment of ice and maintaining the temperature of fish at 0°C-1°C. The quality of fish was assessed periodically by organoleptic, bacteriological and chemical parameters. The fish were found to be acceptable upto 19 days. Amenability of fresh, one-day ice stored, two-day ice stored and three-day ice stored to frozen stored fish was studied. Frozen fish were stored at -18°C and their quality was studied periodically by organoleptic, chemical and bateriological tests. All the frozen fish were found to remain in good condition even after one year.

INTRODUCTION

FISH farming has been receiving considerable attention in recent years especially due to the uncertainties involved and the necessity for high investments even to obtain small increments in fish landings from the seas. Apart from fresh water fish farming, which has been receiving boost, brackishwater fish farming has come to be recognised as a viable technology for augmenting fish production. *Chanos chanos* is being extensively used for brackishwater fish farming in many parts of the country.

Though some work was done on the ice storage and frozen storage characteristics of marine fish (Shenoy and Pillai, 1971 ; Shenoy and James, 1974 ; Chinnamma George, 1975 ; Shenoy, 1976) and fresh water fish (Baliga *et al.*, 1962, 1969 ; Moorjani *et al.*, 1962 ; Devadasan *et al.*, 1978), very little was done in respect of brackishwater fish. In view of the paucity of information on the ice storage and frozen storage characteristics of brackishwater grown *Chanos chanos*, the present work was undertaken and the results thereof are reported in this paper.

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MATERIAL AND METHODS

The milkfish was caught in the local Brackishwater Fish Farm, brought to the laboratory and immediately iced. Fifteen kilogrammes of fish was packed in crushed ice in three layers (fish to ice ratio 1 : 1) in a thermocole (1" thick) insulated second hand tea chest plywood box (36 cm × 49 cm × 36 cm). The temperature of the fish was noted by piercing an alcoholic thermometer. The samples were drawn at definite intervals for analysis. Re-icing was done after every 24 hours, keeping the fish to ice ratio as 1 : 1.

For frozen storage studies, the milkfish *Chanos chanos* was frozen in five different conditions.

1. Fresh fish was washed with water and frozen in a plate freezer glazed with water (F_w).

2. Fresh fish was gutted, washed with water and frozen with water glazing (F_0).

3. Fish after one day ice storage (as

mentioned above) was gutted, washed with water and frozen with water glaze (F_1).

4. Fish after two days ice storage was gutted, washed with water and frozen with water glaze (F_2).

5. Fish after three days ice storage was gutted, washed with water and frozen with water glaze (F_3).

In all the five conditions 1.8 kg of fish was block frozen by adding 750 ml of cold water for glazing with a polyethylene cover (200 gauge). Freezing was done in a plate freezer and the frozen fish was stored keeping in a thermocole insulated plywood box in a cold storage maintained at-18°C. Periodically the samples were drawn, the water glaze was scraped out with a scalpel and a known weight of frozen fish was placed in a closed polyethylene bag and completely thawed in running water for 3 hours. The drip was collected in a measuring cylinder, the volume was noted and the drip was analysed for total nitrogen. The muscle portion from the dorso-lateral part of the fish was taken out for further analysis.

The organoleptic quality of the fish was evaluated by a panel of 5 members. The scoring was done both for the raw and cooked fish following the method of Shewan *et al.* (1953). The changes in the condition of eyes, gills, skin, texture and odour of the raw fish were observed at different stages of storage. The quality characteristics considered for cooked fish were odour, flavour and texture, the sample being boiled in 2% brine for 10 minutes. The average score for each quality factor and the overall mean score for the sample were calculated.

Moisture, ash and Total Nitrogen (TN) were determined by A.O.A.C. methods (1960). The Non-Protein Nitrogen (N.P.N.), Total Volatile Bases (TVB) and α—amino nitrogen were determined from trichloroacetic acid extract of the muscle. Non-protein nitrogen was estimated by kjeldahl method, TVB by conway diffusion method and α—amino nitrogen was by the method of Pope and Stevens (1939). Total fat was estimated by extracting the moisture free sample with petroleum ether (40-60°C) for about 5 hours using soxhlet extractors. For peroxide value estimation, the muscle from thawed fish was ground well with anhydrous sodium sulphate and fat was extracted with chloroform. Peroxide value and free fatty acid were estimated from the extract following A.O.A.C. methods. Total Bacterial Count (TBC) was determined by the standard pour plate method using tryptone glucose agar medium.

Results and Discussion

Ice stored fish

The temperature of the fish during the entire period of ice storage was found to be 0°C-1°C.

Organoleptic scores obtained in respect of the ice stored fish are furnished in Table 1.

Table 1. *Organoleptic scores of ice-stored* Chanos chanos *(whole fish, raw)*

No. of days stored	(Organoleptic score ; maximum 10)					
	Eyes	Gills	Skin	Odour	Texture	Mean
0 ..	10.0	10.0	10.0	10.0	10.0	10.0
2 ..	9.0	9.5	9.5	9.5	1.0	9.5
4 ..	9.0	9.0	9.5	9.5	9.5	9.3
6 ..	8.5	8.5	9.5	9.0	9.0	8.9
8 ..	7.5	8.0	9.0	9.0	8.5	8.4
11 ..	7.0	7.0	8.5	8.5	8.0	7.8
12 ..	7.0	6.0	8.0	8.5	7.5	7.4
14 ..	6.5	6.0	8.0	8.0	7.0	7.1
16 ..	5.5	5.5	7.5	7.5	6.5	6.5
17 ..	5.0	5.0	7.0	7.0	5.5	5.9
18 ..	4.5	4.5	6.5	6.5	5.5	5.5
19 ..	3.5	4.0	6.5	6.5	4.5	5.0
22 ..	0.0	0.0	1.0	2.0	1.0	

Changes in eyes and gills, usually watched by laymen to assess the quality of fish, were more conspicuous than changes in skin, odour and texture. Changes in skin were not easily detectable.

Organoleptic ratings in respect of cooked samples are presented in Table 2.

TABLE 2. *Organoleptic scores of cooked samples of ice stored* Chanos chanos
(Organoleptic score : maximum-10)

No. of days stored	Odour	Flavour	Texture	Mean
0	10	10	10	10
2	10	10	10	10
4	10	10	10	10
6	9	9	8	8.6
8	9	9	9	9.0
11	9	9	8.5	8.8
12	9	9	8.5	8.8
16	7	7.5	6	6.8
18	6	6	4	5.3
19	6	6	4	5.5

Textural changes were more prominent as compared to changes in odour and flavour.

Chemical and bacteriological quality at different stages of ice storage are presented in Table 3.

An increasing trend, though of a low order, was observed in the moisture content of the fish, as the period of storage increased, which is probably due to absorption of moisture by the tissues from the crushed ice. There was a significant decrease in the Non-Protein Nitrogen content (NPN) during the storage period, the reduction being most marked during the first four days of ice storage. A definite decrease was also observed in Total Volatile Basic Nitrogen (TVBN) during storage in ice (Table 3). The fall in non-protein nitrogen and total volatile basic nitrogen contents would have been reduced due to the effect of leaching by ice melt water, the loss of nitrogenous substances being more than their production. The production of nitrogenous substances must also have been diminished due to the reduced enzymatic activity and bacterial multiplication. The bacterial component comprised almost entirely of mesophiles since no growth came up on plates incubated at a temperature of 5°C-10°C. There was no appreciable change in the content of total nitrogen. Based on the organoleptic, chemical and bacteriological quality, ice stored *Chanos chanos* was found to be acceptable upto 19 days.

TABLE 3. *Chemical and bacteriological changes occurring in ice stored* Chanos chanos

No. of days storage	Moisture %	Total Nitrogen gms/100 gm of muscle	N.P.N. mg/100 gm of muscle	α-amino N mg/100 gm of muscle	Total volatile base nitrogen mg/100 gm of muscle	Total plate count/gm
0 ..	74.98	3.080	514	77.96	14	5.3×10^3
2 ..	76.25	2.907	486	113.20	14	1.8×10^4
4 ..	75.85	2.810	356	86.36	10	2.2×10^4
6 ..	77.55	2.830	340	103.40	10	1.8×10^4
8 ..	71.78	2.355	332	94.64	10	8.4×10^5
11 ..	78.10	2.860	320	54.83	6	3.0×10^4
12 ..	77.11	2.551	—	87.97	6	2.5×10^4
14 ..	79.00	2.777	276	79.33	8	2.3×10^4
16 ..	75.84	2.739	336	72.33	13	4.3×10^4
17 ..	77.75	3.028	244	62.30	5	1.6×10^4
19 ..	79.57	2.922	236	58.33	5	8.3×10^4
22 ..	77.87	2.950	144	48.89	5	2.2×10^4

Frozen stored fish

Results of organoleptic, chemical and bacteriological examination of different categories of frozen stored *Chanos chanos* are shown in Table 4.

Changes in odour and texture of fresh ungutted frozen (F_w), fresh gutted frozen (F_0) and one-day iced, gutted frozen (F_1) were not appreciable. Textural changes were more conspicuous with no appreciable change in odour in respect of two-day iced (F_2) and three-day iced (F_3) gutted frozen fish.

Moisture content of fresh as well as ice stored, gutted and frozen fish considerably decreased during storage while the decrease was not appreciable in fresh ungutted *Chanos chanos*. This can be easily understood by the fact that the drip loss was less (2.84 to 4.5 ml per 100 gms of fish) in fresh ungutted frozen fish with no appreciable decrease in moisture content while the drip loss was more (5.7 ml to 10.8 ml per 100 gms of fish) in the other categories.

The total nitrogen content of drip showed an increase with the increasing storage period. The increase was more in gutted fish as compared to ungutted fish. The volume of drip was also more in gutted fish as compared to the ungutted fish. The larger exposed surface area and more tissue denaturation in the case of gutted fish as compared to ungutted fish might be responsible for the differences in the quantities of total nitrogen content and drip volume.

Peroxide values ranging from 3.8 to 15 were obtained after one month storage in respect of all categories of gutted and frozen fish but no organoleptic change could be detected. The peroxide value became negligible after one year frozen storage. This may be explained by the fact that fats initially absorb oxygen, the rate of which increases with time, the period being termed as induction period (Meyer, 1973). The major initial product of oxidation consists largely of hydroperoxide (Karel, 1973). Hematin catalyzed oxidative fat rancidity is an important deteriorative reaction in frozen fish because of the rapid rate of peroxide scission and peroxidative chain reaction initiation (Tappel, 1964). By peroxide value we measure this hydroperoxide. These peroxides are not contributing for the characteristic odour of rancid fat. The compounds responsible for odour of rancid fat are short chain compounds and include aldehydes, acids, hydroxy acids, ketones and keto acids. As oxidation progresses, the break down products of hydroperoxides accumulate and eventually the hydroperoxide concentration decreases (Githa and Moorjani, 1973).

The free fatty acid values remained negligible throughout the storage period. Initially the free fatty acid formed is protected upto certain threshold value by the fat present in fish from reacting with protein to make it insoluble (Hanson and Olley, 1964). But beyond that threshold value the free fatty acids react with protein and solubility of protein decreases.

The total bacterial count remained about the same during storage in all categories of frozen fish.

On the basis of the organoleptic, chemical and bacteriological parameters, the milkfish (*Chanos chanos*) was found to remain acceptable even upto a period of one year under frozen storage conditions.

TABLE 4. *Biochemical changes in* Chanos chanos *during frozen storage*

Analysis	Fresh *Chanos chanos*	Fresh *Chanos chanos* whole (un-gutted) Frozen (F_w)			Fresh *Chanos chanos* gutted and frozen (F_0)		One-day iced *Chanos* gutted and frozen (F_1)		Two-day iced *Chanos* gutted and frozen (F_2)		Three-day iced *Chanos* gutted and frozen (F_3)	
		after one month of storage	after two months of storage	after twelve months of storage	after one month of storage	after twelve months of storage	after one month of storage	after twelve months of storage	after one month of storage	after twelve months of storage	after one month of storage	after twelve months of storage
Moisture (%)	78.1	77.3	77.4	77.89	70.34	69.35	72.68	70.77	70.24	73.03	71.33	70.62
Total Nitrogen (gm/100 gm muscle)	3.08	3.21	2.858	3.156	3.166	3.514	2.964	3.352	3.308	3.403	3.359	3.490
Total NPN% (gm/100 gm muscle)	0.510	0.460	0.340	0.432	0.432	0.496	0.364	0.397	0.448	0.496	0.460	0.496
Thaw drip (ml/100 gm/ frozen fish)	—	4.5	2.8	4.4	8.0	5.7	8.0	6.6	6.7	8.5	8.0	10.8
Drip T.N. (mg/100 ml drip)	—	142.8	288.0	372.8	481.8	761.5	470.4	724.7	587.2	770.5	621.2	807.4
Peroxide value (ml N/500 $Na_2S_2O_3$ per gm fat)	—	16	25	—	10	Negligible	12.5	Negligible	8.88	Negligible	15	Negligible
F.F.A. (% Oleic acid)		Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
TBC/gm	2.9×10^4	1.3×10^4	1.8×10^4	5.5×10^4	4.9×10^4	2.0×10^4	4.6×10^4	2.5×10^4	9.5×10^4	7.9×10^4	3.9×10^4	1.9×10^4
Odour (max. score-10)	10	10	10	9	9	9	9	9	9	8.5	9	8
Texture (max. score-5)	5	5	5	4.5	4	4	4	3.5	4	3	4	2.5

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THE BACTERIAL FLORA OF PEARLSPOT *ETROPLUS SURATENSIS* (BLOCH) CAUGHT FROM COCHIN BACKWATERS

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ABSTRACT

Quantitative and qualitative studies on the bacterial flora of freshly caught pearlspot *Etroplus suratensis*, from Cochin Backwater were made. The aerobic bacterial count on the surface of the fish varied between 10^3-10^4/cm², of gills between 10^4-10^5/gm and of intestines with contents, between 10^3-10^5/gm. Qualitatively, the flora on the skin and of the gills and intestines consisted mainly of asporogenous rods. The predominating flora on the skin surface consisted of *Pseudomonas* spp. (25%), *Alcaligenes* spp. (10%), *Micrococcus* spp. (20%), *Flavobacterium* spp. (5%), *Bacillus* spp. (5%) and 'Coliforms' (5%). The flora of the gill tissue comprised of mainly *Pseudomonas* spp. (35%), *Alcaligenes* (25%) and *Micrococci* spp. (15%). The intestinal flora consisted of *Pseudomonas* spp. (50%), Coliforms (20%), *Flavobacterium* spp. (8%) and *Alcaligenes* (6%).

INTRODUCTION

THOUGH extensive studies have been carried out on the nature of the bacterial flora of fishes of marine origin both in India and elsewhere, not much information is available on the bacterial flora of fishes of fresh and brackish water origin. Kerala abounds with extensive brackishwater areas along her coast and the fishery therein plays an important role in her coastal economy. But so far no serious attempts have been made to study the spoilage and preservation aspects of brackishwater fishes. Further the recent interest in coastal aquaculture makes it all the more necessary to have a clearer picture of the bacterial profile of the fishes so that better means of controlling their spoilage to enhance the quality of the fishes may be deviced. With the object in view we have undertaken an investigation on the nature of the bacterial flora of *Etroplus suratensis*, an important table fish caught from brackish water of the coastal regions. A fully grown fish of this species weighs between 600 gram to 1 Kg.

The spoilage of fish is mainly due to the action of bacteria, although autolysis and oxidation also play their part in this phenomenon. It has often been said that brackish water fishes spoil more rapidly than marine fishes. It is hoped that a study on the nature of the bacterial flora of brackishwater fishes would help to understand and explain the cause of the so-called rapid spoilage in such fishes.

The authors are grateful to (Late) Shri G. K. Kuriyan, Director of the Institute for his keen interest and encouragement. They are also thankful to the technical staff of the laboratory for their assistance.

MATERIAL AND METHODS

Live pearlspots, weighing between 500 to 900 gm were collected from Murinjapuzha which forms a part of Cochin Backwater. The sample was transferred to sterilised wide-mouth bottles and brought to the laboratory immediately.

Sampling

Enumeration of bacterial flora

10-12 gm of muscle with skin were aseptically cut from either side of 2-3 fishes. Similarly, about 2 gm of gill tissue and 1 gm of intestines (with contents) were aseptically transferred to sterile sample dishes. For total plate count, the samples were pour plated using Tryptone Glucose Agar (TGA) containing Tryptone 1%, Beef extract 0.3%, glucose 0.1%, sodium chloride 0.5%, agar agar 1.5% and distilled water. Plates were incubated at 28 ± 2°C (RT) and at 37°C for 3 days and counts taken.

Total coliforms were detected by plating the appropriate dilutions of the tissue homogenates with Desoxy Cholate Agar (DCA) and incubating the plates at 37°C for 24 hours. Typical colonies were transferred to EC medium and incubated at 44.5°C for 24 hours, colonies producing acid and gas in EC medium at 44.5°C were considered as faecal coliforms. Also, IMViC (Indole, Methyl red, Vogeus Prauskaeur and Citrate utilisation) tests were performed with these cultures.

Total streptococci were determined on KF agar and staphylococci were enumerated on Baird-Parker agar. Counts were taken after 24 hours of incubation at 37°C.

Isolation and identification of cultures

After the incubation period, plates showing discrete colonies were selected, each colony picked and transferred to tryptone broth and incubated at room temperature. Each isolate was restreaked three times to ensure purity before their morphological and biochemical characteristics were studied. The pure cultures were maintained on nutrient agar (NA) glants for preservation and further studies.

One hundred and twenty isolates from skin with muscle, ninety from gills and one hundred and five from intestines with contents were examined in detail.

Motility was examined in 16-24 hours old tryptone broth cultures by the hanging drop method (Anon, 1957), using phase contrast microscope. Morphology and Gram-staining were observed on 16-24 hours old cultures grown on NA slants : Gram stain, as modified by Hucker (Anon, 1957) was used for staining. Ability of the cultures to reduce nitrate, to produce indole from tryptone, to liquefy gelatin, to ferment various sugars and to produce H_2S was studied by standard methods (Salle, 1954). Mode of attack of glucose by cultures was determined by using Hugh and Leifson's 'Oxferm' medium (Hugh and Leifson, 1953). The presence of cytochrome oxidase in cultures was detected by the modified Kovac's test (Kovac, 1956). Pigmentation was observed on skim-milk peptone agar. Sensitivity to penicillin and 0/129 compound was determined by pad-plate method. Proteolytic ability was determined by the method of Lerke *et al.* (1963) as modified by Lerke *et al.* (1965).

Differentiation of the bacterial cultures upto generic level was done mainly by the scheme of Shewan *et al.* (1960, a, b) with necessary modifications on the basis of Bergey's manual (Buchanan and Gibbson, 1974).

Results and Discussion

Quantitative aspects

The bacterial load on the skin with muscle was found to vary between 1.2×10^3 and 4.3×10^4/gm, that of gills between 2.3×10^4/gm and 1.14×10^6/gm and of intestines between 1.15×10^5/gm and 2.08×10^8/gm when the plates were incubated at 28 ± 2°C. (Table 1). However at the incubation temperature of 37°C, the counts registered a decrease of one log cycle in the case of skin with muscles 1.2 log cycle in the case of gills and 2 log cycle in the case of intestine with contents (Table 2).

TABLE 1. *Bacterial count at different parts of the fish*

Nature of count	Part of the fish		
	Skin with muscle	Gills	Intestine with contents
Total plate count per gram ..	1.2×10^3—4.3×10^4	2.30×10^4—1.14×10^6	1.15×10^5—2.08×10^8
Total coliforms per gram ..	Nil-1×10^3	Nil-27	7×10^3—2.4×10^5
Total faecal coliforms per gram ..	Nil	Nil	Nil-120
Streptococci per gram ..	Nil-23	Nil-43	Nil-240
Staphylococci per gram ..	Nil	Nil	Nil

The count of the total coliforms was very much higher in the intestines with contents, probably a reflection on the food habits of pearl spot which is reported to feed on faecal matter. But the proportion of the faecal coli to the total coliforms is less. Also, faecal coliforms were not isolated from the skin or gill tissue, eventhough in some cases, nonfaecal coliforms were detected. The presence of streptococci was minimal. Staphylococci were absent.

TABLE 2. *Difference in total plate counts of skin with muscle, gills and intestine, when incubated at two temperatures.*

(Counts given in logarithms)

Sample	Incubation temperature	
	28 ± 2°C Log. TPC/gm	37°C Log. TPC/gm
Skin with muscle ..	3.124	2.093
Gills ..	5.315	4.110
Intestines ..	7.862	5.796

Qualitative aspects

The generic distribution of bacteria in skin with muscle, gills and intestines of pearl spot is given in Table 3. The results show wide variations in the percentage composition of the bacterial genera in the three parts of the body of the fish.

The generic composition of the microflora of skin with muscle, gills and intestines (with contents) as seen from Table 3 show a preponderance of gram negative asporogenous rods of the *Pseudomonas*, *Alcaligenes*, *Flavobacteria/Cytophaga*, *Moraxella* and *Vibrios* groups. *Pseudomonas* is the major group, constituting 25% of the skin flora, 35% of the flora of gills and 50% of the flora of intestines.

TABLE 3. *Generic distribution of bacteria in pearlspot*

Bacterial genus	Part of the fish		
	Skin with muscle %	Gills %	Intestine with contents %
Pseudomonas	25	35	50
Alcaligenes ..	10	25	6
Micrococcus ..	20	15	3
Flavobacterium/Cytophaga ..	5	2	8
Bacillus ..	5	2	0
Moraxella ..	5	6	2
Vibrios ..	7	3	2
Arthrobacter ..	7	4	Nil
Lactobacillus ..	2	Nil	2
Staphylococci ..	Nil	Nil	Nil
Streptococci ..	2	2	3
Total coliforms (includes faecal coliforms) ..	5	>1	20
Faecal coliforms ..	Nil	Nil	4
Yeast ..	3	Nil	Nil
Unidentified ..	4	5	0

Of the gram positive groups, *Micrococci* account for 20% of the skin flora and 15% of the flora of the gills, but only 3% of the intestines with contents. *Arthrobacter* and *Bacillus* were present on the skin and in the gills, but not in intestines.

Table 4 gives the relative distribution of various physiological groups of bacteria. It is to be noted that the cultures were generally biochemically very active, gelatin liquefiers constituting 85%, 70% and 96% in skin with muscle, gills and intestines respectively. It is also very significant that 22%, 24% and 34% of the flora of skin, gills and intestines respectively are putrefiers. And most of these putrefiers belonged to the genus *Pseudomonas*, the group of bacteria which was found to be the major spoiler group of bacteria in the case of marine fish (Shewan *et al.*, 1960). Further, most of the putrefiers were capable of growth at 0°C.

TABLE 4. *Percentage distribution of various physiological groups of bacteria in pearl spot* Total cultures examined = 315

Physiological groups	Part of the fish		
	Skin with muscle	Gills	Intestine with contents
Gelatin liquefiers ..	85	70	96
Nitrate reducers ..	40	56	61
H_2S producers ..	16	22	35
Indole producers ..	8	14	27
Sugar fermenters			
(i) Anaerobic ..	12	7	14
(ii) Aerobic ..	65	48	39
Putrefiers ..	22	24	34
Capable of growth at 0°C ..	10	14	20

A comparison of the flora of pearlspot, a brackishwater fish, to the flora of fresh water fish and marine fish might be interesting. The major genera found on fresh water fishes were *Micrococcus, Flavobacterium, Paracolobactrium, Achromobacter, Alcaligenes* and *Pseudomonas*, whereas the natural flora of Indian sardines (*Sardinella longiceps*) and mackerel (*Rastrelliger kanagurta*) consisted mainly of *Vibrios, Pseudomonas, Achromobacter, Flavobacterium, Coryneform* and *Micrococci* (Karthiayani and Iyer, 1967; Surendran and Iyer, 1976). The proportion of *Vibrios* spp. in the marine fish is much more (upto 36%) than that in brackishwater fish (only 2-7%) of the total flora, while the *Pseudomonas* species are found to predominate in brackishwater fish (25-50%) in comparison with marine fish (14-16%). In the case of fresh water fishes, gram positives are the predominating flora in contrast to both brackishwater and marine fishes.

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STUDIES ON TRANSPORTATION OF *CHANOS CHANOS*

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ABSTRACT

The paper presents the results of studies undertaken to device suitable methods of transportation of fresh and frozen *Chanos chanos* to distant places by rail. Freshly harvested and frozen fish were transported to Calcutta, Delhi and Madras in different types of containers with different insulation materials. Quality of the fish was examined at both despatching and receiving centres in order to follow the changes during transportation. Plywood boxes with expanded polystyrene slab as well as multi-layer gunny insulations, aluminium box with insulation and a dismantlable type galvanised iron box with polystyrene slab insulation were tried for transportation of the iced fish from Kakinada to Calcutta. The journey lasted 40 hours with one transhipment at Samalkot Junction. The fish transported in all the above containers reached the destination in fair to good condition and fetched prices ranging from Rs. 3.50 to Rs. 7.00 per kg. Frozen *Chanos chanos* in the form of blocks were also transported successfully from Kakinada to Calcutta and Delhi, the latter involving a journey of 50 hours and one transhipment at Vijayawada Junction. A few consignments of iced fish sent to Delhi and Madras also reached the destination in good condition. Conventional bamboo baskets with palmyra leaf mat and dry leaf linings inside and gunny wrapping outside were found suitable for transporting iced fish to Madras by rail, where they fetched prices ranging from Rs. 3.25 to Rs. 4.75 per kg.

INTRODUCTION

INDIA has about 2.02 million hectares of culturable brackishwaters, which if exploited properly can produce 4.3 lakh tonnes of fish per annum at a minimum rate of 225 kg/ha/yr (Gopalakrishnan, 1972). Milkfish *Chanos chanos* (Forsskal) is very well suited for culture in such waters. This fish is cultivated in Indonesia Philippines, Thailand, Malaysia, Taiwan, Hawaii, Burma, Pakistan, India, Ceylon etc. It is a much relished table fish and is grown experimentally in brackishwater fish farms throughout our country. There is plenty of scope for developing this on a commercial scale, in the event of which proper handling and utilization of the cultured fish become absolutely essential in order to ensure proper and adequate returns and render the proposition economically viable. So far no research work has been carried out in India on the preservation aspects of this fish.

Even though long term preservation methods like freezing, canning, dehydration/curing etc. will have to be tried in the long run when the production of the fish increases to that extent, under the existing conditions, expeditious transportation to the interior potential consuming centres can solve the problem of economic utilization. Fish in fresh condition is always preferred by the consumer to that preserved by even the most sophisticated method and in this respect one advantage with cultured fish is that they can be harvested according to demand and distributed fresh. However, limiting the market to the immediate vicinity of the

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production centres cannot be expected to work economically. Hence experiments were undertaken to explore the possibility of transporting cultured *Chanos chanos* in iced and frozen condition over long distances and to study the quality changes taking place in them during such transportation. The work was carried out under an All India Coordinated Research Project on Transportation of Fresh Fish sponsored by the Indian Council of Agricultural Research.

The authors wish to place on record their gratitude to Late Shri G. K. Kuriyan, Director and Shri M. R. Nair for kind permission to present these results at this symposium.

Material and Methods

Chanos chanos cultured in the experimental Brackishwater Fish Farm run by the Central Institute of Fisheries Education at Kakinada were used in these studies. Immediately after harvesting, the fish were brought to the laboratory (about 3 km) where most of them reached still in live condition. They were washed clean in fresh water and used for the experiments.

Containers used

Three different sizes of second hand tea chests (plywood boxes) *viz*, ; 36 cm × 49 cm × 36 cm (capacity: 35 kg), 47 cm × 50 cm × 38 cm (capacity : 50 kg) and 56 cm × 44 cm × 35 cm (capacity : 60 kg) were employed in these studies. Expanded polystyrene slabs (25.4 mm thick) cut to fit in the inside of the boxes and sealed in 150 gauge (0.038 mm thick) polythene sheet (Rao *et al.*, 1978) were used as insulants. This type of container is designated 'A' in this paper. Jute fabric as available in the local market was also cut to the size of the inside of the plywood box and double and quadruple layers of the same were stitched together along the borders and sealed in 150 gauge polythene sheet as described above. The containers with 4-and 2- layer gunny insulations are designated 'B' and 'C' respectively in these studies. A dismantlable, polystyrene slab-insulated, returnable, galvanised iron container (Govindan and Gupta, 1978) was also employed for transportation and is designated container 'D'. Traditional split bamboo baskets with palmyra leaf mat lining inside and gunny wrapping outside were used in transportation experiments to Madras for comparison with the other containers and is designated 'E'.

Methods of packing

The cleaned fish was analysed for quality characteristics and packed with 1 : 1 proportion of ice as described by Rao *et al.* (1978). Freezing of the fish was carried out as 3 kg blocks with glazing water. They were packed in the insulated container as described above without any additional ice.

Transportation

The consignments were booked from Kakinada Port Railway Station and were carried by ordinary (un-insulated) parcel vans. The journey to Calcutta (Howrah) normally took 40 hours at ambient temperatures of 25-35°C and involved one transhipment at Samalkot Junction. The duration of the journey was the longest (50 hours) to Delhi and there was one transhipment at Vijayawada Junction. Temperature variations during these experiments were between 25-35°C. Transportation to Madras took the shortest time, 20 hours, by a direct train.

Results and Discussion

Particulars of the experiments carried out from Kakinada to Howrah and the quality characteristics both at the despatching and receiving centres are presented in Table 1.

Organoleptic, chemical and bacteriological qualities before despatch show that the fish is in fine condition. There was a four-fold increase in

total bacterial load during the transportation which is of no significance at all as far as quality is concerned. Coliform counts of 10-20/g were encountered in only four cases, which of course got reduced to nil at the receiving centre. This is to be expected since their initial occurrence itself was low enough and because of their known sensitivity to lower temperatures, besides the leaching out action of the ice melt water. Staphylococci were conspicuous by their absence at both the centres. Increases in total volatile nitrogen values were also negligible during the period of transportation. Organoleptically the fish was in fine state of preservation at the destination. The fish when marketed after sampling by a public sector undertaking fetched selling prices of Rs. 3.50 to Rs. 7.00 per kg.

TABLE 1. *Particulars of transportation experiments conducted from Kakinada to Howrah*

Number of experiments	..	29 (Iced—23 ; Frozen – 6)
Quantity of fish transported	..	1250 kg (Iced – 1072 kg ; Frozen – 178 kg)
Type of containers used and number of experiments with each type	..	'A' – 8 ; 'B' – 2 ; 'C' – 15 and 'D' – 4.
Period of experiments	..	1976 – 1977.

Quality Changes

Characteristic		Despatching centre	Receiving centre
Total bacterial plate count/g Mean & range	..	4.25×10^4 (0.47×10^4—15.0×10^4)	16.86×10^4 (0.1×10^4—61.0×10^4)
Coliforms/g	..	10—20 (Only in four cases)	Nil
Staphylococci/g	..	Nil	Nil
T.V.N. : mg% Mean and range	..	15.82 (5.6—36.4)	18.42 (9.8—32.2)
Organoleptic quality	..	Good	Fair

Particulars of transportation experiments from Kakinada to Madras as well as the quality characteristics at both ends are presented in Table 2. There were practically no increases in bacterial plate counts at all during the transportation. Coliforms were absent at both ends. Increases in TVN were also negligible. There was no significant organoleptic change either and when marketed by the Tamil Nadu Fisheries Development Corporation, the transported fish fetched rates ranging from Rs. 3.25 to Rs. 4.75 per kg. It is of particular interest to note that the fish reached the destination in fine condition even when transported in the traditional split bamboo baskets. This may be attributed to two factors *viz.* ; (1) the extremely high quality of the fish at the time of despatch and (2) the comparatively shorter duration of transportation (20 hours). However, in transportations involving longer journeys, more sophisticated containers like the other ones used in this study will have to be employed. Even for short distance transportation by rail, it is always advisable to employ efficient containers so that the fish do not get spoiled in the event of any unscheduled delays which occur sometimes in our rail traffic.

The details of experiments conducted from Kakinada to Delhi are presented in Table 3. Eventhough the duration of the journey involved was the longest in this series of experi-

ments, there was practically no increase in total bacterial loads and no significant deterioration in organoleptic quality during transportation.

panied by the usual and unavoidable course of deteriorative changes. But the situation is entirely different in the case of farm-harvested

TABLE 2. *Particulars of transportation experiments from Kakinada to Madras*

Number of experiments	..	6 (All iced)
Quantity of fish transported	..	257.5 kg
Type of containers used and number of experiments with each	..	'A'—3 ; 'E'—3
Period of experiments	..	September 1978—January 1979

Quality Changes

Characteristic		Despatching centre	Receiving centre
Total bacterial plate count/g Mean and range	..	1.25×10^4 (0.21×10^4—2.9×10^4)	1.45×10^4 (0.3×10^4—4.52×10^4)
Coliforms/g	..	Nil	Nil
T. V. N. : mg % Mean and range	..	13.4 (11.3—16.0)	16.77 (15.1—21.3)
Organoleptic quality	..	Good	Good

TABLE 3. *Particulars of transportation experiments from Kakinada to Delhi*

Number of experiments	..	3 (All frozen blocks)
Quantity of fish transported	..	134.5 kg
Type of container used	..	'D'
Period of experiments	..	January—March 1974

Quality Changes

Characteristic		Despatching centre	Receiving centre
Total bacterial plate count/g Mean and range	..	2.18×10^4 (0.65×10^4—3.08×10^4)	1.17×10^4 (1.1×10^4—1.3×10^4)
Organoleptic quality	..	Good	Good

Marine fishes are harvested from distant grounds and invariably some time lags take place between catching and landing, accom-

fishes in so far as they can be harvested and handled in the freshest possible condition. One advantage with freezing of the fish before despatching is that comparatively larger quanti-

ties of fish can be packed compactly in the container as no additional ice is required to be used.

Conclusion

Freshly harvested *Chanos chanos* could be transported over long distances like those from Kakinada to Howrah, Delhi and Madras in iced and frozen condition in ordinary (uninsulated) rail wagons at ambient temperatures. While a traditional container like split bamboo basket with palmyra leaf mat lining inside and gunny wrapping outside performed satisfactorily during transportation to Madras, journeys involving longer durations call for more sophisticated containers with insulation materials as heat barriers for better protection.

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TUNA LIVE-BAITFISH INVESTIGATIONS AT VIZHINJAM

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ABSTRACT

Rearing of some species of *Stolephorus* and a few other small sized fish was done within the breakwater area at Vizhinjam, southwest coast of India. 'Well-type' cages made of nylon netting were employed for the purpose. The fish were collected from lift nets operated during night using lights and during morning hours, as well as from commercial boat seines. They were transported to the cages, in large plastic cans and buckets. The period of transportation of fish from fishing site to the rearing cages ranged between 10 minutes and one hour. Mortality in respect of *Stolephorus buccaneeri* during transportation and during the first two days after stocking put together ranged from 10-20% and low thereafter. Transporting about 100 fish of about 75 mm length in cans of 50 litre capacity and continuous addition of fresh sea water during transportation were found to reduce the initial mortality of the fish. It survived in the cages for about three months. Similarly *S. devisi* also was found to be hardy ; it survived in captivity for about two months. In the case of *Stolephorus bataviensis* and *S. indicus*, however, the initial mortality was very high and the fish hardly lived for more than a few hours after stocking. The periods for which other fish were reared in the cages were : *Ambassis gymnocephalus* for nine months ; *Pranesus duodecimalis* 5 months ; *Sardinella gibbosa* two months and *S. longiceps* for four months. Initial mortality on capture, during transportation and stocking was negligible for the foregoing four species of fish. They were fed with pelletized feed. The dissolved oxygen, salinity and temperature of the surface waters of the rearing cages during the period were monitored. The encrusted fauna and flora of the cages are described. Some of the problems associated with rearing of live baitfish in cages have been identified and solutions for some of them outlined.

INTRODUCTION

POLE and line fishing with livebait and purse-seining are at present the two economically viable methods of catching tuna in commercial quantities in tropical waters (Shomura, 1977). Of these two methods the pole and line fishing is the principal method for catching the skipjack tuna *Katsuwonus pelamis*. Though the skipjack is said to be widely distributed in the Lakshadweep Sea, a traditional fishery for it exists in an organised scale only in Minicoy. This is said to be due to non-availability of suitable baitfish in close proximity of other islands. Even in Minicoy, fluctuations in the availability of adequate supplies of baitfish, which are mostly represented by small sized percoid fishes has been reported to affect the tuna fishery often bringing about an abrupt suspension of fishing activity, thereby considerably affecting the economy of the islanders (Jones, 1958, 1960).

Though fragile, many species of *Stolephorus* are reported to possess most of the qualities of good baitfish as pointed out by several authors (Baldwin, 1975, 1977 ; Yuen, 1977 ; Smith, 1977) and form the major baitfish species used in many parts of the Central and Western Pacific Ocean, the best known among them being the nehu, *Stolephorus purpureus* (Uchida, 1970, 1977 ; Wilson, 1977 ; Smith, 1977). Most of these species also occur in the Indian Ocean,

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and their resource potential has been estimated to be very high along the southwest coast by the Pelagic Fishery Project of the UNDP (UNDP, 1974, 1976 a, b, c).

Investigations were undertaken at Vizhinjam to develop suitable methods of capture, transport and stocking in the sea for the wild stocks of *Stolephorus*, as well as to understand their basic requirements in captivity so that large quantities of this fish could be readily made available for livebait purpose in Minicoy. This would reduce the effect of day to day fluctuations in the baitfish supply on the pole and line fishing, eliminate a major non-fishing activity involving catching of bait and lead to expansion of tuna fishing activity in the Indian seas. This paper gives an account of the activities and results obtained in this endeavour in respect of *Stolephorus* and a few other non-predatory fishes incidentally caught during these investigations. In order to present the problem under investigation in its perspective a brief account on the anchovy fishery of the Vizhinjam area and the anchovy resource potential along the southwest coast of India are given in this account. Course of future development for the livebait investigations is discussed in the light of these findings.

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Material and Methods

Live-fish for experimental purpose were collected from shore seines, lift nets and boat seines during 1977-1979. They were immediately transported in plastic cans and released into the culture cages or glass tanks and mortality of fish that occurred at different stages was noted. They were fed with different kinds of feeds. Descriptions of nets and lights, transporting equipments, culture rafts and cages employed during the work are given below.

Two types of lift nets were fabricated and used. The first type essentially consisted of a square box 3.5 × 3.5 × 1.5 m made of monofilament nylon netting and canes along the four sides of the bottom and the rim. To each corner of this box type net was attached a cord which passed over a pulley fastened to a bamboo pole. Thus the two cords of each side passed through two pulleys suspended from one bamboo pole and the two bamboo poles were rigged to the mechanised boat from which fishing was carried out. One adjustable light was suspended from a third pole rigged to the boat so that the light fell at the centre of the net area (Plate I A).

The second type of lift net as described by Floyd (1971) was fabricated and used. It consisted of a metal ring of 1.5 m diameter to which was attached a conical mosquito netting. The net was operated from a T-shaped wooden frame attached to the rear end of the boat. An adjustable light was suspended by means of a cord passing through a hook attached to the vertical limb of the T-frame.

A portable generator working on petrol was the source of electricity to illuminate the surface waters. Initially a generator of 1500 W and 230 V with 1000 W white bulb was used. But later the combination was changed to one of 750 W and white bulb of 230 V, 500 W. The latter was found to be relatively better in attracting livebait. Subsequently an inverted kerosene pressure lamp of about 200 CP illumination was used in place of electric illumination.

Night fishing with lift nets using light was done for fifteen days from 20th March to 26th

April 1978 using different sources and intensities of lights. Fishing was done both inside the breakwater area (depth range 10-15 m) and in the open sea off Vizhinjam (depth range 20-40 m). First, the net was lowered to about 2 m below the surface and the light was switched on. Periodically the lift net was hauled up and the catch was transferred by hand nets into 50 litre capacity cans filled with fresh sea water on board the vessel.

Rafts and cages

Well-type circular cages were suspended from rafts anchored in the breakwater area of the Vizhinjam Fishing Harbour Project, depth of water at the site being about ten metres. Rafts of 6 m × 3 m size were constructed using teak poles, bamboo poles and painted and sealed empty diesel drums of 200 litre capacity as floats (Plate I B, C). Each cage measured 3-5 m deep and 2 m in diameter and was made of monofilament nylon netting of blue colour with a square mesh of 3 mm size. A cage of 3.5 m height can hold 9.5 kl of water in the portion of the cage immersed under water when suspended from a raft. Similarly a cage of 5 m height can hold about 14 kl of water. Rings made of metal (brass, iron) rods of 16 mm thickness were provided one each at the top and bottom of the cage. Each cage was covered with a lid of one metal ring covered with netting of the same material. Two such cages can be suspended from a single raft. As the work progressed more rafts and cages were fabricated, as a result of which by July 1978 there were four rafts and eight cages available for stocking live-bait fish.

Transportation, stocking and feeding

Transportation of fish from fishing site to the rearing cages was done in plastic cans thickly covered with coir and of about 50 litre capacity. Fresh sea water was continuously added to the fish cans during transport to make up for the depletion of dissolved oxygen. On reaching the culture site fish were transferred into the cages and a sample of fish was taken for recording the species composition, length range (total length in mm) and weight of the fish stocked. Details of artificial feed supplied to the fish in captivity are furnished elsewhere in the text.

Environmental factors

Observations on temperature, salinity and dissolved oxygen of the surface water of the rearing cages were made between 9 and 10 a.m. during the period of rearing of fish. Harvey's method was employed for estimating salinity and Winkler's method for dissolved oxygen. The fauna and flora fouling the cages were also examined. The survival capacity of *S. buccaneeri* in different salinities were also examined on fish kept in glass tanks of 75 × 50 × 50 cm size in the laboratory. The fish reared in the cages were used for this purpose. Before starting the experiment the fish were kept in the tanks for three days. Lowering of salinity was done by adding fresh water. In this account 'anchovy' refers to the fishes of the genus *Stolephorus* Lacépède.

Anchovy Fishery at Vizhinjam and its Resource Potential along the Southwest Coast

The average annual catch of *Stolephorus* at Vizhinjam during 1965-'78 was around 275 tonnes. The fishery has two principal seasons namely, June-July and September-October accounting for about 30% and 45% respectively of the annual landings. Boat seines land bulk (64%) of the annual catch, followed by gill net (28%) and shore seine (8%) at an average catch rate (cpue) of 5.53 kg, 24.36 kg and 11.86 kg respectively. Boat seines which have been found to be the only source of live anchovies for culture work at present are operated throughout the year. But the main season of their operation is from May to October with peak during June to August. The catch rate of

anchovy varies between 7.3 kg and 21.7 kg during September-October. Despite high effort by boat seine (about 6,600 units) anchovy catch is generally low during August indicating a seasonal movement of this fish away from the inshore waters of the Vizhinjam area. The seasonal trend of the anchovy landings from all the gear (monthly average values) is given in Fig. 1. Two species form bulk of the anchovy landings. They are *Stolephorus devisi* (47%) and *S. bataviensis* (31%). Among the rest,

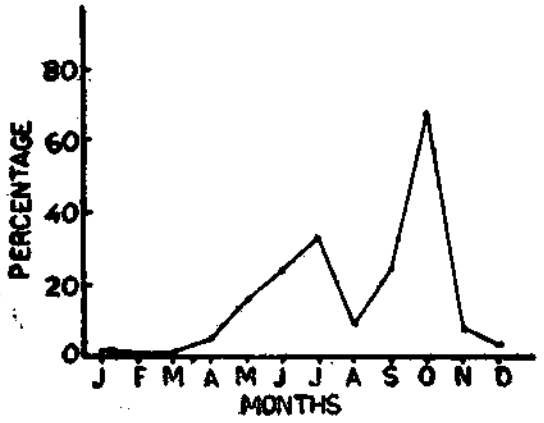

FIG. 1. Seasonal trend of *Stolephorus* catch at Vizhinjam during the period 1965-1978.

S. buccaneeri is important (14%). The other species are *S. indicus* (5.0%), *S. andhraensis* (2.0%), *S. commersonii* (0.5%) and *S. macrops* (0.3%). The above data on species composition relates to the period 1970-'78. Further details on the seasonal trend in the catch per unit effort (catch per one trip of the unit) in boat seine, shore seine and gill net for the first four species in the Vizhinjam area are given in Figs. 2 & 3.

The Pelagic Fishery Project of the UNDP at Cochin during 1973-'75 assessed the standing stock of *Stolephorus* biomass in the shelf and slope waters along the southwest coast of India from Ratnagiri to Cape Comorin and in the Gulf of Mannar to range between 500,000 and 1,5000,000 tonnes. Seasonal variations in the area of abundance of the fish indicated a migratory pattern of the *Stolephorus* stock. The fish appears to start a northward migration from the Gulf of Mannar by about September-October and move to north of Quilon by about December and to north of Ratnagiri by about February-March. The stock appears to move towards south and lie between Kasargod and Quilon by about April-May; and by about July-August most of the *Stolephorus* stock has been reported to move into the Gulf of Mannar in the area south and east of Cape Comorin.

Stolephorus was mostly observed in shallow areas of 20-50 m depth range. They often occur within 10-15 m off the bottom during day time and begin to ascend and get dispersed in mid-water during night time, while they were found frequently near the coast south of Quilon. They were usually located 8-32 km off shore north of Quilon. The composition of the different species of the *Stolephorus* stock is nearly same as observed at Vizhinjam. *S. heterolobus** was reported to be most abundant in areas with 15-45 m bottom depth and *S. bataviensis* in areas with less than 20 m bottom depth while *S. buccaneeri* was mostly in waters beyond 45 m bottom depth. The last mentioned species was found to be abundant during the period of southwest monsoon, soon after the height of southerly transport of shelf waters, indicating that this species at other times of the year is mostly distributed north of Ratnagiri.

OBSERVATIONS

Capture of live-baitfish using lift nets

Details of environmental characters of fishing area, gear used, source of illumination, length

* *Stolephorus heterolobus* and *S. devisi* which resemble each other closely are known to occur in the Indian Seas (Ronquillo, 1967; Whitehead, 1968, 1973). But reports of the UNDP mention the occurrence of only *S. heterolobus* in the area of their investigation. At Vizhinjam as well as at other centres along the Indian coast *S. heterolobus* was encountered only rarely in the commercial catches.

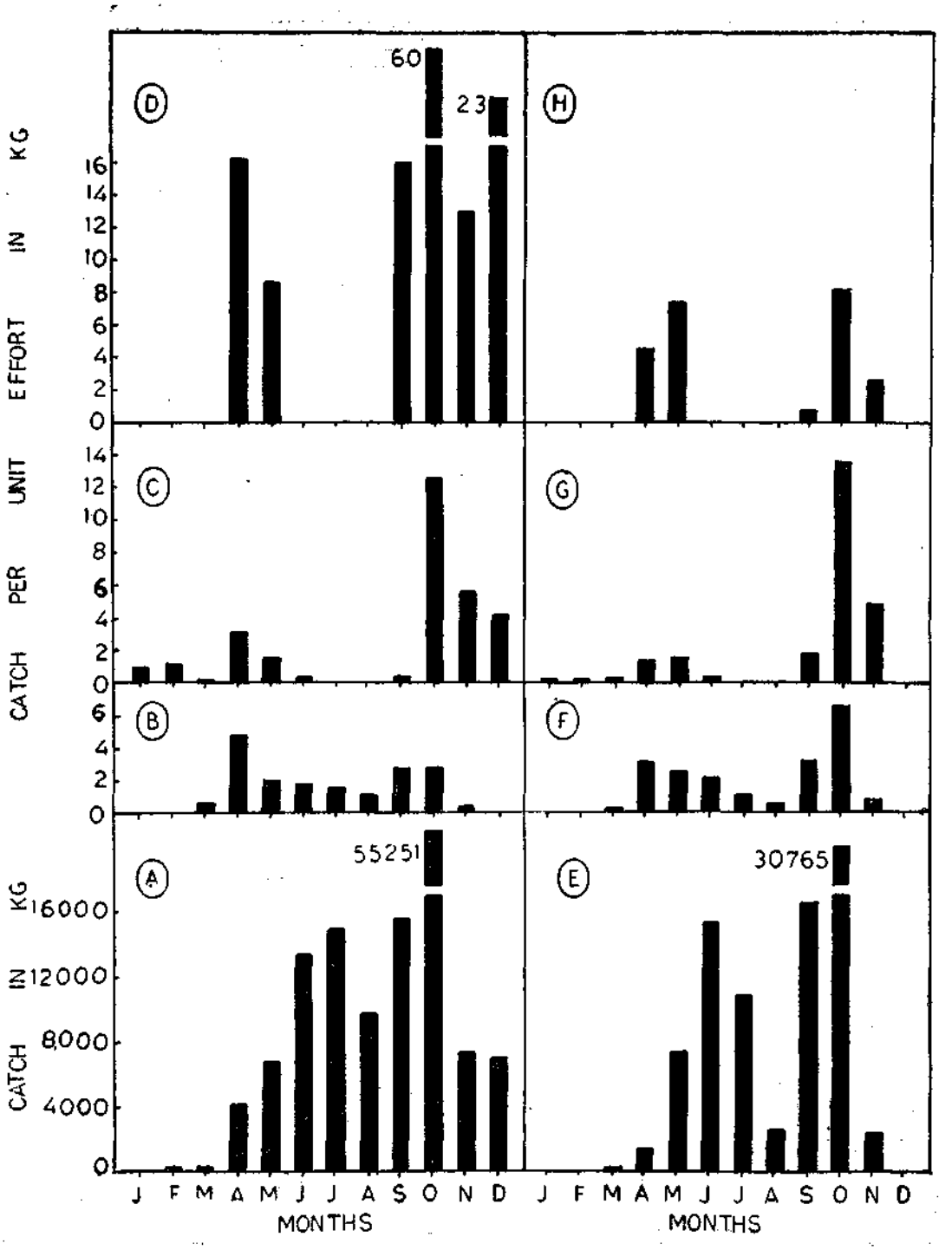

FIG. 2. Seasonal trend in the catch of *S. devisi* (A) and *S.bataviensis* (E) at Vizhinjam ; Catch per unit effort (cpue, catch per one drip of the unit) of *S. devisi* in boat seine (B), shore seine (C) and gill net (D) ; and cpue of *S. bataviensis* in boat seine (F), shore seine (G) and gill net (H).

ranges of fish and squids caught, etc. are given in Table 1. *Loligo singhalensis* and *Sepioteuthis lessoniana* were the dominant species in the catches obtained during night fishing with light using box-type lift net. The other species obtained in this net were *Pranesus duodecimalis*, *Ambassis gymnocephalus*, *Sardinella gibbosa* and *Hemirhamphus* sp., while *Sardinella longiceps*, *Pranesus duodecimalis* dominated in the conical lift net catches. The foregoing fishes other than *Hemirhamphus* were transferred into cages for rearing purpose. While fishing in the open sea, the lift net was drifted off from beneath the light and hence fish gathered below the light could not be caught effectively. On account of this, lift net fishing using light inside the bay was found to be more effective.

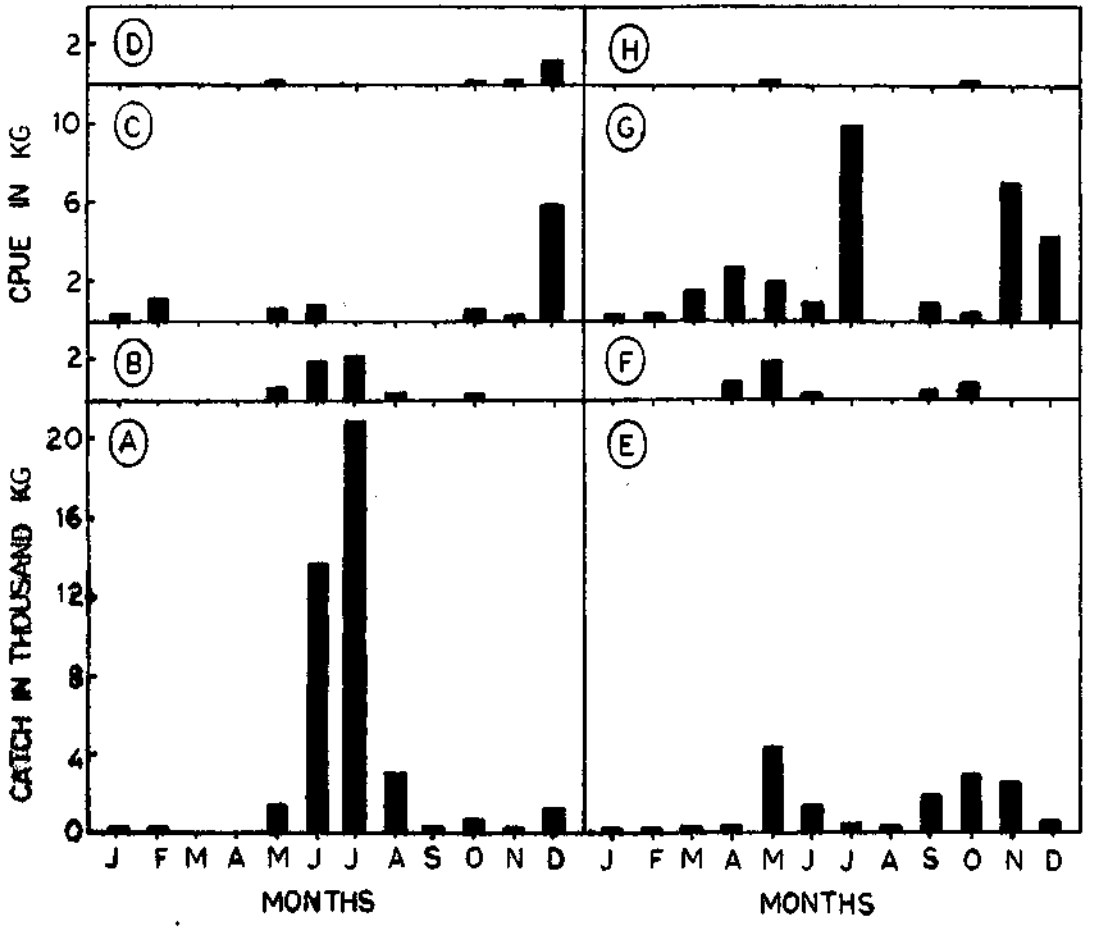

FIG. 3. Seasonal trend in the catch of *S. buccaneeri* (A) and *S. indicus* (E) at Vizhinjam; cpue of *S. buccaneeri* in boat seine (B), shore seine (C) and gill net (D); and cpue of *S. indicus* in boat seine (F), shore seine (G) and gill net (H).

Collections from shore seines and boat seines

As the fish caught in shore seines are dragged towards the shore over a long distance and in huddled condition, they get injured and hence do not live for more than a few hours after they are collected from the net. Initially *Stolephorus devisi* ranging between 40 and 60 mm collected from shore seines and transported in buckets with sea water and kept in glass aquarium tanks under laboratory conditions

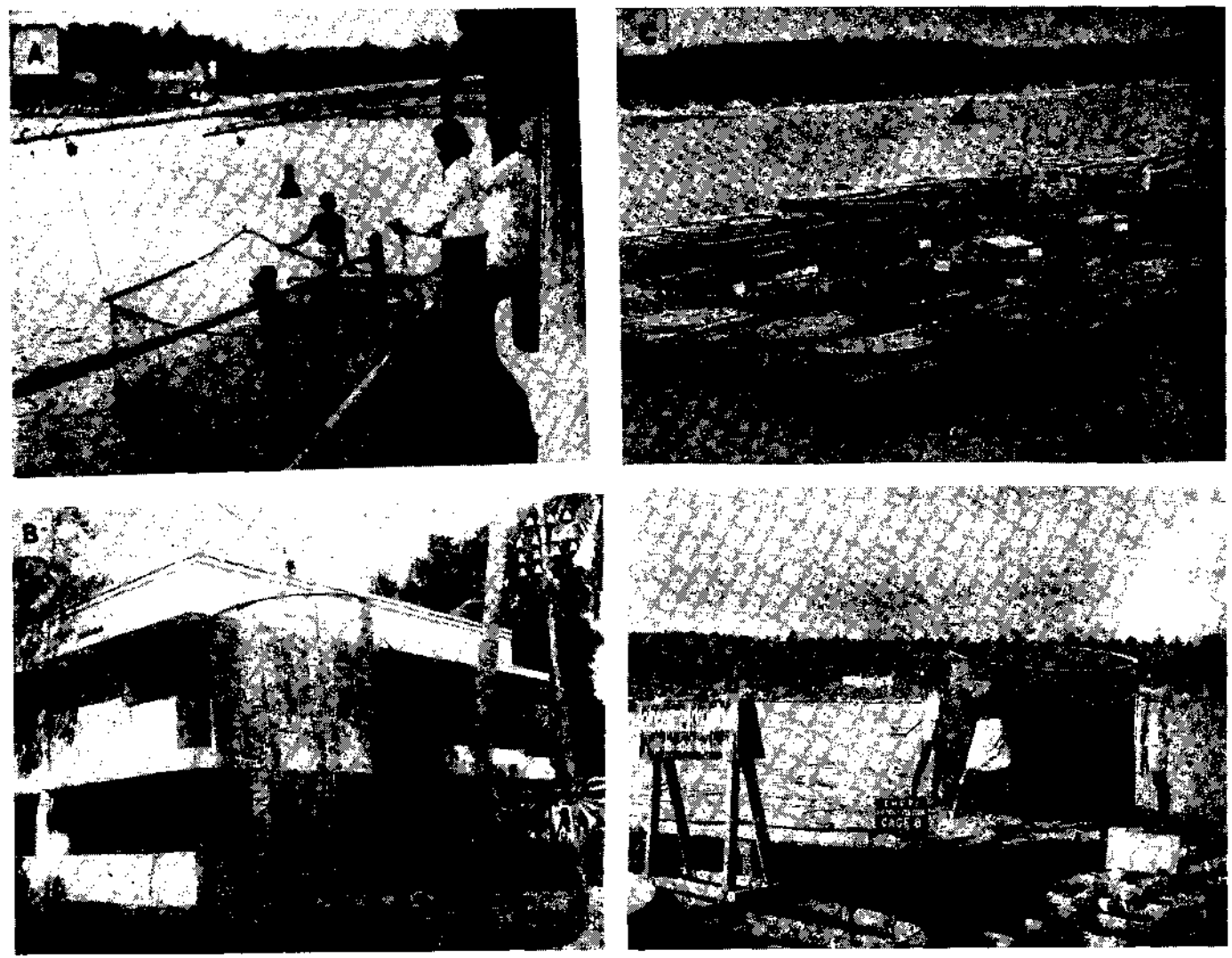

PLATE I. A. Square-type lift net in operation from mechanised boat at Vizhinjam, B. The cage 3.5 × 2.0 m used for rearing anchovies, C. Anchovy culture rafts (in the foreground) and D. The intensity of fouling of the rearing cage after one month of release in water (The upper clear portion of the cage remains above the water).

TABLE 1. *Details of capture of live-baitfish from mechanised boat using light and lift nets during March and April* 1978

Date	Condition of sea	Water temperature (°C)	Depth (metres)	Gear used	Source of light	Place	Time (hrs)	Catch details (Length range in mm is given in brackets)
20th/21st March	Calm	29	10-13	Conical lift net	500 W	Inside break water area	2100-0100	*Sardinella longiceps* (35-48) *Hemirhamphus* sp. (79-250)
21st March	Calm	29.1	10-13	Conical lift net	,,	,,	1800-2000	*Sardinella gibbosa* (33-45)
				Box type lift net	,,	,,	2000-2400	*Loligo singhalensis* (60-136) *Sepioteuthis lessoniana* (—) *Ambassis gymnocephalus* (74-86)
30th March	Slightly rough	29.5	20	Conical lift net	1000 W	Off Vizhinjam	2000-2300	NIL
31st March	,,	29	20	,,	500 W & 1000 W	,,	1830-2330	NIL
3rd April	Calm	29.3	20	Box type lift net	,,	Inside break water area	1930-2330	*Pranesus duodecimalis* (33-66) *Sphyraena obtusata* (90-99) *Caranx* sp. (94-95)
4th April	Slightly rough	29.1-29.5	23	Conical lift net	500 W	Entrance of	1930-2400	*Sardinella gibbosa* (33-45)
				Box type lift net	,,	Vizhinjam break water area	0300-0600	*Sepioteuthis lessoniana* (60-95) *Pranesus duodecimalis* (25-76)
5th April	Slightly rough	29.1-29.3	23	Conical lift net	500 W	Entrance of Vizhinjam break water area	2040-2340	*Pranesus duodecimalis* (29-73)
				Box-type lift net	,,	,,	0330-0530	*Pranesus duodecimalis* (29-73) *Sepioteuthis lessoniana* (85-145) *Hemirhamphus* sp. (89-327) *Sardinella gibbosa* (20-23)
10th April	Calm	29.5	8-13	Box type lift net	Kerosene pressure lamp	Off Vizhinjam	2045-2130	*Loligo singhalensis* (80-125)
					(200 CP)	Inside break water area	2230-2400	*Pranesus duodecimalis* (25-71) *Sardinella gibbosa* (15-25) *Hemirhamphus* sp. (69-75) *Caranx* sp. (16-26) *Balistes* sp. (20-22)

TABLE 1—(*Continued*)

Date	Condition of sea	Water temperature °C	Depth (metres)	Gear used	Source of light	Place	Time (hrs)	Catch details (Length range in mm is given in brackets)
11th April	Slightly rough	29.1-29.3	8	,,	,,	Inside break water area	0330-0515 and 2000-2250	*Sardinella gibbosa* (16-25) *Pranesus duodecimalis* (19-38) *Sepioteuthis lessoniana* (60-76) *Hemirhamphus* sp. (130-239) *Carnax* sp. (17-20) *Balistes* sp. (14-22)
12th April	Calm	29.1	8	,,	,,	,,	2000-2330	*Pranesus duodecimalis* (27-66) *Loligo singhalensis* (45-113) *Hemirhamphus* sp. (46-51)
13th April	,,	29-29.1	8	,,	,,	,,	0345-0600 and 2030-2250	*Pranesus duodecimalis* (41-72) *Loligo singhalensis* (48-110) *Hemirhamphus* sp. (45-53)
14th April	,,	29.3	9	,,	,,	,,	0330-0530	*Loligo singhalensis* (55-110)
24th April	Calm	29.5	9	Box type lift net	Kerosene pressure lamp (200 CP)	Inside break water area	2000-2230	*Pranesus duodecimalis* (34-59) *Loligo singhalensis* (58-98) *Sepioteuthis lessoniana* (50-70) *Sardinella gibbosa* (22-39)
25th April	,,	29-29.3	9-11	,,	,,	,,	0345-0600 2000-2250	*Pranesus duodecimalis* (45-52) *Sardinella gibbosa* (22-35) *Balistes* sp. (30-45)
26th April	Slightly rough	29.1	9	,,	,,	,,	2010-2320	*Pranesus duodecimalis* (30-40) *Sardinella* sp. (23-41) *Sepioteuthis lessoniana* (55-72) *Loligo singhalensis* (54-95)

lived only for two hours. During the course of the observations *Stolephorus* spp. collected from boat seines alone were found to be suitable for rearing. Hence collections were attempted only from boat seines.

Though a variety of fishes are caught in boat seines, attempts were made to sort out *Stolephorus* spp. from the catches. This was achieved by collecting the fish from the catches dominated by *Stolephorus* spp. The fish were then transferred to the plastic cans filled with sea water by means of buckets making sure that only small quantity of fish was taken out from the net together plenty of water. Though boat seine, when compared with shore seine, was found to be a better source for obtaining live anchovies it has certain inherent drawbacks. For instance, if the anchovies are caught along with large sized piedaceous fish, mortality of anchovies would be very high due to injuries. At Vizhinjam the fishery for anchovies by boat seine coincides with the fishery of *Trichiurus* by the same gear, where the latter forms the bulk of the catch and the anchovies thus caught sustain heavy mortality. Even when anchovies form the dominant catch in boat seines, mortality of fish occurs due to the vigorous shaking of the net to remove anchovies entangled in the meshes of the net and the overcrowding of fish in the bag portion of the net during hauling. Hence approximately 20-30% of the fish, depending on the species caught could only be obtained in live condition. Even these fishes are subject to further mortality in due course on account of the shock and injuries they have sustained during capture. *Stolephorus buccaneeri, S. bataviensis, S. devisi* and *S. indicus* were the species available for observations during the present study. Of these *S. buccaneeri* and *S. bataviensis* alone were available in good quantities during the course of the collections.

Transportation

The duration of transportation of fish in cans to culture site ranged between ten minutes to one hour depending on the distance from the fishing site. Observations on the mortality of fish in cans during transportation were made with different densities of fish per can. It was generally observed that when *Stolephorus* catch comprised mainly of *S. buccaneeri* and the fish were handled with utmost care and transported within about half an hour, the mortality was below 5% when about 100 fish of about 75 mm length were carried and when the condition of the sea was not rough. But carrying more fish always resulted in higher mortality due to depletion of dissolved oxygen. For instance, on one occasion about 200 *S. buccaneeri* were introduced into a can with an initial dissolved oxygen concentration of 5.28 ml/litre. After one hour of transportation of fish the dissolved oxygen concentration was found to be 2.64 ml/litre and the mortality of fish was about 80%.

In the case of *S. bataviensis* of 70-90 mm length, mortality was 50-60% during transport lasting for about 30-60 minutes, even when 100 fish were carried per can. Under similar conditions of transport, the mortality was about 90% for *S. indicus* of 120-140 mm length and 50% for *S. devisi* of 60-70 mm length.*

Other small sized fish of *Sardinella* spp., *Ambassis gymnocephalus, Pranesus duodecimalis, Leiognathus* spp., *Dussumieria* spp. and *Sphyraena* spp. showed eligible mortality during transportation.

* During 1980, in an attempt to reduce the further mortality of *Stolephorus* obtained from boat seine, the fish were transferred immediately to cans with less saline water (60-80% sea water of salinity range 21‰—28‰). Within 20-30 minutes some species of *Stolephorus* were observed to slow down their active, irregular movement and assume a steady, circular movement in the cans. This would indicate that the fish have largely overcome the shock they sustained at capture. Thus the mortality of *S. devisi* in less saline water was approximately one-fifth of that in 100% sea water, where the mortality ranged between 45% and 50% for *S. devisi* and *S. buccaneeri*. But *S. bataviensis* and *S. indicus* showed heavy mortality (85-90%).

Rearing of Stolephorus *spp. in cages*

During the present study, observations on rearing were made mainly on *S. buccaneeri* as this was available on many occasions during the period of collections. Other species dealt with were *S. bataviensis*, *S. devisi* and *S. indicus*.

During 1977, collections of *Stolephorus* were made from boat seines operated within the breakwater area and it comprised only of *S. buccaneeri*. About 2,000 *S. buccaneeri* of 40-80 mm length with the modal size at 45-49 mm were stocked in a cage of 4 m height during the last week of June. Mortality of fish was about 80% during the period from the time of capture till stocking; thereafter it was fairly low. Within 2-3 days of captivity mortality came down considerably. Only very few fish were alive by the first week of October '77 and all fish died by the middle of October.

During 1978, collections were made only from boat seines operated off Vizhinjam and inside breakwater. Collections made during middle of July comprised only of *S. buccaneeri*. About 10% mortality was noted during the period from time of capture till stocking. They were stocked in three cages of 3.5 m height at densities of 1,500, 1,500 and 3,500 fish respectively. The initial length ranges of fish stocked were 75-97 mm in the first cage, 52-76 mm in the second and 54-78 mm in the third. On the following day, about 10% of fish was observed in the cages. Thereafter, the mortality was relatively low. However, there was a gradual reduction in the number of fish in the cages during the subsequent three months as a result of which about 200 fish each in the first and the second and about 500 in the third cage only were alive by the last week of October. On 25th October 1978 when fresh collections of *S. bataviensis* were introduced into these cages, all the *S. buccaneeri* present in the cages were found dead on the following day. It would thus appear that *S. buccaneeri* could be kept alive in rearing cages, though with a steady mortality of the fish kept under captivity, for about three months and that addition of fresh fish into a cage that has fish already conditioned to captive environment will bring about mortality of the latter.

S. bataviensis was available for rearing thrice during 1978, all from boat seine catches. About 100 fish were collected off Vizhinjam on 28th September 1978 and transported within half an hour to the culture site. About 50% mortality was observed during transportation. The fish stocked in the cage ranged in length from 72-98 mm. All the fish were found dead the following day. Subsequent two collections were made from within the breakwater area. The first one of 800 fish made on 14th October 1978 consisted of *S. bataviensis* (80%) 70-90 mm length and *S. devisi* (20%) 68-76 mm length. The second one of 18,000 fish of 61-90 mm length made on 25th October 1978 consisted of *S. bataviensis* (90%) and a variety of small sized fishes. In both the instances the transportation time was about ten minutes. Mortalities of fish before stocking in the cages were about 20% in the two attempts. The fish collected on 14th October 1978 was stocked in one cage and that collected on 25th October 1978 was stocked in six cages at densities of 5,000, 5,000, 3,000, 3,000, 1,000 and 1,000 respectively. But the fish did not survive for more than six hours.

In 1979 about 4,500 numbers of *Stolephorus* spp. were collected during middle of July from boat seines operated off Vizhinjam and were transported to the culture site within about 45 minutes. At the time of stocking mortality of fish was about 35%. The species composition was as follows: *S. bataviensis* 24%, *S. devisi* 22% and *S. buccaneeri* 54%. This mixed collection was stocked in four cages in densities of about 1,300, 1,200, 450 and 50 respectively. Species-wise stocking of fish was found to be not practicable. The length range of *S. buccaneeri* stocked was 51-79 mm, that of *S. devisi* 52-76 mm and that of *S. bataviensis*

54-73 mm. A sample of anchovies collected from one of the cages after one month of stocking comprised only of *S. buccaneeri*. The length range of fish in the sample was the same as at introduction, but the mean length of the fish increased from 64.71 mm to 66.68 mm. Possibly, more of the smaller fish have died in the mean time. A gradual reduction was observed in the number of fish present in the cages as in the previous years and by the end of October 1979 only very few *S. buccaneeri* were alive.

About 50 numbers of *S. indicus* ranging between 120-140 mm in length collected within the breakwater area on 3rd November 1979, transported within three minutes and stocked separately in one cage did not survive for more than three hours.*

Rearing of other fish in cages

Observations were made on *Sardinella longiceps*, *Ambassis gymnocephalus*, *Pranesus duodecimalis* and *Sardinella gibbosa* during different periods in the course of study. About 1,000 numbers of *S. longiceps* 60-64 mm modal length incidentally caught along with *S. buccaneeri* during the last week of June 1977 and kept in a cage till second week of November 1977 showed a modal length of 110-114 mm. About 200 numbers of *S. gibbosa* ranging in length 55-70 mm collected from boat seines and stocked on 24th July 1978 were in captivity till 21st September 1978 when they were fished out. The final length range was found to be 80-92 mm.

About 1,150 numbers of *Ambassis gymnocephalus*, 74-88 mm length with a mean length of 80.3 mm were collected by lift nets operated close to the culture rafts on 15th and 16th February 1978 and were immediately stocked in a single cage. Mortality of about 10% was observed during the subsequent ten days period and nil thereafter. They were kept in captivity for about nine months. A sample of fish measured at the close of this period did not show any increase in the mean length. About 3,000 numbers of *Pranesus duodecimalis* of 25-76 mm length collected by lift net from the breakwater area during 3rd-26th April 1978 were stocked in a single cage. Very little mortality was observed during the period of transport and rearing. They were kept in captivity for about five months.

Feeding of fish kept in captivity

During July-October 1977, the fish were fed with boiled and ground beef liver as well as with ground dry *Acetes* made into thick paste. Both the feeds were given twice daily and they were accepted by the anchovies and sardines reared in the cages. During 1978, the fish were fed with artificial pelletized feed made from the following: *Acetes* meal (40%), rice bran (20%), black gram (15%), tapioca (11.4%), ground nut oil cake (7.5%), supermindif (comprising a mixture of minerals used for cattle feed) (5%), yeast (1%) and vitablend (consisting of vitamins used for cattle feed) (0.1%). During 1979, the above feed was modified by replacing *Acetes* meal with fish meal. The material cost per kilogram of the above feeds was Rs. 4 and Rs. 3 respectively. The chemical composition of the two feeds are as follows :

* During 1980 about 3,000 numbers of *S. devisi* in length range of 58-92 mm (average length 72 mm) were stocked in a cage. The fish were alive with only a little mortality for about a month. Thereafter, a gradual reduction in their number was observed and by the end of the second month all fish were dead.

Feed No.	Moisture %	Total ash %	Acid insoluble ash %	Protein %	Starch %	Fat %	Na % mg	K % mg	Ca % mg
1.	7.1	19.94	10.13	36.42	20.98	4.58	7.544	4.634	2.047
2.	8.8	19.35	7.131	36.52	17.71	4.615	8.796	4.212	2.315

Fish were fed with artificial feed twice daily approximately 5% of their wet body weight. Though feed was supplied from the time of stocking, fish began to accept the feed from about the third day onwards. From about fifth day onwards the fish were found to come up towards the surface of water as soon as a small quantity of feed was dropped into the cage. Soon after each feeding the stomach of fish was found to be full, with the artificial feed supplied in addition to trace quantities of copepods, diatoms and algae.

Environmental factors of the rearing cages

The ranges of dissolved oxygen, salinity and temperature of the surface waters of the rearing cages during the periods were 3.38-5.07 ml/litre, 33.60‰-34.8‰ and 21.2°C-26.3°C for *S. buccaneeri* and *S. devisi*; 3.38-7.55 ml/litre, 33.5‰-35.30‰ and 21.2°C-29.8°C for *Pranesus duodecimalis*, and 3.17-7.55 ml litre, 24.40‰-35.50‰ and 21.2°C-29.8°C for *Ambassis gymnocephalus*. *Stolephorus buccaneeri* kept in laboratory tanks exhibited normal activity at a lower salinity of 17.5‰ for five days after which the experiment was terminated.

During the course of rearing fish in the cages, the cages were found to be fouled by a variety of fauna and flora (Plate I D). They were algae, mussels, pearl oysters, sea anemones, gastropods, ascidians, starfishes, sea urchins and polyzoans. Settlements and occurrence of these organisms were found to be intense on the inner surface of the cage than on the other surface and more on the upper two metres depth of the cage from the surface than further below. Anchovies swimming close to the walls of the cages in their normal milling pattern are injured when they come in contact with the shelled molluscs, sea urchins and sea anemones etc. Depletion in the dissolved oxygen of the water inside the cages could have resulted from the restricted circulation of water due to clogging of the meshes of the cage and consumption of oxygen by the fouling organisms. The unconsumed feed and excreta of the fishes that accumulates at the bottom of the cages were also found to foul the cages and pollute the water inside. Occurrence of a variety of fish such as serranids, theraponids, siganids, lutianids, gobiids, chaetodontids etc., and crabs in the cages (which would have entered into them through the meshes of the netting as eggs and early larvae) could have caused severe competition for food and space in the cages and some of them would have caused mortality by preying on the stocked fish, as cages were suspended in water for over three months. Entry of crabs through the gap between the lid and the rim of the cage was prevented by covering the space with net material. Though periodical cleaning of the rearing cage is necessary to ensure free circulation of water in the cage, it is not advisable to do so when the fish is in it since this would kill the fish. Hence cages should be suspended on rafts not much in advance of stocking of fish.

General Considerations and Conclusions

Tunas represent an extensive fishery resource in the oceanic region currently underfished partly due to insufficient supplies of live-bait. About 230 species of fish representing 34 families have been used as live-bait in the pole and line fishing to capture skipjack tuna throughout the Pacific, Atlantic and Indian Oceans with varying degrees of success and many other species were no doubt employed as live-baitfish but not reported in literature (Baldwin, 1975). Whereas anchovies (Engraulidae) and sardines (Clupeidae) are widely used as bait fish in the Pacific and Atlantic Oceans (Baldwin, 1975), percoid fishes represented by families Pomacentridae, Caesiodidae, Apogonidae and Labridae in Minicoy (Jones, 1958) and the red fish *Dipterygonotus leucogrammicus* (Emmelichthyidae) in Sri Lanka (Sivasubramaniam, 1965) are the main groups traditionally used in the Indian Ocean.

The most desirable characteristics of a good baitfish according to Baldwin (1975), Yuen (1977) and Smith (1977) are : (1) highly reflective lateral surface, (2) surface swimming with rapid erratic motion, (3) a tendency to return to the vessel when broadcast, (4) length below 15 cm, preferably 6-8 mm length with elongate body, (5) relative abundance, availability to the fishery and the ease with which it can be handled and (6) hardness and survival for extended periods in captivity. Baldwin (1977) remarks that ' Without question, the anchovies (Engraulidae) provide the greatest source of desirable baitfishes... However, their survival in bait wells, depending upon the species involved, may be from excellent to poor'. The most important anchovies used as live-bait in different geographical areas are : the anchoveta *Cetengraulis mysticetus* in the tropical Pacific Ocean from Mexico to Peru ; the northern anchovy *Engraulis mordax* off California ; the southern anchovy *E. ringens* in the eastern Pacific Ocean ; *E. japonicus* in the Southern region of Japan upto Taiwan ; the nehu *Stolephorus purpureus* in the Hawaiian Islands (Yoshida *et al.*, 1977 ; Baldwin, 1977).

Several other species of *Stolephorus* are being used as baitfish in the tropical Pacific, west of Hawaii. They are *S. buccaneeri*, *S. heterolobus*, *S. devisi*, *S. bataviensis*, *S. indicus* and *S. commersonii*. Though all these species have a high tuna attractability their survival in captivity was found to be poor, daily mortality rates as high as 50% being not uncommon. On some occasions *S. buccaneeri* and *S. heterolobus* alone have shown fairly good survival rate in captivity (Baldwin, 1977). The last mentioned two species as well as *S. devisi* are highly prized as baitfish in Palau, Fiji, Ponape and Papua New Guinea (Uchida, 1970 ; Wilson, 1977 ; Smith, 1977 ; Kearney *et al.*, 1972 ; Hida, 1971 ; Lee, 1973). Information on the evaluation of these species as livebait, their habitat and capture methods in Western Pacific Ocean have been compiled and published by Shomura (1977).

The present investigations indicate that compared with sardines (*Sardinella longiceps* and *S. gibbosa*), the silverside (*Pranesus duodecimalis*) and the glassy perch (*Ambassis gymnocephalus*), the *Stolephorus* anchovies are delicate to deal with. Mortality of anchovies is high on capture and it continues at a reduced rate throughout the period of captivity. Compared with *S. bataviensis*, *S. indicus* and *S. devisi*, the round head anchovy *S. buccaneeri* was found to be more hardy. Detailed work, however, is required to determine the shock intensity, injury and mortality that the fish sustain on capture, the daily rates of mortality of fish in captivity, as well as the optimum density of stocking of fish. Regardless of these considerations *Stolephorus buccaneeri* was found to survive in captivity for about three months, *S. bataviensis* for six hours and *S. indicus* for three hours*. Among the other fish, *Ambassis gymnocephalus* survived in captivity for nine months, *Pranesus duodecimalis* for five months, *Sardinella longiceps* for four months and *S. gibbosa* for two months.

Of prime importance to secure large quantity of baitfish are the effective methods of capture that do not cause any injury to the fish. Bag type of seines would cause injury to the fish caught in them and this would lead to large-scale mortality of fish. Hence lift net and purse seine seem to be the more effective gear for capturing live-bait. But capturing fish such as *S. buccaneeri* which is known to occur far below the surface and largely in the open sea would pose problems. As the anchovies have been found to perform diurnal vertical migrations, fishing using night lights might be helpful. But as mentioned earlier, lift netting is ineffective in the open sea.

Mortality of fish is the major problem for the utilization of *Stolephorus* as live-bait. It occurs at several stages namely (1) at capture,

* During 1980, *S. devisi* was found to survive in captivity for about two months.

(2) during transfer of fish from the capturing net to transporting equipment, (3) during the period of transportation and (4) during the period of stocking in the cages. Injury caused to the fish during capture would lead to large scale mortality later (delayed mortality). Since different species of *Stolephorus* exhibit varying degrees of hardness, mortality of fish varies with the species composition of the collection. For example, boat seine collections yielded the highest rate of survival as much as 20-30% of the fish caught in respect of *S. buccaneeri*, but yielded much less in respect of other species of *Stolephorus*. Random movement of fish, as opposed to milling in compact circles, in the restrictive captive situation is yet another factor that induces mortality of anchovies. Due to this disorientation, the fish hit one against another, often injuring themselves and also waste excessive energy. Provision of circular current and oxygen concentration upto saturation may be helpful in restoring the milling pattern. The presence of hardy and non-predatory schooling fish in the same environment may enhance survival by possibly promoting earlier milling pattern of the captive anchovies.

Smith (1977) considered mortality of anchovy live-bait to be due to causes such as injury caused by net abrasions or contact with other individuals, with resultant loss of scales and mucus; and due to stress or shock reaction induced by the trauma of capture and handling. Shock rather than physical injury has been implicated as the major killer.

Mortality of live-bait that occurs at different stages could perhaps be minimised by taking the following precautions: capturing fish by lift nets or encircling nets; allowing the fish to swim from one captive condition to another; keeping fish in water of lower salinity soon after capture; maintaining the dissolved oxygen of holding tank or bait well water at saturation level; installing in the holding tank or bait well a device that would suck in or help in the removal of scales and mucus that get dispersed in the holding medium; removing predators from the bait wells, retaining only hardy species that would promote early milling of anchovies; avoiding addition of new stock of fish into a holding tank that has already conditioned fish in it; holding baitfish in pens prior to transporting them; and avoiding transportation of live bait in rough weather and for long distances (Struhsaker *et al.*, 1975; Shomura, 1977).

The foregoing observations and general considerations suggest that any attempt to utilise the *Stolephorus* resources of the Indian seas should be directed towards utilising *S. buccaneeri*. But this fish accounts for only about 14% of the anchovy resource. However, the possibility of this species being available in larger quantities in the shelf waters north of Ratnagiri remains to be investigated. This also calls for a detailed study of the biological and fisheries characteristics of this anchovy. From what is known at present *S. buccaneeri* occurs in the inshore waters of Southwest Coast during the period of southwest monsoon, soon after the height of southerly transport of shelf waters and mostly remains offshore beyond 45 metres depth zone during rest of the period. During the monsoon period the average monthly cpue of this species in boat seine at Vizhinjam varied between 0.43 kg and 2.26 kg. Lewis (1977) states that the catches of this species tend to be either too large (upto 500 kg) or quite small.

From the observations of Smith (1977) on the survival of *S. devisi* and *S. heterolobus* it would appear that this species complex accounting for about 47% of the anchovy catch along the West Coast could also be utilised for stocking for live-bait purpose. This raises the possibility of attempting to utilise about 60% of the anchovy resource available along the West Coast for this purpose.

Though *S. buccaneeri* has been found to remain in captivity for about three months

there is a gradual mortality of fish in captivity. Further it is still not clear as to the period over which at least 50% of the stocked fish would remain alive.* Observations of Smith (1977) indicate that *S. devisi* and *S. heterolobus* could be held in captivity for 14-16 days before cumulative mortality reaches 50%. Applying this criterion, it would appear that the foregoing three hardy species of *Stolephorus* cannot be stocked much in advance of tuna fishing season, which in Minicoy (Lakshadweep) lasts from November to April; nor fish collected in distant grounds could be transported to the Lakshadweep.

Information on the anchovy resources around the Lakshadweep is totally lacking. There is thus an urgent need to explore how the resources of *S. buccaneeri, S. heterolobus* and *S. devisi* are distributed in the oceanic waters of the West Coast. Establishment of the necessary infrastructure for capture and holding of anchovies and other desirable baitfish such as *Spratelloides delicatulus*, whose potential as live-bait has been pointed out by Jones (1960 a, b), in suitable localities in the Lakshadweep and introduction of *Herklotsichthys punctatus*, which is abundant in the Andaman waters, into this area would go a long way to increase live-bait fish supplies for the tuna live-bait fishing in the Lakshadweep.

* *S. devisi* was found to remain in captivity for about two months.

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EFFECT OF FERTILIZATION AT DIFFERENT FREQUENCIES ON THE GROWTH OF MULLET FRY *LIZA PARSIA* (HAMILTON) IN BRACKISHWATER POND SOIL

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ABSTRACT

Rationalization of fertilization using urea (45% N) and single superphosphate (16% P_2O_5) in relation to nutrient availability and growth of mullet fry *Liza parsia* is discussed in this paper.

Fertilization experiments were carried out in glass jars of 10 l capacity on equivalent nutrient basis at the rate of 100 kg N/ha—50 kg P_2O_5/ha at frequencies of 3, 7, 15, 30 and 60 days. Salinity in the water of the jars was adjusted to near about 20‰.

Among the different frequencies of fertilizer application the average nutrient values of both nitrogen (NH_4+NO_3—N—1.15 ppm) and phosphorus (P_2O_5—0.38 ppm) in water were recorded maximum in 3 days' frequency of application, which was correlated to highest density of plankton production 217 u/c). Plankton density ranged from 94-217 u/cc in treated jars in contrast to that of 35 u/cc in control.

The growth of mullet fry was also much better in 3 days' frequency of fertilization due to abundance of more of natural food. The average increment in growth of fry in the above treatment was found to be 354 mg/45 days over control (214 mg/45 days) as compared to other treatments as 241-328 mg/45 days. The study indicated that shorter frequency of fertilization at an interval of 3-7 days would be more effective in enhancing fish growth through sustained yield of natural fish food organisms supported by regulated application of nutrients.

INTRODUCTION

FERTILIZATION of ponds for increased fish production is a common practice in freshwater aquaculture since long. The concept of fertilization of brackishwater fish ponds is different from that of freshwater ponds. The objective, however, is the same to encourage production of natural fish food organisms resulting in higher yield of fish. In freshwater, fertilization of water is done to augment plankton production ; while in brackishwater ponds fertilizers are applied subaqueous, as fertilization of the soil has been found to be more effective for promoting growth of benthic algae as well as plankton.

Saha *et al.* (1978) reported a record fish production by use of chemical fertilizers in freshwater ponds. In contrat, the benefit of chemical fertilization of brackishwater ecosystem is yet to be assessed. However, the use of fertilizers for stepping growth of benthic algae is extensively practised in Taiwan, Philippines and Indonesia (Ling, 1970). The results of experiments in fertilization of brackishwater pond soils at different frequencies are presented in this paper.

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Material and Methods

The soil samples for the experiment were collected from brackishwater impoundments commonly known as *bheries* at Taldi, 24-Parganas, West Bengal. The experiment was set up in glass jars of 10 litres capacity with a soil base of initial conditions such as pH 7.6, available N 15.1, phosphorus (P_2O_5) 4.5 mg/100g and organic carbon 0.6%. Saline water (18‰) collected from the *bheri* was used. Urea (45% N) and superphosphate (P_2O_5 16%) at the rate of 100 kg N/ha and 50 kg P_2O_5/ha were used as fertilizers at different frequencies, *viz.* 3, 7, 15, 30 and 60 days. Fry of *Liza parsia* were used as test animals.

Water samples collected from the jars were analysed fortnightly by following standard methods (A.P.H.A., 1965) and the soil samples were analysed for pH by Colorimetric method, available N by the Subbiah and Asija's method (1956) and organic carbon by rapid black's method (Piper, 1947).

Experiments

Laboratory experiment

The experiment was conducted in order to assess the effect of fertilization at different frequencies on the extent of nutrient availability in the water phase in absence of algal growth. Eighteen glass jars were grouped into 6 sets, each of 3 jars. One such set was kept as control. A soil base of 500 gm. was given in each jar which was waterlogged with 8 litres of bheri water (salinity—18‰). After equilibrium attained between soil and water phases the fertilizers urea and superphosphate were applied to the jars such as 0.018 and 0.27 g/3 days, 0.035 and 0.053 g/7 days, 0.07 and 0.106 g/15 days, 0.14 and 0.212 g/30 days and 0.28 and 0.424 g/60 days respectively. To prevent algal growth in the ecosystem the jars were covered with black paper throughout the experimental period. The data relating to this experiment have been presented in Table 1.

Yard experiment

The experiment was further carried out to assess the effect on fertilization on plankton production and the mullet fry growth. The set up of the experiment and the fertilization schedule were same as in the case of laboratory experiments ; except that the jars were exposed to sunlight. The mullet fry before introducing into the experimental jars were conditioned for 48 hours in the same bheri water (18‰) used

Table 1. *Water qualities in jars during laboratory experiments*

Frequency of fertilization	Temperature (°C)	pH	Total Alkalinity	Phosphate (P_2O_5)	Nitrogen (NH_4+NO_3—N)	Salinity (‰)
			(ppm)			
Control ..	28.4	8.5	111.12	0.07	0.39	18.84
3 days ..	28.2	8.2	73.69	1.66	1.74	19.36
7 days ..	28.1	8.2	81.68	1.54	1.54	18.57
15 days ..	28.1	8.2	78.74	1.52	1.54	18.63
30 days ..	28.2	8.3	73.18	1.53	1.42	18.97
60 days ..	28.2	8.1	62.25	1.52	1.29	21.83

in the experiment. Fifteen days after fertilization, 5 mullet fry of average initial length and weight of 23 mm/170 mg were released in each of the jars. After introduction a few mortality of fry was noticed at initial stage of the experiment which was replaced immediately by the stock fry maintained. Thereafter no mortality of fry was noticed till the end of the experiment. The survival rate was cent per cent in all treatments. Fertilization was continued till the end of the experiment and the growth of mullet fry was recorded after one-and-a-half months of rearing. In 60 days' frequency the fertilizers could be applied once only as the experiment could not be continued beyond two months apprehending mortality might take place. No artificial food was given to fry which utilised only natural food developed in the jars. No aeration was done but loss of water due to evaporation was made up occasionally by adding freshwater and salinity adjusted. The data relating to the water qualities, plankton and fish growth have been presented in Table 2.

Results and Discussion

In other countries where brackishwater aquaculture has been developed, the preparation of pond bottom soil by fertilization is an important practice for promoting the growth of benthic algae. The optimum production of benthic algae depends on adequate supply of nutrients as required in soil water interface. For the purpose, both organic and inorganic fertilizers may be used. Organic manures consist of cow dung, poultry droppings, rice bran etc., while chemical fertilizers consist mainly of nitrogen and phosphorus (Ling, 1970).

From Table I it is seen that at the same rate of fertilization in each of the frequency, viz. 3, 7, 15, 30 and 60 days, the average concentration of nutrients was found to be the highest in 3 days' frequency of fertilization. The values of dissolved inorganic nitrogen (1.74 ppm) and phosphorus (1.66 ppm) were maximum in the above treatment as compared to the control (0.39 and 0.07 ppm). The lowest value (1.52 and 1.29 ppm) were, however, recorded in the treatment of longest frequency (60 days). It was also noticed that the alkalinity values ranging from 62.25—81.68 ppm in the treatments were considerably lowered due to fertiization as compared to the control 111.12 ppm.

Consequently, the pH values 8.1-8.3 were also lower than that in the control (8.5). The variation in the salinity (18.84—21.83‰) both in the treatments as well as in the control was more or less same except in 60 days' frequency in which a little higher value was recorded.

It is also seen in the yard experiment (Table 2) that shortest frequency of fertilization at an interval of 3 days maintained highest concentration of nutrients (NH_4+NO_3—N 1.15 and P_2O_5 0.40 ppm) as compared to the control (0.07 and 0.02 ppm respectively). The alkalinity of water in yard experiment recorded higher values (121.67—132.55 ppm) as compared to control (119.35 ppm) ; correspondingly the pH values ranged from 9.0—9.2 in treatments were higher than that in control 8.7. The relationship between pH and alkalinity in general was discerned in both the experiments with and without algae. The increase in total alkalinity in treated jars might be due to NH_3 and other organic substances which resulted from the decomposition of algal matter.

The biological productivity as shown in the Table 3 indicates that fertilization had positive effect on plankton production and fish growth. Maximum production of plankton (217 units/cc) and average growth of fry of *L. parsia* (36 mm/568 mg) were recorded in 3 days' frequency of fertilization as compared to control (35 units/cc and 28 mm/214 mg respectively). The increase in growth of mullet fry (weight) in the above treatment was about two-and-a-half times more than that in the control. In longest frequency of fertilization (60 days) the increase in growth of fry was

TABLE 2. *Water qualities in jars during field experiments*

Frequency of fertilization	Temperature (°C)	pH	Total Alkalinity	Phosphate (P_2O_5)	Nitrogen (NH_4+NO_3—N)	Salinity (‰)
			(ppm)			
Control ..	32.4	8.7	119.35	0.02	0.07	19.13
3 days ..	32.8	9.2	121.67	0.38	1.15	19.93
7 days ..	32.0	9.2	127.55	0.28	1.09	18.52
15 days ..	32.6	9.0	132.55	0.27	1.09	18.62
30 days ..	32.5	9.2	128.77	0.22	0.95	18.07
60 days ..	32.7	9.2	130.37	0.37	0.91	19.61

TABLE 3. *Effects of fertilization at different frequencies on plankton production and growth of mullet fry* (L. parsia)

Frequency of Fertilization	Plankton					Fry : *L. Parsia*	
	Phyto/cc	Zoo/cc	Total/cc	Dominating Phyto plankters	Dominating Zoo plankters	Av. initial growth L/wt	Av. final growth L/wt
Control ..	19	16	35	*Oscillatoria* sp.	*Ciliates* *Rotifera*	23 mm/170 mg	28 mm/214 mg
3 days ..	170	47	217	*Synedra ulna* *Nitzschia* sp.	(*Brachionus* sp.) *Distyla* sp.	,, ,,	36 mm/568 mg
7 days ..	74	23	97	*Navicula* sp.	etc. *Vorticella* sp.	,, ,,	36 mm/522 mg
15 days ..	75	34	109	*Clostridium* sp.	*Arcella* sp.	,, ,,	34 mm/508 mg
30 days ..	60	34	94	etc.	etc.	,, ,,	36 mm/542 mg
60 days ..	85	46	131			,, ,,	35 mm/455 mg

comparatively less than those of shorter frequencies (3 and 7 days) of fertilization.

It appears from the study that shorter frequency of fertilization will be more effective in brackishwater ponds, because it will ensure steady supply of nutrients in the media for the growth of plankton and minimise the loss of nutrients, particularly nitrogen. Although a good growth of plankton was noticed in the longest frequency of fertilization at the initial stage, it was not found maintained uniformly throughout. The loss of nutrients was more when larger quantity of fertilizers was applied at one time.

The dominant species of phytoplankton are *Synedra* sp., *Oscillatoria* sp, *Nitzschia* sp., *Navicula* sp. and *Clostridium* sp. and the zooplankton are *Brachionus* sp., *Distyla* sp. and *Vorticella* sp.

In Indonesia, Djajadiredja and Poernomo (1970) reported highest yield of milkfish by the application of 130 kg/ha urea, 65 kg/ha triple superphosphate and 1,000 kg/ha rice chaff. They also reported that 'complesal' containing 20% N and 20% P_2O_5 was not superior to combined effect of urea and triple superphosphate.

In U.A.R., Zarka and Fahmy (1968) found that phosphate fertilizers were effective in increasing the yield of mullet in brackishwater ponds by 166.7%, as compared to that in the control pond. However, Tang and Chen (1967) stated that inorganic fertilizers did not give significant increase of milkfish yield.

The benefits of inorganic fertilization in brackishwater ponds in India have not yet been properly assessed. If suitable technique of fertilization is developed in our country, it will be of great help in enhancing fish production. Therefore, a detailed study on fertilization is necessary. Considering the optimal ratio of N : P (4 : 1) for the growth of phytoplankton, the N-bearing inorganic fertilizer may yield better results in brackishwater aquaculture.

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FOOD AND FEEDING EXPERIMENTS IN RABBITFISH *SIGANUS JAVUS* (LINNAEUS)

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ABSTRACT

Juveniles of *Siganus javus*, a herbivore fish were reared in the laboratory fed with natural food. *Oscillatoria* sp., *Phormidium* sp., *Chaetomorpha* sp., *Gracilaria edulis*, *Enteromorpha intestinalis*, *Halophila* sp. and *Cymodocea* sp. were offered separately and also as mixed food.

Fishes fed with *Enteromorpha intestinalis* and *Gracilaria edulis* increased in length ranging from 5 to 15 mm and showed a weight increase of 74% to 185% in 30 days, while fishes fed with *Halophila* sp. and *Cymodocea* sp. lived for only 2 to 3 days. Fishes fed with *Oscillatoria* sp., *Phormidium* sp. and *Chaetomorpha* sp. lived for 5 to 7 days but did not show appreciable growth. Fishes fed with a mixture of all these incresed in length from 10-20 mm and showed a weight increase of 225% to 315% in 30 days.

INTRODUCTION

SIGANIDS are now attracting the attention of mariculturists in many countries (Lam, 1974 ; Von Westernhagen and Rosenthal, 1976). Six species of Siganids occur in Sri Lanka and Peninsular India (Munro, 1955). Considering the great interest evinced recently in the culture potentialities of siganids, a preliminary study of *Siganus javus* (Linnaeus) was carried in 1978 and the results of food and feeding experiments are presented here.

MATERIAL AND METHODS

Specimens of *Siganus javus* were collected from cast net operated in Vellar Estuary and trawl catches from inshore waters of Parangipettai from January 1978 to August 1978. Formalin preserved specimens were analysed for gut contents. Experimental fishes were kept in cylindrical glass troughs (5 litres capacity) containing estuarine water of 32‰ to 32.8‰ salinity. The water was changed daily and well aerated. Everyday soon after the change of water, fresh supply of food weighing 50 to 100 gms were introduced into the glass troughs containing the fish.

OBSERVATION

Gut contents of hundred specimens ranging in size from 28 mm to 145 mm in standard length were examined of which eleven were found to have empty stomachs. Forty-eight fishes had their stomachs full with food material, while thirty-two had half-full stomachs. In the case of nine fishes there were only little material in their stomachs.

Filamentous algae formed the dominant food of the fish. In twentyfive fishes, small quantities of animal material like bits of jelly fish, polychaete worms, polychaete egg mass, Amphipods, *Apseudes*, Gastropod egg masses and fish tissue were encountered in the gut contents.

Enteromorpha intestinalis and *Gracilaria edulis* occurred dominantly in all fishes while *Halophila* sp. and *Cymodocea* sp. were present in small quantities in the gut contents. Further it

was found that *Halophila* sp. and *Cymodocea* sp. material were rotting stuff and not fresh ones.

Kaliyamurthy and Janardhana Rao (1972) have reported that *Siganus javus* and *S. oramin* are herbivorous fishes. In the present study also it is seen that *Siganus javus* is mainly a herbivorous fish like other siganids (Von Westernhagen, 1974).

Feeding experiments and growth

Juveniles of same size from the estuary were collected and kept in circular glass trough for experiments. Five fishes were killed and the average total length and standard length were 34 mm and 27 mm respectively, while the average weight was 0.520 gm. Sets of five fishes each were kept in troughs and each set was either fed exclusively with a single algal or plant diet or with a mixture of all algae and plant material. Feeding experiment was stopped after thirty days.

Out of five fishes which were fed with *Enteromorpha intestinalis* only one died the next day and another the day after. After thirty days the three fishes when measured were 32 mm, 35 mm and 42 mm in standard length showing an increase of 5, 8 and 15 mm from the average of of 27 mm and their weights were respectively 0.910 gm, 1.040 gm and 1.482 gm. The percentage of weight increase was 75%, 100% and 185%.

Out of five fishes which were fed with *Gracilaria edulis*, two died on second day and a third on fourth day. Only two survived and after thirty days the two fishes showed a length increase of 5 mm and 14 mm, while they increased in weight respectively by 0.385 gm and 0.520 gm (i.e. 74% and 100% increase in weight).

Fishes fed with *Halophila* sp. and *Cymodocea* sp. lived for only 2 to 3 days, while fishes fed with *Oscillatoria* sp., *Phormidium* and *Chaetomorpha* sp. lived for 5 to 7 days and did not show appreciable growth.

Out of five fishes fed with a mixture of all these as food items, two died on second day and a third fish on sixth day. Only two survived and the two fishes showed an increase in length by 10 mm and 20 mm while they showed a weight increase of 225% and 315% after 30 days.

In contrast to the experiments of Von Westernhagen (1974) mortality occurred in the present experiments and Ben-Tuvia *et al.* (1973) have also reported about mortality in their experiments. Values of weight and length increase over 30 days period are lesser than that reported by Von Westernhagen (1974) and Ben-Tuvia *et al.* (1973) who used commercial pelleted food.

Fingerlings and juveniles of *Siganus javus* occurred from January to August and they were abundant from March to May. Each cast net haul operated in shallow water brought about 10 to 20 fingerlings. Siganids being herbivorous can be tried in monoculture or in polyculture in India. Von Westernhagen (1974) have reported that polyculture of milkfish and siganids does not seem to be economically feasible in Philippines. Since *Siganus javus* feeds on algae, it can be introduced in mussel culture ponds and clam culture ponds and the fish will help to reduce the filamentous algal growth in these ponds.

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EXPERIMENTAL CULTURE OF THE SHORT-FINNED EEL *ANGUILLA BICOLOR BICOLOR* McCLELLAND

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ABSTRACT

In this paper the various techniques adopted in the culture of eels (*Anguilla* spp.) and the results obtained in the experimental culture of the short-finned eel, *Anguilla bicolor bicolor* McClell and in running water and in recirculating running water have been dealt with. Experimental culture of the eel, *A. bicolor bicolor* in running water was conducted during 1974-76 at the Regional Centre of Central Marine Fisheries Research Institute, Mandapam Camp. The average size of the elvers stocked at the beginning of the experiment was 13 cm in length and 3 g in weight. It has been found that the average size of the eels at the end of one year was 28 cm in length and 43 g in weight. The average length at the end of second and third years were 38 cm and 42 cm and weights 123 g and 177 g respectively. The overall increase in growth obtained in this experiment was found to be not rapid and the probable reasons for the same are pointed out. Studies on conversion efficiency of different eel foods have shown that silverbellies give high conversion ratio and sardines low conversion ratio. Clams, prawns and mixed foods have also been found to give better conversion ratio than sardines. From this experimental culture the net production potential has been estimated to be 2.2 kg/sq. m in one year and 4.11 kg/sq. m in two years.

In another experiment, the short-finned eel *A. bicolor bicolor* was cultured in re-circulating running water in an outdoor cement tank of 6 m length × 3 m width × 1 m height, with natural mud bottom. By suitable arrangements the water in the culture tank was automatically re-circulated after filtration and oxidation. About 1/3 of the water in the culture tank was drained out weekly and replenished with fresh water. In the beginning of the experiment 9 kg of eels, each eel, with an average weight of 43 g were stocked in the tank at a rate of 500 g per sq. m area.

An eel feed in the form of a paste made of minced silverbellies, broken rice and oil cake mixed in 2 : 1 : 1 proportion with 0.2% multivitamins was given to the eels at a daily ration ranging from 5 to 10% of their body weight. At the end of five months the total weight had increased to 47.7 kg which works out to a net increase of 430% of the initial stocking weight. The average weight of eel had increased from 43 g to 232.8 g in five months. The survival rate was 98.6%. The net production rate works out to 2.15 kg/sq. m in five months period.

INTRODUCTION

EEL CULTURE is a commercially profitable industry in several East Asian countries, particularly in Japan and Taiwan, where the Japanese eel *Anguilla japanica* Temminck and Schlegel is cultured on a large scale since several decades. Cultured eels are a delicacy and as there is great demand for the same, the production is increasing steadily. Throughout the world on an average about 25,000 tonnes of wild eels and 26,000 tonnes of cultured eels are harvested annually, of which Japan alone produces about 2,000 tonnes of wild eels and 24,000 tonnes of cultured eels (Usui, 1974). Faced with shortage of elvers for culture purpose Japan imported large quantities of elvers from countries like Taiwan, South Korea, China, Hong Kong, Philippines, New Zealand, France, Spain, Italy, Great Britain, Canada and United States of America (Folsom, 1973; Forrest, 1976). In India elvers of two species of *Anguilla, viz.*,

Anguilla bicolor bicolor McClelland and *Anguilla nebulosa nebulosa* McClelland are known to be available in the east coast rivers Tamraparni, Godavari and Hooghly (Rahimulla *et al.*, 1944 ; Pantulu, 1956 ; Ibrahim, 1961 ; Nair, 1973 ; Nair and Dorairaj, 1975). A recent survey has brought to light for the first time immigration of glass eels and elvers in many rivers in Tamil Nadu (Dorairaj and Soundararajan, 1980). Even though many fish species of both fresh and salt waters are being successfully cultured in India (Alikunhi, 1957 ; Tampi, 1960, 1969 ; Hickling, 1970), no attempt has been made to culture the Indian eels until 1971 when experimental culture of *Anguilla bicolor bicolor* was undertaken at the Central Marine Fisheries Research Institute at its Regional Centre at Mandapam Camp (Nair, 1973). In this paper the results obtained in the experimental eel culture in running and recirculated running water and food conversion studies are presented. The general techniques employed in eel culture at various stages are also briefly given.

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Eel Culture Techniques

Elvers are the starting point for eel culture. Seed elvers of 55-100 mm in length and 0.16-2.0 g in weight are collected during night time by using several types of nets like scoop nets, screen nets, bag nets and a special type of net known as 'Japanese Elver fishing net' when they ascend rivers immediately after a freshet. Very early stage elvers-glass eels-are completely transparent and thread like whereas last stage elvers are pigmented and slightly thicker in size. The elvers are transported in different types of containers like conventional fish tin carriers made of galvanised sheet metal, PVC containers, specially made wooden boxes, styroform containers etc. For conducting eel culture a good supply of fresh water or brackish water is very essential. In the initial phase of eel culture elvers are to be stocked and reared in small nursery ponds, the size of which may range from 150-600 sq. metres in area and 70 cm deep. After about three months elvers have to be stocked in bigger ponds known as fattening or adult ponds varying in size from 0.08 to 4 hectares and 1 to 1.5 metres deep. The adult ponds should be long, narrow and rectangular as it has been observed that the shape of the pond has an effect on growth and that eel locate food more easily in such ponds (Bardach *et al.*, 1972). The collected elvers have to be sorted accoring to size and stocked in densities which depend upon the quantity and quality of water supply. Stocking density is always higher in running water culture than in still water culture. The optimum stocking density is 30 elvers each weighing 0.16-0.2 g or 20 young eels of about 15 gm each per sq. metre.

In eel culture feeding is an important aspect. Elvers do not take food for the first few days after their capture and they have to be slowly acclimatised to a regular feeding habit. Crushed earthworms are to be given to the elvers when they begin feeding and later on a mixed food of earthworms and fish flesh. After a month the growing elvers may be supplied with fresh or cooked fish like sardines, silverbellies, trash fishes along with prawns and clam meat. Eels prefer to feed in a dark place. Therefore the feeding place should be provided with a shelter. Feeding should be done only in a particular place in the pond, preferably in a corner by placing the food in a wire basket or perforated tray and suspending it just above the water to prevent contamination of water. The elevers are given food at a ration of about 40% of their body weight and

the growing eels about 10% of their body weight. Growth rate in eels is observed to be very rapid during April-October period. Therefore eels should be given as much food as possible during the above period. Concentrated dry food in the form of pellets are also being widely used and has been found to give higher conversion ratio than the fish foods.

The success of eel culture also depends upon the proper maintenance of the farm. The ponds should have a minimum water depth of about 60 cm. Even under optimum conditions of good water supply, temperature, stocking density, adequate food and proper maintenance, cultured eels exhibit a wide range in growth rate, both in terms of length and weight. Therefore, at periodical intervals in all stages of culture culling should be done which will ensure uniform size of eels at the time of harvesting. Control and eradication of eel diseases is another important aspect in eel culture. Many types of diseases such as Fungus disease, Red disease, Gill disease, White spot disease, Myxidium disease etc. are known in eels. The diseases could be controlled by using suitable anti-bacterial drugs and flushing the pond with fresh water. The introduction of concentrated dry food has facilitated mixing of drugs in eel food which could be supplied to the eels to cure their diseases. The cultured eels are harvested when they reach marketable size. The principal nets used for harvesting are scoop nets, trap nets, cast nets, screen nets and seine nets. When a partial or selective harvest is done the water in the ponds is not drained but in the final harvest ponds are usually drained before fishing.

The production or yield per hectare varies with the type of culture method adopted. Eels are cultured by two methods *viz.*, running water culture and still water culture. The principal aim in these two methods is to achieve maximum production in a short period of time by culturing eels in a confined area and providing extra oxygen and more food. In running water culture a continuous supply of freshwater will be maintained to the pond and simultaneously an equal amount of water will be drained to keep the water level in the pond constant. In this method eels are supplied with a large amount of fresh oxygen through constant flow of fresh water. In still water culture the pond water will be more or less static and only about 5% of the volume of the pond water is changed daily. There is production of dense phytoplankton which in turn through photosynthesis increases the oxygen content of the pond water, thus providing extra oxygen for the eels. Depending upon the availability of water any one of the above two methods could be adopted in eel culture.

Results of Experimental Eel Culture

Culture in running water

A total of about 1200 elvers of *Anguilla bicolor bicolor* McClleland, collected from Srivaikundam Anicut near Tuticorin, during November 1973, were reared in eight fibre-glass tanks (122 cm × 76 cm × 76 cm) in densities ranging from 330 g per sq. m to 1,500 g per sq. m. Each fibre-glass tank was provided with independent running water facilities. The elvers and growing eels were fed twice daily to satiation with fish flesh and clam meat. At periodical intervals the total weight of elvers and growing eels in each tank, were taken and the lengths and weights of about fifty numbers from each tank were masured to determine the growth rate. To measure live elvers an anaesthetic technique was followed. Out of the eight tanks growth studies were followed in four tanks for two years. At the end of two years culling was done and growth rate was followed for bigger size groups. The results obtained in the growth studies are given in Table 1.

TABLE 1. *The average sizes of eels* A. bicolor bicolor *in different tanks during different periods in experimental running water culture (Average weights are given in parentheses)*

Month	Tank 1	Tank 2	Tank 3	Tank 4	Average
November '73 ..	119 (2.1)	115 (1.9)	146 (4.2)	146 (4.0)	131 (3.0)
March '74 ..	149 (6.3)	150 (6.5)	189 (13.1)	175 (10.3)	166 (9.1)
May '74 ..	167 (8.5)	175 (9.6)	213 (16.9)	185 (11.2)	185 (11.6)
October '74 ...	280 (47.7)	289 (45.9)	288 (44.5)	256 (31.8)	278 (42.5)
February '75 ..	335 (92.6)	354 (96.6)	334 (80.1)	315 (68.7)	334 (84.5)
March '75 ..	364 (104.8)	366 (102.3)	345 (90.0)	327 (76.8)	350 (76.2)
July '75 ..	381 (115.4)	377 (106.4)	351 (86.7)	316 (60.7)	355 (92.3)
October '75 ..	430 (163.9)	384 (123.2)	348 (91.0)	358 (92.8)	380 (119.3)
November '76 ..	..	..	..	..	419 (177.0)

TABLE 2. *Total weights of eels in different periods and monthly rate of weight increase in percentage of previous total weight* (The density rates in g per sq. m are given in parentheses)

Tank	Total weight of eels (in g) and monthly weight increase in %			
	Initial	At the end of		
		1 month	2 months	4 months
I ..	581 (710)	957 (1153) 64.4%	1328 (1600) 38.8%	1901 (2290) 21.6%
II ..	702 (846)	1096 (1321) 56.1%	1657 (1996) 51.3%	2260 (2723) 18.2%
III ..	977 (1177)	1254 (1511) 28.4%	1557 (1876) 24.2%	1955 (2355) 12.8%
IV ..	1430 (1722)	1729 (2083) 21.0%	2062 (2484) 19.3%	2656 (3200) 14.4%

In the beginning of the experiment in November 1973 the sizes of elvers ranged from 71 mm to 191 mm in length weighing 0.3 g and 9.5 g respectively, with an average of 131 mm in length and 3 g in weight. At the end of six months the average size of elvers was 185 mm in length and 11.6 g in weight. The net increase in length and weight was 54 mm and 8.6 g respectively with a monthly growth rate of 9 mm and 1.4 g. At the end of eleven months the elvers had reached an average size of 278 mm (43 g), showing an increase of 147 mm and 39.9 g from initial average size. The monthly growth rate works out to 13.4 mm in length and 3.6 g in weight. During the second year an average growth increase of 102 mm and 76.3 g was observed with a monthly growth of 8.5 mm and 6.4 g. Thus in about two years the average size of growing eels had reached to 380 mm (119 g) and the increase was 249 mm (116 g). At the end of third year the average size of the eels was 419 mm in length and 177 g in weight. During the third year the monthly growth rate was 3 mm in length and 4.5 g in weight. It was observed that the length increase was faster in the first year and slower in the second and third years while the weight increase was more in the second year compared to first and third years. In the present experimental culture differential growth was observed among the eels reared in the tanks (Table 1). In the first year the average sizes attained by eels in different tanks were more or less similar except for one tank and were comparable with overall average size of about 28 cm and 43 g. But in the second year the differential growth of eels in different tanks was much marked which ranged from 60 mm (46.5 g) to 150 mm (122.2 g). It may be of interest to note here that the average size attained by the eels at the end of second year in one tank was higher than the overall average size of the eels at the end of third year.

There seems to be an inverse relationship between the rate of density and the rate of weight gain in eels in succeeding months. As the density increases, the rate of weight increase was found to decline progressively (Table 2).

Food conversion studies

Experiments were conducted to study the conversion efficiency of different animal feeds that were available locally so as to select an economically better feed for commercial culture of eels. The materials such as sardines, clam meat, silverbellies and prawns were given either separately or in mixed combinations. Seven types of feeds, namely (1) Sardines, (2) Clam meat (3) Silverbellies, (4) Prawns, (5) Sardines 50% and clam meat 50%, (6) Sardines 50% and prawn 50% and (7) Sardines 25%, clam

TABLE 3. *Results of conversion rates of various food items*

Type of feed	Daily food consumption in % of body weight		Increase in weight (g)	No. of days	Total amount of food consumed (g)	Gross conversion rate	
	Range	Average				Monthly range	Average
Sardines ..	1.9- 4.5	3.1	1,214	123	22,916	11.5-24.3	18.9
Sardines and clam meat ..	5.2- 9.6	7.0	2,700	218	19,933	5.22-8.3	7.38
Clam meat ..	5.5-10.3	7.7	3,060	218	25,128	6.4- 9.9	8.21
Sardines & prawns ..	3.2- 6.5	4.5	995	218	16,476	10.7-27.7	16.56
Sardines, clam, silverbellies & prawns ..	4.0- 8.1	5.0	2,678	218	22,364	7.9- 9.5	8.35
Silverbellies ..	3.1- 6.2	4.5	2,230	218	15,510	5.7- 8.2	6.96
Prawns ..	3.4- 6.0	4.6	1,660	218	11,619	6.0- 9.8	7.00

meat 25%, silverbellies 25% and prawn 25% were tested for gross conversion efficiency. The elvers and the growing eels were fed twice daily, morning and evening, to satiation. The feed was supplied in excess quantity at a ration of about 5 to 15% of the body weight. Usually the elvers and the growing eels were found to feed very actively when the feed was offered and within ten or fifteen minutes majority of them would have fed to satiation. However, the feed was kept for a longer time upto about one hour and then only the left over feed would be removed. The total weights of the feed supplied and the left over were taken to determine the actual consumption. The results obtained in the feeding experiments are given in Table 3.

It may be seen from the above table that the daily average consumption of eel feeds in percentage of body weight varied from 3.1 for sardines to 7.7 for clam meat. Silverbellies and prawns were found to give better conversion rate than the other feeds. The gross conversion rate of silverbellies was between 5.7 and 8.2 with an average of 6.96. Similarly for prawns the range was between 6.0 and 9.8 with an average of 7.0. The next best average conversion rate of 7.38 was for a mixed feed made of sardines and clam meat. Sardines had given the lowest gross conversion rate which ranged between 11.5 and 24.3 with an average of 18.9. Though the silverbellies and prawns were found to give more or less a similar conversion rate of 7.0, silverbelly feed is considered to be the best suitable feed for the eel culture at the locality because of its cheap price and easy availability. The nutritional values of silverbelly feed are as follows : crude protein 13.61%, fat 6.59%, ash content 7.18% and moisture 70.70%.

Production

For estimating the production rate the increase in total weight of elvers during the period from March 1974 to March 1976 has been taken into account. During March 1974, 7.28 kg of elvers were stocked in fibre glass tanks having a total surface area of 6.65 sq. m. At the end of one year the total weight of grown up eels was 22.22 kg, with a net increase of 14.94 kg. At the end of second year the total weight of cultured eel was 34.61 kg. The net increase from initial weight in two years was 27.33 kg. The net production in one year works out to 2.247 kg/sq.m and in two years 4.112 kg/sq. m.

Eel Culture in Re-Circulating Water

In August 1978, another experiment was conducted to culture *A. bicolor bicolor* McClelland in re-circulating running water. For this purpose a separate cement tank of 6 m × 3 m × 1 m size with natural mud bottom was constructed. By sluice gate arrangement the bottom water was gravitationally drained out and passed through a filtering medium consisting of big and small granite stones and charcoal arranged in alternate layers and with a layer of sand at the top. The filtered water was allowed to settle in a settling tank. In the settling tank partitions using asbestos sheets, were erected in such a way that water travelled longer distance thereby allowing time for settlement. The clear water in the settling tank was then allowed to overflow to the oxidation tank. From the oxidation tank the water was pumped up into a small over-head tank and from it fed to the culture tank. Thus the water from the culture tank was reused again and again after filtration and oxidation. Weekly once about 1/3 of the water in the culture tank was drained out and replenished with fresh water. Water level was maintained at 70 cm in the culture tank.

An effective feeding method was adopted in this experiment. A sheltered feeding area was provided on one side of the culture tank in the form of a wooden platform with a small

door in the middle. The sides below the platform were covered with black cloth to cutdown direct light to the feeding area. The eel feed in the form of a paste made of minced silverbellies, broken rice and groundnut oil cake mixed in 2 : 1 : 1 ratio with 0.2% multivitamin was placed in a plastic tray and suspended through the door at the water level. Then the door would be closed. The eels in the tank would immediately congregate near the tray, climb over it, dart to the food, take a mouthful and slip back into the water. After gulping the food the eels would again climb the tray and take another mouthful of food. This is repeated and after satiation the eels would settle down at the bottom of the tank. The tray with leftover food would then be lifted out through the door. By this method contamination of water by food was effectively avoided. The eels were fed at a daily ration ranging from 5 to 10% of their body weight. The food values of the compound feed were : crude protein 23.20%, fat 7.63%, carbohydrate 21.51%, ash content 3.90% and moisture 43.76%.

In the beginning of the experiment on 1-8-1978, 9 kg of young eels, 208 in numbers, the size ranging from 20 g to 65 g with an average total weight of the eels was 47.8 kg. The net weight of 43 g, was stocked in the culture tank at a stocking rate of 500 g per sq. m. At the end of each month a sample of about 50 to 100 eels in the tank was scooped out and individual weights were recorded. Based on the average weight of the eel at the end of each month, the total weight of the eels in the tank was estimated. The results obtained in the experimental culture are given in Table 4. It may be seen from the table that the average weight of the eel has increased from 43 g to 84 g in one month, 132 g in two months, 203 g in four months and 232.8 in five months and ten days. At the time of harvest the increase in total weight works out to 430% of the initial stocking weight. The survival rate was 98.56%. The gross food conversion ratio for the four month period (from August to November '78) was 1 : 5.3. The stocking rate at the beginning of the experiment was 0.5 kg/sq. m. At the end of 5 months it had increased to 2.65 kg/sq. m. The net production rate works out to 2.15 kg/sq. m in five months.

TABLE 4. *Results of the experimental eel culture in re-circulated running water. The details of average weight, total weight, percentage increase, survival rate and gross food conversion during different months are given*

	1-8-78 (at stocking)	1-9-78	1-10-78	1-12-78	10-1-79 (at harvest)
Average weight of eel in g ..	43	84	132	203	232.8
Total weight of eel in the tank in kg ..	9	17.5	27.5	42.0	47.8
Percentage weight increase in initial stocking weight		94.58	206.0	366.7	430.0
Survival rate ..		100%	100%	99.5%	98.5%
Quantity of food consumed in kg. ..		34.57	37.82	102.98	
Gross food conversion ratio ..		1 : 4.0	1 : 3.8	1 : 7.1	
Average gross food conversion ratio ..			1 : 5.3		

DISCUSSION

Though the eel culture has been in vogue for the last ten decades in Japan, in India it was first done only in 1971 (Nair, 1973 ; Nair and Dorairaj, 1975). In their experimental eel

culture in running water, elvers with an average size of 10 cm and 2 g had reached an average size of 35 cm and 106 g at the end of about one year and 42 cm and 160 g at the end of second year with an average monthly increment of 8.6 g and 4.5 g during the first and second year respectively. In the present study, the size attained at the end of one year works out to about 29 cm in length and 49 g in weight and at the end of two years 38 cm and 119 g. As compared to the earlier results the present results are low. It may be mentioned here that in the present work elvers and growing eels were cultured in fibre glass tanks and they were subjected to constant handling and disturbance due to daily cleaning of the tank and periodical anaesthetisation for taking measurements of length and weight. Culture in fibre glass tanks and frequent disturbance could have inhibited the growth rates to a certain extent. The growth rate obtained in the re-circulated running water in the present study provides evidence to substantiate the above conclusion. When the eels of 43 g size were stocked in the outdoor tank with natural mud bottom, the average weight reached to 232.8 g in about 5 months, where as the same size eel cultured in fibre glass tank reached only to 76.2 g in the same duration (Table 2 and 4). Further, the result obtained in the re-circulated running water culture has been found to be very high as compared to results obtained in experimental eel culture in Europe. In Channel system 30 g European eel had reached to 160 g in 12 months and in river ponds 49 g European eel reached 109 g in six months (Tesch, 1977). In Japan, according to Usui (1974) 60 g Japanese eels reach marketable size of 150-200 gms in about twelve months.

The conversion rates of traditional foods and artificial feeds obtained in eel culture in Japan and Taiwan are given by Bardach *et al.* (1972). In Japan the sardines had been found to give conversion rates ranging from 5.4 to 7.2 and the mixed feed i.e. chopped fish, silk worm pupae etc. had given a conversion rate of 5.5. In Taiwan the conversion rates for trash fish ranged from 10-15. In the present work sardines had given poor conversion rates ranging from 11.5 to 24.3 with an average of 18.9. The conversion rate of the mixed feed, composed of silverbellies, broken rice and oil cake with 0.2% multivitamin given to the eels cultured in re-circulated running water, was more or less similar to those of chopped fish, silk worm pupae etc. Fresh fish feed, such as mackerel, atka fish, saury pike, miscellaneous types of brown fishes etc. used in Japanese eel farms, had given a conversion rate from 4.8 to 6.9 (Forrest, 1976). The conversion rate of silverbellies and prawn (7) obtained in the present feeding experiment is comparable to the above feed. Since silverbellies are available in this region in large quantities at cheap price it will be a best suited feed for commercial eel culture.

With regard to the production rate, what was obtained in one year (2.25 kg/sq. m.) in running water culture had been achieved in about five months in recirculated running water. In Japan the production potential in running water in one year is stated to be 26,360 kg/hectare which works out 2.6 kg/sq. m (Bardach, 1972).

Research work done so far to artificially spawn the *Anguilla* spp. has met with very little success only. By injecting three harmones and pituitary extract of rainbow trout, an adult female eel had been made to spawn about 5 million eggs (Anon, 1971) Artificial fertilisation and early development of larvae (5 days) in Japanese eel were successfully carried out by Yamamoto and Yamokuchi (1974).

There are good prospects for commercial eel culture in India as the Indian species had given encouraging results in the experimental culture. The recent survey undertaken to locate the elvers in Tamil Nadu had brought to light many promising centres for large scale elver collection. What is required now is to undertake the culture on pilot scale to work out the economics of culture operation.

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EFFECTS OF DDT ON THE ENERGY COMPONENTS OF AN ESTUARINE CATFISH

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ABSTRACT

Data on growth rate in different environmental conditions is essential before undertaking fish farming as also information on the effects of pesticides on their growth and metabolism because of increasing pollution of our coastal waters due to leaching of pesticides from spraying of the fields. In the present study, tests were conducted with juveniles of an estuarine cat fish *Mystus vittatus* at different DDT concentrations. Changes in feeding rate, oxygen consumption, conversion efficiency were estimated by feeding fishes *ad libitum* with dry liver of goat for 6 weeks exposure time. Temperature and water quality were kept constant.

Feeding rate, oxygen consumption, growth rate and conversion efficiency were found to be varying at different DDT concentrations tested. Conversion efficiencies decreased with increase in DDT concentration. The exoretion of faeces was also found to be more in treated ones. Oxygen consumption also showed an increasing trend with increasing DDT concentration. Results have been interpreted and discussed.

INTRODUCTION

THE EFFECTS of pollutants introduced into the environment either directly or indirctly by man through his activities has received much attention in recent years. Of particular interest are the effects on fish production due to an increase in pollution of our coastal waters by leaching of pesticides sprayed in the paddy fields. Metabolism and growth response in relation to food consumption are important variables affecting the overall energetics and growth in a fish. The scheme of energy balance followed in the present work is the IBP formula (Petrusewicz and Mac Fadyen, 1980), represented as C=P+R+F+U, where C is the energy consumed, P the growth, R the energy lost as heat due to metabolism, F the faeces and U the nitrogenous excretory products. The components are generally affected by environmental conditions, which may decrease food consumption, metabolism, growth, etc. depending on the type of stress.

Energy losses in growth and food conversion due to conifer-ground wood paper fibre (Smith *et al.*, 1967), carbaryl pesticides (Carlson, 1971), Kraftmill effluents (Tokar and Owens, 1968 ; Webb and Brett, 1972), endrin (Grant and Merle, 1973) and pentachlorophenate (Krueger *et al.*, 1968 ; Warren, 1971 ; Webb and Brett, 1973) have been reported. Webb (unpublished data) pointed out a twofold increase in standard metabolism in sockeye salmon exposed to bleached Kraftmill effluent at one-tenth of the concentration that was lethal to 50% of fish after 96 hrs of explosure in an acute lethal bioassay In salmonids, Fenitrothion caused regurgitation and thus reduced food consumption. Only a few workers have published complete energy budgets incorporating the effects of pollutants on the energy components (Tokar and Owens, 1968 ; Webb and Brett, 1972, 1973). The present investigation was attempted to gather information on the effects of DDT on overall

changes in the energy budget of an estuarine catfish *Mystus vittatus* (Bloch).

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Material and Methods

Mystus vittatus used in this study were obtained from the Vellar Estuary, Porto Novo (11°29' N 79°49' E) using a cast net and only those specimens in the weight range of 2-2.5 gm were used for the study. Fishes were transported to the laboratory in large buckets and kept in acclimatization tank, where, expecting for feeding and observation, there were least disturbances. They were fed with oven-dried pieces of goat liver and were acclimatized to laboratory conditions for 5-7 days.

Experiments were conducted in plexi-glass tanks of 40 l capacity. Tap water (salinity 3‰) was used as the medium. Groups of five fishes were exposed to DDT concentrations of 0, 2 and 4 ppb. Preliminary tests showed that these concentrations were not lethal. Dissolved oxygen was maintained between 90 and 100% air saturation. The temperature of the water was kept constant at 29± 1°C. Each treatment was replicated to check for 'inter-tank' variability.

Fishes were fed *ad libitum* once a day at 0800 hrs in the morning. The food was left in the tank for one hour and after that time the remaining food was collected to estimate the amount of food consumed. Faeces were collected daily by filtering the water through a fine glass-fibre filter. The water was constantly aerated and care was taken to fill with fresh medium twice a week with least disturbance. The duration of the experiment was 6 weeks and wet weight measurements were taken at two-week intervals. The fish were starved for 24 hours before weighing. Initial and final measurements of fish included dry weights and calorific value. Oxygen consumption was measured using a closed type respirometer. After estimating levels of all energy components 'U' was computed from the forementioned equation. All the components of the energy equation are expressed in calories.

Calorific Analysis

The fish, food and faeces were dried to constant weight at 80°C for 24 hours and the dried samples were powdered for further calorific analysis.

Calorific contents of the samples were determined using a Parr oxygen bomb calorimeter supplied by Parr Instrument Company, INC, Illinois, U.S.A. The bomb calorimeter was standardised using naphthalene. Corrections were applied for the increase in calorific value of the sample due to presence of nitrogen and sulphur.

Results

Food intake

There was marked day-to-day fluctuations in food intake in all the three DDT concentrations tested (Figs. 1, 2 & 3). Increased food intake was noticed at 2 and 4 ppb concentrations compared to the control and the maximum intake of food was at 2 ppb concentration. Each day of non-feeding is indicated by a break in the graph. There was no significant increase in food intake after a day of non-feeding when weights of the fish were taken. The changes in food intake at 2 week intervals for the three concentrations tested are given in Fig. 4.

Growth

Physiologically useful energy in excess of metabolic requirements is available for deposition as body tissue for growth or for synthesis

of reproductive products. Maximum growth indicated by an increase in calorific values could be recorded in fishes exposed to 0 ppb DDT and minimum at 4 ppb DDT. In all the three experiments, the growth did not follow a uniform pattern or rate but seemed to take place in distinct stanzas (Fig. 5). At 0 ppb DDT, in the first two weeks, there was a steep rise in growth of the fish but the growth line was almost parallel to the X-axis in the last 4 weeks showing only a very slight increase in growth during this period. At 2 ppb concentration a sudden rise in growth was noticed in the last phase of the experiment. The growth was not much significant at 4 ppb DDT concentration. The fish, at the start of the experiments, had an average calorific value of 5,154 cal/g dry weight ; this varied significantly for fish subjected to different DDT concentrations at the end of the experiment. The final tissue samples analysed gave 5,043 cal/g dry weight, 5,001 cal/g dry weight and 4,817 cal/g dry weight at 0, 2 and 4 ppb DDT concentrations respectively.

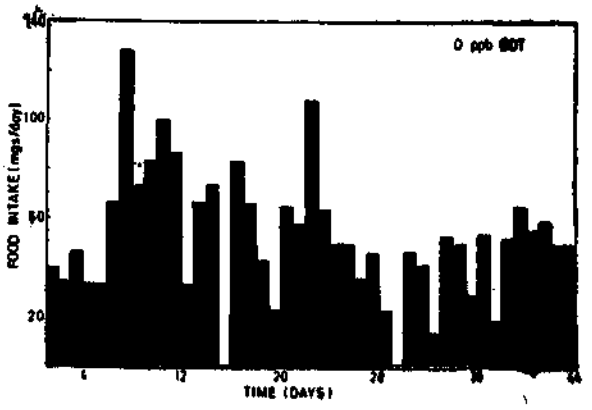

Fig. 1. Daily fluctuations in food intake at 0 ppb DDT concentration.

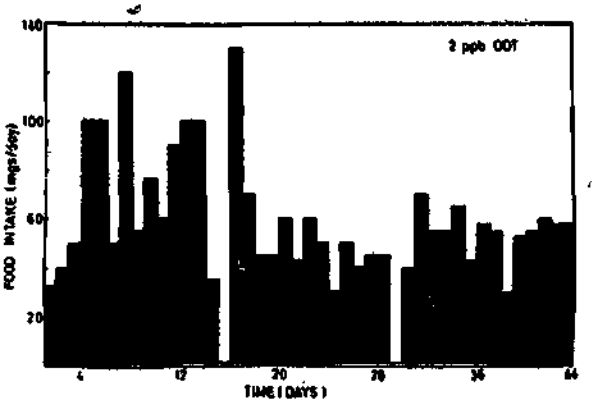

Fig. 2. Daily fluctuations in food intake at 2 ppb DDT concentration.

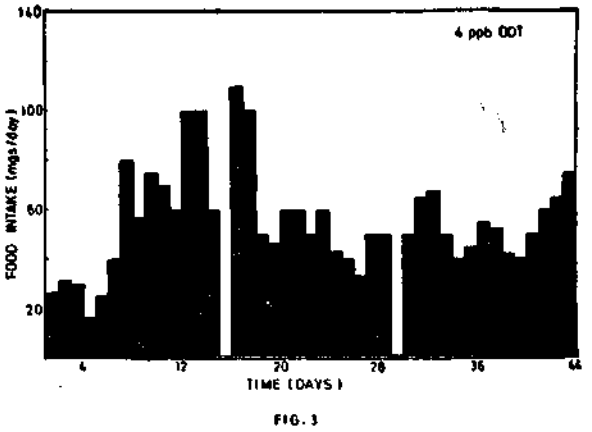

Fig. 3. Daily fluctuations in food intake at 4 ppb DDT concentration.

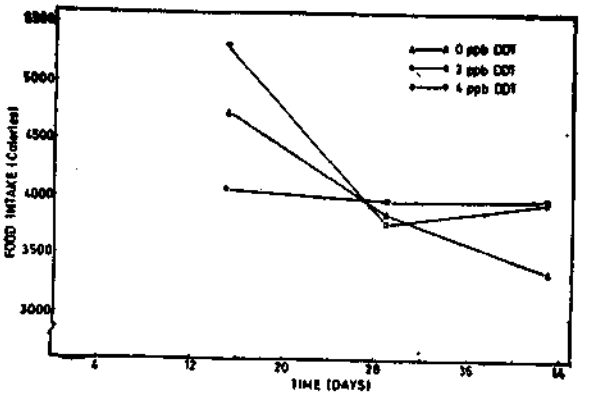

Fig. 4. Effect of DDT on fortnightly food intake.

Metabolism

Oxygen consumption is often taken as a measure of metabolic expenditure and includes energy dissipated in locomotion, osmotic regulation and other activities necessary for the well being of an animal. The oxy-calorific equivalent of oxygen consumption was calculated according to Winberg's (1956) estimates of 4.8 K cal/LO_2.

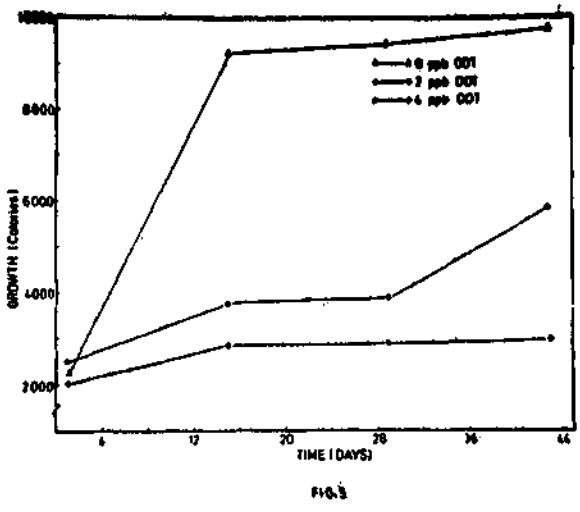

Fig. 5. Effect of DDT on the growth.

There was positive correlation between metabolic rates and DDT concentration. The results of metabolic measurements at 3 different DDT concentrations are given in Fig. 6. On an average, for 6 week experimental duration, the energy lost in metabolism increased from 3,753.4665 cal/day at 0 ppb DDT, to 5,808.0753 cal/day and 7,278.7785 cal/day at 2 ppb and 4 ppb DDT, respectively.

Energy loss in faeces

Energy losses in faeces increased remarkably with increase in DDT concentration (Fig. 7). When the losses were expressed as a proportion of daily energy intake also, they showed an increasing trend with more stress indicating that this increase was not dependent on the daily intake of food. At 0 ppb DDT concentration, the energy lost in faeces was maintained almost normal without much fluctuation for the 6 week exposure. For the first 4 weeks the energy loss in faeces increased, but showed a decreasing trend for the last 2 weeks at 2 ppb DDT. In 4 ppb DDT concentration, an increase was seen in the energy loss through

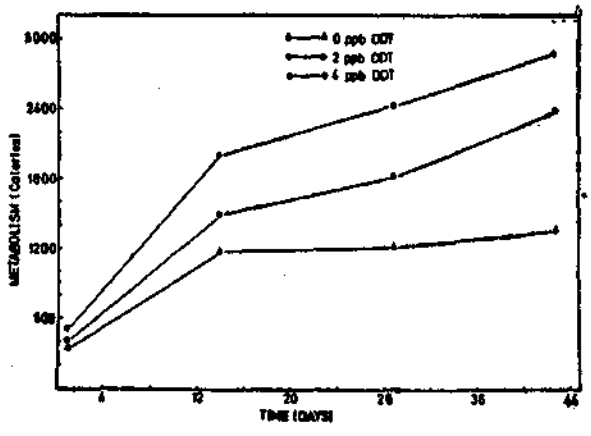

Fig. 6. Effect of DDT on the energy loss in metabolism.

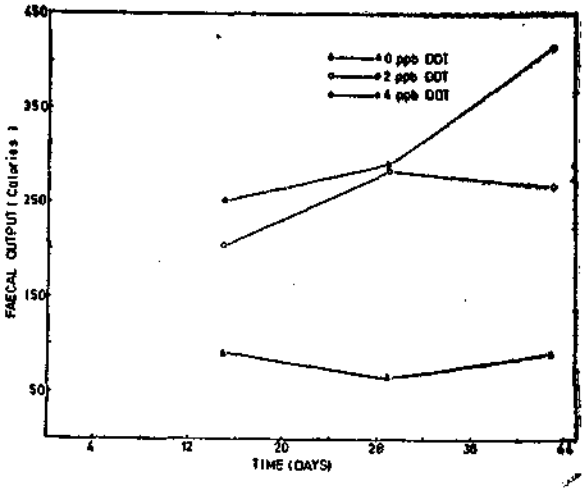

Fig. 7. Effect of DDT on the energy loss in faeces.

faeces throughout the experiment. The important result of the experiment is that eventhough the energy consumed was more at 2 and 4 ppb DDT concentrations, most of the energy was not used as physiologically useful energy,

but was lost in faeces. The calorific values of the faeces analysed showed an increase from 1,595 cal/g dry wt in 0 ppm DDT to 1,526 cal/g dry wt in 2 ppb DDT and 1,896 cal/g dry wt in 4 ppb DDT.

Discussion

There was marked fluctuation in the food intake as observed by other workers (Brown, 1964 a ; Pandian, 1967 ; Brett, 1971 ; Pardom *et al.*, 1972 ; De Silva and Balbontin, 1974). In the present study higher food intake could be recorded in fishes in higher DDT concentrations than in controls. Warren (1971) also reported the same in the cichlid *Cichlasoma bimaculatum*, where the herbicide pentachlorophenol induced an increase in food consumption. According to him it acted as a masking factor elevating the metabolic rate and the fish compensated for it with increased food intake. The ability of the fish to increase food intake when under stress leads to unanswered questions of voluntary appetite control (Webb, 1978). In contrast, the pesticide dieldrin brought about reduced food intake in *Cottus perplexus* (Brocksen and Chadwick cited by Warren, 1971). Due to regurgitation, Fenitrothion showed decreased food consumption in salmonids (Symons, 1973, Wildish and Lister, 1973). But the Kraftmill effluent showed little or no effect on the appetite and palatability of food (Tokar and Owen 1968 ; Warren, 1971). The increased food intake may be related to the increased stomach evacuation rate caused by DDT stress.

According to Warren and Davis (1967) growth is most appropriately measured as energy changes. In the present study growth decreased with an increase in DDT concentration (7483.8525 cal at 0 ppb DDT to 5330.2308 cal and 2953.1376 cal at 2 and 4 ppb DDT concentrations respectively). Eventhough there was higher intake of food at 2 and 4 ppb DDT, the growth was found to be low at these concentration. Decrease in growth and food conversion efficiencies caused by fibre (Smith *et al.*, 1967), low oxygen levels (Herman *et al.*, 1962 ; Skwart *et al.*, 1967 ; Pickering,1968), Kraftmill effluents (Tokar and Owens, 1968 ; Webb and Brett, 1972), the pesticides carbaryl (Carlson, 1971), endrin (Grant and Merle, 1973), pentachlorophenate (Krueger *et al.*, 1968 ; Warren, 1971 ; Webb and Brett, 1973) and heavy metals (Mount and Stephan, 1969 ; Pickering and Gast, 1972 ; McKim and Benoit, 1974) have been reported by many workers. An increase in growth at low levels of toxicants has been reported by Webb and Brett (1972) and by McLeay and Brown (1974). Further McLeay and Brown have also discussed the mechanism of growth stimulation in salmon at low level exposure to Kraftmill effluents.

Growth and production studies are not concerned solely with growth or scope for growth, but also with the efficiency of food conversion into flesh (Kleiber, 1975).

$$\text{Gross conversion efficiency } (k_1) = \text{(*gross)} \quad \frac{\text{Calories converted for growth}}{\text{Calories consumed}} \times 100$$

$$\text{Net conversion efficiency } (k_2) = \text{(*net)} \quad \frac{\text{Calories converted for growth}}{\text{Calories absorbed}} \times 100$$

Higher food conversion efficiencies were shown in embryos when *gross was found to vary between 60 to 70% (Winberg, 1956 ; Brett, 1970 b). In experiments conducted with young ones of *Mystus vittatus*, gross conversion efficiency was 62.5491% at 0 ppb DDT concentration which agreed with the results of earlier workers (Winberg, 1956 ; Brett, 1970 b and others). But at 2 and 4 ppb DDT *gross decreased significantly from 62.5491% to 44.6382% and 24.5267% respectively (Fig. 6).

Net conversion efficiency decreased from 66.5984% at 0 ppb DDT to 50.0952% and 28.8619% at 2 and 4 ppb DDT concentrations respectively. Because of the high efficiency with which the consumed food was absorbed, "gross was only slightly higher than "net. Reduced growth rates at higher DDT concentrations were found to be associated with reduction in conversion efficiencies.

Absorption efficiency has been expressed in the present paper as the percentage of the food that is absorbed in relation to the food that is consumed.

$$\text{Absorption efficiency} = \frac{\text{Calories absorbed*}}{\text{Calories consumed}} \times 100$$

Absorption efficiency usually varied between 89 to 96% for a wide variety of species (Pandian, 1967; Beamish, 1972; Niimi and Beamish, 1974). In the present investigation Absorption efficiency decreased from 93.9199% at 0 ppb DDT to 89.1068% and 84.9795% for 2 and 4 ppb DDT concentrations respectively (Table 2).

Of the many environmental factors which may influence the metabolic rate of fish, none is more important than pesticides. The food energy assimilated, minus nitrogenous losses after assimilation, is the energy available for metabolism and growth. Results of the present study show that energy loss in metabolism was more when DDT concentrations increased.

TABLE 1. *Details of calorific analysis*

Details	Percentage Nitrogen	Calorific value Cals/gm
Dried pieces of goat liver ..	1.953	5274
Initial tissue sample ..	1.777	5154
Final tissue sample (0 ppb DDT) ..	1.707	5043
Final tissue sample (2 ppb DDT) ..	1.240	5001
Final tissue sample (4 ppb DDT) ..	1.045	4817
Faeces (0 ppb DDT) ..	0.2621	1595
Faeces (2 ppb DDT) ..	0.1866	1626
Faeces (4 ppb DDT) ..	0.2478	1896

When stress is more, energy loss in metabolism also normally increased (Webb, unpublished data). Thus, DDT stress can be associated with increased energy loss in metabolism which inturn reduces the proportion of energy available for growth in *Mystus vittatus*.

TABLE 2. *Energy budget of the catfish* Mystus vittatus (Bloch) *at* 3 *different DDT concentrations*

Energy components expressed in calories	0 ppb	2 ppb	4 ppb
Food consumption (C) ..	11964.754	13061.061	12040.436
Growth (P) ..	7483.8525	5830.2308	2953.1316
Metabolism (R) ..	3753.4665	5808.0753	7278.7785
Faecal out put (F) ..	247.1683	757.0247	955.2899
Nitrogenous excretory products (U) ..	480.297	665.731	853.236
Absorption efficiency ..	93.9199%	89.1068%	84.9785%
Gross conversion efficiency (k_1)	62.5491%	44.6382%	24.5267%
Net conversion efficiency (k_2) ..	66.5984%	50.095%	28.8619%

* Calories absorbed = Calories consumed—Calories in the faeces.

Increase in the energy loss through faeces and nitrogenous excretory products at higher DDT concentrations show that the fish is not able to convert most of the food into physiologically useful energy as presented in Table 1.

Though all components of the baic energy equation showed variations in different DDT concentrations in the present study, it can be stated that growth and metabolic loss are more sensitive indicators of DDT stress compared to other components of the energy equation (Table 2).

From the point of view of aquaculture, conclusions drawn on the effects of DDT on growth and its related energetics adds more dimension to the need for an understanding of the effects of pollutants, in general, which is essential for production optimization and maximum fishery exploitation.

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FIN AND TAIL ROT DISEASE IN *POMADASYS HASTA* (BLOCH)

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ABSTRACT

The occurrence and nature of fin and tail rot disease in the fish *Pomadasys hasta* (Bloch) was studied. The consistent and most striking feature of the disease was necrosis of one or more of the fins. Advanced necrosis resulted in fraying of fin edges, separation of rays and gaps in fins. Severely eroded fins were usually haemorrhagic. Some fish lacked scales over large areas of their bodies and in few fishes skin erosion exposed the underlying muscle. Microscopic examination of swab samples from the necrotic fins showed the abundance of a slender, rod shaped, Gram-negative bacteria. Totally 17 bacterial cultures were isolated from the diseased fish and all were found to be *Vibrio* spp. Morphological biochemical and physiological properties of all these isolates were also studied. The ability of the isolates to elaborate lipase, amylase and protease was tested. These isolates showed good growth in the medium containing 3% sodium chloride and may therefore be assumed to be 'marine types'. The role of pathogenic bacteria in fish disease in natural and in laboratory conditions is discussed.

INTRODUCTION

INCREASED interest in fish both as food and as pets has prompted an awareness of problems associated with their health. Within the context of infectious diseases of fish, the bacterial diseases, particularly those caused by Gram-negative bacteria which cause mortality has been emphasized by several ichthyopathologists. Such diseases can pose many practical problems in aquatic environments, in open waters, but principally in commercial fish culturing. The literature on fish diseases is extensive (Amlachar, 1961 ; Sindermann, 1966 ; Mawdesley Thomas, 1972). But very little attention has been shown on diseases of marine fish in India (Selvaraj *et al.*, 1973 ; Lakshmanaperumalsamy *et al.*, 1976).

Fin rot or fin erosion, a disease characterized by the progressive loss of fin tissue, has been observed in fishes from a number of geographically disperate marine environments (Levin *et al.*, 1972 ; Perkins *et al.*, 1972 ; Mahoney *et al.*, 1973 ; Mearns and Sherwood, 1974 ; Walke, 1975 ; Chandramohan *et al.*, 1976). The fin rot disease which is usually slow but persistent, where the fins and tail erode away, was found to be caused by Gram-negative, non-spore forming bacteria (Sindermann and Rosenfield, 1954 ; Snieszko, 1958 ; Oppenheimer, 1958 ; Mahoney *et al.*, 1973 ; Murchelano and Ziskowskii, 1977). Since the information on the prevalence of bacterial diseases of marine fish, particularly fin and tail rot is not available in Indian Coast, the present study was undertaken. The purpose of this report is to document the occurrence of fin and tail rot disease in economically important food fish *Pomadasys hasta* (Bloch) and its etiology.

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Material and Methods

Fin and tail rot diseases of fish in the Porto Novo coastal area (Lat. 11° 29'N; Long. 79° 46'E) was observed during August 1978 to January 1979 on examination of commercial pound net catch samples. Moribund and freshly dead fishes were examined for the presence of fin necrosis. The infected specimens were brought to the laboratory in sterile containers for microbiological analysis. The fin tissue of infected fishes was picked by sterile loop, Gram-stained and observed microscopically.

The sterile inoculation needle was inserted into the infected area (below the necrotic fins). The streaking material picked by sterilized loop was directly transferred to Fish Extract Nutrient Agar (Peptone 10 g, Beef extract 3 g, Agar 15 g, aged sea water 1 ltr, 10% by volume of fish extract) and incubated at room temperature (26±2°C) for 2 to 3 days. The bacterial cultures were purified by repeated streaking onto FENA and were transferred to nutrient agar slants for further studies. The schemes used to identify the bacteria were essentially that of Shewan *et al.* (1960) and Simidu and Aiso (1962). Further, identity of the isolates were confirmed following the method as suggested by Bain and Shewan (1968) for Vibrios pathogenic to poikilothermic animals.

For Gram-staining, Jensens modified method was applied.

Tests for oxidase was performed following Kovac's (1956) method and motility by stabbing in semisolid nutrient agar and by phase contrast microscopy (X 600).

The oxidative and fermentative test was carried out adopting the method of Hugh and Liefson's (1953) using glucose.

The dissimilation and assimilation of dextrose and lactose in concentration of 1% in the basal medium (Peptone 2 g, Yeast extract 3 g, Bromothymol blue 0.01 g, aged sea water 1000 ml, pH 7.5) were also studied. The tubes were incubated under aerobic and anaerobic conditions.

For the detection of lysine and ornithine decarboxylases and arginine dehydrolase, Moller's (1955) test and stab inoculation into semisolid arginine medium (Thornley, 1960) were followed respectively.

Sensitivity to Penicillin (2.5 I.U/ml) (Simidu and Aiso, 1962) and to Vibriostatic compound 0/129 (2,4-diamino-6,7-di-isopropyl pteridine phosphate, BDH, Poole, England) was tested following standard methods (Hendrie *et al.*, 1970).

The ability of the isolates to liquefy gelatin, hydrolyse casein and starch and lipolysis of Tween 80 was tested with gelatin 15% (W/V), Casein 5%(W/V), Starch 1% (W/V) and Tween-80 2% (W/V) in nutrient agar medium respectively.

The effect of sodium chloride on the growth of the isolates was also tested on nutrient agar (Peptone 10 g, Beef extract 3 g, agar 15 g, distilled water 1 ltr, pH 7.4) to which various quantities (0.5%, 1.5%, 3%, 4.5%, 6%, 7.5%, 10%, W/V) of sodium chloride were added.

The effect of temperature on the growth was studied by incubating the cultures at different temperatures (20°, 30°, 37° and 44.5°C) for 5 days.

Results

The diseased specimens collected were examined for pathological conditions and the most striking character of the disease in the specimens was necrosis of one or more of the fins. Necrosis in advanced condition, resulted in fraying of fin edges, separation of rays, gaps in the fins

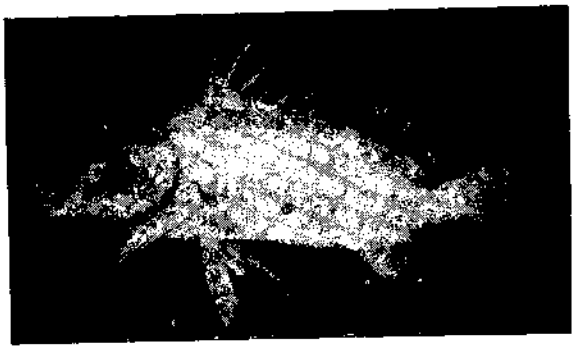

Fig. 1. Bacterial disease of fish *Pomadasys hasta* (dorsal, pectoral, pelvic and caudal fins).

and frequently, complete necrosis. Severely eroded fins were usually haemorrhagic, some fish lacked scales over large areas of their bodies and in few specimens advanced skin erosion exposed the underlying muscles (Fig. 1).

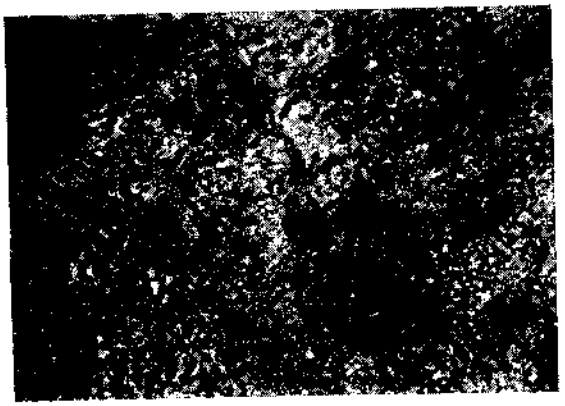

Fig. 2. Slender, rod shaped, Gram-negative bacteria (600 x).

Microscopic examination of the necrotic fins showed a slender, rod shaped bacteria (Fig. 2). Totally 17 bacterial cultures were isolated from the infected fish. The pure cultures were examined for morphological, physiological and biochemical characters (Table 1). All the isolates were found to be Gram-negative rods, motile, oxidase positive, fermentative, non-pigment producers, alkaline reaction in Thornley's arginine medium, non-luminous, decarboxylase negative. No growth was observed at 0.5% and above 7.5% sodium chloride.

Table 1. *Morphological, biochemical and physiological characteritics of the selected isolates*

Tests	Reaction*
Gram staining	—
Shape	Rod
Motility	+
Oxidase	+
Fermentative (H & L medium)	+
Gas from glucose	—
Pigment production	—
Growth at 37°C	—
Alkaline in Thornley's arginine medium	+
Lysine decarboxylase	—
Acid from inositol	
Gelatin liquefaction	+
Growth at low salt concentration	—
Growth at 7.5% sodium chloride	—
Spreading in sea water agar medium	—
Luminosity	—
Inhibition by penicillin	—
Inhibition by 0/129	+
Indole	—
Methyl red	+
Voges-proskauer	—
Citrate	+
Proteolytic	+
Amylolytic	+
Lipolytic	+

\+ Positive; — Negative;
* 100% of the isolates (Total 17).

All the isolates preferred 3% sodium chloride concentration in the medium for optimal growth. These were identified as *Vibrio* spp. The vibrios attacking poikilothermic organisms were found to be alkaline positive in Thornley's arginine medium whereas, other vibrios were found to be negative (Bain and Shewan, 1968).

All the isolates were found to produce amylase, protease and lipase (Table 1). They were found to be indole-negative, methyl red positive, Voges-Proskauer-negative and grew well in the medium containing citrate as sole carbon source. All the isolates were found to be sensitive to vibriostat 0/129 and not to penicillin.

Discussion

Surveys for diseased marine fish have documented the occurrence of fin rot disease in fish from Gulf of Maine (Sindermann, 1966), the Irish Sea (Perkins *et al.*, 1972), the New York Bight (Mahoney *et al.*, 1973), the coastal waters of Southern California (Mearns and Sherwood, 1974) and the coastal waters of Porto Novo (Chandramohan *et al.*, 1976). In contrast to the histopathologic studies of fin rot diseases in flatfishes from Southern Californian coastal waters (Mearns and Sherwood, 1974), the New York Bight (Murchelano, 1975) and Puget Sound (Wellings cited by Murchelano and Ziskowski, 1977), in the present investigation, bacteria were found in necrotic fin tissue. They were Gram-negative, slender, rod-shaped bacteria. Similar Gram-negative, slender, rod-shaped bacteria were reported earlier in fin rot diseases of Atlantic herring *Clupea harengus* (Sindermann and Rosenfield, 1954), Norwegian cod fish *Gadus callarias* (Oppenheimer, 1958) and in two summer flounders *Paralichthys dentatus* (Murchelano and Ziskowski, 1977). Oppenheimer and Kesteven (1953) reported that all external lesions on fish in salt water aquaria, bacterial tail rot or fin rot was most common and the pathogen was identified as *Vibrio ichthyodermis* (*Pseudomonas ichthyodermis*). Oppenheimer (1958) isolated *Pseudomonas* sp. from diseased fish *Gadus callarias*. Sindermann (1966) also cited cases of bacterial dermatitis sometimes accompanied by ulceration and fin rot and usually associated with *Pseudomonas* sp. in wild population of marine fish. Mahoney *et al.* (1973) isolated 75 bacterial cultures from the necrotic fins and in fish with advanced fin necrosis in the internal organs. Sixty of them belonged to 3 genera, *Aeromonas*, *Pseudomonas* and *Vibrio*. Each of the two isolates of the three genera from the above collection produced necrosis of the caudal fin of the mummichog when the fin was first abraded and bacteria rubbed on. But the *Vibrio* isolates caused most of the mortalities in the laboratory studies which was carried out by surface application, intraperitonial infection and oral transmission of the virulent strain. The above study supports the possible isolation of *Vibrio* sp., the causative of fin and tail rot diseases in fish. In the present investigation, all the isolates were identified as *Vibrio* sp. The identification was supported by comparing the characteristics of the *Vibrio* isolates causing diseases in poikilotherm animals as reported by Bain and Shewan (1968). Further, all the isolates required sodium chloride for their growth and therefore presumably concluded as 'marine' types. Similar observations have been reported by Mahoney *et al.* (1973).

The presence of heavy systemic bacterial infection in diseased fishes indicate a bacterial etiology (Mahoney *et al.*, 1973; Mearns and Sherwood, 1974). In the present investigation, such heavy bacterial infections were noted in the diseased fish.

There is considerable evidence that two conditions, bacterial population and environmental stress to fish are pre-requisite for the occurrence of epizootics (Mahoney *et al.*, 1973). Wood (1968) described conditions which promoted epizootics caused by aeromonads and pseudomonads among salmonids in hatcheries. Organic enrichment in the habitat permitted abundant growth of the bacteria in water. Accompanying this, the fish suffered with some environmental stress which increased their susceptibility to infection by the bacteria. Bullock (1968) in a study of

fin rot in brook trout *Salvelinus fontinalis*, suggested that bacterial invasion occurred through a lesion resulting from the presence of another disease, nutritional imbalance, injury or other disposing factors. Bullock and Snieszko (1970) stated that fin and tail rot were associated with poor sanitary conditions in aquaria and water pollution in nature (Mearns and Sherwood, 1977).

In the present investigation, the preliminary finding of the possible bacterial etiological agent (*Vibrio* sp.) of fin and tail rot disease is reported. But no histopathological or reinfection study (Koch's postualate) was attempted. Detailed investigation on the nature of pathogenicity, histopathology, host specificity if any, of the bacterial isolates of fin and tail rot is in progress.

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SOME OBSERVATIONS ON THE DISEASE OF THE SHORT FINNED EEL *ANGUILLA BICOLOR BICOLOR* McCLELLAND

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ABSTRACT

During the course of the experimental culture of the short-finned eel *Anguilla bicolor bicolor* McClelland in running water at Mandapam Camp, seven kinds of diseases namely Fungus disease, Tail fin rot disease, Gas disease, Red pest and botches disease, Swollen intestine disease, Gill disease and Cripple body disease were identified. The fungus disease was observed in elvers on their body surface as an outgrowth of whitish or greyish mass, spreading from the affected region. The tail-fin rot disease was noticed both in elvers and in growing eels and the affected portion gradually spreads due to the activity of the causative bacteria resulting in putrefaction. Mostly the glass eels were affected by the gas disease, when the O_2 or N level in the water was too high. The Red pest and botches disease caused by bacteria was observed in elver as well as in grown up eels, the visible symptoms of this disease being rash-like reddening of the body musculature, particularly near the abdominal and anal regions. The swollen intestine disease has been found to attack both the elvers and the growing eels whereas the gill-disease and cripple body disease were observed only in grown up eels. Diagnosis and some of the preliminary preventive measures for the above seven eel diseases are briefly discussed in this paper.

INTRODUCTION

IT is a well known fact that ' as the intensity of fish culture operation increases there is a greater chance of problems from fish diseases '. In eel culture which is being carried out in an intensive scale in Japan, diseases are not uncommon. About twenty kinds of eel diseases are reported from Japan, of which nine are considered very serious as they had caused considerable economic losses to eel culture (Usui, 1974 ; Forrest, 1976 ; Tesch, 1971 ; Egusa, 1979 ; Nishio, 1979). However, no information is available on the disease of Indian species of eels. During the course of the experimental culture of the short finned eel *Anguilla bicolor bicolor* seven kinds of eel diseases were observed. In the present paper the preliminary observation made on eel diseases are briefly presented.

I express my sincere thanks to Dr. E. G. Silas, Director and Shri S. Mahadevan, for their guidance and scrutiny of this paper.

MATERIAL AND METHODS

The glass eels and elvers of *Anguilla bicolor bicolor* collected at various centres in Tamil Nadu during 1976-78 were reared in running water tanks at the Regional Centre of CMFRI at Mandapam Camp. The live as well as the dead specimens obtained during the culture operation formed the basis of this study. Wherever possible, the diseased specimens were kept separately, treatments were given and observations were made.

Results

Seven kinds of eel diseases namely, Fungus disease, Tail fin rot disease, Gas disease, Red pest and botches disease, Swollen intestine disease, Gill disease and Cripple body disease were observed during the experimental culture of *A. bicolor bicolor* in running water.

Fungus diseases

This disease was observed only in elvers during January-March months. The diagnosis of this disease is the presence of whitish or greyish threads on the body surface especially near the margins of dorsal and ventral fins and also on the tail region, in the form of tuft of cotton wool. This disease was also observed in specimens already affected by tail fin rot disease. Usually the infection spreads from an injured area of the animal, hence it may be considered as a secondary infection. The causative parasitic aquatic fungi was not identified. However, in Japan, the fungus disease in eel is stated to be caused due to the fungi *Saprolegnia parasitica* (Usui, 1974). The elvers affected by this disease become very inactive and lethargic and die in about a week's time.

Tail fin rot disease

This disease has been found to attack both the elvers and growing eels. Partial or complete damage to the skin and musculature of the tail region are the visible symptoms of this disease. This disease gradually spreads on the same animal from the affected part to the other portions of the tail region due to the activity of the bacteria, resulting in pealing of the skin, exposure of the musculature, severe haemorrhage and putrefaction. In a medium sized specimen of 172 mm in length, affected by this disease it was found that the entire skin and flesh on the tail region was pealed off exposing the vertebral bones. The affected specimens were very much inactive and refused to take food. Usually the specimens affected by tail fin rot disease could not fully use their tail region for locomotion. They may either settle down at the bottom of the tank or swim very slowly and hang on near the surface of the water at one corner of the tank. This disease was observed to be more common during March-August period. This disease is stated to be caused due to a pathogenic bacteria *Aeromonas liquefaciens* (Forrest, 1976).

Gas disease

This disease was observed only once during December 1978 in a consignment of about 1200 glass eels kept in two numbers of 3' dia polycraft pools with aerators. In one pool by about 10 AM on 12-12-78, in a few glass eel's head two air bubbles were formed one on either side. Within fifteen minutes such air bubbles on the head were formed in almost all the glass eels in the pool. Similarly the glass eels kept in another 3' dia polycraft pools were also affected by this disease. The glass eels became inactive and were lazily swimming near the surface of the water as they could not go down through the water due to the presence of air bubbles on their head. This disease occurs when oxygen or nitrogen level in the water was too high. Immediately treatment for this disease was given. The aerators were cut off and in each tank about ½ kg of crushed ice was added in order to bring down the oxygen level and the temperature of the water. In about half an hour's time, the bubbles formed on the head of the glass eels had vanished, the glass eels become normal and thus all the glass eels were saved.

Red pest and botches disease

This disease was observed in elvers as well as in grown up eels, cultured in 12' dia polycraft pool in running water. In elvers, the visible symptom of this disease is rash-like redding of the body musculature, particularly near the abdominal and anal regions and on the

base of the dorsal and ventral fins. In advanced condition, the affected portion is very raw and exposed, with oozing of blood. In growing eels (measuring from 110-650 mm) the symptom for this disease is the appearance of tumor like out-growths, about the size of a pea, in red colour on the body and tail regions. The botches may burst and discharge the pus into the water. Thus this disease is contagious. Elvers affected by this disease invariably die within one week. In big eels, healing is possible, if they are kept in running water. It is stated that this disease is a serious bacterial disease caused by the bacterium *Aeromonas* (*Pseudomonas*) *punctata* (Tesch, 1977).

Swollen intestine disease

Small elvers of *Anguilla bicolor bicolor* were affected by this disease, particularly during the acclimatization period in the laboratory after their capture from the wild. As the name implies, the visible symptom for this disease is swelling of the intestine. When the elvers, were attacked by this disease their intestine bulge slightly, they become inactive, refuse to take food and become very thin and lean. They swim very lethargically near the surface of the water and finally die.

One instance of swollen intestine disease was observed on 7-11-1977 in a big cultured eel *A. bicolor bicolor* measuring 481 mm in length and 140 g in weight. The eel was separated and kept in a PVC square drum for observation and treatment. The intestine of the eel had swollen to a considerable extent and appeared like a balloon. The eel was actually floating in the water, as it could not go down in the water due to the bulging of the intestine. In addition to the bulging of the belly, the eel had a small cyst on the tail region. On two occasion the eel was treated with Methylene Blue and the belly was slightly reduced. The eel, however, died on 15-12-1977. The dead eel was cut open and the internal organs were examined. It was found that the entire intestine was swollen and bulging. The kidney was very reddish in colour and was also slightly bulging. The intestine contained small quantity of a colourless liquid.

Gill disease

Only one instance of gill-disease was observed in *Anguilla bicolor bicolor*. One big eel, 632 mm in total length weighing 445 g in weight reared in 12' dia polycraft pool was found dead on 23-1-'77. Externally there were no indications of any disease or injury. The internal organs were in good condition, but the gills on both sides of the eel were found to be in a very damaged condition. The gill-filaments were very short and they were found broken in the middle or at the base. More than half of the total surface area of the gills were either damaged or missing. The damaged gill-filaments in fresh condition without staining were examined under the microscope, but the causative bacteria could not be detected. The above symptom of erosion of the gills strongly indicates that the eel had died due to the gill-disease. *Chondrococcus columnaris* is stated to be the causative bacteria for the gill disease in eels (Usui, 1974; Forrest, 1976).

Cripple body disease

This disease was observed in a cultured eel *A. bicolor bicolor* measuring 253 mm in length which died on 27-6-'78. The body of the eel was misshapen, particularly in the region between anus and tail. It is in the form of two short bends, in a zig zag manner. In all other respect the eel was normal. It is stated that this disease is caused due to the attack of the muscular system by the protozoan parasite of the gena *Plistophora* (Usui, 1974). In the present case the causative parasite could not be either located or identified. Only by observing the external distorted appearance of the eel, it was indirectly concluded that the eel was affected by cripple body disease. In another

specimen, the same disease was noticed in December '78.

Remarks

During the course of the culture operation, mortality was met with in glass eels, elvers and in growing eels but in many cases the cause for the death couldnot be definitely ascertained. During January-June 1976, out of 1,648 elvers, 315 numbers (19%) had died in the laboratory. There were no external indication of any injury or disease in the dead elvers. However, the elvers were found inactive for one or two days before their deaths. It was observed that most of the elvers were prior to their death, violently shaking and twisting their bodies.

13 numbers of *A. bicolor bicolor* reared in the Aquarium in running water, died suddenly on 3-7-1978. The size of the dead eels ranged from 288 mm to 615 mm and the weight from 20 g to 475 g. Externally there were no indication of any diseases. All the internal organs of the dead eels were also in good condition. However, in the liver and in the bile fluid rod shaped live bacteria were found in very large numbers. The exact cause for the death of the eel was not known. Immediately one live eel in the same aquarium measuring 390 mm length and 120 g in weight was sacrificed and the internal organs were examined. The liver and the bile fluid were also examined. The rod shaped bacteria found in the dead eel were not present in the liver and bile fluid of the sacrificed eel. This suggests that the probable cause for the death of the eel may be due to rod shaped bacteria found in large numbers in the liver and bile fluid.

The main objective of this study was to document the various eel diseases of the Indian species of eels in culture condition. In most of the cases, the disease were observed only in advanced condition. However, the fungus disease, tail fin rot disease and gas disease were detected well in advance. For the fungus and tail fin rot diseases salt water bath and Methylene Blue bath (about 2 ppm) were tried periodically but with very little success. For the gas disease, the temperature of the water was immediately reduced to about 22°C by adding ice cubes. This treatment had given 100% recovery from the disease.

In the experimental culture operation, instance of eye blindness, excessive secretion of mucus on the body, deformities of the body like absence of one pectoral fin, loss of some portion of the caudal region have also been observed. A few white patches were also seen on the surface of the body of big cultured eels. These white patches have gradually disappeared when more water was circulated in the tanks.

The incidence of eel diseases met with in the present experimental eel culture are isolated in nature and hence quantitative estimation was not possible. Further intensive research work is necessary in order to develop a suitable diagnosis and control measures for the Indian eels.

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PRELIMINARY STUDIES ON CULTURE OF FIN-FISHES IN CAGES IN THE COASTAL WATERS OF PALK BAY AT MANDAPAM

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ABSTRACT

The present study has been aimed at investigating the possibilities of culturing a few species of economically important marine fishes in suitable low cost cages suspended in coastal waters. In this paper, the results of a preliminary study on culture of rabbit fishes (*Siganus* spp.), groupers (*Epinephelus* spp.) and whiting *Sillago sihama* (Forsskal) in cages fabricated with different materials and suitability of cages are given. The experiments were conducted from March 1979 to October 1979. Five cages of the dimensions 1.5 × 1.0 × 1.0 m and 1.0 × 1.0 × 1.0 m were used. Among the five cages the one fabricated with palmyra leaf stalks was the cheapest but the two cages fabricated with nylon nettings were durable. These cages had been kept tied to casuarina poles and rested on the sea bottom at a depth of about 0.75 m at low tide level in coastal waters of Palk Bay.

Two species of rabbit fishes, namely, *Siganus canaliculatus* Park and *S. javus* Linnaeus were reared in cages. *S. canaliculatus* were reared in bamboo split cage (1.5 × 1.0 × 1.0 m). The initial sizes of *S. canaliculatus* ranged between 78 and 120 mm (7.5 and 24.0 g) and the stocking density was 60 nos/sq. m. *S. javus* were reared in two nylon net cages (1.0 × 1.0 × 1.0 m). In one cage (stocked in April) the size ranged between 67 mm and 90 mm (5.2 g and 13.0 g) and stocking density was 200 no/sq. m. In the other cage (stocked in May) the sizes ranged between 87 mm and 117 mm (11.5 and 32.3 g) and the stocking density was 160 no/sq. m. Initially for two months both the species were fed with a food prepared out of seaweed, prawn head, fish and rice bran mixed in equal proportions and later on instead of fish and rice bran, fish meal and ground nut oil cake were substituted. For *S. canaliculatus* the average growth increment per month was 8.5 mm and 3.1 g and for *S. javus* average growth increment per month was 6.2 mm and 2.0 g in one cage and 5.6 and 3.4 g in the other cage.

Two species of groupers, namely, *Epinephelus tauvina* (Forsskal) and *E.hexagonatus* (Forster) were stocked in palmyra leaf stalk cage (1.5 × 1.0 × 1.0 m) The stocking density rate was about 13 nos/sq. m and these were fed with chopped fish. The initial sizes of *E. tauvina* ranged from 173.0 mm to 354.0 mm (80.0 g and 580.0 g) and of *E. hexagonatus* from 224.0 mm to 300.0 mm (190.0 g to 380.0 g). After six months the size of *E. tauvina* ranged from 299.0 to 450.0 mm (405.0 g to 1,497.0 g) whereas *E. hexagonatus* has not shown any consistent increase in size.

In *Sillago sihama*, stocked in G.I. wire cage (1.5 × 1.0 × 1.0 m), the initial size of fish ranged from 63.0 to 95.0 mm (2.8 g to 6.0 g) and the stocking density was about 70 no/sq. m. This species was fed with fish meal and groundnut oil cake mixed in equal proportion. The average growth increment per month was 10.0 mm and 1.6 g from July to September.

INTRODUCTION

CAGE CULTURE of fish originated in the Far East and was later adopted in several countries. It has numerous advantages over other culture techniques but there are some serious limitations which must be taken into consideration before it is applied on a large scale. Cage culture is being practiced in several countries with equal success in fresh (ponds, rivers, reservoirs, lakes), brackish and salt water environments. Cages may be resting on the bottom, floating at the surface (predominant

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type) or submerged (either floating in mid-water or resting at bottom). Materials used for fabrication of cages are netting, bamboo and metal, floating net cages having widest application. Ideally, cages have to be inexpensive, durable and easy to handle. These criteria are met in different ways, depending on the materials available locally, on the type of culture undertaken and on the possible investments which may be made according to local economic conditions. Artificial feeds used in cage culture vary from raw materials obtained locally to nutritionally balanced pelleted feeds. While most of the feeding is by hand, the use of mechanised feeders is increasing.

In this paper, results of preliminary experiments on the culture of a few species of fin-fishes in cages in the coastal waters of Palk Bay near Mandapam on the south east coast of India are given.

Material and Methods

The present experiment on culture of fishes in cages was carried out from March 1979 to October 1979 in the coastal waters of Palk Bay.

Five cages were fabricated using different materials. All the cages were rectangular in shape and the frames were made of palmyra wood. Of these, two cages had the sides covered with nylon twine nettings (2.0 mm thickness), the first one had the mesh size of about 10 mm and the other of about 15 mm. These two cages had the dimensions of 1.0 m $\times$ 1.0 m 1.0 m (1.0 m^3). The other three cages had the dimensions of 1.5 m $\times$ 1.0 m $\times$ 1.0 m (1.5 m^3). Among these three cages, the first one had all the sides covered with palmyra leaf stalks closely nailed together, the second one had the sides covered with closely nailed bamboo splits and the third one had been covered on all sides with G.I. wire mesh (5 mm). All the five cages had been provided with a half-door to facilitate opening and closing the cages for purposes of feeding etc. These cages were tied along the four corners to casuarina poles erected at a depth of about 0.75 m at low tide level at the Palk Bay side off Manakkad near Mandapam. These cages were placed on the bottom and one concrete block was tied to the bottom of the cage to serve as an anchor to keep it in the position.

Three groups of fishes, namely rabbit fishes, groupers and whiting were selected for experimental culture in the cages. Among rabbit fishes, two species namely *Siganus canaliculatus* Park and *S. javus* Linnaeus and among groupers two species, namely, *Epinephelus tauvina* (Forskal) and *E. hexagonatus* (Forster) were collected. The *Siganus* spp. were collected from shore seine operations and *Epinephelus* spp. were collected using fish traps. About 100 numbers of *S. canaliculatus* were collected in the middle of March and the size ranged between 71.0 mm and 91.0 mm (4 g and 10 g) with an average size of 83.0 mm and 7.1 g. These were reared in a 12' diameter plastic pool till April middle and were then transported to bamboo split cage (1.5 m^3). During one month period about 10 numbers had died and the remaining 90 numbers were stocked in the cage (60 no/sq. m). The size range at the time of stocking was 78.0 mm (7.5 g) to 120.0 mm (24.0 g) with an average size of 91.0 mm (9.9 g).

About 400 *S. javus* were collected during April-May. The first batch of about 200 numbers were collected in the middle of April and the size ranged between 67.0 mm (5.2 g) and 90.0 mm (13.0 g) with an average size of 73.9 mm (8.0 g). These were stocked in one nylon net cage (1.0 m^3) having the mesh size of about 10 mm. The second batch of about 200 numbers were collected in the middle of May and of these about 160 were stocked in another nylon net cage (1.0 m^3) having a mesh size of about 15 mm. The size of the

fish ranged from 87.0 mm (11.5 g) and 117.0 mm (32.3 g) with an average size of 103.1 mm (19.2 g).

Eleven numbers of *Epinephelus tauvina* ranging in size from 173.0 mm (80.0 g) to 354.0 mm (580 g) and eight numbers of *E. hexagonatus* ranging in size from 224.0 mm (190 g) to 300.0 mm (380.0 g) were stocked in palmyra leaf stalk cage (1.5 m^3) and the stocking density rate was about 13 no/sq. m.

119 numbers of live *Sillago sihama* were collected in the middle of July, using a drag net and of these 13 died during transportation. 106 numbers were stocked in the G.I. wire mesh cage (1.5 m^3). The sizes ranged from 63.0 mm (2.8 g) to 95.0 mm (6.0 g) and the average size was 81.9 mm (4.1 g).

The *Siganus* spp. were fed with a composition of prawn head, fish, rice bran and seaweed mixed in ratio of 1 : 1 : 1 : 1 initially for two months. Later on, instead of fish and rice bran, fish meal and ground nut oil cake were substituted. The *Epinephelus* spp. were fed with chopped fish. *Sillago sihama* were fed with fish meal and groundnut oil cake mixed into 1 : 1 proportion. All the fishes were fed once daily. Monthly measurements were taken to record the growth rates.

Results

Cost of cages

Among the five cages the cost of the palmyra leaf stalk cage was the lowest (1.5 m^3 cage — Rs. 182) and that of G.I. wire mesh was the highest (1.5 m^3 cage — Rs. 315). The cost of the bamboo split cage (1.5 m^3 cage — Rs. 195) was lower in comparison to two nylon netting cages (Rs. 254 and Rs. 270).

Suitability of cages

The cages were put in the sea in March '79 and the conditions of the cages were observed till October '79. The two nylon net cages were in good condition throughout the period. The palmyra leaf stalk cage was in good condition till September and afterwards a few stalks had become soft and could not withstand the wave action. In the bamboo split cage on a few occasions longitudinal gaps widened as a few splits had come off. The G.I. wire mesh cage was in good condition till September and subsequently in October while removing the cage the mesh along the side corners was torn off as the mesh had been weakened at these areas by shaking of mesh in water movement. The palmyra wooden frames in all the cages were in good condition throughout the period. All the cages were heavy and submerged to the bottom. Of all the cages, nylon net cages were easy to handle. Fouling was not much during the period. Barnacle settlement was observed to some extent on the upper frames of the cages especially on the inner sides. In palmyra leaf stalk cage and in bamboo split cage organisms like algae, sponges had grown on the lower half of the inner sides of the cage and these prevented water movement to some extent. These could be easily cleaned.

Rearing of the fishes

Siganus canaliculatus : The initial sizes of the fishes in March ranged from 71.0 mm to 91.0 mm (4.0 g to 10.0 g) with the average size of 83.0 mm and 7.1 g. In about one month, the average size increased to 91.0 mm and 9.9 g. The individual sizes ranged between 78.0 mm and 120.0 mm (7.5 g and 24.0 g). Of the stocked 100 fishes about 10 died during March and the remaining 90 were stocked in the bamboo split cage in April. The average size increased to 101.1 mm in length and 13.0 g in weight in May and 108.5 mm and 16.4 g in June. The average growth increment for about 3 months was 25.5 mm and 9.3 g. Thus the average growth increment per month works out to 8.5 mm and 3.1 g. The average growth increments in different months varied between 7.5 mm (2.8 g) and 10.0 mm (3.4 g).

63 numbers survived till May and 57 numbers till June. However, subsequently in the month of July, most of the fish had escaped through a gap that had formed in the cage as a bamboo split had come off. Only four fishes could be recovered. The average size was 124.5 mm and 28.0 g.

S. javus : In nylon net cage 200 numbers of *S. javus* weighing about 1,437.0 g were stocked in April. The sizes ranged between 67.0 mm and 90.0 mm (5.2 g and 13.0 g) and the average size was 73.9 mm and 8.0 g. The average size increased to 111.1 mm and 19.7 g by October. The average growth increment for about six months was about 37.2 mm and 11.7 g and the average growth increment per month works out to 6.2 mm and 1.95 g. The average growth increment was almost nil during June-July and the growth increment was more comparatively in April-May and August-October. The average growth increments in different months ranged between 0.1 mm and 16.0 mm (0.0 g and 6.2 g) in different months. 121 numbers survived till October which works out to nearly 60% of the initial stocking. The total weight was 2,358 g.

In another nylon net cage about 160 numbers of *S. javus* weighing a total of 2,055 g were stocked in May. The sizes ranged between 87.0 mm and 117.0 mm (11.5 g and 32.3 g). The average size was 103.1 mm and 19.2 g. It increased to 131.0 mm and 36.4 g by October. The average growth increment for about 5 months was 27.9 mm (17.2 g) and it works out to 5.6 mm and 3.4 g per month. The average growth increments in different months varied from 0.4 mm to 20.1 mm (0.2 g to 11.0 g). 52 numbers only survived which works out to 32.5% of the initial stocking weight. The total weight was 1,973 g.

Epinephelus tauvina : The initial sizes of 11 numbers ranged between 173 mm and 354 mm (80.0 g and 580 g) in April. The average size was 241.7 mm and 234.1 g. The total weight was 2,575 g. In October the sizes ranged between 299 mm and 450 mm (405 g and 1,497 g). The average size had increased to 355.6 mm and 758.0 g. The average growth increment per month was 19.0 mm and 87.3 g. The monthly growth increment in individuals ranged between 3.0 mm and 57.0 mm and the average growth increments in different months varied between 6.7 mm and 34.2 mm (62.3 g and 117. 8 g). Till October, 8 numbers survived (72.7% of initial stocking number) and the total weight was 6,506 g.

Epinephelus hexagonatus : 8 individuals with initial sizes ranging from 224 mm to 300 mm (190.0 g to 380.0 g) were stocked in April. 3 numbers had escaped in May and for the remaining five the sizes ranged between 234 mm and 318 mm in October. In this species the growth increments were negligible and the maximum growth increment observed was 6.0 mm in one month. Many individuals did not grow at all and remained on the same size.

Sillago sihama : 106 numbers were stocked in July and the sizes ranged from 63.0 mm (2.8 g) to 95.0 mm (6.0 g) and the average size was 81.9 mm (4.1 g). In August the average size increased to 99.3 mm (6.5 g) and in September to 102 mm (7.3 g). The average growth increment for two months was 20.1 mm and 3.2 g. The average growth increment per month works out to about 10 mm and 1.6 g. In October the cage mesh had torn off and all fish had escaped.

The results of the experiments on the growth of various species are summarised in Table I.

REMARKS

Although vast expanses of water areas suitable for cage culture are available in India, serious attempts have so far not been made to culture fishes in cages in fresh water or salt water. The only experiment on record is the experimental culture of fishes in cages conducted

TABLE 1. *Details of size ranges and mean sizes (in parentheses) of different species in cages from April to October* 1979 *(length in millimetres and weight in grams)*

Month	*S. canaliculatus* Length	*S. canaliculatus* Weight	*S. javus* (I cage) Length	*S. javus* (I cage) Weight	*S. javus* (II cage) Length	*S. javus* (II cage) Weight	*E. tauvina** Length	*E. tauvina** Weight	*Sillago sihama* Length	*Sillago sihama* Weight
March ..	71-91 (83) (in aquarium tank)	4-10 (7.1)	..	—	—	—	—	—	—	—
April ..	78-120 (91)	7.5-24 (9.9)	67-90 (73.9)	5.2-13 (8)	—	—	173-354 (241.7)	80-580 (234.1)	—	—
May ..	88-119 (101.1)	9-23 (13.0)	74-91 (82.2)	7.2-13.5 (9.2)	87117 (103.1)	11.5-32.3 (19.2)	197-370 (275.1)	90-740 (300.0)	—	—
June ..	93-118 (108.5)	10.5-21 (16.4)	74-94 (86.3)	8-13.6 (11.3)	111-149 (123.2)	21.5-49.8 (30.2)	210-394 (282.6)	125-895 (362.3)	—	—
July ..	—	—	78-98 (86.4)	(11.2)	(125.1)	23.5-53 (30.8)	224-40 (298.3)	174-972 (438.6)	63-95 (81.9)	2.8-6 (4.1)
August ..	—	—	84-100 (88.8)	10-16.0 (11.9)]	111-144 125.5)	19-45.6 (31)	250-420 (322.8)	220-1150 (542.8)	80-117 (99.3)	3.5-11 (6.5)
September ..	—	—	84-105 (95.1)	10-18 (13.5)	110-147 (188.5)	20-46 (32.3)	285-437 (343.9)	340-1300 (660.6)	80-117 (102)	3.5-11 (7.4)
October ..	—	—	96-125 (111.1)	12-28 (19.7)	120-153 (131.)	24-51 (36.4)	299-450 (355.6)	405-1497 (758)	—	—
Average growth per month ..	8.5	3.1	6.2	2.0	5.6	3.4	19.0	87.3	10.0	1.6

* Growth data on *E. hexagonatus* are not given as the speci es has not shown any consistent growth.

at Ghorajan *beel*, a vast derelict water body, situated on the north bank of river Brahmaputra near Gauhati in Assam (Dehadrai *et al.*, 1975). This experiment was conducted for a period of three months only with split bamboo mat cages of 152 × 76 × 76 cm size. The growth and production of *Heteropneustes fossilis* and *Anabas testudiens* were studied in different stocking densities. Few years ago some experiments were conducted by the Central Marine Fisheries Research Institute for rearing oilsardine and mackeral in floating cages in the sea and also in the estuary. Oil sardines could be kept successfully for four and a half months in cages in the estuary. While the experiments have proved that these fishes could be kept in cages without artificial feeds the increase in growth was not impressive. Therefore, the present preliminary study on culture of fishes in cages in the marine environment is the first concerted effort of its kind.

In the present experiment different materials have been used for constructing cages in order to study the suitability of local materials, their durability and cost structure. Among these cages with nylon nettings seem to be more suitable than those made of other materials *viz.*, palmyra leaf stalk, bamboo and metal. Palmyra leaf stalks and bamboo splits work out cheaper but their durability in sea water has not been satisfactory. This can be overcome to some extent by curing of the materials before using. Nevertheless meshed coverings are more advantageous than those longitudinally nailed materials (leaving vertical gaps for flow of water) for culturing fishes from very small sizes. Fouling also could be greatly avoided by using nylon nettings.

Among the fishes cultured, only groupers gave encouraging results. In *E. tauvina* the growth per month has been about 19.0 mm and 87.0 g. The yield has been about 2.5 times in about six months. The survival rate was about 73%. Therefore, this species may be suitable for culture in cages. In Malaysia *E. tauvina* has been reared in floating pens and it has been found that fingerlings of 8 to 15 g require 2 to 3 months to attain marketable size of 900 g which works out to an average growth of about 71 g per month. When an artificial feed prepared in moist pellet form was offered the growth has been enhanced by 11.5% (Anon, 1977). In the present experiment *S. canaliculatus* has shown a growth of 8.5 mm and 3.1 g per month. According to Lam (1974), in Philippines, Lavina and Alcala (1973) have recorded a growth of 8 cm in about 3 months, 10 cm in about four and a half months and 14 cm in about seven months for the species and in Singapore Ben Tuvia *et al.* 1973) have found the species to grow to about 120 grams in about 9-11 months. In the present experiments, *S. javus* also did not show good growth and the average growth was only about 5.6 mm to 6.2 mm and 2.0 g to 3.4 g. However, since these fishes are known to grow fast in floating cages (Lam, 1974) more experiments seem to be necessary before coming to conclusions.

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SPAWNING GROUNDS OF THE MILKFISH AND SEASONAL ABUNDANCE OF THE FRY ALONG THE EAST AND SOUTHWEST COASTS OF INDIA

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ABSTRACT

The fish seed resources surveys conducted along the east and southwest coasts of India have shown the occurrence of fry and fingerlings of *Chanos chanos* in appreciable quantities during different months. An attempt is made to present a quantitative distribution of fry of the milkfish in space and time in the study area. The occurrence of spawners and fry along some stretches of the coast indicate the proximity of spawning grounds of the milkfish and these are delineated. The research programmes on controlled breeding of *Chanos* and its culture aspects underway at the Central Marine Fisheries Research Institute are also discussed.

INTRODUCTION

The milkfish *Chanos chanos* (Forsskål) is important in the economy and nutritional needs of some of the developing countries in the Indo-Pacific. It is the prime finfish species in coastal aquaculture operations in countries such as Philippines, Indonesia and Taiwan. Although it spawns in the sea and spends a good part of its life in the marine environment, it is highly adaptable and can be acclamatised and cultured in situations ranging from fresh water to sea water. Interest in milkfish culture in India dates back to a few decades and credit goes to the Fisheries Department of the Govt. of erstwhile Madras State for attempting culture in different habitats including fresh water, in areas far distant from the coast. The early efforts of the Central Marine Fisheries Research Institute, in the late forties and fifties of culturing chanos in saline water ponds at Mandapam yielded useful results, but the work was discontinued. The revival of interest in coastal aquaculture has once again drawn attention to the importance of chanos as a good candidate species for culture in a wide variety of available habitats and under farm conditions. The mote point has been whether we should go in a large way in developing techniques for induced breeding of chanos by adopting techniques which have been successfully tried in other countries such as Indonesia and Philippines or depend only on wild seed presently available in plenty along some parts of our coast.

The fry and fingerlings of chanos are available in the coastal waters, lagoons, estuaries, creeks and mangrove areas along the east coast of India and sporadically along the west coast in Gujarat, Goa and southwards. Adult chanos are taken in coastal gillnet fisheries in some areas and pertinent earlier references from Indian seas are as follows : Chacko, 1951, 1952 ; Panikkar *et al.*, 1952 ; Chacko *et al.*, 1953 ; Devanesan and Chidambaram, 1953 ; Chacko, 1955 ; Chacko and Mahadevan, 1956 ; Tampi, 1957 and Chacko and Thomas, 1962. Occurrence of milkfish fry have been cited by various authors from different localities (Chacko, 1942 ; Job and Chacko, 1947 ; Ganapati *et al.*, 1950 ; Panikkar *et al.*, 1952 ; Krishnamurthi, 1957 ; Alikunhi, 1957 ; Mahopatra, 1966 ; Evangeline, 1967 ; Saha *et al.*, 1967 ; Rao, 1969,

1970; Tampi, 1973; Rao and Gopalakrishnan, 1975; Basu and Pakrasi, 1976; Pati and Rao, 1978; Rao *et al.*, 1978; Sundararajan *et al.*, 1978; Dhawan and Gopinathan, 1978).

Despite this, there is practically no information on the spawning grounds and the seasonal abundance of the fry along the Indian coasts. In order to understand this problem better, a base line study all along east and south-west coasts of India was made on a time bound programme to understand the regional and seasonal abundance of the milkfish fry in the coastal waters. The survey along the coasts of Karnataka, Kerala and Tamil Nadu have been carried out on a comprehensive basis over a period of one year enabling quantifications for different seasons.

Aquaculture of milkfish is rapidly developing in many countries. At present the only source of the seed for the farmer is from the natural waters. This is often irregular and inadequate. To facilitate steady supply of seed to the farmer, natural and induced breeding of milkfish is necessary (Schmittou, 1975). Induced breeding and artificial propagation of milkfish from the wild and captive stock have been attempted by various scientists in a number of countries (Liao and Chang, 1976; Alikunhi, 1976; Nash and Kuo, 1976; Liao and Chen, 1979; Liao *et al.*, 1979; Vanstone *et al.*, 1976, 1977; Chaudhri *et al.*, 1977; Kuo *et al.*, 1979). The Central Marine Fisheries Research Institute is making an attempt to develop broodstock of milkfish for induced breeding experiments.

Biological data from fifteen adult milkfish from the Gulf of Mannar and Palk Bay area was also collected.

Based upon the availability of spawners and fry recorded in the present investigation and correlating the observations made by various workers from different localities during different periods, possible spawning grounds along the Indian coasts have been identified.

Study Area and Methods

Observations on the availability of milkfish fry were carried out in the coastal waters, bar mouth regions, estuaries, backwaters, lagoons and creeks from Ichapuram in the north east coast to Kasargod in the northern part of Kerala Coast. To facilitate collection and analysis simultaneously at all the centres of investigation, the sampling was carried out on zonal basis. Table 1 gives the area of study, investigation period, number of stations covered and the methods of sampling.

Milkfish spawners were collected from the Gulf of Mannar and Palk Bay area during 1978 and 1979 employing bottom set gill nets and drift nets. The specimens were analysed for biological data such as length, weight, sex, length and weight of gonad, GSI value, ova diameter and maturity stage.

The location of the possible spawning grounds in the Indian waters was attempted based on the availability of spawners and fry in the present investigations as well as observations made by earlier workers.

Results

Occurrence of adult milkfish

In the present study the authors could gather some interesting information on the availability of milkfish spawners along the Palk Bay and Gulf of Mannar areas. Occurrence of adult milkfish is a regular phenomenon in the Theodai and Ariyankundu areas in the Palk Bay and Pudumadam and Appatheevu in the Gulf of Mannar. At Ariyankundu about 100 numbers of milkfish spawners are caught every year, the abundant period being January to April. They are in the size range of 1.0 to

1.5 metres in length and 7.00 to 15.00 kg in weight. The milkfish are caught by bottom set nylon gill nets with mesh size of 17 cm. In this region the sea forms a shallow bay with a stretch of coral sand rocks with a depth of 2 fathoms. A few numbers of milkfish spawners are caught during October-November seines. During the present observations, on 4th November 1978 one female milkfish weighing 8 kg was obtained. Adult milkfish are caught from Appatheevu area during the month February-March and November-December every year.

TABLE 1

Area of investigation	Period of investigation	No. of stations covered	Method of sampling
Zone I Andhra			
Ichapuram Bellupude Kusumpuram	April-June May-June 1976, 1977 & 1978	4	Velon screen stretched as drag-net usually operated by two men
Zone II Madras			
Arambakam in the north to Muthupet lagoon in the south	March 1976-March 1978	31	-do-
Zone III Mandapam			
Sundarapandipatnam in the north to Keelakkarai in the south	January 1976-June 1978	59	-do-
Zone IV Tuticorin			
Mayanikulam in the north to Kanyakumari in the south	January 1976-June 1978	65	-do-
Zone V Vizhinjam			
Kanayakumari in the south to Sakthikulankara in the north	March 1976-June 1978	39	-do-
Zone VI Cochin			
Neendakara in the south to Ponnani in the north	March 1976-June 1978	34	Quantitative estimation by sampling one cubic metre of water
Zone VII Calicut			
Ponnani in the south to Kasargod in the north	March 1976-March 1978	83	Velon screen stretched as drag-net usually operated by two men

every year from Theedai region and we also could collect a gravid female on 15th October 1978 weighing 8 kg. During the months of November and December a few adult milkfish are caught from Pudumadam area in shore

The authors could examine fifteen milkfish, the largest number ever analysed from the wild from any place in India. Fourteen fishes were caught from Ariyankundu and one from Appatheevu (Table 2).

TABLE 2. *Details of the adult milkfish analysed in the Palk Bay and Gulf of Mannar region*

(Gonad weight, GSI and Fecundity of adult milkfish)

Date of catch	Place	Total length (mm)	Body Weight (Kg)	Sex	Gonad weight (gm)	GSI	Ova diameter (mm)	Maturity stage according to P. R. S Thampi (1957)	Fecundity (Total No. of eggs in million)	No. of eggs/Kg body wt of fish in thousand
10-4-1978	Ariyankandu	1161	9.00	Female	909	10.10	0.67	III	—	
10-4-1978	„	1131	7.00	Male	73	1.04	—	II	—	
25-1-1979	„	1075	7.00	Male	20	0.29	—	I	—	
29-1-1979	„	1290	15.00	Female	310	2.07	0.37	II	3.45	230
30-1-1979	„	1270	15.00	„	1257	8.85	0.80	III	5.32	355
7-2-1979	„	1175	9.50	„	147	1.55	0.42	II	1.42	150
14-2-1979	Appa Island (Kilakarai)	1290	14.50	„	355	2.45	0.29	II	3.52	243
17-2-1979	Ariyankundu	1055	7.50	Male	19	0.25	—	I	—	
18-2-1979	„	1235	14.00	Female	235	1.68	0.32	II	1.78	127
22-2-1979	„	1340	13.50	„	330	2.44	0.37	II	3.42	253
22-2-1979	„	1152	11.40	„	920	8.07	0.71	III	3.57	313
23-2-1979	„	1294	14.00	„	1170	8.36	0.71	III	4.45	318
23-2-1979	„	1042	9.00	Male	275	3.06	—	III	—	
23-2-1979	„	1145	10.50	Female	965	9.10	0.74	III	3.90	371
26-2-1979	„	1186	12.00	„	1090	9.08	0.76	III	3.09	257

The fishes were obtained during January, February and April. Of the 15, eleven were females measuring from 1145 to 1290 mm in total length and 9 to 15 kg in weight. The ovary length varied from 370.5 mm to 461.5 mm and weighed between 0.147 kg to 1.327 kg. The GSI value for the stage II of maturity fishes was between 1.55 and 2.45 and that of mature fishes (stage III) was between 8.36 and 10.10.

NO	DATE OF CAPTURE	PLACE OF CAPTURE	LENGTH mm	WEIGHT kg	SEX	GONAD LENGTH mm	GONAD WEIGHT kg	EGG dia. mm	MATURITY STAGE +
1	10-4-1978	ARIYANKUNDU	1160·5	9·0	f	410·0	0·909	0·672	III
2	10-4-1978	,,	1113·0	7·0	m	489·0	0·073	—	II
3	25-1-1979	,,	1075·0	7·0	m	391·5	0·020	—	I
4	29-1-1979	,,	1290·0	15·0	f	372·5	0·031	0·37	II
5	30-1-1979	,,	1270·0	15·0	f	415·5	1·327	0·79	III
6	9-2-1979	,,	1175·0	9·5	f	380·0	0·147	0·42	II
7	17-2-1979	,,	1055·0	7·5	m	173·5	0·019	—	I
8	18-2-1979	,,	1235·0	14·0	f	370·5	0·235	0·32	II
9	22-2-1979	,,	1240·0	13·5	f	458·0	0·330	0·37	II
10	22-2-1979	,,	1152·0	11·0	f	407·0	0·920	0·71	III
11	23-2-1979	,,	1294·0	14·0	f	461·5	1·170	0·71	III
12	23-2-1979	,,	1042·0	9·0	m	326·0	0·275	—	III
13	23-2-1979	,,	1145·0	10·5	f	445·0	0·965	—	—
14	26-2-1979	,,	1196·0	12·0	f	391·0	1·090	—	—
15	14-2-1979	APPATHEEVU (Near Keelakkarai)	1290·0	14·5	f	390·5	0·355	0·28	II

(+After Tampi, 1957)

Fig. 1

The size of the males ranged from 1042 to 1113 mm in total length and 7 to 9 kg in weight. The length of testes varied from 173 mm to 489 mm and weighed between 0.019 kg to 0.275 kg. The GSI value was 0.25 to 0.29, 1.04 and 3.06 for the Ist, IInd and IIIrd stages of maturity respectively.

Occurrence of milkfish fry

The place of occurrence during the period of investigation, the total of milkfish fry in numbers and the size range of the fry collected during each month are presented in Table 3 and illustrated Fig. 1.

ANDHRA ZONE

Every year large quantities of milkfish fry are collected from Ichapuram area during April - June and two persons could easily collect 20,000 fry/day during the peak season.

TABLE 3. *Details of milkfish fry collected from the east and southwest coasts of India*

(Monthwise numbers and the size length in mm of the fry)

Place of occurrence	Months, Numbers and the size range of *Chanos* fry caught											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Andhra Zone												
Ichapuram (Orissa)												
Bellupuda												
Kusumpuram												
Burjapalam												
Madras Zone												
Kovalam					249 (20-25)			2000 (75-80)	2280 (75-85)			
Thirumalairayan pattinam					3 (60-72)							
Mandapam Zone												
Seeniappa Dharga (backwaters)	1 (35)											
Pamban tidal pools		58 (31-56)		6101 (14-90)	375 (19-72)	88 (21-90)	88 (32-68)	12 (30-86)	—	27 (32-71)	9 (42-71)	64 (39-90)
Chinnappalam Creek	81 (38-52)	11 —	4 —	373 (30-95)	70 (35-90)	115 (37-97)	35	9 (31-61)	1 (41)	432 —	8 —	71 —
Pillaimadam	8 (43-48)											2 —
Tuticorin Zone												
Valinokam	1 (144)	1 (144)		1045 (10-41)								
Vaipar												2 (80-8)
Kallurani Creek											1 (17)	

TABLE 3—*Contd.*

Place of occurrence	Months, Numbers and the size range of *Chanos* fry caught											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Kallar Estuary (Mouth)			547 (11-17)									
Muthiapuram Estuary							22 (63-129)	1 (112)				
Mullacad Creek		1 (15)										
Palaya Kayal (North)		11 (10-76)		333 (13-35)	12 (27-42)							
Punnai Kayal (South)	6 (19-83)	2 (46-68)		690 (13-64)	12 (30-41)		74 (21-89)		1 (143)	..		
Arumuganeri (backwater)					5 (13-14)			1 (36)				
Tiruchendur Estuary			2 (20-22)	70 (14-44)								
Manapad				14 (15-41)								
Thottarippu Creek				29 (11-53)								
Wattakotai	109 (12-14)			792 (13-53)								
Wariyoor	2 (27-28)											
Leapuram				179 (14-33)								
Chinnamuttom				20 (31-41)								
Vizhinjam Zone	—	—	—	—	—	—	—	—	—	—	—	—
Cochin Zone												
Ampalapuzha			1 (14)									

Place of occurrence	Months, Number and the size range of *Chanos* fry caught											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Thottappally			2		2							
Tirukkunnapuzha			2									
Alum Kadavu				1 (13)								
Alleppey seaside			5 (9-14)									
Aruthungal								1 (14)				
Anthakaranazhi				4	4					1 (13)		
Chellanum			5 (11-14)									
Fort Cochin (barmouth)			2 (12-12.5)									
Narakkal					1	3 (6-9)						
Azhikode				1 (14)		1 (11.5)						
Kaipamangalam		2										
Nattika				1								
Ponnani			3 (6.5-13)		1							
Puthuponnani		2	2 (12-13)				1 (10.5)					
Chetwai			1									
Calicut Zone												
Chavai River	5 (16-20)											
Kadulundi Estuary						2 (36-42)						

Bellupude, Kusumpuram, Barjapalam and Bhimilipatnam waters of Andhra Pradesh appear to be very promising sources for milkfish fry collection. During the month of May and June as much as 988 to 2599 fry/hr could be collected from shallow areas of 30-45 cm water depth in the early hours of the day in drag-net operations. The average size of the fry collected was 12.0 mm.

Madras Zone

During August and September 1976 young milkfish of 75-85 mm size were collected from Kovalam waters. However, during May 1979, 20-25 mm fry occurred in this area. From Thirumalarayanpatinam area 60-62 mm young milkfish were caught during December 1978.

Mandapam Zone

Milkfish fry have been recorded from Seeni appa Dharga Backwaters, Pamban tidal pools, Chinnapalam creek and Pillaimadam areas. The monthly size range of the fry and young fish recorded during the period of investigation was January 35-48 mm, February 31-56 mm, March-April 14-95 mm, May 19-90 mm, June 21-97 mm, July 32-68 mm, August 30-86 mm, September 41 mm, October 32-71 mm, November 42-71 mm and December 39-90 mm.

Tuticorin Zone

Around Tuticorin and Kanyakumari areas chanos fry have been recorded from Valinokam, Kallurani Creek, Kallar Estuary, Palayakaya Estuary, Punnakayal Estuary, Arumuganeri Estuary, Tiruchendur Estuary, Thottarippu Creek, Wattakottai Creek, Wariyoor Creek and Leapuram Creek. The monthly size range of the fry and young fish occurring in this zone were as follows: January 12-83 mm, February 10-76 mm, March 11-22 mm, April 10-64 mm, May 13-42 mm, June and July 21-129 mm, August 36-112 mm, September 143 mm, November 17 mm and December 80-83 mm.

Vizhinjam Zone

No milkfish has been recorded in between the waters of Kanyakumari in the south to Sakthikulankara in the north during the period of investigation.

Cochin Zone

Of the 33 Stations covered in this zone milkfish fry have been recorded from 16 stations *i.e.*, Ampalapuzha, Thottappally (seaside), Thrikkunnapuzha, Alumkadavu, Alleppey (sea side), Aruthingal, Anthankaran azhi, Chellanum, Fort Cochin (barmouth), Narakkal, Azhikode, Kaippamangalam, Nattika, Ponnani, Puthu ponnani and Chetwai. The monthly size range of the fry occurring was as follows in this area of investigation. January, February, March, 6.5 to 14 mm, April 13-14 mm, May-June 6-11.5 mm, July 10.5 mm, August 14 mm, September, October 13 mm.

Calicut Zone

Milkfish fry have been recorded from Chovai River during January 1976 and in the Kadalundi Estuary during June 1977. The size of the fry recorded was 16-20 mm and 36-42 mm in Chovai River and Kadalundi Estuary respectively.

Occurrence of Eggs, Fry and Adult Milkfish from Indian Waters—A Review

Apart from the present investigations, the authors have attempted to present the details of the earlier works relating to adult milkfish,

occurrences of plankton eggs and fry from the Indian waters and this is shown in Fig. 2.

Adult milkfish have been recorded from Indian waters along the Coramandal coast; Palk Bay and Gulf of Mannar and Malabar Coasts by earlier workers (Chacko, 1950, 1951, 1952; Chacko *et al.*, 1953; Devanesan and Chidambaram, 1953; Chacko, 1955; Chacko and Mahadevan, 1956; Tamni, 1957; Panikkar *et al.*, 1952; Chacko and Thomas, 1962).

creek (Jacob and Krishnamurthy, 1948) and Kurusadai Island (Chacko, 1950).

The occurrence and abundance of the milkfish fry all along the Indian coasts have been cited by various workers during different time (Chacko, 1942; Job and Chacko, 1947; Ganapati *et al.*, 1950; Panikkar *et al.*,1952; Alikunhi, 1957; Krishnamurthi, 1957; Mahopatra, 1966; Saha *et al.*, 1967a, 1967b; Evangeline, 1967; Rao, 1969, 1970; Tampi, 1973; Rao and

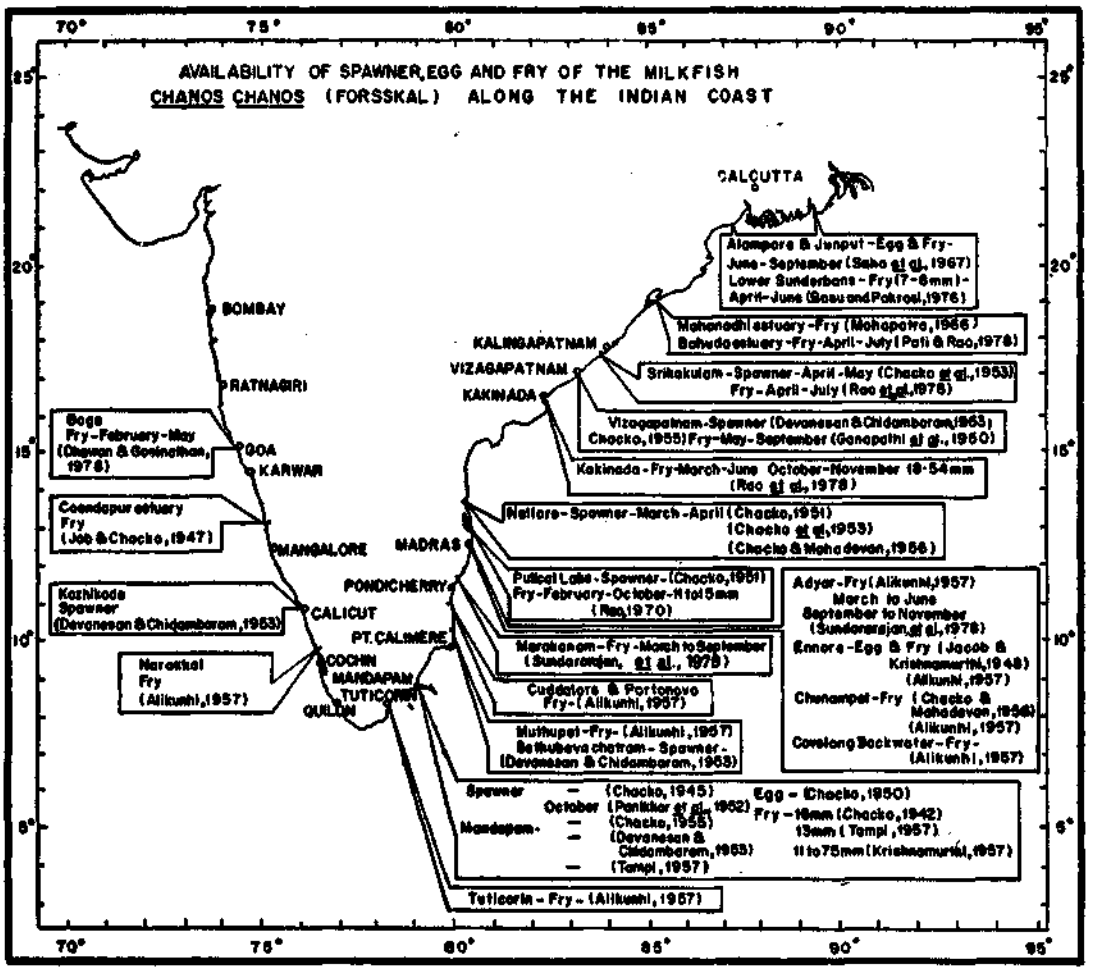

Fig. 2

Egg of *Chanos chanos* has been recorded from Junpat and Alampore coasts of West Bengal (Saha *et al.*, 1967a, 1967b); Ennore

Gopalakrishanan 1975; Pati and Rao 1978; Rao *et al.*, 1978; Sundararajan *et al.*, 1978 Dhawan and Gopinathan, 1978).

Spawning Grounds of the Milkfish

Along the East Coast

Based on the availability of Milkfish spawners and the fry in the present investigation and also the earlier findings of other workers on the occurrence of adult milkfish, eggs and fry all along the Indian coast, an attempt is made by the authors to map the possible spawning grounds along the Indian Coast (Fig. 3).

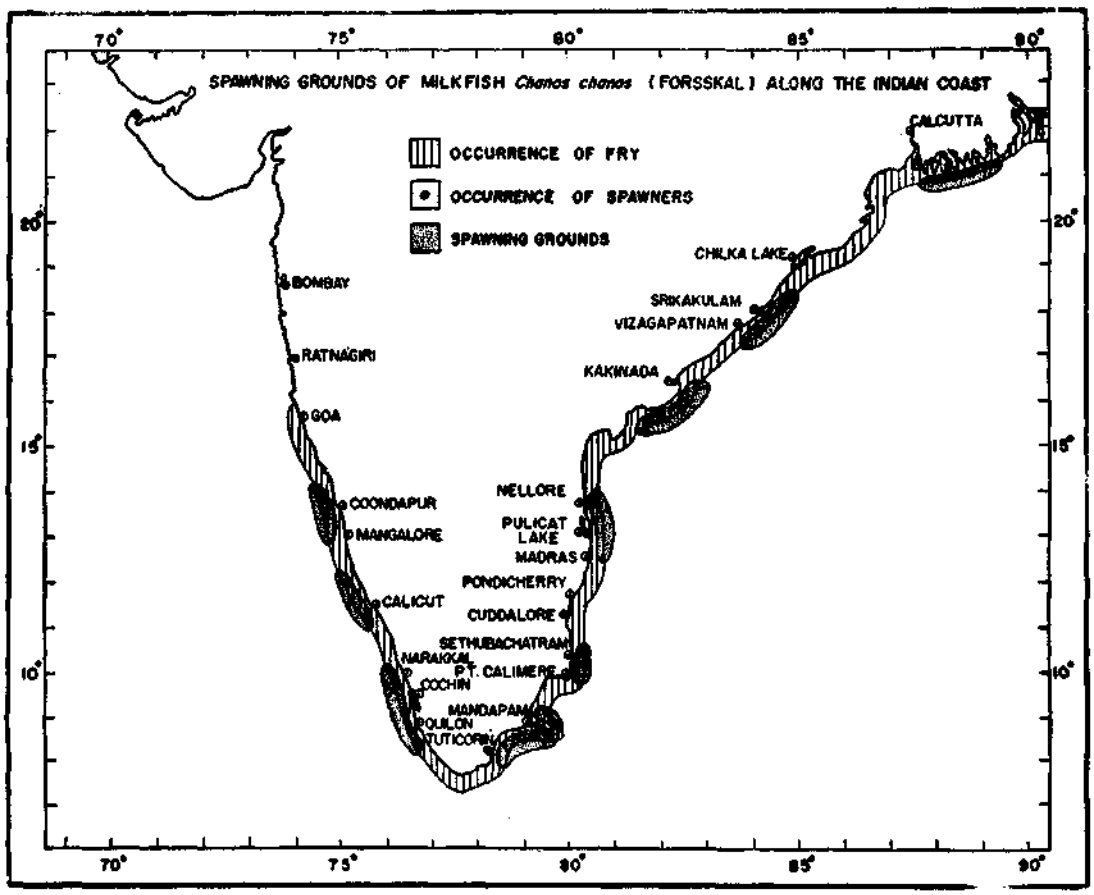

Fig. 3

The occurrence of mature fishes and fish in ripe running condition, eggs and small fry in the near shore and estuarine waters is indicative of milkfish spawning in the vicinity.

Availability of 7-8 mm larvae along the eastern bank of Hooghly Estuary (Basu and Pakrasi 1976) and the occurrence of uneyed ova to fry of 20 mm size along the Junput and Alampore coasts (Saha *et al.*, 1967a, 1967b) shows the possible existence of spawning grounds in the near by waters. A probable spawning ground may exist in waters around Mahanadi and Behude Estuaries and Ichapuram since small sized fry have been recorded in this area by earlier workers (Alikunhi, 1957 ; Mahopatra 1966 ; Tampi, 1973 ; Pati and Rao, 1978) as well as in the present investigation.

Existence of potential spawning grounds along the Coramandal Coast is supported by the

occurrence of small sized fry from Bellupuda, Kusumpuram, Burjapalam (12 mm) and Kovalam (Madras) waters (20-25mm). The earlier workers have also recorded spawners (Chacko 1951, 1952; Devanesan and Chidambaram, 1953; Chacko *et al.*, 1953; Chacko, 1955; and Chacko and Mahadevan, 1956), small sized fry (Ganapati *et al.*, 1950; Alikunhi, 1957; Evangeline, 1967; Rao, 1969; 1970 Tampi 1973; Rao and Gopalakrishnan, 1975; Rao *et al.*, 1978 and Sundararajan *et al.*, 1978) and egg (Jacob and Krishnamurthy, 1948) from the coastal waters, estuaries and creeks all along the Coramondal Coast which also supports the possible existence of spawning grounds in this region.

The appearance of milkfish spawners at Ariyankundu—Theedai region (Palk Bay), Pudumadam and Appatheevu (Gulf of Mannar) areas indicates the existence of potential spawning grounds along the Gulf of Mannar and Palk Bay region. This is also further supported by the occurrence of small sized fry at Seeniappa Dharga (35 mm) Pamban tidal pool (27 mm) Chinnappalam creek (30 mm) and Pillaimadam area (43 mm) in this region. In the past also appearance of adult spawners (Sablo) have been recorded (Panikkar *et al.*, 1952; Chacko, 1955; Tampi 1957; and Chacko and Thomas 1962).

Chacko (1950) could collect milkfish eggs from the waters around Kurusadai Island. Abundance of milkfish fry from Gulf of Mannar and Palk Bay area is cited by various authors (Chacko 1942; Job and Chacko 1947; Ganapati *et al.*, 1950; Panikkar *et al.*, 1952; Krishnamurthi 1957; Alikunhi 1967; and Tampi 1973). The results of the present investigation on the occurrence of the spawners and the abundance of the fry and the observations made by earlier workers clearly indicate the existence of spawning grounds in near shore waters of the Gulf of Mannar and in the Palk Bay.

Around Tuticorin and Kanyakumari, milkfish fry have been recorded in good numbers. The occurrence of small sized fry in Valinokam (10 mm), Kallurani Creek (17 mm), Kallar Estuary (11 mm), Palayakayal Estuary (10 mm), Punnakayal Estuary (14 mm), Arumuganeri Estuary (16 mm), Tiruchendur Estuary (14 mm), Thottarippu Creek (11 mm), Wattakottai Creek (12 mm), Wariyoor Creek (13 mm) and Leapuram Creek (12 mm) are clearly indicative of spawning of milkfish in inshore waters along a long stretch of the coast in the Gulf of Mannar. Earlier workers (Alikunhi, 1957; Tampi, 1973) have also indicated the abundance of milkfish fry in these waters.

Along the West Coast

Milkfish fry have been recorded from the Malabar Coast in the areas of Ampalapuzha (14 mm), Tottappalli, Thirukkunnapuzha, Alumkadavu (13 mm), Alleppey (9 mm), Aruthingal (14 mm), Anthankaran Azhi (13 mm), Chellanum (14 mm), Fort Cochin (12 mm), Narakkal (6 mm) Azhikode (11.5 mm), Kaippamangalam, Nattika, Ponnani (6.5 mm), Puthuponnani (10.5 mm) and Chetwai. The occurrence of small sized fry in these places clearly indicates the existence of spawning grounds in the coastal stretches in this area. This is further supported by the records of milkfish fry from along this coast by earlier workers (Alikunhi, 1957; Tampi, 1973).

Milkfish fry have also been recorded from the Kadalundi Estuary (36-42 mm) and Chovai River (16-20 mm) during the present study. Devanesan and Chidambaram (1953) examined a spawner from Kozhikode. Abundance of the fry in the Kozhikode waters was earlier reported by Alikunhi (1957) and Tampi (1973). The investigations in the present study and the observation made by earlier workers clearly indicate the existence of a spawning ground along Kozhikode waters. Inshore waters around Coondapur Estuary along Karnataka Coast may also be a spawning ground of the

milkfish if we look upon the abundance of the milkfish fry as reported by earlier workers (Job and Chacko 1947; Alikunhi, 1957; Tampi, 1973; Dhawan and Gopinathan, 1978). Recently Dhawan and Gopinathan (1978) have identified Baga Estuary (20 kms north of Panaji) as a potential ground for milkfish fry collection thereby indicating the possibility of the species spawning in the adjacent inshore waters.

Seasonal Abundance of Milkfish fry

East Coast

The seasonal and regional abundance of the milkfish fry all along the East and South west coasts of India is illustrated in Fig. 2.

It is found from Ichapuram area where every year thousands of milkfish fry have been collected during the period April-June, and two persons could collect as many as 20,000 fry/day during the peak season. In Bellupuda, Kusumpuram and Burjapalom areas also milkfish fry is abundant during May and June. Along Madras Coast, milkfish fry could be collected during May, August and September. However, since the seed encountered during August and September were fairly large size (60-85 mm), it becomes very difficult to be sure of any peak season for fry during August-September in this region. From the analysis of the data it is evident that milkfish seed is abundant during April-June along the Coramandal Coast.

Milkfish fry have been collected from the Gulf of Mannar and Palk Bay area almost throughout the year. Occurrence of minimum sized fry during January (31 mm), February (35 mm), April (14 mm), May (19 mm), June (21 mm), July (32 mm), August (31 mm), September (41 mm), October (32 mm), November (42 mm) and December (38 mm) indicates the availability of the fry throughout the year with a primary peak period of abundance during April-June and a secondary peak during October to December.

It is also interesting to note the occurrence of spawning population of milkfish in this region during the months of January, April and October to December. It confirms the occurrence of two spawning seasons in these waters.

In and around waters of Tuticorin and Kanyakumari, milkfish fry was recorded during nine months, (except in June, September and October). Further the availability of the small sized fry during January (19 mm), February (10 mm), March (11 mm), April (10 mm), May (13 mm), July (21 mm), August (36 mm) and November (17 mm) indicates the prolonged seasonal abundance of the occurrence of fry in this area. The peak period of collection was found to be March-April.

Along the South West Coast

During the present investigation the authors could collect milkfish fry from the Kerala coastal waters during the months of February to August and October. No fry was encountered during November, December and January. Occurrence of small sized fry during February, March (9 mm), April (13 mm), May, June (6 mm), July (10.5 mm), August (14 mm) and October (13 mm) indicates the prolonged seasonal availability of the fry along Kerala coast. The peak period was March-June.

Discussion

The location of the spawning grounds of the milkfish based on the availability of spawners/eggs/fry have been attempted by various earlier workers. While occurrence of spawners and planktonic eggs are a direct evidence of the existence of a spawning ground in the vicinity the occurrence of fry can also give some indication about the spawning ground. Schuster (1960) opined that the abundance of the fry can

be used to assess the spawning ground more or less accurately giving credit period of one or two weeks which the fry need to travel from the spawning ground to the coast. Delsman (1929) quoted by Schuster (1960) feels that the larvae occurring in the sea should of 10 days old and the larvae may be living for few days in the inshore waters before entering the lagoons, creeks and backwaters. Ten day old larvae have to cover a distance of three kilometres a day from the hatching place to the collection site and hence the fry collected from the wild may be two or three weeks old. This was recently confirmed by Liao *et al.* (1979) while tracing the larval development by artificial propagation technique, where the larvae reached 5.9 to 7.5 mm on 10th day ; 6.4 to 11.8 mm on the 14-15th day and 13.5 to 16.5 mm on 21st day.

Reijntjes (1926) as quoted by Schuster (1960) reports milkfish spawning above submerged coral reefs along the south east coast of Indonesia. Delsman (1929) collected 14 nos. of ova from Java Seas at a distance of 15.17 nautical miles from the shore in clear waters of less than 40 m in depth where the salinity was between 32.0‰ and 32.8‰. Sanio *et al.* (1954) based on the abundance of the fry in Indonesian waters concluded that milkfish spawn close to the coast in clear waters of 20-30 fathoms depth. Recently Martosudarma *et al.* (1976) could observe adult milkfish in Karimum Java waters off the north coast of Indonesia from sandy and coraline bottom of 2-10 m depth indicating the existence of spawning ground in the near shore waters.

Herre and Mendoza (1929) and Blanco and Villuloiz (1939) were also of the opinion that milkfish spawns close to the coast not far from the sheltered bays, coves and gulfs in Philippine waters. Senta *et al.* (1976) and Schimittou (1977) suggested a spawning ground in the Philippines adjacent to Batbatan Island off the coast of Antique Province, Panay Island. This was later confirmed by Vanstone *et al.* (1977), Kumagai *et al.* (1978) and Lia *et al.* (1979) from where they could get milkfish spawners for controlled breeding experiments.

In India Chacko (1945 and 1949) while investigating food of chanos had noted specimens of above 100 cms in size from the Gulf of Mannar region and later during 1950 recorded milkfish egg from waters around Krusadai Island and from this it was inferred that milkfish spawns close to the coast. Jacob and Krishnamurthy (1948) also noted milkfish ova from Ennore Estuary. Chacko (1951 and 1952) and Chacko *et al.* (1953) observed congregation of gravid milkfish of 3-5′ (90-150 cm) in length and 24-30 pounds (10.9 to 13.63 kg) in weight in shoals of 60-80 in number during the new moon periods of March, April and May and expressed the view that milkfish, though an oceanic form spawns in selected places in the inshore regions of the coastal water preferably close to backwaters and estuaries where there is a slight reduction in salinity which will facilitate drifting of eggs and larval stages into the backwaters and tidal pools. Panikker *et al.* (1952) recorded an adult milkfish from the Gulf of Mannar, which had a total length of 1240 mm with spent ovaries. Devanesan and Chidambaram (1953) could analyse adult milkfish from the coastal waters of Vizakhapatnam, Pulicat Lake, Sethubavachatram (Tanjore District) ; Pamban and Krusadai Island in the Gulf of Mannar and Kozhikode waters along the Kerala Coast indicating the possible existence of spawning grounds in these areas. Tampi (1957) also could analyse few adult milkfish from the Mandapam area.

Schuster (1960) while reviewing the earlier findings on the abundance of milkfish fry in the Indo-Pacific region says, 'No fry or juveniles is recorded from the shore areas affected by efflux of silt by great delta forming river like Indus, Ganges, Irravady, Mekong and other rivers of Sumatra, Java, Borneo and the fry collection end abrubtly when sandy beaches change to muddy, indicating

that milkfish spawn in clear shallow waters or sandy or coral bottom'. But, Saha *et al*, (1967a 1967b) could collect uneyed ova to 2 cm fry from Junput and Alampore coasts of West Bengal. Basu and Pakrasi (1976) collected milkfish larvae of 7-8 mm size from the Eastern Bank of Hooghly indicating the existence of a spawning ground in the adjacent sea. Hence, we have reservation about the requirement of a sandy or coral bottom for milkfish spawning.

Ganapati *et al*, (1950) tabulated the milkfish fry abundance along parts of the south Indian coasts ; however, it is not clear whether the size of the fry was taken into account by these authors. Their work gives the impression that the peak period of abundance of fry starts during April in Pamban area and June in Northern districts of Coramondal Coast. This made Tampi (1957) to suspect the movements of fry with the water currents from South to North along the east and west coasts of India. However, in the later findings of various authors as well as in the present investigation, the same sized fry have been encountered during the same period of April-June at several centres along the Indian coasts. Based on spawning behaviour of chanos, Tampi (1957) suspected the existence of two races of milkfish along the Indian Coast, spawning in two different seasons. This has not been substantiated.

It is concluded from the present investigation that the best season for the milkfish fry collection in India is April-June along Coramondal coast ; April-June and October- November in the Gulf of Mannar and Palk Bay areas ; January-April along the Tirunelveli and Kanyakumari Coast and March-June along the Kerala Coast.

Controlled Breeding and Culture of Milkfish

At present milkfish culture in India mainly depends upon the natural seed availability which is seasonal, highly irregular and subjected to many environmental factors. Hence, it is necessary to develop a dependable source of seed for intensive culture operations. Realising the importance of this Scientists in various countries are trying to develop techniques of induced maturation and artificial propagation of captive stock and wild milkfish. Limited success has been achieved in this line in recent years. (Chaudhuri *et al.*, 1977, Vanstone *et al.*, 1977, Kuo *et al.*, 1979, Liao *et al.*, 1979.) The Central Marine Fisheries Research Institute has recently taken up an active programme on priority basis for developing techniques for artificial propagation of milkfish. The technical programme includes (a) Collection, transportation and conditioning of milkfish spawners from the wild (*b*) Development of a viable captive brood stock (*c*) Developing techniques for induced maturation and artificial propagation through hypophysation (*d*) Developing a suitable hatchery technology including food for larvae, fry and fingerlings and (*e*) Monoculture and poly culture of milkfish.

Earlier workers have revealed that milkfish, seldom attain maturity in captivity (Alikunhi, 1976 ; Liao and Chang, 1976) and even seven to eight years old pond cultured milkfish were found to be sexually immature. However, spawners collected from the wild had given promising results in Philippines, in the artificial propagation experiments. The team working on the breeding of milkfish in the Institute is trying to develop the technique of artificial propagation by collecting spawners from the wild presently at Mandapam and development of brood stock is also under progress at Narakkal, Cochin.

The availability of spawners in the wild is highly seasonal. Fixed gear such as the Otoshi-ami or similar traps as used in the Philippines may have to be tried for obtaining spawners in good condition. Our experience on the transportation of fish caught in gill net has not been good, although on more than one

occasion they have been kept alive for a few days. We feel there is considerable stress from capturing and handling from the gill nets. Future programme of the Institute will also attempt induced maturation of the stock presently reared in captivity.

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FEASIBILITY OF REARING *SIGANUS ORAMIN* (*SIGANUS CANALICULATUS*) IN CLOSED SYSTEM IN THE STATE OF BAHRAIN

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ABSTRACT

The Rabbitfish is a common species around the Island. The two species found in Bahrain waters are *Siganus oramin* (*S. canaliculatus*) and *Siganus javus* (Local name Safet). Siganidae is considered second in yield from the sea after shrimp, contributing 200,000 Kg which is about 10 per cent of the total landing (Mohamed, 1978).

Experiments were set up to study the possibility of rearing *Siganus oramin* to marketable size. Fingerlings were available in large numbers during July-September and were transferred to the Laboratory. They were between 60-70 mm in length and 4-6 g in weight. Fingerlings fed well on local pellet diets for 180 days of an average of 10 per cent wet weight of the fish. They grew from an average of 60 to 140 mm in length and 4 to 40 g in weight in five and a half months.

Due to the difficulty of getting sea water to the Laboratory, experiments were carried out in closed-system. Study of water quality was carried out to correlate with the mortality and growth. Weight-length relationship of reared *Siganus* spp. was studied.

INTRODUCTION

THE RABBITFISH (Siganidae) is widely distributed in tropical and subtropical regions (Ben-Tuvia, 1963). This is considered as one of the commercially important marine food fish suitable for culture in the state of Bahrain.

However, there is little information about the species, such as distribution, seasonal occurrence, young juveniles of stockable size, spawning, larval history and other ecological and behavioural aspects. Fingerlings (fry) were collected on 13 occasions during the period June-July and August 1976. Seven collection procedures were used and after having established that young *Siganus* spp. could be kept in captivity under controlled conditions, rearing experiments were carried out from 19-7-1976. The main objectives of these experiments were (*a*) to obtain fast-growth rate, in relatively short time, (*b*) to study weight-length relationship of reared fish and (*c*) to study the quality of rearing conditions.

MATERIALS AND METHODS

The experiments were conducted over a period of 180 days in a closed sea water system (Westernhagen and Rosenthal, 1975). The water was passed through an ordinary gravel filter to the sump and pumped to the outdoor rearing tanks. Fingerlings were stocked in four experimental, fibre glass tanks (220 cm × 120 cm × 120 cm depth, capacity 2,5000 l each). The fishes were left in the tanks for several days to become acclimatized to their new environment in captivity. Then on 19th July 1976, a random sample of 75 fishes were taken

for measurements, the netting out of the fish was not an easy task because they are very fast swimmers. Three-fourths of the water in the tanks were emptied to catch the fish. The total length in mm from the snout to the end of the upper lobe of the caudal fin was determined using a measuring board and then they were placed in a beaker of known weight to determine their wet weight in gm.

salinometer and when it was very high (40-45‰) fresh water was added to decrease it.

The concentration of ammonia, nitrite and nitrate were measured by a spectrophotometer. The mortality was recorded daily and the length and weight of the dead fish were measured. Dissection was made to study the internal organs and to detect any disease. Siganidae

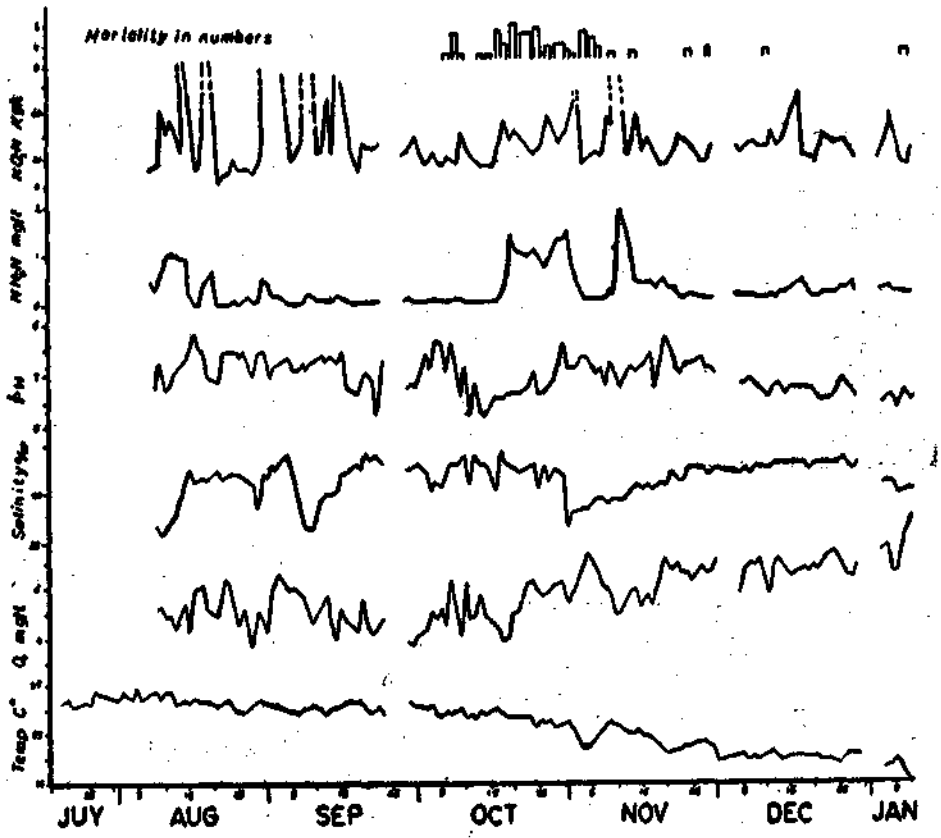

Fig. 1. Water quality analysis of tank No. 1.

The stocking rates in the four tanks T1 to T4 were 325, 340, 167 and 210 respectively. The temperature was measured twice daily in °C and tanks were shaded when the temperature was very high. Oxygen level was measured twice a day to make sure that there was no deficiency in oxygen in rearing tanks. Salinity of the water was measured using a

are primarily herbivorous in nature and their most preferred food is the algae *Enteromorpha*. However, the availability of *Enteromorpha* is seasonal and therefore cannot be provided at all times. Since *Siganus* sp. are known to feed on a wide variety of food in captivity, three types of prepared diets have been used in this experiment.

Diet 1 : This diet consisted of minced fish (*Scolopsis* spp.), Alfalfa and wheat bran in equal quantities. Single cell protein is added, with starch as binder (100 g of starch for every 12 kg of components).

Diet 2 : This diet differred from diet 1 in that instead of wheat bran, wheat flour is added, but in the same ratio as that of bran. No binder is added because the diet itself was sticky.

Diet 3 : It has the same ratios of fish and Alfalfa, but bran is mixed with the flour (2 : 1).

Alfalfa 4 kg, minced fish 4 kg, bran 2.4 kg, flour 1.2 kg, protein 0.6 kg. No binder is used.

Results

Laboratory observations

Fingerlings of *Siganus spp.* when fed on three types of noodle-shape pellets, seemed to orientate themselves optically towards their food. At the beginning of the experiment with diet 1 the fish come to the surface very fast to feed on the floating pellets. Unfortunately fish fed on floating pellets for short time and remained without food for the rest of the day, because pellets were removed by overflow water from the rearing tanks. With diet 2 a large number of mortalities occurred possibly due to the extra carbohydrates (the wheat flour). The best results were observed with diet 3.

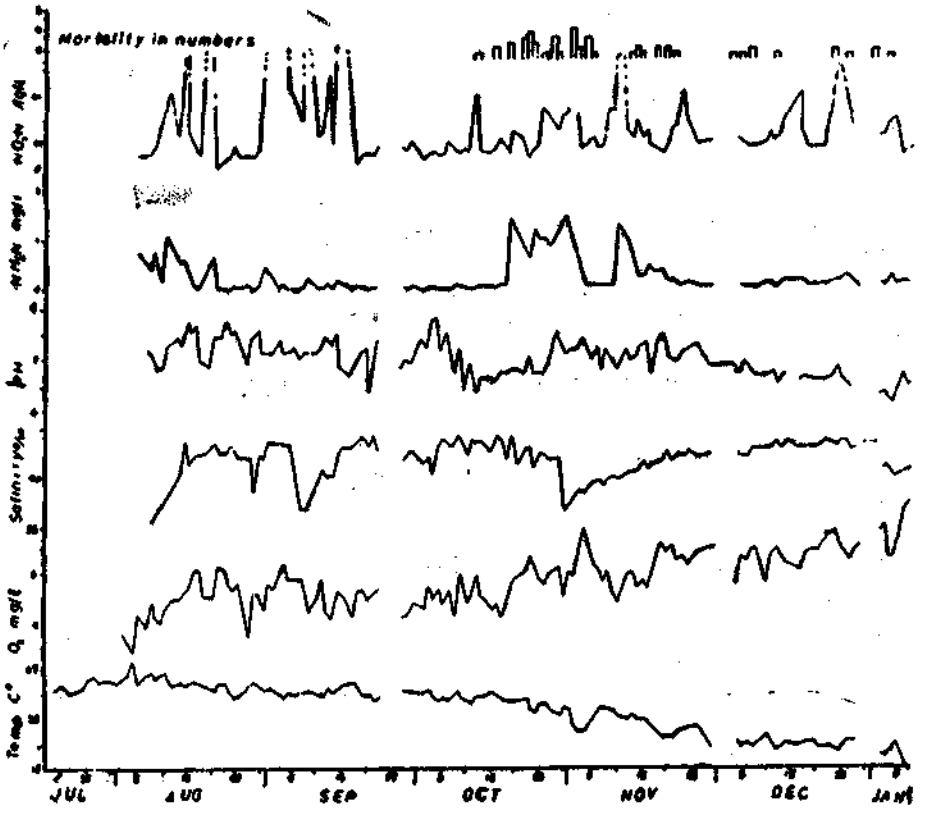

Fig. 2. Water quality analysis of tank No. 2.

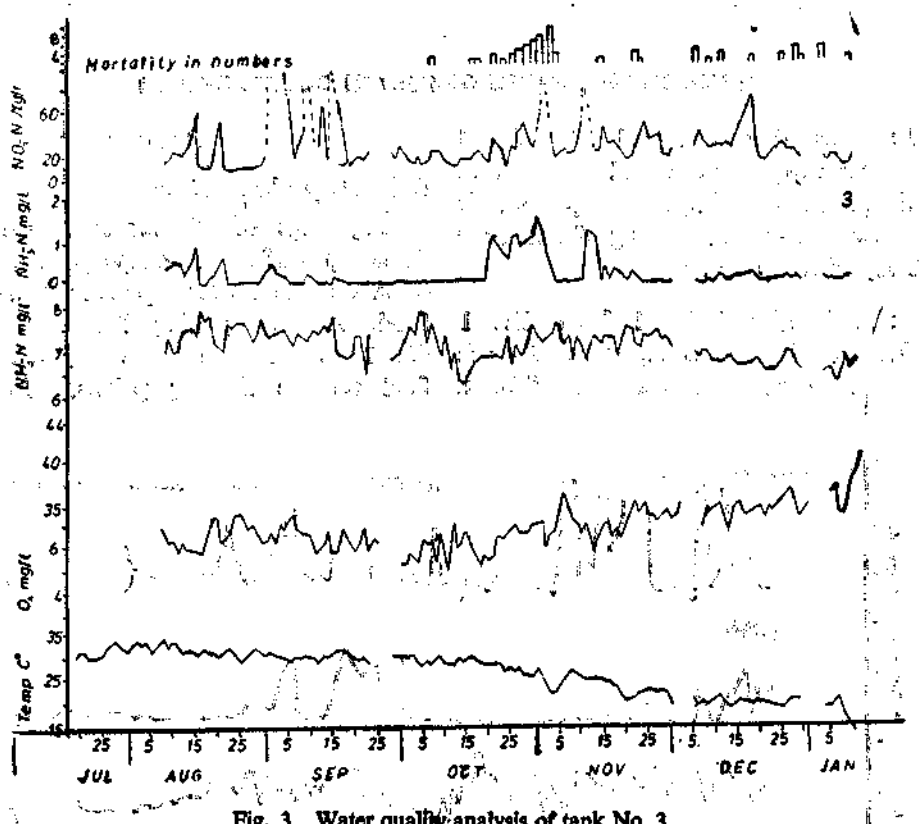

Fig. 3. Water quality analysis of tank No. 3.

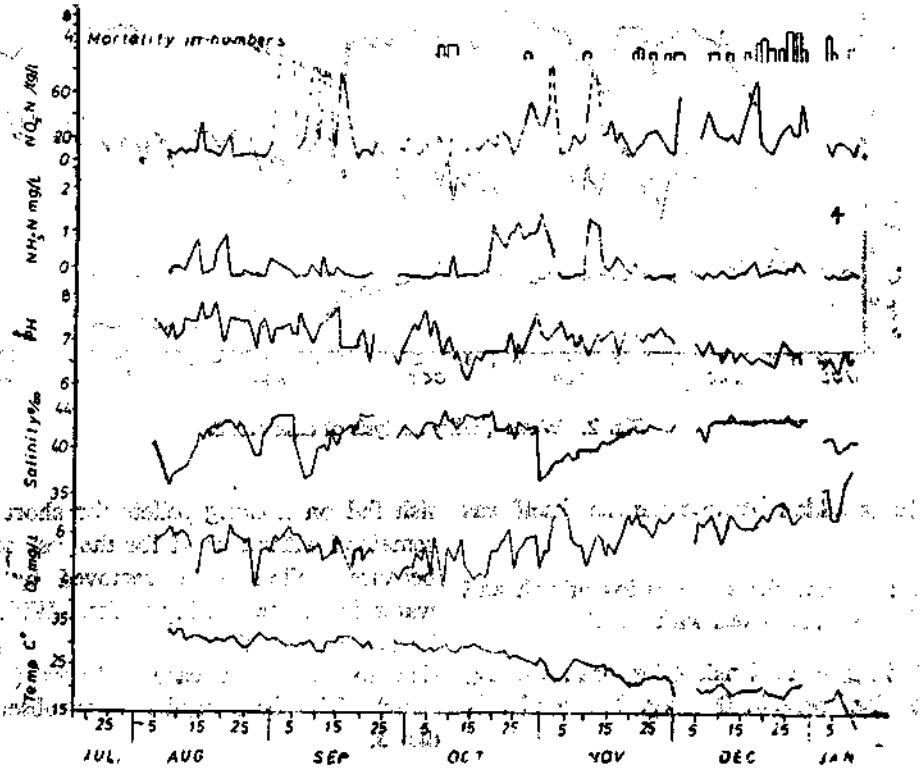

Fig. 4. Water quality analysis of tank No. 4.

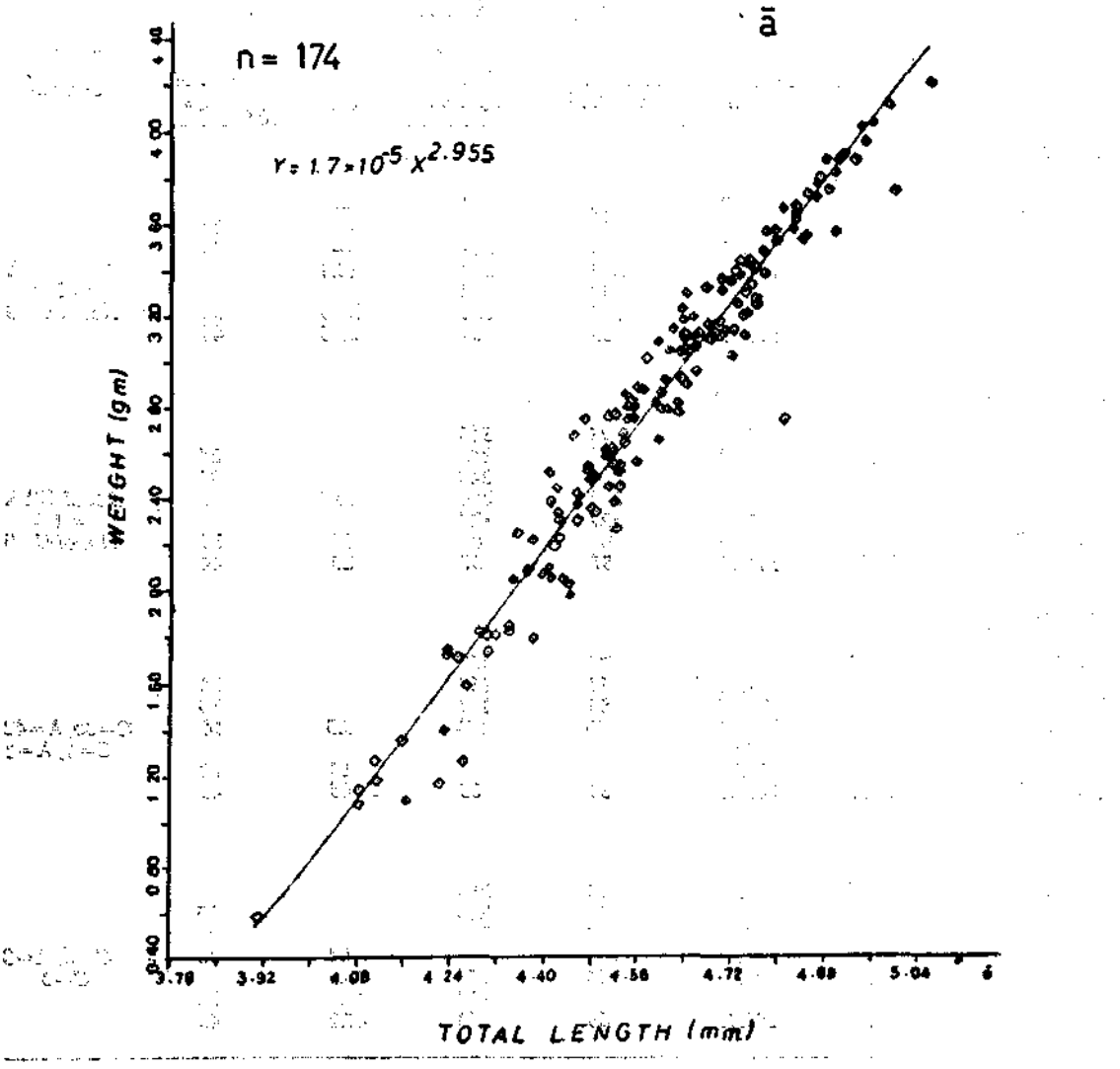

Fig. 5. Length-weight relationship of *Siganus* spp. reared in closed sea water system.

Growth and length-weight relationship

The fish adapted to their capture conditions very fast and started to feed on the next day of stocking. They remained healtby and showed increase in weight and length (Tables 1-4). From Table 5 it can be seen that fish in tank 4 attained the best growth in both length and weight (151.5 mm; 47.6 g), whereas tank 3 showed the lowest growth rate (140 mm; 37.5 g). The fish in tank 1 and 2 attained more or less equal growth rate. The fish in each tank were separated in three groups :

1. The culled fish (C) which were not in good health, very slim and not normal in swimming,
2. The non-growing fish (A) which stopped growing at about 100 mm and
3. The normal fish (N).

TABLE 1. *Monthly measurement records*

Date	Mean wt. (gm)	Mean length (mm)	No. of fish measured	Total No. of fish present	Mortality (%)	No. of days	Remarks
Experiment 1							
19-07-1976	4.86	68.87	75	325	—		
10-08-1976	8.61	87.00	50	325	—	22	
12-09-1976	9.29	87.28	54	325	—	33	
24-10-1976	16.42	101.12	279	279	14.1	42	No. of C&A = 137
	19.40	109.78	142	142			
27-11-1976	33.14	133.87	102	102	28.0	34	No. of C=3
10-01-1977	40.03	144.31	89	89	10.0	44	
Experiment 2							
19-07-1976	4.86	68.87	75	340			
12-08-1976	8.38	87.32	50	340		24	
12-09-1976	7.41	81.90	50	340		31	
25-10-1976	16.88	96.75	304	304	10.5	43	No. of C&A = 177
	20.84	112.60	127	127			
27-11-1976	31.95	132.06	81	81	36	33	No. of C=5
10-01-1977	41.21	144.65	57	57	25	44	
Experiment 3							
19-02-1976	4.86	68.87	75	167			
18-08-1976	6.11	77.62	64	167		30	
20-09-1976	8.16	82.07	54	167		33	
04-11-1976	16.50	102.82	153	153	8.3	14	C=30, A=42
	19.96	114.84	76	76			C=1, A=1
28-11-1976	29.42	129.35	66	66	13	24	
10-01-1977	37.59	140.86	35	35	45	43	
Experiment 4							
19-07-1976	4.86	68.87	75	210			
23-08-1976	9.59	90.12	60	210		35	
21-09-1976	13.73	95.07	44	210		29	
27-10-1976	27.23	122.75	163	163	34.4	36	C=6, A=3
	27.50	123.80	154	154	34.4		C=3
28-11-1976	37.87	141.43	132	132	14.0	32	
10-01-1977	47.61	151.51	68	68	47.2	43	

TABLE 2. *Comparison in the growth rate of the four experiments*

	T_1	T_2	T_3	T_4
1st stocking density ..	325	340	167	163
2nd stocking density ..	142	127	76	154
Final mean weight (gm) ..	40.03	41.21	37.57	47.61
Final mean length (mm) ..	144.31	144.65	140.86	151.51
Rate of growth in weight after 5 months & 3 weeks ..	35.17	36.35	32.73	42.75
Rate of growth in length after 5 months & 3 weeks ..	75.45	75.78	71.99	82.65
Mortality % ..	37	55	53.9	55.8

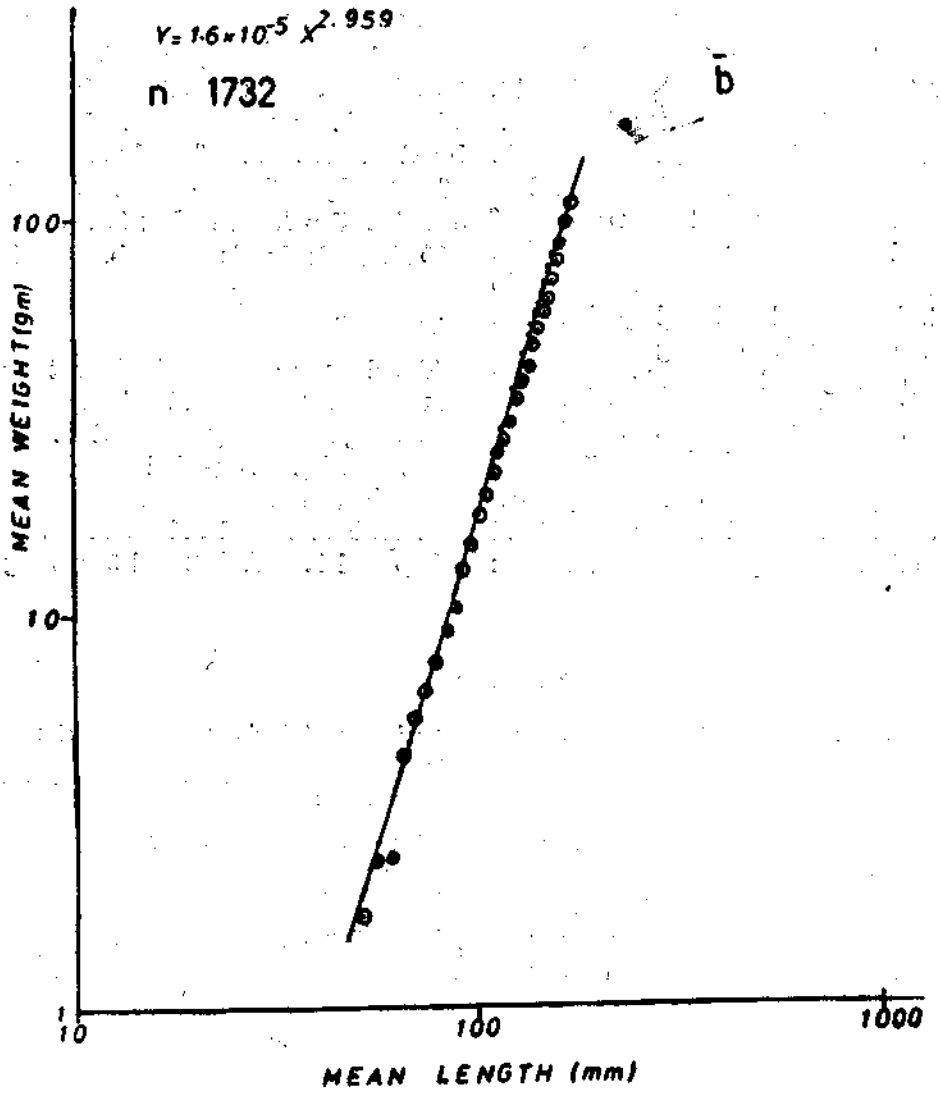

Fig. 6. Mean length-weight relationship of *Siganus* spp. reared in closed sea water system.

Discussion

Our observations showed that fingerlings of *Siganus* spp. is available in large quantities during July-September, enough to initiate stocking for fish farming. They can be reared in captivity on artificial local diets and reach marketable size in a period of 180 days, starting from a length of less than 50 mm.

Artificial diet was available throughout the year and *Siganus* spp. are herbivorous in nature and grow better on *Enteromorpha* diet (Bentuvia *et al.*, 1973; Propper and Gundermann, 1973, 1975). Our observation also showed that *Enteromorpha* diet is available during the spring season (January-June) and that availability of algae species could greatly help to start smallscale commerian fish-farming.

The fish fed well on diet 3, but large mortalities occurred after using diets 1 and 2, this might be due to the reason that diets 1 and 2 had more carbohydrates, which may also account for the turbidity and increase in NH_3 level in the tanks. More research work is needed to study the larval history and the problem of feeding and the quality of water. More knowledge about the weight-length relationship is needed, from reared and wild species. The fisheries laboratory is planning to work on induced spawning and to study the larval history and other problems associated with rearing and early stage larval feeding.

Length-weight relationship in curve (*a*) was based on total length and wet weight of 174 reared live fish. The equation arrived at was : $Y = 1.7 \times 10^{-5} \times 2.955$ (Y = total length mm and X = wet weight *g*). The value of *b* (2.955) is not significant (Prob. less 0.001). Whereas in curve (*b*) the line determined was based on the means of total length and means of wet weight of all specimens and it gave the equation $Y = 1.6 \times 10^{-5} \times 2.959$. The value of *b* (2.959) is significant (Prob. less 0.4).

Water quality

The daily water analysis showed a drop in temperature at the end of the experiment, where high mortality occurred in tank 4 at 10°C. During the period from October to November, an increase in NH_3 level concentration has been noticed and the mortality during this period in tank 1, 2 and 3 was high.

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COPEPOD PARASITES OF FISHES OF PULICAT LAKE

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ABSTRACT

In the Pulicat Lake, seven species of copepod parasites infest four species of edible fishes. *Ergasilus latus* Fryer and *Nipergasilus bora* (Yamaguti), both collected for the first time from India are parasitic on *Mugil cephalus*. While the former infests the juvenile hosts, the latter prefers only the adults. *Parataeniacanthus platycephali* Yamaguti, *Lernanthropus shishidoi* (Shishido) Shiino and *Acanthochondria bulbosus* Heegard are also new records for India, but the male of *A. bulbosus* is described for the first time. Two copepods *Parabomolochus gerres* and *Lernanthropus spinicephala* are new to science and they are found to infest a common host *Gerres oyena*.

INTRODUCTION

PULICAT LAKE (lat : 13.24° N-13.47°N ; long : 80.02°E-80.16°E) is a large brackishwater lake with an area of nearly 280 sq. kilometres. It is situated on the east coast of peninsular India, opening into the Bay of Bengal at Pulicat Village which is about 56 kilometres north of Madras City. It is the second largest brackish water body in India and has very rich, but poorly studied fauna. There is no information on the fish-parasites of this lake and infact parasites of estuarine fish in India have not been systematically studied. During the course of our studies on the fish-parasites from the Pulicat Lake, seven species of copepod parasites have been found to infest four species of important food-fishes. *Ergasilus latus* Fryer and *Nipergasilus bora* (Yamaguti), both collected for the first time from India, are parasitic on *Mugil cunnesius* which is a new host species recorded for these two parasites. While *E. latus* infests the juvenile hosts, *N. bora* has been found to occur only on adult hosts. *Parabomolochus gerres* and *Lernanthropus spinicephala* are both new to science and they are found to infest a common host fish *Gerres oyena*. The copepod *Parataeniacanthus platycephali* Yamaguti, is a new record for India. This species has been found to be host specific. *Lernanthropus shishidoi* (*Shishidoi*), Shiino has been collected for the first time from the Indian waters. Both the males and females of this copepod have been obtained from the gills of *Mugil cephalus*. *Acanthochondria bulbosus* Heegard, is a new record for India and has been collected from the fish *Platycephalus insidiatrix*. The male of this species is described for the first time.

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Family : *Bomolochidae*

Genus : *Parabomolochus* Verwoort

Parabomolochus gerres sp. nov.

(Fig. 1 a-o)

Material

Two females were collected from the gills of one specimen of *Gerres oyena* (Forsskal) caught at Karimanal shores of the Pulicat Lake. Total length : 2.0 mm.

Female

Carapace broader than long, with a prominent incision and a pair of lateral shallow incisions (Fig. 1 a) ; second trunk segment with concave hind border, much narrower than carapace ; third segment narrow and transversely ovate ; fourth and fifth segments small and narrow, fifth segment partially fused with the genital segment ; genital segment large, broad and long ; abdomen short and three segmented ; anal laminae (Fig. 1 o) longer than broad with apical setae. Egg sacs elongate-oblong, eggs polygonal and multiseriate.

First antenna (Fig. 1 b, c) indistinctly six segmented, first three segments partially fused, with a strong apically curved chitinized process, fourteen stout plumose setae and four modified spine like setae, third modified seta stout and long ; third segment of first antenna with an upwardly directed short seta and three downwardly directed setae in the proximal portion and one upwardly directed spine in the distal portion ; distal segment of second antenna (Fig. 1 d) with longitudinal rows of short, blunt spines ; margin with closely packed blunt teeth, distal border with a blunt toothed process and a bunch of five claws ; mandible (Fig. 1 e) with two blades, upper blade large and curved, lower also curved, but much smaller ; first maxilla (Fig. 1 f) with four plumose setae, one of which is very short ; second maxilla (Fig. 1 g) with a spinule in addition to two barbed blades, upper blade slender, lower large ; maxilliped (Fig. 1 h) with three plumose setae, inner one short ; claw with a prominent curved and acute accessory process.

First leg (Fig. 1 i) flattened with three segmented rami, exopod smaller than endopod, rami with plumose setae ; exopod of second leg (Fig. 1 j) pustulose with six spines, first spine plumose, next five denticulated, all spines with a sub-apical spinule ; endopod broad, with six stout plumose setae and two short spines each with an apical spinule ; third leg (Fig. 1 k) with prominently pustulose exopod ; exopod with five spines and six setae, spines externally toothed and with sub-apical spinules ; endopod broader than exopod and with four setae, third segment with two stout spines longer than those on the second leg ; fourth leg (Fig. 1 l) with slender and long rami, both pustulose ; exopod with five spines and five plumose setae, spines externally toothed, each with a sub-apical spinule ; endopod broader and longer than exopod with two pectinate spines one each on the first two segments, and three apical spines on the last segment. The outer spine of these three toothed, middle one very long and plumose, inner one short and winged.

Fifth leg (Fig. 1 m) uniramous, prominently spiny, distal segment with three pectinate spines and slender plumose seta ; Sixth leg (Fig. 1 n) with three simple setae.

Remarks

Verwoort (1962) transferred eight species of *Bomolochus* Nordmann to a new genus, *Parabomolochus*. According to him, ' this genus is characterized by particulars of the antennules, the antennae, the maxillipeds and the legs and therefore it is much more homogeneous than *Bomilochus, sensu stricto*. In addition to the type species *Parabomolochus bellones*, the following species are included under this new genus : *Bomolochus unicirrus* Brian, *B. megaceros* Heller, *B. decapteri* Yamaguti, *B. xenomelanirisi* Carvalho, *B. tumidus* Shiino, *B. hyporhamhi* Yamaguti and Yamasu. '

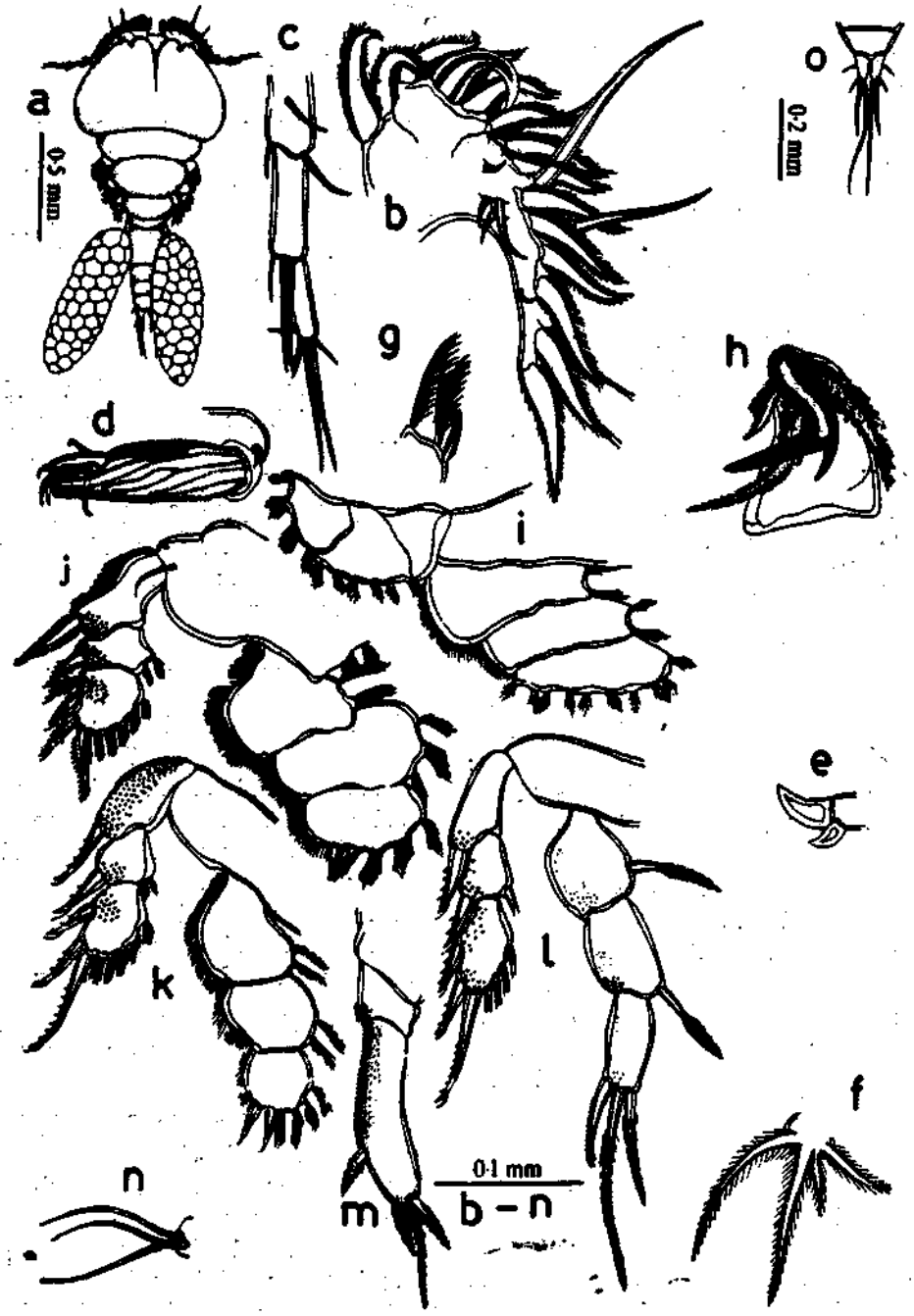

Fig. 1. *Parabomolochus gerres* sp. nov.: *a*. Female, *b*. First antenna, *c*. Hind portion of first antenna, *d*. Second antenna, *e*. Mandible, *f*. First maxilla, *g*. Second maxilla, *h*. Maxilliped, *i*. First leg, *j*. Second leg, *k*. Third leg, *l*. Fourth leg, *m*. Fifth leg, *n*. Sixth leg and *o*. Anal laminae.

One common feature of all these aforesaid species is the presence of a chitinized apical hook on the first antenna. Pillai (1965) described three new species *Bomolochus selaroides*, *B. hemiramphi* and *B. monoceros* and subsequently transferred them to the genus *Parabomolochus*, as these three species possess the characteristic chitinized hook on their first antenna.

The present species *Parabomolochus gerres* closely resembles *Parabomolochus decapteri* (Yamaguti), *P. selaroides* general body shape and in the structure of the appendages, but differs from them in the following features.

(1) *Parabomolochus gerres* differs from *P. decapteri* in having a less robust body and in the presence of a short pectinate spinule in the second maxilla. Also, in the general pattern of the legs, the two species do not agree; (2) *P. gerres* differs from *P. selaroides* in the presence of a spinule in the second maxilla. In *P. selaroides* the endopod of leg 1, is pustulose. In *P. gerres* the endopod of the first leg is not pustulose. There is also great difference in the armature of spines between these two species; (3) *P. gerres* resembles *P. hemiramphi* in the presence of a pectinate spinule in the second maxilla. But in the latter the exopod segments of legs 2 to 4 are not pustulose and the spines are winged and (4) *P. gerres* differs from *P. monoceros* in having a less robust body. In *P. monoceros* the egg sacs are long with round eggs. In *P. gerres* the egg sacs are oblong and the eggs are polygonal. Also, in the general pattern of the legs, the two species do not agree.

Only two specimens of this new species could be collected, during the present survey. This however does not mean, that these copepod parasites are very rare forms. The host *Gerres oyena* is a very common fish occurring in the Pulicat Lake. Therefore there is a good possibility of this parasite, to occur in plenty. In the present survey only twelve specimens of this host-fish were examined.

Parataeniacanthus platycephali Yamaguti 1939

(Fig. 2 k-n)

Material

Three hundred and forty four females were collected from thirty four specimens of *Platycephalus insidiatrix* Schlegel, from the Pulicat Lake. They were found on the inner surface of the operculum and on the gills of the host. Total length 3.5 mm.

Female

Body long, carapace swollen and roughly circular (Fig. 2 n); first trunk segment partially fused with the carapace, segments 2 to 4 of the same length, but narrowing gradually; fifth segment indistinctly fused with the genital segment; abdomen narrow and four segmented; anal laminae long with apical setules. Egg sacs elongate, eggs multiseriate.

First antenna distinctly seven segmented, first four segments with 21 stout plumose setae and one long modified seta; a stout curved maxillar process immediately behind first antenna. Second antenna with seven claws; mandible ending in two blades, upper one large and pointed, lower one small and slightly curved; first maxilla (Fig. 2 k) with two prominent setae; second maxilla with a small pectinate spine and two unequal barbed blades; basal segment of maxilliped Fig. 2 l) stout with two setules, terminal process curved and apically bifid, convex margin with a few blunt teeth.

Rami of first leg (Fig. 2 m) highly flattened and indistinctly fused, with short and stout plumose setae; second leg with subequal rami; exopod with five winged spines, terminal segment of endopod with three short and stout winged spines; third leg similar to second, but the terminal segment of the endopod with three spines and two setae; rami of fourth leg unequal, exopod with five spines, terminal segment of endopod with three apical spines.

Fifth leg uniramous with four apical spines, and sixth leg with three simple setae.

Remarks

These specimens agree in all respects with *Parataeniacanthus platycephali* Yamaguti, excepting in the following features.

In the present specimens, the terminal segment of the endopod of the first leg (Fig. 2 m) has seven plumose setae. The first maxilla (Fig. 2 k) has only two setae. The terminal process of the maxilliped (Fig. 2 l) is distinctly bifid and there are only three transverse folds or ridges on its under margin.

In the specimens described by Yamaguti, the terminal segment of the endopod of the first leg has only six plumose setae. The first maxilla has four setae and the terminal process of the maxilliped has been shown to be blunt and not bifid. Also there are as many as eight transverse folds on the convex surface of the terminal process.

This species is a new record from the Indian waters.

Family : *Ergasilidae* Nordmann

Genus : *Ergasilus* Nordmann

Ergasilus latus Fryer, 1960 (Fig. 2 p)

Material

Twenty-one adult females were collected from the gills of fourteen specimens of *Mugil cunnesius* Cuvier, at Karimanal shores of Pulicat Lake. Total length 0.7 mm.

Female

Body cyclopoid ; head completely fused with first thoracic segment, with blunt conical rostral projection ; first thoracic segment enlarged and pear shaped narrowing gradually to the concave posterior margin ; second, third and fourth thoracic segments well marked and distinctly separated from each other by lateral incisions ; fifth thoracic segment very much reduced and indistinctly separated from fourth ; genital segment wider than long ; abdomen three segmented ; caudal rami ending in long spine setae ; body markedly attenuated from second thoracic segment backwards. Egg sacs plumpy and cylindrical and eggs numerous.

First antenna small, six-segmented bearing a number of setae ; second antenna large, five segmented, terminal segment bearing a curved unguis ; mouth parts situated some distance from the second antennae ; mandible two segmented, proximal segment with pectinate palp, distal segment with setae on inner margin ; first maxilla with heavy shaggy tip.

First leg larger than the rest, biramous, rami subequal and three segmented ; second and third legs equal in size, biramous, rami subequal and three segmented ; fourth leg small, biramous, exopod with two segments and endopod with three segments ; fifth leg conspicuous and uniramous with two or three setae at its tip.

Remarks

The present species resembles in all respects *Ergasilus latus* Fryer except that in the former, the furcal setae are short. This species has been found to infest only juvenile hosts. Large sized adult hosts showed practically no infestation of this parasite. This copepod is a new record from Indian waters and *Mugil cunnesius* is also a new host record for this parasite.

Genus : *Nipergasilus* Yin

Nipergasilus bora (Yamaguti) (Fig. 2 o)

Ergasiloides bora Yamaguti ; 1939.

Yamagutia bora Fryer ; 1956.

Nipergasilus bora Yin ; 1956. Yamaguti, p. 38, pl. 38, Fig. 1.

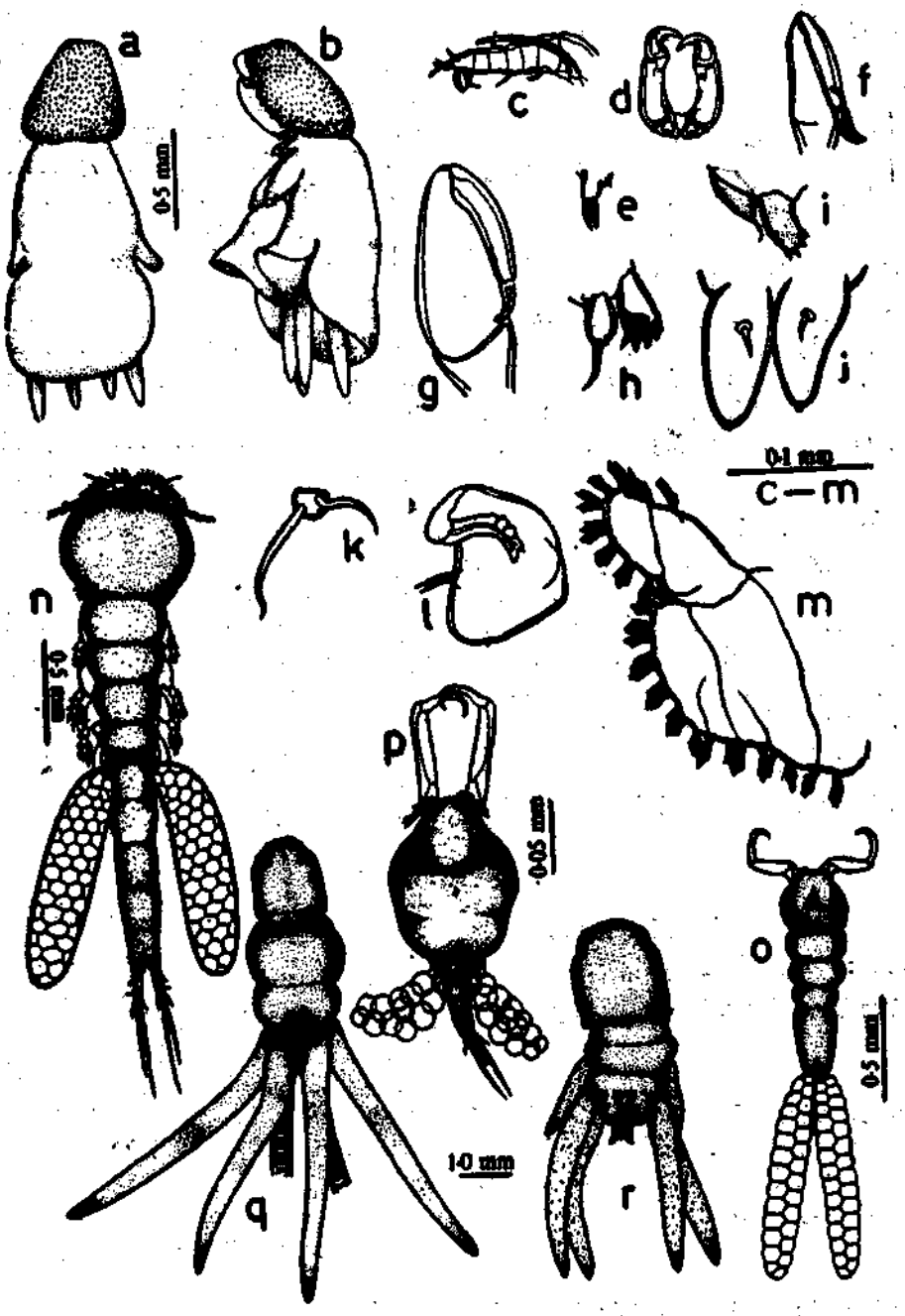

Fig. 2. *Lernanthropus spinicephala* sp. nov.: *a*. Female—dorsal view, *b*. Female—ventral view, *c*. First antenna, *d*. Second antenna, *e*. Maxilla, *f*. First maxilliped, *g*. Second maxilliped, *h*. First leg, *i*. Second leg and *j*. Anal laminae. *Parataeniacanthus platycephali* : *k*. First maxilla, *l*. Maxilliped, *m*. First leg. *n*. *Nipergasilus bora* : *o*. Female. *Ergasilus latus* : *p*. Female. *Lernanthropus shishidoi* : *q*. Female an *r*. Male.

Material

Fourteen adult females were obtained from the gills of seven large specimens of *Mugil cunnesius* Cuvier, collected from the Karimanal shores of the Pulicat Lake. These specimens exhibit some hitherto unexplained features. Total length 2.0-2.5 mm.

Female

Carapace broader than long with rounded sides, anteriorly narrowing into a blunt conical antennal area; posterior border of carapace straight, slightly overlapping the first thoracic segment; thoracic segments well-marked, with conspicuous lateral incisions between segments; second and third segments not as broad as first three combined, narrowing gradually towards the posterior end; hind margin slightly sinuous; fifth segment completely fused with the fourth; genital segment small, with rounded sides; abdomen three-segmented, terminating in a pair of short caudal rami with long setae.

First antenna small, six-segmented, with numerous setae bordering the outer margin and the tip; second antenna large, five segmented and prehensile, with a slightly curved unguis.

Mouth parts situated some distance from the second antenna; mandible two segmented, proximal segment with pectinate palp, distal segment broad, with pectinate margin; first maxilla with two setae, second maxilla with its tip fringed with numerous bristles.

First three legs equal in size, biramous, rami three-segmented; fourth leg smaller, biramous, rami two-segmented; fifth leg short, subcylindrical, uniramous with three setae at its tip; egg sacs cylindrical, long, eggs round and arranged in three longitudinal rows.

Remarks

The genus *Ergasiloides* was established by Yamaguti (1939) based on some specimens collected from *Mugil cephalus* Linnaeus, at Lake Hamana, Japan. Since the name *Ergasiloides* was preoccupied, Fryer (1956) changed the generic name to *Yamagutia* Since *Yamagutia* was also unavailable, Yin (1956) proposed the name *Nipergasilus*.

The genus *Nipergasilus* contains only one species, *viz.*, *Nipergasilus bora*. The most important characters of the genus are the elongated cylindrical body, clearly marked off first to third thoracic segments and the distinct long fourth thoracic segment which is completely fused with the fifth.

The present specimens agree in all respects with *Nipergasilus bora* as described by Yamaguti. This is the first record of this parasitic copepod from Indian waters, extending the geographic distribution of this species to the oriental region also. These parasites are also from an estuarine habitat very much like Yamaguti's specimens, but from a new species host, viz., *Mugil cunnesius*.

Family: *Anthosomidae*

Genus: *Lernanthropus* Blainville

Lernanthropus spinicephala sp. nov.

(Fig. 2 a-j)

Material

Five females were collected from the gills of two specimens of *Gerres oyena* caught from the shores of Donirevu on the Pulicat Lake. Total length 2.0-2.5 mm.

Female

Body stout, carapace pear-shaped and spiny surfaced (Fig. 2 a, b); antennal area clearly demarcated, lateral parts forming ventrally directed flaps; trunk smooth, anterior part narrow, regularly widening posteriorwards; dorsal plate expanded, roughly circular with evenly convex posterior border; genital segment small, abdomen longer than broad; anal laminae (Fig. 2 j) short with one or two apical setules.

First antenna (Fig. 2 c) seven segmented with a few stout setae ; accessory process stout and long with a swollen base ; second antenna (Fig. 2 d) large, basal segment with a proximal and a distal tubercle, carrying a spinule, distal segment with a swollen base carrying a curved stout spine ; maxilla (Fig. 2 e) with two lobes, outer lobe with two spines, inner with one spine ; first maxilliped (Fig. 2 f) slender, distal segment with a small spinule and a serrated unguis ; second maxilliped (Fig. 2 g) with a stout basal segment, distal segment slender and curved with two spines, unguis distinct.

First leg (Fig. 2 h) with inner seta, exopod with five spines, endopod oblong, smaller than exopod, with a long spine ; both rami sparsely spinose ; exopod of second leg (Fig. 2 i) with five spines one of which is very small ; endopod with a long spine ; both rami sparsely spinose, subequal in length ; inner seta absent ; third leg (Fig. 2 b) with the exopod small and flap like, endopods completely fused and directed downwards ; fourth leg (Fig. 2 b) short, rami subequal, half the rami projecting beyond the dorsal plate.

Egg comparatively large.

are distinctly absent in *L. sillaginis* and *L. villiersi*.

Lernanthropus shishidoi (shishidoi),
Shiino (Fig. 2 q, r)

Lernanthropus nudus Basset-Smith p. 368-371 pl. 12, figs. 2-4.
Lernanthropus shishidoi 1955, p. 64-68, figs. 6-7.
Kristisinghe 1964, p. 93-95, fig. 124.

Material

Thirty one females and ten males were obtained from the gills of eight specimens of the Grey mullet *Mugil cephalus* Linnaeus caught from the shores of Donirevu on the Pulicat Lake. The females range from 5.0 to 8.0 mm in length and the males from 4.0 to 5.0 mm.

This copepod parasite is a new record from Indian waters.

Family : *Chondracanthidae* Dana
Sub Family : *Chondracanthinae* Dana
Genus : *Acanthochondria* Leigh-Sharpe and

part of carapace raised, with a pair of blunt elevations ; first thoracic segment uniformly narrow and well defined ; second thoracic segment longer than carapace and gradually broadening posteriorwards ; anterior division of the trunk broad and round and clearly demarcated from the dorsal plate below, with lateral incisions ; dorsal plate produced into two pointed lobes hanging freely and separately ; genital segment and abdomen well exposed ; abdomen round and small, devoid of caudal rami, but with a pair of blunt lateral projections.

First leg (Fig. 3 j) fleshy and biramous. Exopod twice as long and broad as endopod ; second leg long, flat and uniramous. Tip of second leg indistinctly bilobed.

Egg sacs cylindrical, stout and long. Eggs rounded and multiseriate.

Male

Body short and slender (Fig. 3 c) ; carapace large and subcylindrical, with a distinct median incision ; first thoracic segment much reduced

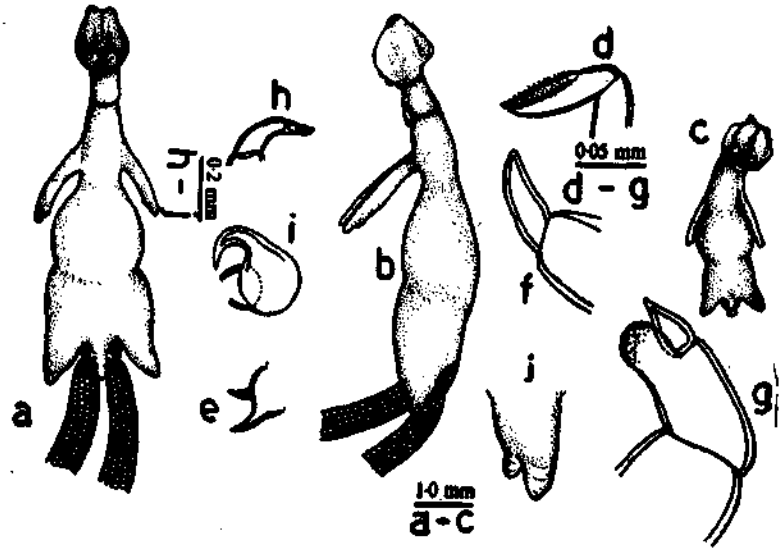

Fig. 3. *Acanthochondria bulbosus* : *a.* Female—dorsal view, *b.* Female—lateral view, *c.* Male, *d.* Mandible, *e.* First maxilla, *f.* Second maxilla, *g.* Maxilliped, *h.* First antenna, *i.* Second antenna and *j.* First leg.

First antenna (Fig. 3 h) short, fleshy and indistinctly three segmented ; second antenna (Fig. 3 i) large and stout with a strong curved spine ; mandible falcate, distal portion finely toothed (Fig. 3 d) on either edges ; first maxilla (Fig. 3 e) with two short setae mounted on a broad base ; distal part of second maxilla (Fig. 3 f) with a stout unguis ; maxilliped (Fig. 3 g) large and bilobed, inner lobe fringed with short bristles at its tip ; outer lobe with a broad based stout spine.

and sunk in the carapace ; second thoracic segment gradually broadening posteriorly ; trunk with dorsal plate produced into two pointed lobes as in female ; antennae terminal and well exposed ; mandible, first and second maxillae and maxilliped as in female.

First leg fleshy and distinctly biramous ; second leg uniramous, narrow and long ; abdomen large and distinct with a pair of small anal laminae.

Remarks

Acanthochondria bulbosus Heegard (1943), was earlier recorded from *Platycephalus insidiatrix* Schlegel, from Fengtien, Hulutao, the Yellow Sea.

Heegards description of this species is based only on two badly preserved female specimens. The description is very much incomplete and the diagrams are inadequate. According to him 'unfortunately, the two specimens present were both badly preserved, as also was the host for which reason the mouth appendages themselves could not be made out perfectly distinctly, and therefore I have not made a special figure of the mouth appendages, but only a rough diagram included in the figure of the head from the ventral side. The present collection of specimens (114 females and 1 male) in excellent condition is recovered from several specimens of *Platycephalus insidiatrix* Schlegel.

This is the first record for this species from Indian waters and the male, hitherto unknown, is recorded and described for the first time.

These copepod parasites have been found to occur within the crevices of the gill arches on the buccal floor of the host. The head is well burried in a round vesicle of the host tissue. The parasites could be freed only by rupturing the vesicles. The parasite is whitish and is extremely sluggish in its movements.

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FISH CULTURE IN PENS IN THE GULF OF MANNAR, INDIA

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ABSTRACT

Realising the immense potentialities which India holds for large-scale coastal aquaculture with its numerous bays along its coast line, experiments on the culture of fish in the pens in the sea were initiated in the beginning of 1977 at Mandapam Regional Centre of Central Marine Fisheries Research Institute on the southeast coast of India. Two pens, made out of bamboo screens, were erected at a site in the Gulf of Mannar near CMFRI Jetty, Mandapam camp.

Constructional details of pens and the measures taken to protect them from heavy seas during rough weather are given. The pens, which consisted of double layered screens made out of bamboo splits, were firmly fixed to the sea bed with the aid of casuarina poles. They were square in shape and each pen covered an area of 81 sq. m.

3,288 fingerlings of *Mugil* spp. and 77 fingerlings of *Chanos chanos* were introduced in the first pen, the mean size of the former being 32 mm and the latter 72 mm. Another batch of 80 milkfish fingerlings of the size range 46-108 mm was introduced in the second pen. Good growth rates in respect of mullets and milkfish were observed. An account of the hydrological conditions prevailing in the pen enclosure and the food given to the stocked fishes are also given.

Constraints faced in the maintenance and operation of the pens in the sea and suggestions to overcome them are presented and discussed.

INTRODUCTION

IN INDIA, an awareness has developed in recent years on the need to carry out aquaculture and especially coastal aquaculture on a scientific basis, as a means to augment fish production and to provide greater job opportunities to the rural folk. This has become all the more important in the context of wide fluctuations in the landings of some of the major capture fisheries in India (Silas *et al.*, 1976). Realising the immense potential of coastal aquaculture, which this country offers with its coastal lagoons, estuaries, backwaters and mangrove swamps, the scientists of the Central Marine Fisheries Research Institute initiated at the beginning of 1977 an intensive programme of pen and cage culture using cheap indigenous materials.

Taking advantage of the existence of intertidal mudflats, creeks and calm bays in the southeast coast of India and availability of fish, prawn and crab seeds in plenty in this region, experiments relating to culture of the same in pens and cages were carried out at Mandapam and Tuticorin. The details of pen culture, which is of pioneering nature, carried out at Mandapam on the Gulf of Mannar side in the southeast coast of India are presented in this account.

We are highly grateful to Dr. E. G. Silas, Director, Central Marine Fisheries Research Institute for the guidance, encouragement and suggestions given in carrying out the pen culture work. We are thankful to Mr. M. Najmuddin, for the analysis of the water samples from the pen and to Shri. V. Gandhi for the assistance rendered in the maintenance of the pen.

Material and Methods

Site

A site in the Gulf of Mannar, about 366 m from the western side of C.M.F.R.I. jetty was selected for the erection of two pens as the sea forms a small Bay at this place and is relatively calm even during rough weather. Further, a test survey in this area showed that the sea bottom was mostly sandy and suitable for driving casuarina poles into the bottom. In order to arrest the action of the waves over the pens, a crescent shaped barrier of casuarina poles was constructed for a length of 57.9 m driving five hundred poles of 4.9 m length and 0.2 m diameter into the sea bed for a depth of 1.8 m. In order to strengthen the barrier, the vertical poles were supported with horizontal poles and braced cross-wise by bolts and nuts. Stones were also laid on the outer and inner sides of the casuarina barrier upto the same length for a height of 2.4 m from the bed of the sea to give further protection to the pens from the action of waves and to prevent silting.

Pens

Bamboo pens specially designed to withstand the action of the waves and to last for a long period in the sea were made. The pen was a square enclosure of 9 m long and sides of 3 m height. It was made of double layered *thatti*, an outer layer of bamboo splits of 9 mm thickness and an inner layer of 5 mm thickness. These were firmly joined together by iron straps. Three *thatti* pieces (3 x 3 m) were joined together to form each 9 m long side. Altogether a single pen consisted of twelve 3 x 3 m *thatties*. Tar was applied upto a height of 0.5 m from the bottom of the *thatti* and over it kriside was painted. These structures when fixed to the sea bed formed an enclosure covering 81 sq. m.

In order to strengthen the *thatties* country wood reapers of 3 m length, 0.2 m breadth and 13 mm thickness were fixed horizontally on either side of each *thatti* at 0.6 m interval. In addition to this, two runners of 9 m length and 0.1 m breadth were fixed to the *thatties* at 0.6 m intervals and these ran on all the four sides of the pen. The pen was supported on each side by 15 casuarina poles and the reapers/runners, *thatties* and casuarina poles were firmly attached to one another by bolts and nuts. These *thatties* were joined together at the corners with a wooden pole 4 m in height so that no gaps were left at the corners. The depth of water in the pen ranged from 1.2 m in the low tide to 1.8 m in the high tide. The bottom was mostly sandy. There was good exchange of the sea water through the minute crevices in the *thatties*. Two pens were erected in the same area, one in 1977 and the other in 1978.

Fingerlings

Fingerlings of *Chanos* and *Mugil* spp. were collected from Chinnapalam creek and tidal pools at Pamban, Pillaimadam and Athankarai Estuary. Before introducing the fingerlings in the pen, all predators present inside the pen were fished by a net. Further the bottom of the pen was checked to ensure that there were no crevices below the water level which may allow escape of fingerlings. The weight, size and the number of fingerlings of each species were recorded before release in the pen.

The fishes were fed every morning with a known quantity of food equivalent to 1/10 of the weight of the fingerlings introduced and it comprised of equal proportions of minced fish meat and oil cake paste. The food was kept in an aluminium tray of the size of 0.5 $\times$ 0.5 $\times$ 0.2 m which was fixed at the centre of the pen in such a way that the tray was just above the low tide water level. They also fed on natural food like algae, phytoplankton and zooplankton available in the pen.

Periodic estimates of salinity, oxygen and pH in the pen site were made. In the first pen, the salinity ranged from 23.75 to 35.00‰ and the dissolved oxygen content varied from 1.40

to 5.75 ml/l. The oxygen values were very low during June (1.70 ml/l) and July (1.40 ml/l) when the *Trichodesmium* bloom occurred in the sea. In the second pen the salinity range was from 33.36 to 36.72°/$_{oo}$ and the range in dissolved oxygen content was from 2.34 to 5.25 ml/l. The pH ranged from 7.2 to 8.0.

Results

Altogether 3,288 fingerlings of *Mugil* spp. of the size range 20-60 mm and mean size 32 mm were introduced in the first pen in March, 1977. During a three month period of March to June their size increased to 87 mm thereby registering a growth of 18 mm per month. The average weight of fish increased from 0.8 g to 15 g. In the same month, 77 fingerlings of milkfish *Chanos chanos* of the size range 60-90 mm were introduced in the first pen, their mean size being 77 mm. In June, the mean size of fish increased to 227 mm thus showing a growth rate of 50 mm per month. The initial average weight of fish which stood at 3 g rose to 77 g at the end of three months.

Another batch of 80 milkfish fingerlings of the size range 46-108 mm was introduced in the second pen in February, 1978. At the time of introduction, the mean size was 84 mm and it increased to 226 mm in May, the growth rate during this period being 47 mm per month. The mean weight increased from 4 g to 110 g during this period. In the subsequent period of June to September the mean size increased from 226 to 380 mm registering a growth rate of 51 mm per month and the mean weight increased from 110 g to 448 g.

Discussion

This is the first time that pens have been erected in the shallow bays in the Indian seas. This is an arduous task because the pens would have to face the hazards of the sea like the impact of tides and waves and withstand the attack of fouling organisms. Bearing these factors in view, care was taken to erect the pens firmly in the sea and the materials used were treated with anti-fouling paints along their submersible portion.

The growth rates of milkfish and mullet fry and fingerlings introduced in the pens were found to be very satisfactory. The growth rates of milkfish and mullet were found to be 47 to 50 mm per month and 18 to 29 mm per month respectively which compares favourably with the results obtained elsewhere (Bensam, 1974).

Some constraints were observed in the maintenance and operation of the pen in the sea extending over a period of two years. The bamboo screens did not last for more than a year in the sea due to fouling organisms like marine borers and due to wear and tear caused by the action of waves. Experiments are under way to construct pens made out of palmyrah leaf stem and sliced palmyrah wood to study their durability and cost factor.

One of the major problems encountered in the operation of the pens was the large accumulation of sea grasses in and around the pen during southwest monsoon months of the year. The hydrogen sulphide released by the decomposed sea grasses polluted the sea water and brought down the dissolved oxygen content in the pen site thereby causing mortality of fish. Blooms of the green algae *Trichodesmium* were also observed during the above months which also caused mortality of fish inside the pen. To overcome these difficulties culture work can be carried out in the Gulf of Mannar side of the Mandapam Regional Centre over a period of seven to eight months starting from September and extending upto May when the sea is free from pollution caused by the accumulation of sea grasses and blooms of blue green algae. Further, during this period the sea is

calm and normally devoid of cyclone which causes uprooting of the pens. The elaborate props for supporting the pen may not be required thereby reducing the cost of erection of pens. The screens made out of bamboo or palmyrah leaf stems can be removed from the sea during the non-operation period. During this period the maintenance work of the same such as applying tar and fastening the splits with binding wire can be attended to.

Valuable experience has been gained on the design, maintenance and operation of the pens in Indian seas as a result of the work so far carried out and based on this, it is proposed to improve the techniques of pen culture in the coming years. The availability in abundance of the seeds of mullets *Mugil* spp. and milkfish *Chanos chanos* (Tampi, 1973) shows that there is a great scope to develop culture fisheries along the southeast coast of India.

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FOOD AND FEEDING HABITS OF THE PEARLSPOT *ETROPLUS SURATENSIS* (BLOCH)

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ABSTRACT

The major items of food consumed by *Etroplus suratensis* consisted of diatoms, filamentous algae, higher aquatic plants, rotifers, insect larvae, cladocerans, copepods, other crustaceans, gastropods and detritus. The larvae were found to feed on a mixed diet almost equal in quantity of both diatoms and protozoans. The feeding habit of the juveniles and mature specimens of *E. suratensis* showed a herbivorous nature since more than 75% of the food items were composed of micro and macro-vegetative matter. The feeding intensity of pearlspot at different sizes showed that the highest feeding intensity was observed in the fishes belonging to the size group of 105-114 mm. The fishes that were about to attain maturity recorded the maximum feeding intensity.

INTRODUCTION

THE PEARLSPOT *Etroplus suratensis*, locally known as 'Karimeen' is a very common food fish of great importance. Inspite of its economic importance and culture possibilities only limited information is available regarding its biology (Bhaskaran, 1946; Job *et al.*, 1947; Rahimulla, 1946; Prasadan, 1971). Our knowledge of the food of the species is confined to the brief reports of Job *et al.* (1947), Alikunhi (1957), Prasadan (1971) and Devaraj *et al.* (1975). A note on the weed destryoing habit of *E. suratensis* has been reported by Gopinath (1948). All available information indicates that *E. suratensis* is predominantly a herbivore, feeding mainly on aquatic micro and macro-vegetation. The present investigation was undertaken to elucidate the food and feeding habits of *E. suratensis*.

We are extremely grateful to Dr. N. Balakrishnan Nair, Prof. and U. G. C. National Fellow, Dept. of Aquatic Biology and Fisheries, for rendering facilities in the Department and for constant encouragement. One of us (V. Jayaprakash) is thankful to the UGC for the award of a Junior Research Fellowship during the tenure of which the investigation was carried out.

MATERIALS AND METHODS

In evaluating the different food organisms, the 'points method' of Synnerton and Worthington (1940) as reviewed and modified by Venkataraman (1960) was adopted. Fortnightly random samples of *E. suratensis* were collected from Veli Lake and from a local market. The specimens were measured and sorted into the following length groups, 25-64 mm, 65-104 mm, 105-144 mm, 145-184 mm and 185-224 mm. The fish were then dissected out and the state of maturity of the gonads was noted to find out any possible correlation between feeding and breeding cycle.

The digestive tract of each fish was carefully exposed and the intensity of feeding was

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recorded. Depending on the degree of fullness of the stomach, points 50, 40, 20, 10 and 0 were given to heavy, good, medium, poor and empty stomach respectively.

The stomach contents were then carefully removed and examined immediately in the fresh condition as far as possible, or were preserved in 5% formalin for subsequent examination. The stomach contents of all the specimens were examined separately.

For evaluating the preference of food consumed, the different food items were assessed under the categories swarms, plenty, common, a few, very little and rare. Points 50, 40, 30, 20, 10 and 5 were allotted. The points gained by each food items were then summed and scaled down to percentages to indicate the percentage composition of food items for various months.

Depending on the distention of gut and the amount of feeding the degree of feeding (Feeding intensity) can be ascertained as under any one of the five categories, heavy, good, medium, poor or empty. The feeding index for any one particular month is the ratio for the number of fish whose feeding intensity was either good or heavy to the number of fish examined in that month multiplied by 100.

Results

(a) *Food of all size groups*

The percentage composition of various categories of food in the stomach in each month is illustrated in Fig. 1. It is evident from the present study that the major item of the food of *E. suratensis* consists of diatoms, filamentous algae, aquatic plants, zooplankton and detritus. Of special importance are the diatoms, filamentous algae, higher aquatic plants, rotifers, insect larvae, cladocerans, copepods, other minute crustaceans, gastropods and detritus. Unicellular algae such as, *Pleurosigma* sp. *Navicula gracilis* and *N. longicephala, Nitzschia* sp., (*Nitzschia sigmoidea* and *N. palea*), *Fragillaria* sp. and *Hemidiscus* sp. were generally found in the stomach. *Pleurosigma* and *Navicula* were more common than *Nitzschia* and *Fragillaria*. The diatoms *Hemidiscus* sp. was found only in the guts of the larvae, fingerlings and early juveniles below 2 cm. The diatoms recorded their peak during the months of June-July-August and November-December-January and February.

Filamentous algae : Comprising of *Spirogyra* sp., *Oscillatoria* sp. *Anabaena* sp. and *Ulothrix* sp. occurred abundantly throughout the year, of which *Spirogyra* and *Oscillatoria* were the main constituents. *Spirogyra* was particularly abundant during the pre-monsoon and moonson months *viz.*, from March to September. Though present throughout the year, the filamentous algae were particularly conspicuous during the period from June to August and December to February.

Higher aquatic plants : The occurrence of the leaves and stems of *Hydrilla, Elodea* and *Chara* were found in abundance in the stomach of *E. suratensis* of all length groups analysed. The roots and leaves of the weed *Salvinia* were also occasionally noticed in the stomach.

Rotifers : The rotifers found in the stomach were *Brachionus* sp. and *Keratella* sp., of these the former was more common than the latter. The rotifers were mostly preferred by the juveniles.

Insect larvae : The larvae of the insects of the order Hemiptera and coleoptera were recorded in the stomachs almost throughout the year. The insect larvae were completely absent in the fish above 145 mm in the total length.

Cladocerans : Daphnia sp. and *Cerodaphnia* sp. were quite common in the diet, especially of the younger size groups.

Copepods : Copepods were found not too common in the stomach contents, but frequently they were found in few numbers.

Other crustaceans : These included crustaceans such as mysids, amphipods, decapod larvae and exoskeletal parts and bits of appendages which could not be identified and occurred almost throughout the year in small amounts.

Mollusca : Represented by some gastropod shells which were negligible in quantity.

Detritus : Decaying organic matter mixed with sand and mud were noticed consistently throughout the year. In the case of juveniles, the detritus formed only a negligible item in the diet while it formed an important item in the diet of the adult fish.

Polychaete worms : In very few cases polychaete worms were found in the stomach contents which might quite incidental.

(b) *Food preference of various length groups*

Food of the fingerlings and early juveniles : The larvae were found to feed on a mixed diet, almost equal in quantity of diatoms and zooplankton. The fingerlings of pearlspot were found to feed largely on diatoms and few zooplankton. They showed a special preference for the diatom *Hemidiscus* sp. The food comprised of a high percentage (40%) of *Hemidiscus*, bits of *Fragillaria* and *Chlorella* (both together formed 20%). The early juveniles (below 25 mm) took aquatic insect larvae, filamentous algae and other plant materials (60%) in addition to diatoms and zooplankton (40%).

(c) *Composition of the food of the* 25-64 *mm length group*

The monthly variations in the percentage composition of the food of the above length group is illustrated in Fig. 1.

About 91% of the 115 specimens, all juveniles had recognizable food remains in their stomach. Filamentous algae (39.18%) and diatoms (22.63%) formed the major items in the stomach throughout the year. Ranking next in importance were the green leaves and bits of stems and roots of higher aquatic plants, forming 10.22% in the diet throughout the year. Other crustaceans (9.48%), detritus (5.23%) insect larvae (4.79%), cladocerans (3.9%), rotifers (3.85%) and copepods (2.65%) formed the other food items in that order. Gastropods occurred in negligible quantities (0.14%) only twice in the year.

(d) *Composition of the food of the* 65-104 *mm length group*

The percentage composition of various food items in the diet of the fish belonging to the 65-104 mm length group is illustrated in Fig. 1.

About 88% of the 121 specimens examined had recognizable food remains in their stomachs. Filamentous algae (39.51%), diatoms (16.84%) and higher aquatic plants (13.62%) again formed the dominant items of food of the fish belonging to this length group also. Ranking next in importance was detritus (10.61%) which constituted a substantial amount of food of this length group. Other items of importance were insect larvae (4.49%), other crustaceans (4.04%), cladocerans (3.56%), rotifers (3.49%), copepods (2.65%), polychaetes (0.69%), and gastropods (0.63%). The quantity of animal matter in the diet showed a remarkable decrease (19.55%) in this length group.

(e) *Composition of the food of the* 105-144 *mm length group*

About 91% of the 205 specimens examined had recognizable food remains in the stomach. In this length group also, filamentous algae were the most important item of food (36.27%), higher aquatic plants ranking next in importance (27.12%) while the diatoms occupied the third position (12.51%). Detritus still formed one of the important food items (10.87%) next to diatoms. The insect larvae which contributed about 5% of the diet of the previous length groups, had been reduced to an average of 1.29% in this length group. Food items which

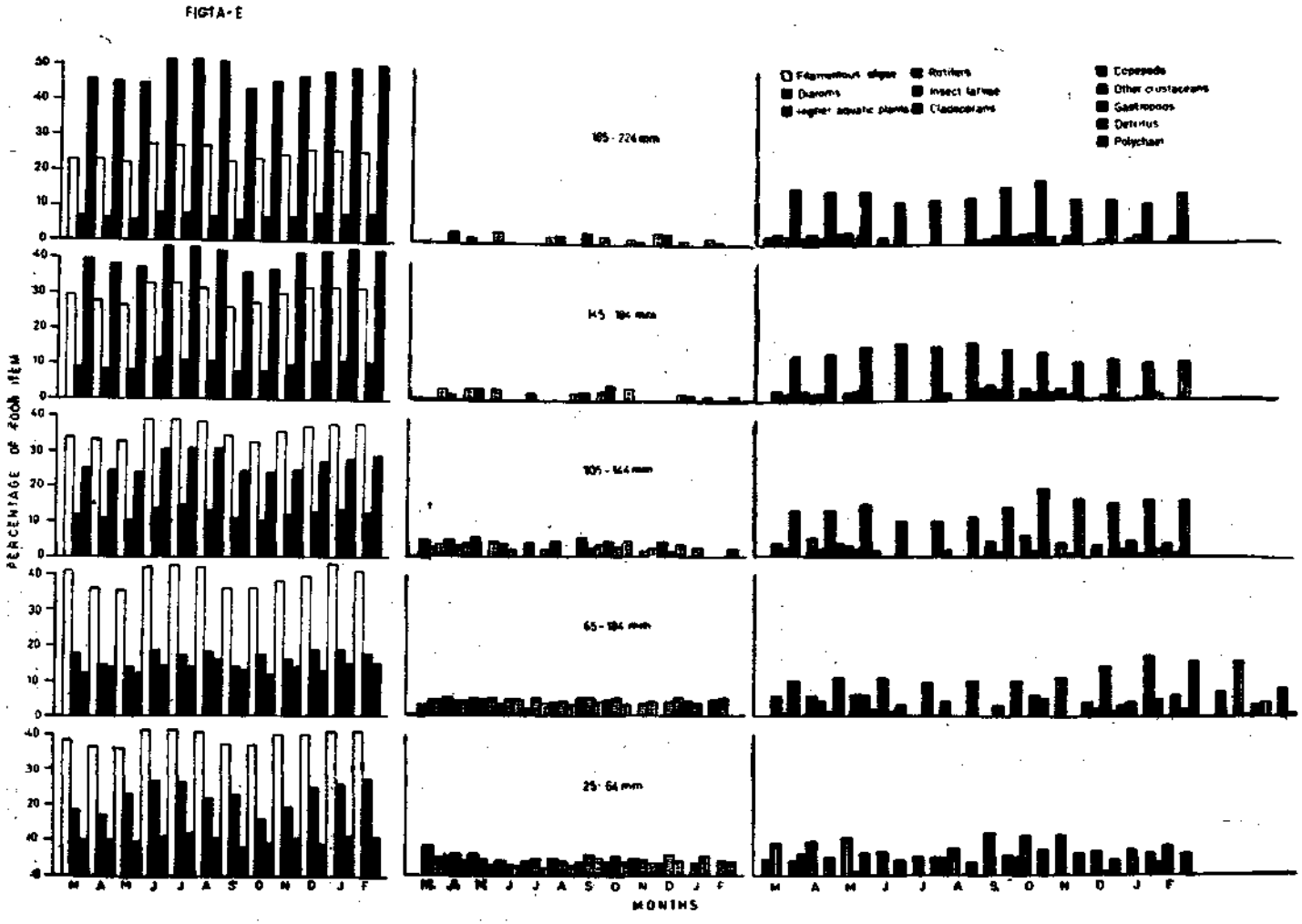

Fig. 1. Percentage composition of various food items in the stomach of *E. suratensis* of different size groups.

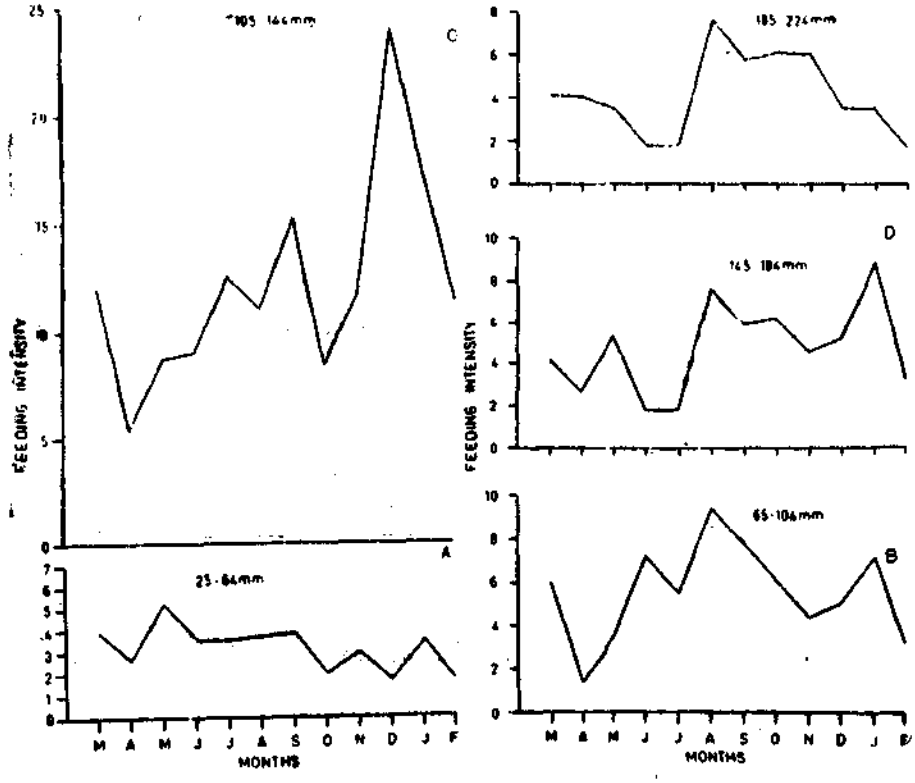

Fig. 2. Feeding intensity of various length groups of *E. suratensis*.

showed a decline in their occurrence were the other crustaceans (3.91%), rotifers (3.15%), cladocerans (2.10%), gastropods (0.91%) and copepods (0.86%).

(f) *Composition of the food of the mature specimens of* 145-185 *mm length group*

About 77% of the 137 specimens examined had recognizable food remains in the gut. Here, higher aquatic plants formed the most important item of food (40.59%). Filamentous algae ranking only next in importance (29.91%). Detritus (12.92%) and diatoms (9.98%) were the other major food items of this length group. Insect larvae were completely absent in the food of this length group throughout the year. Items such as cladocerans (1.78%), other crustaceans (1.46%), rotifers (1.37%), gastropods (1.22%) and copepods (0.94%) were negligible in quantity in the food. Thus higher aquatic plants, filamentous algae, detritus and diatoms together constituted more than 93% of the total food items consumed by the fish of this length group.

(g) *Composition of the food items of older specimens of* 185-224 *mm length group*

About 78% of the 101 specimens examined had recognizable food remains in the stomach. Higher Aquatic plants formed the most important single food item (47.54%) representing more than 50% in certain months such as June, July, August and February. Ranking second in importance were the filamentous algae (24.79%), followed by detritus (13.93%). Next in importance were the diatoms (7.21%). gastropods (1.62%), other crustaceans (1.38%), cladocerans (1.28%), rotifers (1.15%) and

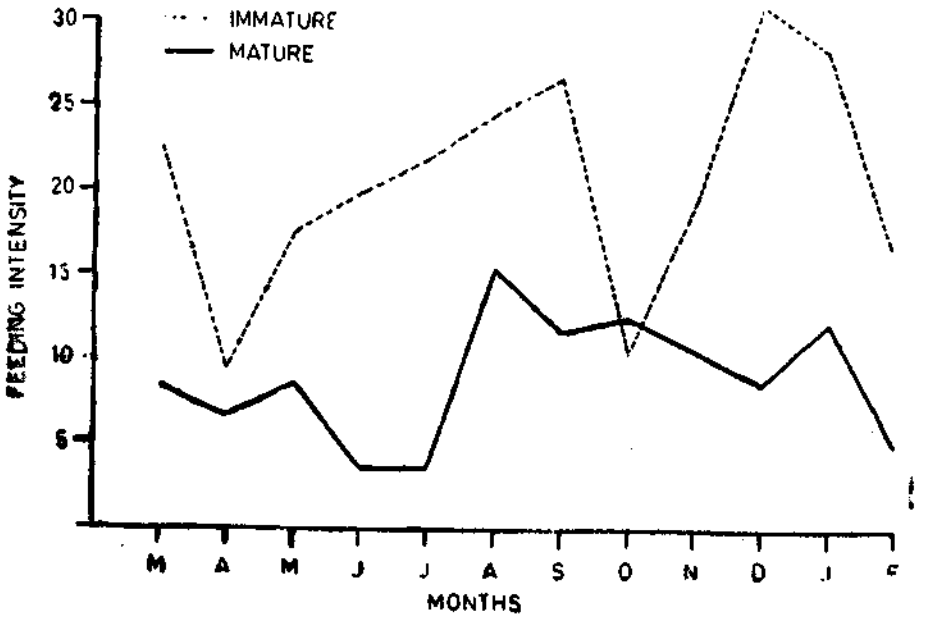

Fig. 3. Feeding intensity of mature and immature specimen of *E. suratensis*.

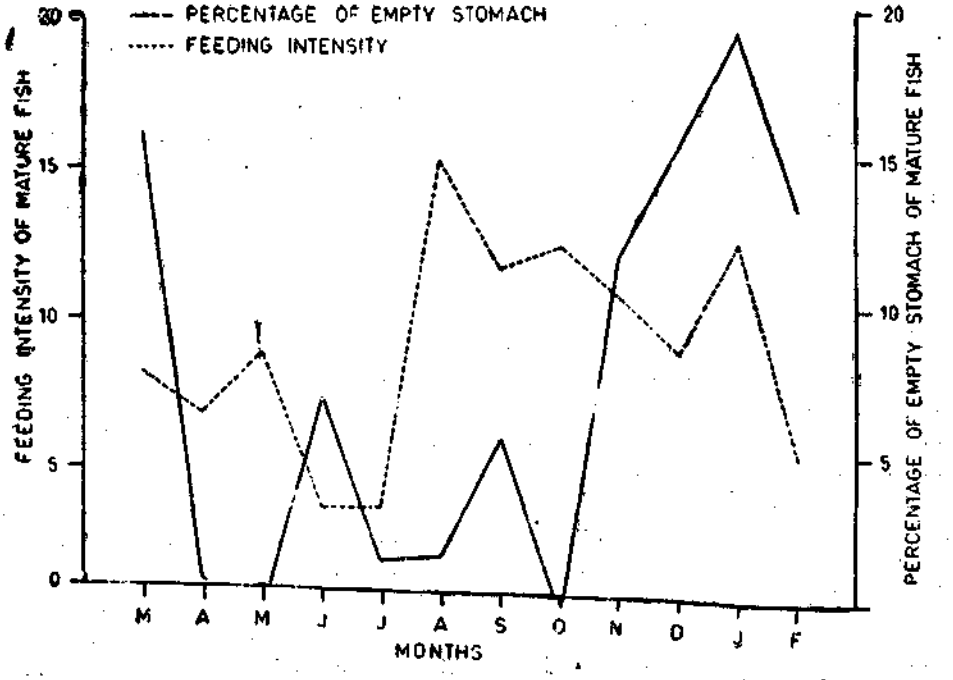

Fig. 4. Feeding intensity and the percentage of empty stomach of mature specimens of *E. suratensis*.

copepods (0.95%) were the other items in that order. Hence the older fish showed a much more herbivorous habit than the other length groups with detritus contributing a substantial portion of the diet.

(h) *Feeding intensity*

From the results, it would appear that maximum feeding intensity was shown by specimens in the length group 105-144 mm, followed in succession by those in the length group of 65-104 mm, 185-224 mm, 145-184 mm and 25-64 mm. The maximum feeding intensity was shown by the fishes which were just attaining maturity.

The variations in the feeding intensity were further studied by grouping the fishes into two broad categories *viz.*, immature (below 144 mm) and mature (above 145 mm) (Fig. 3). During the period of investigation, generally, for immature fish, the feeding intensity was higher than that of the average for mature fish. Monthly variations in the feeding intensity of (fishes above 145 mm in total length) mature fish and the percentage of empty stomachs in each month are shown in Fig. 4. It would suggest that there were two periods of intense feeding, one lasting from March to May and the other from August to December. Maximum feeding intensity was noticed during August-September-October and November and another in April-May when majority of fishes had ripening and ripe gonads. The lowest feeding intensity was noticed particularly in females during June-July and December-January and February, representing the prespawning and spawning months, the marked decline in feeding being a reflection of peak maturity and spawning.

Discussion

Alikunhi (1957) in his brief remarks on the food of *E. suratensis* stated that the hairweed, *Spirogyra* is a specially preferred food item. Hora and Pillay (1962) in an account of food *E. suratensis* observed that adults are mainly herbivorous feeding on blue green algae (*Oodogonium, Spirogyra, Oscillatoria Lynbya, Cladophora* and *Volvocales*) and also decaying plant remnants. They also feed on tender leaves of water weeds like *Blyxia* and *Ultricularia.* Besides vegetable matter pearlspot also takes zooplanktonic organisms, such as copepods, daphnids, crustaceans and insects and worms. In Chilka Lake, the fish had been found to feed on weeds, detritus, gastropods and other miscellaneous items like bivalves, insects, mysids etc. (Jhingran and Natarajan, 1966). Prasadan (1971) in a brief report on the food of pearlspot from Pulicat Lake, recorded that specimens upto 85 mm length feed predominantly on filamentous algae, macrovegetation, detritus, hydrozoans, sponges, bryozoans, etc. and those beyond 85 mm feed predominantly on macrophytes and decayed organic matter. Devaraj *et al.* (1975) have given a comparative study on the food of juveniles collected from estuarine and freshwater environments and stated that fish in both the environments are found to feed on a wide variety of items such as filamentous algae, detritus, microcrustaceans insect larvae and plant materials.

The present observations of the food of *E. suratensis* agree to some extent with those of all previous workers, but also reveal a lot of differences as to the nature of preference of the food items in the various length groups examined. A perusal of the data presented in Fig. 1 brings forth certain interesting aspects of the feeding habits of this fish. It would appear that the larvae and fingerlings are omnivorous. Thus the food of the larvae are chiefly composed of diatoms and minute zooplankton. The fingerlings show a mixed diet of diatoms like *Hemidiscus* sp. *Fragillaria* sp. and *Chlorella* and zooplankton such as protozoans and cladocerans. The early juveniles (upto 25 mm) feed on aquatic insect larvae, filamentous algae and other plant materials in addition to the diatoms and zooplankton.

It is evident from the food items that the juveniles had already changed to a more herbivorous feeding habit. Thus the stomach contents of specimens of early juveniles (15.25 mm) give evidence of a distinct preference for a herbivorous diet.

It is evident from the data that the food of the size group 25-64 mm is mainly composed of filamentous algae, diatoms and higher aquatic plants. The other food items of lesser importance are the other crustaceans, detritus, insect larvae, cladocerans, rotifers, copepods and gastropods. It is seen that a predominantly herbivorous feeding habit is being noticed by the presence of more than 70% of the food comprising of filamentous algae, diatoms and higher aquatic plants at this juvenile stage. In the length group, 65-104 mm, a distinct preference for filamentous algae, diatoms and higher aquatic plants is noticed and the other food items occurred in the order of preference were, detritus, insect larvae, other crustaceans, cladocerans, rotifers, copepods, polychaetes and gastropods. Thus as the fish grows, the quantity of zooplankton and animal matter present in the food items are greatly reduced in amount, while the plant matter shows a distinct increase. In the length group 105-144 mm, filamentous algae are still preferred to other items and others in the order of preference are higher aquatic plants, diatoms, detritus, other crustaceans, rotifers, cladocerans, insect larvae, gastropods and copepods. It is thus evident that this preference for filamentous algae and diatoms marks a change as the fish grows and the specimens of length group 145-184 mm show a distinct preference for higher aquatic plants. The other food items noticed in the stomach of this length group did not show marked variations. In the size group 185-224 mm and above higher aquatic plants are still preferred to other items. Even the largest specimens examined seem to show a preference for this food item. The other items in the order of their preference are filamentous algae, detritus, diatoms, gastropods, other crustaceans, cladocerans, rotifers and copepods. The results thus suggest a dominant herbivorous diet for this fish supplemented from time to time by such varied items available in the habitat as insect larvae, rotifers, cladocerans, copepods, other crustaceans, gastropods and detritus. Thus a predominantly herbivorous feeding habit is fully supported by the foregoing account on the nature and preference of the various food items observed in the stomach of *E. suratensis* of various size groups examined. It is also established that the omnivorous feeding habit of the larvae fingerlings and early juveniles are being changed to a more herbivorous feeding habit as the fish grows to maturity.

Menon and Chacko (1956) stated that fishes feeding on filamentous algae, molluscs and worms and in whose gut contents, sand grains in fair proportion are found, are to be placed under the group of bottom feeders. In the case of *E. suratensis*, the fingerlings and early juveniles seem to belong to the surface feeders. The fishes 65 mm and above presumably belong to the bottom and column feeders as evidenced by the occurrence in substantial quantities of filamentous algae, higher aquatic plants, mud and detritus in their stomach. Thus the older fishes seem to belong to the bottom and column feeders.

The gradual change of preference from diatoms and zooplankton to filamentous algae to higher aquatic plants, may be to avoid effectively the direct competition for food between the juveniles, younger immature group and the mature adult group of fish. Thus this difference in the feeding habit is of survival value reducing the likelihood of intraspecific competition and making it easier for fish of different sizes to occupy the same habitat. Such variation in the diet has been recorded in a few other fishes such as *Gasterosteus aculeatus* (Hynes, 1950), *Bagrus docmac* (Corbet, 1961), *Clarias senegalensis* (Thomas, 1966)

and anchovies (Bapat and Lal, 1950 ; Venkataraman, 1960).

From the observations on the feeding intensity of the various size groups, the maximum feeding intensity is shown by specimens in the size groups of 105-144 mm, while a more reduced rate of feeding is noticed in the older specimens. This maximum feeding intensity observed in fishes which are about to attain maturity may be due to the increased requirements of food for gonad development and maturity. Karekar and Bal (1958) have correlated the feeding intensity with the maturity stages in *Polynemus indicus*. According to them, feeding slows down with the progress of maturity stages particularly in females and when the fish reaches the final stages of maturity feeding is considerably reduced. The present study also suggest a more or less close correlation between feeding and breeding in the case of mature female fish, with the feeding intensity showing a fall by the presence of an increased percentage of empty stomachs during the period of peak maturity and spawning. While in the case of the immature ones there is no such correlation of the rate of feeding with the breeding season or sexual cycle.

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SOME EXPERIMENTS ON ACCLIMATISING, PACKING AND TRANSPORT OF MULLET FRY *LIZA PARSIA* (HAMILTON)

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ABSTRACT

Unconditioned fry gave 0.0% to 77% survival with an average of 41% after liberating in a dug out pit. When transported to the laboratory kept in a jar for one hour after one hour conditioning, 50 fry in 1 litre brackishwater gave 36% survival. When conditioned for 24 hours 50 fry gave 100% survivel. 250 fry gave 90% survival. When packed under oxygen 400 fry gave 100% survival.

INTRODUCTION

THE INCREASING interest in (brackishwater) fish farming during the last decade necessitates the provision of adequate quantity of brackishwater fish seed. The species which are cultivated in brackishwater impoundments of West Bengal commonly known as *bheris* have been mentioned by Pakrasi (1965) and Pakrasi *et al.* (1966) and out of the cultivated fishes the grey mullet *Liza parsia* is the most dominant form. This fish can also be acclimatised to fresh water conditions (Ghosh, 1967). The seed of *Liza parsia* is available in plenty in the shore regions and euryhaline zones of estuaries. They are distributed to brackishwater impoundments with the tidal influx and the quantum of such distribution varies from place to place. Therefore, for supplying seed to distant inland areas as well as to stock freshwater ponds of lower deltaic West Bengal, successful transportation technique of mullet fry has to be evolved. The main difficulty of mullet fry transport is to acclimatise them from lotic to lentic condition as large number of fry succumb due to the change of environment. In fresh water fry transport, detailed studies have been done by Mitra (1942), Khan (1946), Basu (1949, 1951), Vass (1952), Saha *et al.* (1956 1956a, 1956b), Ramachandran (1969) and a host of other scientists, but the transport on mullet seed could not be taken up on a commercial scale because of their susceptibility to handling and environmental changes. Sarojini (1958) was successful in transporting 200 fry of 0.5—3.0 cm size in 22 litres of water for four and half hours. Bhimachar and Tripathi (1967) have also made successful attempts in transporting 100 fry for 24 hours under oxygen packing. Present study is on the minimising of mortality of mullet fry during transport. While conducting these experiments it was observed that fry when placed in enclosed water having same salinity, temperature and dissolved oxygen as that of estuarine river, died in large numbers.

EXPERIMENTS

Four experiments were conducted to find out the best possible way to have a better survival rate when they are subjected to confined water.

The first one was carried out 115 times on the river side in different areas and the other experiments were repeated 20 times. The range and the average of the experiments are given in Tables 1 to 4. The results of the first experiments are the average of observation made at

TABLE 1. *Experiment with* Liza parsia *fry liberated in earthen* (4 m^3) *on the river side after hauling from estuary and observed after* 2 *hours*

No. of fry liberated in each haul	Initial pH	Initial O_2 ppm	Initial CO_2 ppm	No. of fry survived	Survival %	Final pH	Final O_2 ppm	Final CO_2 ppm	Remarks condition of fish
8-335 (205)	7.6-7.8 (7.7)	7.0-8.6 (7.8)	Nil	0-234 (85)	0-77% (41%)	7.6-7.8 (7.7)	6.0-7.8 (7.4)	0.1-0.4 (0.2)	All fry were in hectic motion.

Length of fry 1.2—2.2 cm, Salinity—23.0‰ Temp. 29.5-32.5°C, No of hauls 115 (Average in parenthesis)

TABLE 2. *Experiment with* Liza parsia *fry conditioned for* 1 *hour in plastic pool* (400 *litre*) *in the laboratory and liberated in glass jar* (10 *litre*) *and observed after* 24 *Hours*

No. of fry liberated	Initial pH	Initial O_2 ppm	Initial CO_2 ppm	No. of fry survived	% Survived	Final pH	Final O_2 ppm	Final CO_2 ppm	Remarks on condition of fry
50	7.8-8.0 (7.9)	7.2-8.6 (7.8)	Nil	30-37 36	60-74 (72)	7.6-7.8 (7.7)	1.0-1.4 1.2	2.5-3.9 2.8	Good condition
100	7.8-8.0 (7.9)	7.2-8.6 (7.8)	Nil	41-47 (44)	41-47 (44)	7.4-.7.6 (7.5)	0.7-0.9 (0.8)	4.8-6.8 (5.5)	Survival under stress
150	7.8-8.0 (7.9)	7.2-8.6 (7.8)	Nil	30-37 (33)	20-24.6 (22)	7.4-7.8 (7.6)	0.3-0.5 (0.4)	9.8-10.9 (9.8)	Dying condition
250	7.8-8.0 (7.9)	7.2-8.6 (7.8)	Nil	18-20 (19)	7.2-7.8 (7.6)	7.4-7.6 (7.5)	0.1-0.3 (0.2)	12-3-14.8 (12.9)	Dying condition

Glass jar 10 litre (cap.), Estuarine water 1 litre, No. of replication experiments 20.
Length of fry 1.3-2.2 cm, Temp. 29.5-32.5°, Salinity 23.0‰, Average in parenthesis.

TABLE 3. *Experiment with* Liza parsia *fry conditioned in laboratory in plastic pool* (400) *litre for* 24 *hours before liberating in glass jar containing one litre of esturarine water and observed after* 24 *hours*

No of fry	Initial pH	Initial O_2 ppm	Initial CO_2 ppm	No. of fry Survival	Survival %	pH	Final O_2 ppm	Final CO_2 ppm	Remarks on condition of fry
50	7.8-8.0 (7.9)	6.8-8.0 (7.8)	Nil	50	100	7.6-7.8 (7.7)	1.8-2.5 (2.1)	1.6-2.0 (1.4)	Good
100	,,	,,	Nil	98-100 (99)	98-100 (99%)	7.4-7.8 (7.7)	1.2-1.5 (1.3)	2.4-5.6 (2.7)	Good
200	,,	,,	Nil	180-196 (190)	90-98 (95)	7.4-7.7 (7.5)	0.4-0.8 (0.6)	4.8-7.3 (6.9)	Strained
250	,,	,,	Nil	220-230 (225)	88-92 (90)	7.0-7.4 (7.2)	0.4-0.5 (0.45)	6.9-9.3 (8.8)	Living Under strees

Glass jar 10 litre (cap.), Estuarine water 1 litre, No. of replication of experiments 20.
Length of fry 1.3—2.2 cm. Temp. 29.5-32.5°. Salinity 23.0‰. Average in parenthesis.

TABLE 4. *Experiment with* Liza parsia *fry conditioned in laboratory in plastic pool (400 litre) for 24 hours and kept under oxygen packing - observed after 24 Hours*

No. of fry	Initial pH	Initial O_2 ppm	Initial CO_2 ppm	No. of fry survival	Survival %	Final pH	Final O_2 ppm	Final CO_2 ppm	Remarks on condition of fry
150	7.6-8.0 (7.8)	7.6-8.0 (7.8)	Nil	150	100	7.2-7.6 (7.4)	4.3-5.9 (5.2)	2.6-4.2 (3.2)	Good
300	7.6-8.0 (7.8)	7.6-8.0 (7.8)	Nil	300	100	7.2-7.4 (7.3)	3.8-5.3 (4.4)	6.2-8.8 (7.6)	Good
400	7.6-8.0 (7.8)	7.6-8.0 (7.8)	Nil	400	100	6.4-7.2 (7.0)	1.9-2.4 (2.1P)	7.3-9.9 (8.9)	Survived under stress
500	7.6-8.0 (7.8)	7.6-8.0 (7.8)	Nil	442-451 (450)	88-4-90.2 (90.0)	6.8-7.2 (7.0)	1.6-1.9 (1.8)	9.6-11.0 (10.8)	Survived under stress
700	7.6-8.0 (7.8)	7.6-8.0 (7.8)	Nil	512-526 (515)	73.2-75.2 (75.0)	6.4-7.0 (6.8)	0.8-1.0 (0.85)	10.4/14.7 (12.5)	Dying condition
1000	7.6-8.0 (7.8)	7.6-8.0 (7.8)	Nil	501-533 (520)	50.1-53.3 (52.0)	6.5-6.8 (6.6)	0.5-0.6 (0.55)	18-1-24.3 (21.9)	Dying condition

Plastic bag 16 litre. Estuarine water 1 litre, No. of replication of experiments 20.
Length of fry 1.5-2.2 cm. Temp. 29.5-32·5°, Salinity 23.0‰, Average in parenthesis.

Bagbazar Canal, Maratha Ditch, Calcutta in Mahanadi Estuary as well as in Kakdwip, Muriganga River.

In the first experiments the fry just after collection with a happa net (rectangular net made of mosquito curtain cloth) from the estuary was liberated in earthen dug out pits on the river bank itself (from 0 kilometre to 2 kilometre hauling site) and the survival rate was noted in Table 1. In the first experiment survival rate was 0% to 77% the average being 41%.

It showed that huge mortality occurred as soon as the fry was transferred from lotic to lentic condition. There is every possibility that the physiological stress of the sudden change caused these high mortality. Black (1955) states that the fish generally responds to even slight stimuli with spasmodic hyperactivity. As a result lactic acid tends to accumulate in their tissue and severe 'oxygen debt' are created. The dissolved oxygen present in the pit water was 6.0—7.8 ppm and carbon dioxide was 0—0.4 ppm and these were sufficient for their survival. But at times 100% death has occurred when the fry were liberated in stagnant water having all required physico-chemical condition.

In experiments No. 2 stocking rate were 50, 100, 150 and 250 fry per litre. In the second experiment mullet fry was brought to the laboratory located 1.5 km away and kept in a plastic pool containing same estuarine water for one hour. Then it was placed in ten litre glass jar, each containing one litre estuarine water. An inverse relationship of the survival with the number of fry was found, *i.e.* more the number liberated less was the survival. 50 uncondition fry had reduced the oxygen level from 7.8 ppm to 1.0—1.4 ppm in one hour, but when the number was increased to 250, the oxygen level came down to 0.1 to 0.3 ppm and the carbon dioxide level also reached 12.9 ppm which was near lethal limit. Only 19% survived under dying condition. 100 fry decreased the oxygen level below 1.0 ppm and increased the carbon dioxide level to 5.5 ppm. Both the levels are not congenial for survival of the fry.

In the third experiment also same no of jars and fry as experiment number 2 were taken. In this experiment the fry was conditioned for 24 hours in the laboratory in 400 litre plastic container before placing in the experimental jars containing a litre of estuarine water of same salinity. They were much more stabilized and could be handled with less risk. So when 50 fry were liberated 100% survival was found and dissolved oxygen was 2.1 ppm. Carbon dioxide was also 1.4 ppm. 100 fry also survived in a healthy condition, leaving an oxygen balance of 1.3 ppm and carbon dioxide 2.7 ppm. Even at the case of 250 fry 90% survival was found, but dissolved oxygen and carbon dioxide came near the lethal limit and fry was in distressed condition.

In the fourth experiment the fry conditioned for 24 hours in 400 litre plastic pool in the labora tory was kept under oxygen packing in one litre of estuarine water in polythene bag (16 litre) packing with the advantage of regular oxygen supply in the water. Three hundred fry survived in a good condition for 24 hours and left dissolved oxygen of 4.4 ppm. Even hundred per cent survival was found when 400 fry were liberated, but some distress was found in the fry. When the number were increased the rate of mortality was simultaneously increased. When thousand fry were kept under oxygen packing the survival rate was 52%, the fry were in dying condition as both dissolved oxygen (Av. 0.55 ppm) and carbon dioxide av. 21.9 ppm). came to lethal limit.

Mullet fry should not be transported before conditioning because it covers a risk of 100% mortality. The fry conditioned for 4 hours in a plastic pool or bigger water area, even 100 fry of *Liza parsia* can be transported in 1 litre of estuarine water. 400 fry (24 hours conditioned) can be transported under oxygen packing.

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ON THE IDENTIFICATION OF FRY OF GREY MULLET *VALAMUGIL CUNNESIUS* (VALENCIENNES)

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ABSTRACT

There has been considerable confusion in distinguishing the different species of grey mullet at fry stage owing to their close resemblance. As scientific fish farming involves selective stocking, stock manipulation and other methods to increase production, evolving easy method of segregation of the desirable seed of quick growing species from the slow growing ones is of prime importance. Adipose eyelids, axillary scales and the spot on the pectoral fin are some of the characters used in the identification of mullets. In this communication, the early development of these taxonomic characters in *V. cunnesius* fry are presented as these would be helpful in sorting out this species at fry stage with increased accuracy.

INTRODUCTION

MULLET FRY are remarkably uniform in their external characters and considerable difficulty is felt in distinguishing the species at that stage. As scientific fish farming involves selective stocking, stock manipulation and other methods to increase production, evolving easy method of segregation of the seed of quick growing species from the slow growing ones is of prime importance. Adipose eyelids, axillary scales and the dark spot on the pectoral fin are some of the characters used in the identification of grey mullet. These characters are present in some species and are absent in others. For example, axillary scale at the axil of pectoral fin are present in *Mugil cephalus* and *Valamugil cunnesius* while the axillary scale and the spot are absent in *Liza macrolepis*. No information is available on the formation of these characters in *V. cunnesius* and it would be therefore worthwhile recording their first appearance at fry stage. In this communication, the early appearance of these taxonomic characters and other identification features of *V. cunnesius* fry are presented, as these would be helpful in sorting out this species at fry stage with considerable accuracy.

V. cunnesius is a common mullet occurring in both the coasts of India. The biology of the species has been investigated from Bengal waters (Sarojini, 1958). The breeding season extends from May to August. The species attains a length of 83, 131 and 174 mm in its first three years.

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MATERIAL AND METHODS

In the Ennore Estuary, near Madras, the fry of *V. cunnesius* swarm in large numbers during Sept.-Nov. The fry of mullets were collected from the Ennore estuary with a velon net and preserved in 5% formalin for further

examination. Alizarin transparency was prepared for examining hard parts. The breadth of adipose eyelids and pectoral fin spot and length of axillary scales were measured with an ocular micrometer. The morphometric measurements for calculation of body proportions were taken under a microscope as suggested by Sarojini (1962).

Observations

General description of the fry

Total length : 26-33 mm. Body laterally compressed ; dorsal side of the fry is generally greenish blue or sometimes greyish in colour, while the sides are silvery ; pigmentation not heavy and appear as minute dots and arranged as a streak along the lateral side of the body from th axil of pectoral fin to the base of caudal fin ; rows of pigmentation also present along the myotomes ; pigmentation is clear in formalin preserved specimens. Origin of D_2 behind origin of anal ; length of pectoral less than head length, height of body and length of caudal fin, but comparable to the height of head ; pectoral fin elongated, reaching the base of the first dorsal and when folded forwards it reaches eye. Axillary scales present ; adipose eyelids not visible. Snout is blunt and not pointed as in *Liza parsia* ; maxilla concealed and visible when mouth is opened ; posterior end of preorbital is broad and not curved as in *M. cephalus* (Fig. 1). Fin formula : D_1 IV ; D_2 : I + 8 ; P : 14-15 ; V : I + 5 ; A : III+9 ; L.I : 32-33 ; L.tr : 9-11 ; caudal fin has 14 principal rays (12 branched and the adjacent unbranched rays on either side) and 18 secondary rays ; principal rays are divided into two groups, 7 above and 7 below. there are 9 rays on the dorsal and ventral aspects of the caudal fin ; and anal has 9 soft rays.

Proportionate measurements

Total length/Head length : 3.714-4.400 (4.1799) ; Standard length/head length : 3.833-3.000 (3.333) ; Total length / Height of body : 4.714-5.777 (4.910) ; Standard length/Height of body : 3.571-4.666 (3.917) ; Head length/eye diameter : 2.106-2.800 (2.570) ; Head length/Height of head : 1.166-1.400 (1.267) ; Head length/Pectoral fin length : 1.071-1.555 (1.290) ; Total length/length of caudal fin : 4.076-5.200 (4.779) ; Standard length/snout to D_1 : 1.750-2.217 (1.963) ; Head length/caudal peduncle height : 2.146-2.666 (2.157).

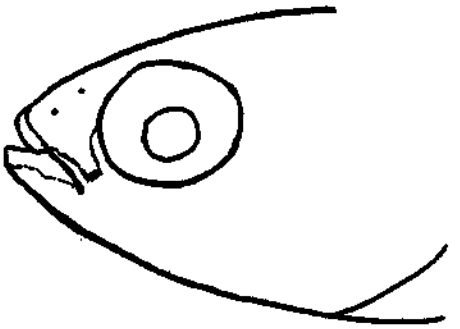

FIG. 1. Fry of *V. cunnesius* (26 mm total length) : maxilla and preorbital bones.

Formation of adipose eyelids

In adult fish the adipose tissue covers a part of the anterior and posterior regions of the eye. Present observations showed that there is not much difference in the breadth of anterior and posterior adipose eyelids and therefore the development of anterior adipose eyelid is described here. The adipose eyelids are first seen at 38 mm length when they measure 0.3 mm in breadth and at 44 mm size, it is 0.4 mm broad ; it reached a breadth of 0.5 mm at 56 mm length. Fig. 2 shows the adipose eyelids in a 47 mm fry. The eyelids attain a breadth of 0.8, 1.0 and 1.5 mm when the fish has grown to 64, 74 and 86 mm long. The development of adipose eyelids (Y) in relation to total length (X) of fish can be expressed by the formula : $Y = -0.492 + 0.020\ X$. Fig 5 depicts the relationship between total length and adipose eyelid development.

Formation of axillary scales

Modified scales are found above pectoral, dorsal and pelvic fins. The early appearance and progressive development of these elongated axillary scales were studied and the results presented.

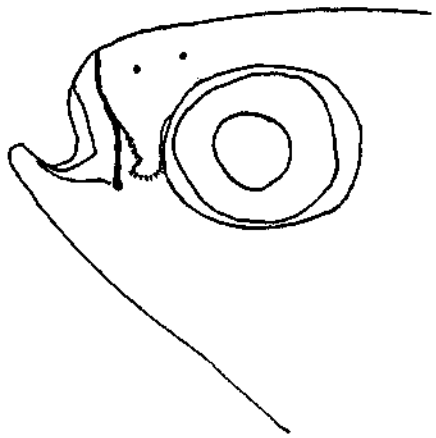

FIG. 2. Fry of *V. cunnesius* (47 mm total length): adipose eyelids, maxilla and preorbital.

The axillary scale at the axil of pectoral fin begins to appear when the fish is 24 mm in total length. At this size the scale measures 0.7 mm in length of which 0.3 mm is visible outside; at 26 mm length, the scale is 1 mm long of which 0.5 mm is seen outside at the axil of fin and at 38 mm the scale measures 1.7 mm of which 1 mm is visible outside. It develops progressively and attain a length of 2.0, 2.8 and 4.0 mm respectively when the fish has grown to 46, 56 and 66 mm in total length. The sizes of scale visible outside at these lengths are 1.5, 2.0 and 2.5 mm. The progressive development of axillary scale (Y) in relation to total length (X) of fish was examined and a relationship of the form $Y = -1.7576 + 0.0871\ X$ was obtained.

The elongated scale below first dorsal fin makes its appearance at an early stage of 18 mm. At this stage the scale measures 0.5 mm in length of which 66% visible outside. When the fry grows to 24, 28, 36, 42, 54, 58 and 66 mm long, the scale also correspondingly increases to 1.0, 1.3, 2.2, 2.8, 3.1, 4.2 and 6.4 mm in length respectively. However the

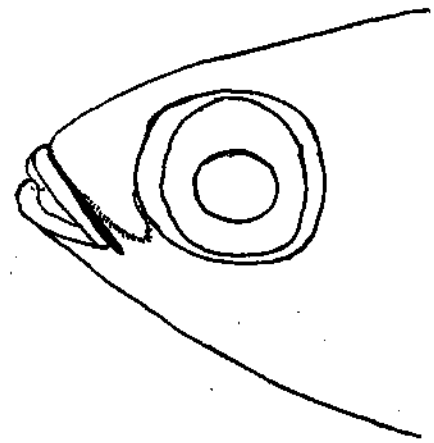

FIG. 4. Fry of *M. cephalus* (40 mm total length): adipose eye lids, maxilla and preorbital.

sizes of scales visible outside at these lengths are 0.5, 1.0, 1.5, 2.2, 2.5, 3.0 and 3.5 mm respectively. The progressive development of dorsal scale (Y) in relation to the total length of fish could be expressed by the formula: $Y = -0.8471 + 0.0805\ X$.

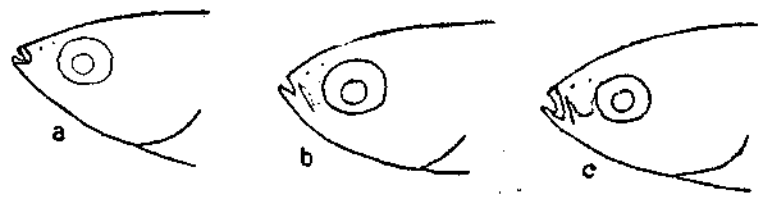

Fig 3. Nature of snout in mullet fry : 25 mm total length
A: L. parsia B: V. cunnesius C: M. cephalus.

FIG. 3. Nature of snout in mullet fry (25 mm total length): a. *L. parsia* b. *V. cunnesius* and c. *M. cephalus*.

The elongated scale (0.3 mm long) above the ventral fin is also noticed at an early stage of 18 mm fry; at 24 mm length, the scale is

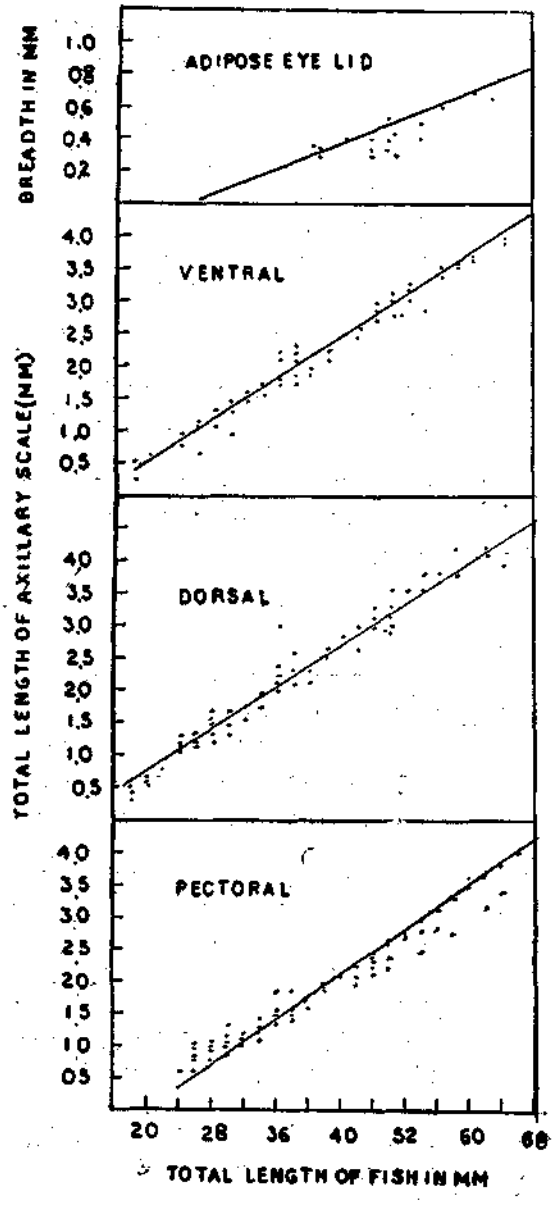

FIG. 5. Relationship between total length of fish and axillary scales and breadth of adipose eyelid.

0.9 mm long of which 0.5 mm is visible outside above the fin; when the fry grows to 32, 38, 42, 52 and 58 mm long, the scale also grows correspondingly and attains a length of 1.4, 2.2, 2.6, 3.2 and 3.5 mm and the sizes of scale visible outside at these lengths are 1.0, 1.5, 2.0, 2.5 and 3.0 mm respectively. The growth of scale (Y) in relation to total length of fish

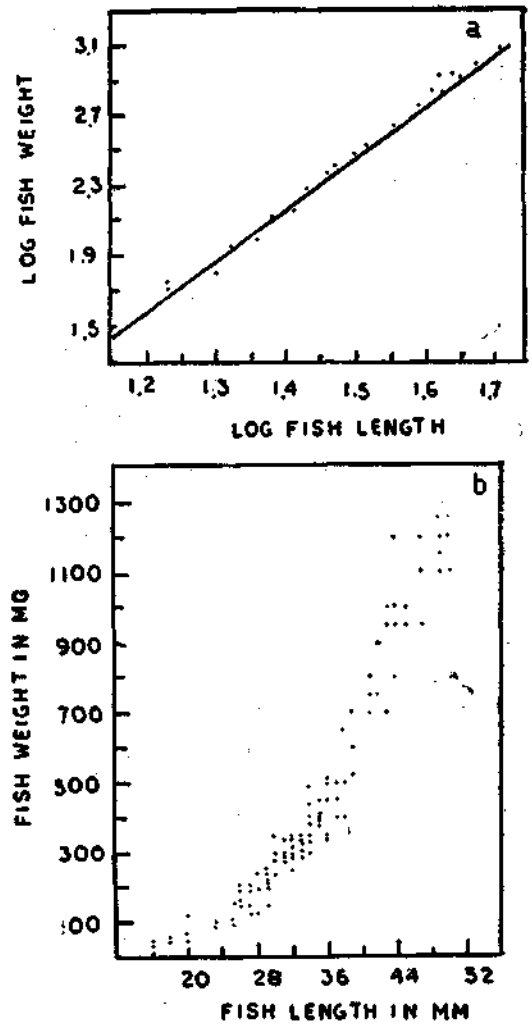

FIG. 6. Length—weight relationship in *V. cunnesius* fry: a. Parabolic and b. Logarithmic.

(X) was worked out and it was found to be: $Y = -1.0967 + 0.0817$. Fig. 5 illustrates the relationship between total length and pectoral (A), dorsal (B) and ventral (C) scale length.

Formation of pectoral fin spot

The dark spot at the axil of pectoral fin makes its appearance as a minute dot at 26 mm fry ; at 30 mm the dot is somewhat clearly visible to the naked eye and measures 0.2 mm broad. The spot attains a size of 0.5, 0.8 and 1.0 mm, at 40, 52 and 66 mm length, between 86-90 mm it is about 1.5 mm broad and when the fish reaches 100 mm, the dark spot is about 2 mm broad. By plotting the breadth (Y) of the spot against the total length (X) of fry an equation of the form $Y = -0.363 + 0.021\ X$ was obtained.

Length-weight relationship

Since no equation describing the relationship is available for the fry stage, it was therefore thought worthwhile to derive an equation and also examine whether the equation followed the isometric growth or not. Sarojini (1958b) gave an equation for all the size groups of the species, but she did not indicate whether the regression coefficient followed the cubic value or not. The length-weight relationship of the fry (16-51 mm) can be described by the formula $\log Y = -2.0231 + 3.0024 \log X$ where X and Y correspond to the length and weight of the fry. The regression cofficient was tested against 3 and was found not to depart significantly from 3. The length-weight parabola and its logarithmic form are given in Fig. 6.

Discussion

Sarojini (1962) and Luther (1974) have reviewed the systematic position of Indian grey mullet. Thomson (1954) included the species under the genus *Valamugil* and the same is followed here.

The fry of *V. cunnesius* can be identified with the following characters : Laterally compressed body, blunt snout, elongated pectoral fin, broad posterior end of preorbital, pigmentation arranged as a streak on lateral side and rows on transverse, axillary scale and spot on pectoral fin and adipose eyelids (higher lengths). The distinguishing characters of two other important mullet fry is given here for comparison. The fry of *M. cephalus* can be distinguished by the presence of light soft rays on the anal (nine soft rays in *V. cunnesius*), 13-15 transverse rows of scales, preorbital curved at posterior end (broad in *V. cunnesius*) and the longitudinal streak of pigmentation is absent. The fry of *L. parsia* can be distinguished by the presence of short pectoral, pointed snout and the visibility of maxilla. Fig. 3. depicts the nature adipose eyelids, axillary scales and the spot. The present study throws light on the size at first appearance of adipose eyelids, axillary scales and pectoral fin spot. The adipose of snout of *V. cunnesius*, *M. cephalus* and *L. parsia* fry. In Fig. 4 the position of maxilla, preorbital and adipose eyelids in *M. cephalus* fry are shown.

Sarojini (1953 ; 1962) and Pillay (1954) have reported the absence of adipose eyelids in young stages of *M. cephalus*, *L. parsia* and *L. tade* and observed their progressive development with the growth of the fish. Sarojini (1958 a) described the mullet fry of Bengal waters, but she did not mention the appearance of eyelid is first noticed at 38 mm fry when it measures 0.3 mm broad. In *M. cephalus* fry the eyelids are observed to appear at 30 mm length (Rangaswamy, 1979). In this species the eyelids measure 0.5 and 1.0 mm at 46 and 59 mm in length. In *V. cunnesius* the adipose eyelid measures 0.5 and 1.0 mm at 56 and 74 mm length respectively. The development of adipose eyelid seems to be slower in *V. cunnesius* than in *M. cephalus*, the rate of increase being 0.020 per each mm of fish length.

The elongated scale at the axil of pectoral fin is seen at 24 mm fish length and when 1 mm of the scale is visible outside the fish length is 38 mm. In *M. cephalus* fry the scale

appears at an early stage of 20 mm. The dorsal and ventral axillary scales in *V. cunnesius* appear probably simultaneously at 18 mm. However, the rate of increase per mm of fish is observed to be more or less the same for all the three scales.

In adult *V. cunnesius* a dark spot is seen at the axil of pectoral fin. Such a spot is seen in other mullets like *M. cephalus* and *V. seheli*. In *V. cunnesius* fry less than 26 mm the dark spots are not evident. In *M. cephalus* fry the blue sopt appears at 24 mm. In *L. vaigiensis* the spot was observed at 15 mm (Rangaswamy, 1978).

From the foregoing account, following conclusions can be drawn : in *V. cunnesius* the axillary scales at dorsal and ventral fins appear first at 18 mm, followed by the one at pectoral fin at 24 mm. After this, the dark spot at pectoral fin appears at 26mm, which is followed by the appearance of adipose eyelids at 38 mm.

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THE DEVELOPMENT OF COASTAL AQUACULTURE IN WEST AFRICA

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ABSTRACT

The potential for coastal aquaculture in West Africa is reviewed and its current status described. The prospects for progress in the area and limiting factors are considered along with the ways in which the potential of the resources available can be exploited. This is illustrated by a description of the turnkey design, construction and operation of a *Tilapia* farm in the Ivory Coast.

INTRODUCTION

TO DATE, fish farming in West Africa has been largely restricted to freshwater culture of tilapia on a subsistence basis, with emphasis directed towards the establishment of inland village fish farms.

This paper describes

1. Current developments in fish farming in West Africa.
2. Coastal resources available and national plans for aquaculture in the coastal states *viz.* Mauritania and Senegal, The Gambia and Guinea, Sierra Leone and Liberia, Ivory Coast and Ghana, Togo, Benin and Cameroun and Nigeria (Fig. 1).
3. Factors limiting the exploitation of these resources are Financial, Socio-political and Technical.
4. Exploiting the potential in the private sector need proper layout and operation of 150 tonne p.a. tilapia farm, supply of materials and equipment, construction method, and management.

Current developments

Table 1 lists the species of fish currently farmed in the various countries of West Africa. This covers a variety of different types, which range from trout farming for anglers in the Togo highlands, through experimental culture of catfish, carp, or grey mullet, to small-scale pond farming of *Tilapia nilotica*. This Tilapia farming is increasingly integrated with rural development programmes and is likely to represent the mainstay of the industry throughout the region in the immediate future. Its origin owes much to colonial assistance, notably by the CTFT (Centre Technique Forestier Tropical at Bouake), but international agencies have also helped. Thus Ghana, Ivory Coast and Nigeria participated in the FAO/UNDP first regional workshop on Aquaculture planning in Accra during 1975. Indeed the current Economic Development Plans for certain countries, such as Nigeria, have already recognised aquaculture as being the only means of meeting their projected demand for fish.

Coastal resources available and National Plans for Aquaculture

Mauritania and Senegal : In both countries, the fishing industry has undergone rapid development recently and last year 1 million tonnes were landed in Senegal alone, of which much was exported.

Fish farming has not aroused much interest in either country to date. Le Saloum in Senegal has been identified as having good potential for brackishwater cultivation and conditions here would favour marine fish and shellfish farming.

Ivory Coast and Ghana : The village ponds in the equatorial rain forest of southern Ivory Coast have been extensively stocked with Tilapia by CTFT whose Bouake station is now looking also at catfish and Nile perch farming. In northern and upper Ghana a smallscale rural industry has been established by rearing fish in irrigation reservoirs.

TABLE 1. *Fish farmed in West Africa*

Family	Genera and Species	Countries
Bagridae	*Auchenoglanis occidentalis*	Togo (experimental)
Cichlidae	*Tilapia nilotica*	Cameroun, Ivory Coast, Benin, Togo, Nigeria, Senegal
	Tilapia rendalli	Nigeria
	Hemichromis spp.	Cameroun, Ivory Coast, Togo
Citharinidae	*Citharinus citharus*	Nigeria (experimental)
Clariidae	*Clarias lazera*	Ivory Coast
Cyprinidae	*Barbus occidentalis*	Nigeria (experimental)
	Cyprinus carpio	Nigeria
Gymnarchidae	*Gymnarchus niloticus*	Nigeria (ecpermental)
Mugilidae	*Mugil* spp.	Nigeria (experimental)
Osteoglossidae	*Heterotis niloticus*	Cameroun, Ivory Coast, Nigeria
Salmonidae	*Salmo gairnderi*	Togo
Serranidae	*Lates niloticus*	Nigeria, Ivory Coast

The fishing industries in these countries are only just commencing development with the help of external aid commencing development with the help of external aid (*e.g.* European Development Fund). Suitable sites for coastal farming exist, particularly in Gambia, but lack of fishery infrastructure and export facilities might make the product difficult to handle.

Sierra Leone and Liberia : The coastal plains of these countries are intersected by tidal lagoons, marshes and creeks, which appear well suited for marine farming projects. Thus oysters have aroused some interest recently in Sierra Leone, and there is little doubt that freshwater and marine crustaceans and finfish could be farmed for export in the area.

The Ghanaian Fisheries Department hopes also to stimulate fish culture in rice fields, stream beds and in coastal lagoons. Ghana imports about 90,000 tons of fish yearly and hopes to cultivate 65,000 tons of fish annually by 1985. By the same year, Ivory Coast hopes to cultivate 16,500 tons by similar means, although attention is apparently limited to freshwater fish.

Togo, Benin and Cameroun : Tilapias are

farmed in all three countries and the European Development Fund is assisting further expansion of this activity in Benin. The coastline of Togo and Benin, which comprises a low smooth sandbar backed by marshy creeks and lagoons, would seem ideal for marine farming although this has not been developed.

Nigeria : The national plan projects a yearly fish farm production of 105,500 tons by 1985 and advocates that 1.5 million hectares of delta swampland be developed to this end. Brackishwater culture of tilapia and mullet is envisaged as the main component of this with some emphasis also on carp and mangrove oysters.

Since Nigerian expertise to date has been mainly restricted to freshwater culture on a subsistence basis, it is difficult to see how these targets will be achieved without substantial imports of expertise. However, the Government's commitment to expanding aquaculture in the private and public sectors may ease the problem of foreign investments in this sector.

Limiting factors

Despite this huge potential for coastal aquaculture in West Africa, there has been little progress towards exploiting the opportunities which exist in many parts of the region. The factors which have limited development to date can be summarised as follows :

Finance : Finance for public-sector projects (usually aimed at increasing production of fish for food) depends on Government support, usually backed by loans or grants from outside agencies such as UNDP or the European Development Fund.

To date, little finance has been available for fish farming projects in West Africa ; most attention has been given to the fishing industry, particularly the development of inland fisheries, although this has involved stocking exercises using farmed fish in countries such as Ivory Coast.

Finance for private-sector projects has been almost totally lacking to date, partly due to the socio-political factors considered below, and the lack of expertise available to initiate and carry out projects successfully. There seems little doubt that the absence of any commercially successful fish farms would continue to inhibit the establishment of new projects.

Socio-political factors : Political stability in the region is an important factor determining confidence of development agencies and financial institutions considering investment in public sector projects. Investment by the private sector in individual projects which are not buffered by government or large institutions, is probably more sensitive to these factors.

The traditions, tribal organisation and basic nature of the population throughout the region are also important factors to consider. This is particularly important in overall planning of aquaculture projects, *i.e.* location in relation to labour supply, and choice of farming method will often be dictated by the skills of the local labour force.

Technical factors : A high level of expertise with a variety of technical components is required to initiate and manage coastal aquaculture projects successfully. The steps which have to be considered are well known, but may be summarised briefly as follows :

Market characteristics for fish

- — distribution, acceptability, price
- — impact of farmed production on market prices

Species selection

- — marketability
- — technical feasibility of culture
- — suitability to local climatic conditions
- — stock availability
- — availability of suitable feedstuffs

Site selection
- — water quality and quantity related to selected species and production levels required
- — land availability, suitability for hatchery service buildings
- — location : access, feed supplies, product distribution, labour available, etc.

Farming method
- — choice appropriate to species, site, feedstuffs available, production level required, finance and labour available

Economic feasibility
- — an estimation of capital and operating costs, sales revenue and profitability

Design criteria
- — appropriate to site and farming method

Construction
- — choice of materials local imported
- — appointment of contractors local labour
- — supervision of construction to design criteria

Commissioning
- — start-up of pumps, systems, filling ponds to ensure efficient opertaion

Management
- — husbandry and management of fish
- — personnel management
- — repairs and maintenance of farm
- — marketing production

Clearly, in any substantial project, a variety of disciplines, and not least fish farmers, are required.

There is no tradition of fish farming in West Africa so little relevant expertise is available from within the region. Qualified personnel of the other disciplines required are also scarce, and almost none have experience related to fish farming. To overcome this limitation, expertise has to be imported from outside West Africa.

Exploiting the potential in the private sector

Recognising the potential for fish farming in general and coastal aquaculture in particular, a major private-sector company operating in the West African region approached Fish Farm Development International Ltd. for assistance. This agency specialises in the establishment of turn-key fish farming projects and was able to supply the various levels of expertise required. The investor possessed sufficient finance to consider a substantial (upto 500 tonnes p.a. production) project in any suitable country in West Africa. This was to be the first large scale private sector investment in fish farming in West Africa.

An initial survey indicated that, mainly for socio-political reasons, the most suitable country for the establishment of the project was the Ivory Coast (Fig. 1).

There are many coastal lagoon sites in the country, but the Lagoon Ebrie (Fig. 2) was preferred for its proximity to Abidjan, the capital city ; this provided a large and growing market (population 500,000) and would be easy to supply with fresh, farmed fish.

For such a substantial project, the technical feasibility for farming the species selected must be well established. Although there are attractive longer term prospects for farming catfish and shrimp in the area, this limited the species choice to tilapia. The water quality characteristics and temperature profile of the Lagoon Ebrie are suitable for tilapia culture.

Although not particularly highly priced on the Abidjan market, a study showed that the tilapia market was undersupplied and could

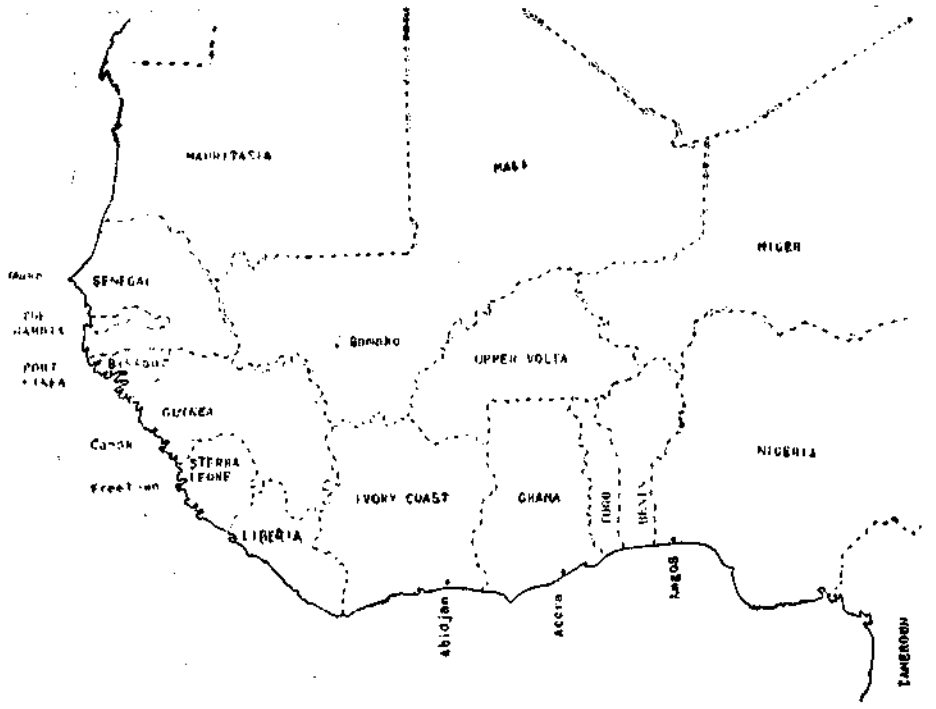

Fig. 1.

absorb the anticipated farm production without markedly affecting the price.

Rearing fish in floating cages in the lagoon was chosen as the most appropriate farming method, although it was considered sensible to locate the spawning and early rearing operations in a shore-based tank system.

Finally, a cost study showed that the projetc was sufficiently attractive for the investor to continue, and the first phase of the development (to 150 tonne p.a. production) was commenced.

Layout and operation of 150 *tonne p. a. Tilapia farm*

The site finally chosen for the project was an area of 15 ha. on the shore of the lagoon near the bush village of Bapo (Fig. 2).

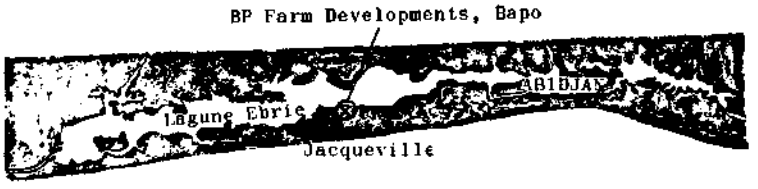

Fig. 2. Site Location.

The layout of the farm is shown in Fig. 3 and can be described as follows :

(*a*) Service building, containing two 37 kva generators supplying power to the site, a fish packing area and ice room containing a 2 tonne per day capacity icemaker, a workshop, office, laboratory

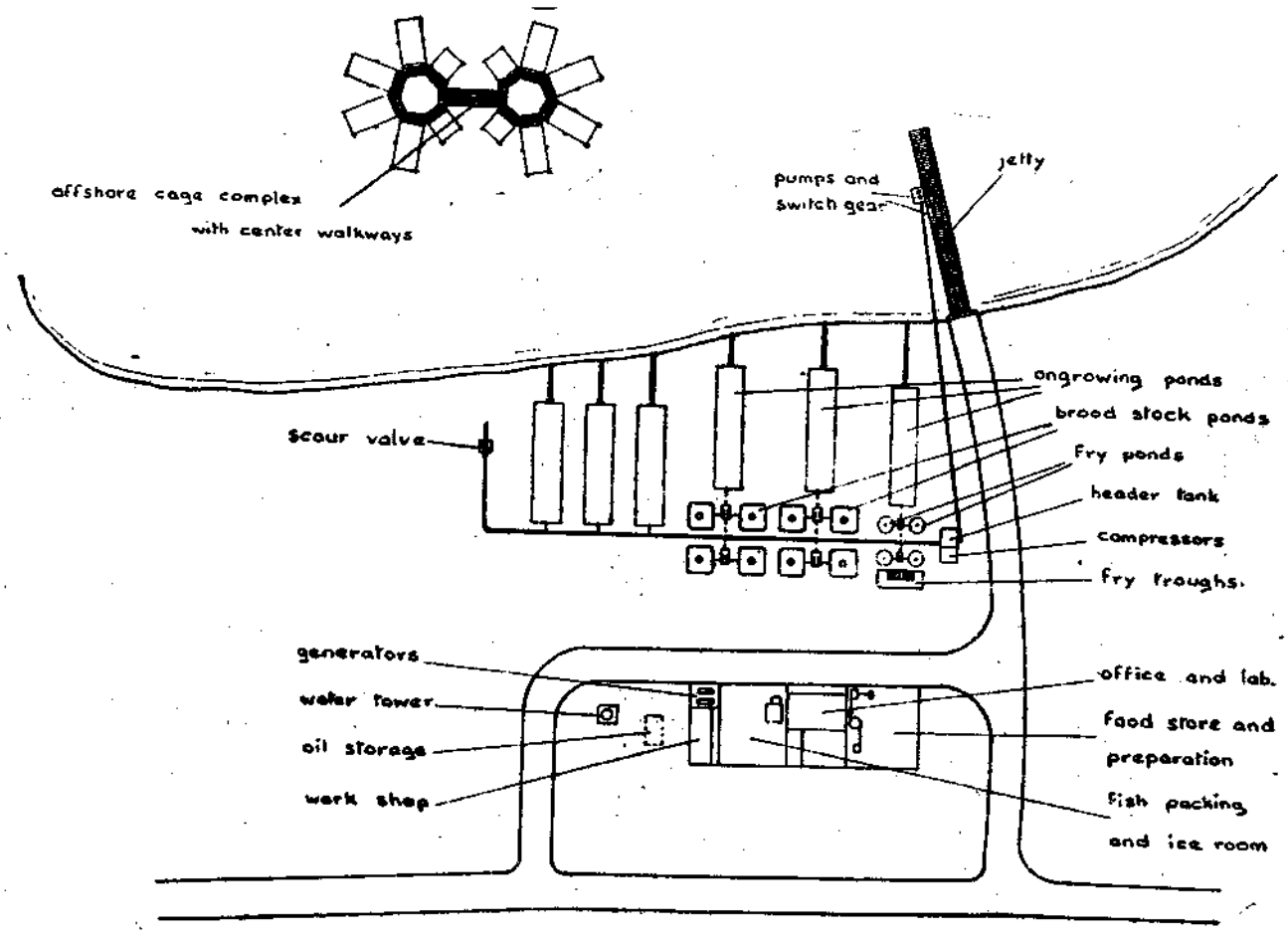

Fig. 3. Layout plan of B.P. developments : Tilapiafarm at Bapo,

for disease diagnosis and water quality monitoring, and a feed store and food preparation area, capable of producing 2 tonne pelleted feed per day.

The farm is thus virtually self-sufficient, an important consideration in the West African bush. The infrastructure is capable of supporting a production level of 500 tonnes per annum.

(*b* On-shore tank system, comprising four 2m diameter glass reinforced plastic (GRP) fry ponds, 12 GRP fry troughs, eight 4m square GRP spawning ponds and six rectangular on-growing ponds 20 m × 3.8 m × 0.5 m constructed from galvanised iron sheeting.

(*c*) Water supply system, comprising three 10 litre per second submersible pumps located on a wooden jetty projecting 45 m into the lagoon. Water is pumped to a fibre-glass header tank and distributed to the ponds via PVC pipe and valves.

(*d*) On-shore aeration system, comprising low pressure blower units, PVC pipeworks and ceramic diffusers located in all ponds.

The on-shore system are fully protected by a comprehensive alarm system.

(*e*) Off-shore cage complex, comprising 28 floating cages 8.5m × 4.25 m with nylon nets suspended to a depth of 1.5 m. The cages are of galvanised metal construction with polystyrene flotation.

(*f*) Standby aeration and pumping system for cages, fully protected by an alarm system.

Broodstock (mainly *Tilapia nilotica*) are retained in the 4m spawning ponds. Fry production (120,000 per month) is by a combination of natural and induced spawning. The fry are stocked initially in the troughs, then the 2 m fry ponds until they reach a size of 5-10 g. Size grading takes place every two weeks. Feeding is by a crumbled pellet formulated and prepared on the farm.

The non-shore system is designed to operate continuously and at intensive stocking levels; however, due to the escalation in the price of fuel oil, additional pond space (six rectangular ponds) was provided to reduce stocking densities and enable the generators to be turned off for upto 12 hours per day.

Fish are transferred to the off-shore cage complex for on-growing to the market size of around 200g. Growth time from spawning ranges from 4-6 months.

With monthly fry production and frequent size grading, production is nearly continuous and averages three tonnes per week.

Supply of materials and equipment

Specialist fish farming equipment is not available in West Africa, so the choice lies between making do with materials available locally, or importing the equipment of choice.

This decision will vary from location to location, country to country and client to client; in this case, becasue of the high price of conventional building materials in Ivory Coast and the complete lack of ancillary equipment, it was appropriate, with the exception of the service building structure, to import all the components of the farm.

The main components of the farm are detailed in Appendix 1.

Construction methods

The balance required between the engineering requirements of design and construction, the biological requirements of the fish, and the operational requirements of farm management, are difficult to achieve.

The choice between employing local contractors for construction or importing specialists to supervise local labour is usually clear-cut. The balance referred to above could not be achieved in West Africa without specialist supervision.

In this case, two ex-patriot project engineers and a staff of upto 27 Ivorians completed construction in four months from the arrival of equipment in containers.

Management

Ex-patriot management is essential for such projects. At Bapo, the staff consists of one ex-patriot manager with five years African experience, one African assistant with some previous fish-culture experience, and 13 labourers.

Conclusions

The turn-key approach to aquaculture development is a particularly cost-effective means of bringing fish farming projects to successful production.

In this particular case, the concept of the first large scale commercial fish farm in West Africa has been taken from an initial feasibility study, through the design, supply of equipment and construction stages to successful production.

APPENDIX I

Main Components of 150 tonnes p.a. Tilapia farm

1. Two cage complexes comprising 28 floating cages with suspended nets
2. Two rope booms with warning lights surrounding cage complexes
3. Two fibreglass shallow draft boats with outboard motors
4. Two fibreglass fish transport tanks with integral aeration
5. Standby aeration and water pumping system for cages
6. Full off-shore alarm system for cage complexes
7. Full off-shore lighting system for cage complexes
8. 12 rectangular fibreglass on-shore tanks with associated pipeworks
9. Fibreglass header tank with associated pipeworks
10. Dual aeration system supplying each tank from blower units
11. Three 10 litre per second submersible pumps
12. Two 42 kva generators plus complete electrical distribution system.
13. On-shore alarm system — audible and visual warning of systems failure
14. Complete food preparation system (2 tonnes per day)
15. Ice maker (2 tonnes per day)
16. Comprehensive husbandry equipment
17. Comprehensive range of disease diagnosis and water quality analysis equipment
18. Serviced aquaria for experimentation
19. Complete set tools
20. Assorted spares
21. Service building comprising feed production area, packing area, laboratory, store, office, generator housing, blower housing and night watchman's room,

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ISOENZYME STUDIES IN CULTIVABLE FISHES

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ABSTRACT

Multiple forms of LDH were compared for eye-lens, vitreous humor, heart, muscle, intestine, gills, brain and liver. Tissues like brain and vitreous humor exhibited species specificity. Polyacrylamide-disc gel electrophoresis was carried out and zymograms of LDH isoenzymes were studied. A remarkable variation is recognised in both the number and mobility of LDH isoenzymes. Hence this LDH isoenzyme is considered to be useful for the taxonomic studies of fishes.

INTRODUCTION

ISOENZYMES have been investigated in a wide variety of organisms in the broad biological spectrum. The study of isoenzymes involves both genetic and biochemical methodology and they have become an important biochemical tool in taxonomy. The enzyme LDH presides over the interconversion of pyruvate and lactate in the glycolytic pathway and thereby serves as an important source of the oxidised coenzyme NDA during periods of transient anaerobiosis.

Fishes vary very much in the complexity of LDH isoenzyme patterns than do warm blooded vertebrates. The existence of LDH isoenzymes has been reported in Teleosts and other fishes by a number of workers (Markert and Faulhaber, 1965 ; Nakano and Whitley, 1965 ; Hochachka, 1966 ; Horowitz and Whitt, 1972 ; Fischer and Whitt, 1978). Isoenzymes have been used for phylogenetic studies in cichlid, cottid and percoid fishes (Cowan, 1972 ; Page and Whitt, 1973) as wel as for tissue and species specificity (Ohno, 1968 ; Taniguchi *et al.*, 1972). The present work was undertaken to highlight the existence of species specificity and tissue specificity of LDH patterns in the families Cichlidae, Mugilidae and Siluridae of Pulicat and Adyar Estuaries. The present paper is a preliminary report of the LDH patterns of three species *i.e.*, *Etroplus suratensis*, *Liza macrolepis* and *Mystus gulio*.

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Material and Methods

Weekly collections of the adults of the three species of fishes were made from Adyar and Pulicat Lake and transferred to the laboratory soon after. Eyelens, vitreous humor, heart, liver, muscle, intestine, gills and brain were separated. Care was taken to avoid contamination of the lens by vitreous-humor. Tissues were then weighed (100 mg) and homogenized in 2 ml of Tris HCl buffer 0.1 M (pH 7.00). The homogenate was centrifuged for 30 minutes at 4°C in a refrigerated centrifuge at 10,000 g.

Results and Discussion

Isoenzyme patterns in *Etroplus suratensis*, *Liza macrolepis* and *Mystus gulio* are shown in Fig. 1. The patterns of eyelens, heart, muscle and gills of *Etroplus suratensis* revealed the presence of a single LDH isoenzyme band characterised by the same electrophoretic mobility. The liver, intestine and brain showed the presence of two distinct bands, but with different electrophoretic mobility. In the brain the slow moving fraction showed increased activity compared with the fast moving fraction. But it is very interesting to note that the vitreous humor exhibits five bands. Fractions 1 and 5 showed equally

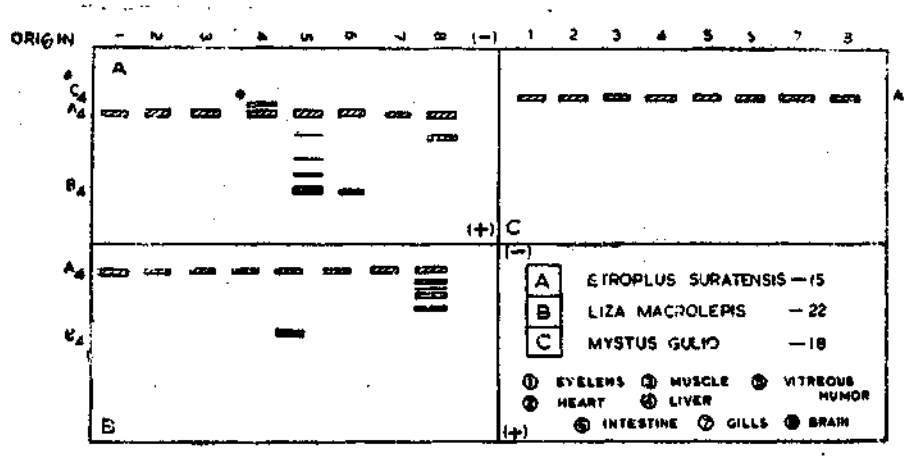

Fig. 1. L D H Isoenzyme zymogram.

A_4 skeletal muscle fraction

B_4 heart fraction

C_4 new fraction. (Number against each fish shows the number of specimens investigated).

About 20—30 units of enzyme activity of the supernatant was subjected to polyacrylamide-gel electrophoresis. The separating gel was prepared at 5.5 (Dietz *et al.*, 1972). The current flow was adjusted to 2.5 mA per tube and run for 45 minutes. The gels were removed and stained.

increased activity while the remaining bands showed feeble activity. In *Liza macrolepis*, excepting the vitreous humor and the brain, all the other tissues under investigation exhibited only one isoenzyme band. But in vitreous humor, there were two bands. In contrast, the brain showed five bands and

among them, the fifth showed intense activity whereas the first was very feeble. It is very interesting to note that in *Mystus gulio* all the tissues under investigation revealed only one band with the same electrophoretic mobility.

LDH isoenzymes of fishes are proven to be excellent gene markers (Whitt, 1970). As specific gene products, isoenzymes (multiple molecular forms of an enzyme) are useful as taxonomic characters. Markert and Faulhaber (1965) classified fishes based on their investigation of muscle LDH patterns into four groups namely single, double, triple and five banded groups. Goldberg (1966) detected the presence of five isoenzymes in the speckled trout, *Salvelinus fontinalis* and they were demonstrated to be species and tissue specific. The existence of three isoenzymes in the brain of a number of species of fishes has been detected by Bonavita and Guarneri (1963).

The knowledge of LDH pattern in clear vitreous humor is scanty, which in our present work, appears to be very highly specific for the species. Our studies confirm that vitreous humor of *Etroplus suratensis* contains five isoenzymes, *Liza macrolepis* contains two isoenzymes and *Mystus gulio* has only on isoenzyme. Further brain tissue of *Etroplus suratensis* contains two isoenzymes, *Liza macrolepis* contains five isoenzymes and *Mystus gulio* contains only one. The occurrence of C_4 isoenzyme has been reported in mammals, birds and teleost fishes (Perce *et al.*, 1967; Whitt *et al.*, 1973). A third LDH locus *i.e.*, LDH C which arose from a duplication of the LDH B locus was observed in the primitive bony fishes *i.e.*, the Chondrosteans. Whitt (1974) in his survey, has discovered that the C_4 isoenzyme of teleostean fishes exists either as a highly anodal isoenzyme or as a cathodal liver predominent isoenzyme. Similar C_4 isoenzyme was observed in the liver of *Etroplus suratensis* alone among the three species of the present investigation. Subsequent observations with regard to other species of Cichilidae, Mugilidae and Siluridae clearly indicate that LDH patterns of vitreous humor, and brain can be used as effective biochemical parameter for problematic taxonomic assemblages of fishes. Further work is in progress with reference to various other species of families referred to above with other isoenzymes in order to make the biochemical profile complete and distinctive.

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ECOLOGY OF THE PARASITES OF *PLATYCEPHALUS INSIDIATRIX* SCHLEGEL, FROM THE PULICAT LAKE

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ABSTRACT

Among the 16 species of edible fish infested by parasites, *Platycephalus insidiatrix* Schlegel exhibits extensive infestation. Six different regions of the body of the host, namely, the chin, gills and operculum, buccal floor, stomach wall musculature, stomach and intestinal epithelium and the gonad are infested by as many as six species of parasties belonging to the groups Nematoda, Digenea (Trematoda), Copepoda and Isopoda. An year round study of the incidence of these parasites, their intensity of infestation in relation to the age and sex of the host, has yielded very interesting results towards the understanding of the host-parasite relationships and the ecology of the parasites.

INTRODUCTION

DURING the course of study (February 1967—January 1968) on the fish parasites from the Pulicat Lake (Lat. 13° 24′—13° 47′ N; Long 80° 02′ - 80° 16′ E), a brackishwater lake on the eastcoast of peninsular India, *Platycephalus insidiatrix* Schlegel was infested by several groups of parasites. The host fish came from 19 different locations of the lake. They were collected by several methods, by angling, by cast netting and by seining and examined either in living or dead condition.

The host fish *Platycephalus insidiatrix* is commonly called the Indian flat-head. Munro (1955) synonymizes this with *Thysanophrys indicus* (Linneaus). It grows to a length of about 450 mm and occurs all through the year though in less numbers in the Pulicat Lake. It is a carnivorous bottom dwelling cottoid fish, feeding on prawns like *Penaeus carinatus* and *P. indicus*.

MATERIAL

In the present survey a total of 178 fish was examined for parasites. Among the 38 juveniles and 140 adults examined, 13 juveniles and 124 adults were found to be infested. Six different parts of the body of the fish have been found to be infested.

Chin region	: infested by isopod parasites.
Gills and operculum	: infested by copepod parasites.
Buccal floor	: infested by copepod parasites.
Stomach wall musculature	: infested by digenetic trematodes occurring in cysts.
Stomach and intestinal epithelium	: infested by digenetic trematodes.
Gonad	: infested by nematode parasites.

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The following parasites were collected from the fish.

TREMATODA (Digenea)	: *Didymozoon brevicolle* Yamaguti.
	Helicometrina platycephali sp. nov.
NEMATODA	: *Philometra insidiatrix* sp. nov.
COPEPODA	: *Parataeniacanthus platycephali* Yamaguti
	Acanthochondria bulbosus Heegard
ISOPODA	: *Cymothoa krishnai* sp. nov.

DISCUSSION

Juvenile hosts and parasites

Specimens of *Platycephalus insidiatrix* measuring below 200 mm in length and weighing between 5 and 40 grams have usually immature gonads. These fish are taken as juveniles for the present study. Details of their range in length and weight and percentage of infestation for each species of the parasite every month are given in Table 1. The nematode parasite, *Philometra insidiatrix* observed in the gonad of the fish, has never been found to infest the juveniles and hence excluded from the Table 1.

From Table 1, it is clear that the juvenile hosts are less frequently infested by parasites when compared with the adult hosts (Table 2). The most intensive period of infestation is from October to January. Five out of six species of parasites known from this host, have been recorded in the juveniles during this period.

Random sampling of *Platycephalus insidiatrix* from the Pulicat Lake reveals that the juveniles are correspondingly fewer in the lake. They seem to occur approximately in the ratio of 1 to 4 adults. This comparative rarity of juveniles may suggest that they are predominantly marine, frequently entering and leaving the lake. This movement of the juveniles in space and time from the lake into the sea and vice versa may be responsible for the less frequent infestation by the parasites. Perhaps the parasites do not find the sea frequenting host suitable for infestation. It can also be deduced that the parasites are strictly brackishwater forms. They infest heavily the adults which are mostly brackishwater bound and less commonly migratory. The frequent migratory habit of the juveniles also reduces their contact with the adult hosts, mostly confined to the lake. This relative absence of contact between the two age groups in the same niche, may also account for the low incidence of parasites in juveniles.

The comparative rarity of the juveniles leads one to speculate that the adults migrate from the lake to the sea for breeding. The absence of fingerlings in the plankton samples of the lake also confirms this breeding habit of the fish. Other fishes like *Mugil*, *Sillago*, etc. breed in the lake and their fry and fingerlings occur in large numbers in the plankton samples.

Adult hosts and parasites

Specimens of this host fish measuring above 200 mm in length are usually observed to have mature gonads. These are classified as adults in the present study. Fish ranging between 201 and 340 mm in length and between 50 and 220 gms in weight were examined for parasites. The total adult individuals examined are 140, comprising 80 females and 60 males. Details of their range in length and weight and percentage of infestation by each species of the parasites are given in Table 2.

Incidence and intensity of infestation

The overall percentage of parasitic infestation in adults as compared with their juveniles is considerably high all through the year (Tables 1 and 2). Five species of parasites are found to infest the adults all the year round. A sixth species, *Cymothoa krishnai* a rare parasite

TABLE 1. *Incidence of parasites in juvenile hosts*

Month	No. of Juveniles examined	Length Range in mm	Weight Range i ngm	*D. brevicollie* No. infected	% Infection	*P. platycephali* No. infected	% Infection	*H. platycephali* No. infected	% Infection	*A. buibosus* No. infected	% Infection	*C. krishnai* No. infected	% Infection
Feb. 1967	Juveniles unavailable in the collection												
Mar. 1967	6	87-165	5-30	Nil	x	Nil	x	Nil	X	2	33.3	Nil	x
Apr. 1967	Data not collected												
May 1967	Data not collected												
June 1967	11	110-194	10-40	Nil	x	Nil	x	Nil	x	Nil	x	Nil	x
July 1967	3	138-185	18-35	Nil	x	Nil	x	Nil	x	Nil	x	Nil	x
Aug. 1967	Juveniles unavailable in the collection												
Sept. 1967	Juveniles unavailable in the collection												
Oct. 1967	4	130-140	15-20	Nil	x	Nil	x	1	25	Nil	x	Nil	x
Nov. 1967	3	130-138	20-25	Nil	x	Nil	x	1	33.3	1	33.3	1	33.3
Dec. 1967	5	127-187	20-35	1	20	1	20	1	20	Nil	x	Nil	x
Jan. 1968	6	65-141	5-30	3	50	2	33.3	Nil	—	Nil	x	Nil	x

TABLE 2. *Incidence of parasites in adult hosts*

Month	No. of adults examined	Length Range in mm	Weight Range in gm	*D. brevicolle* No. infected	% infection	*H. platycephalli* No. infected	% infection	*P. insidiatrix* No. infected	% infection	*H. platycephali* No. infected	% infection	*A. bulbosus* No. infected	% infection	*C. Krishnai* No. infected	% infection
Feb. 67	13	215-294	100-160	8	61.6	13	100	6	46.2	1	77	1	7.7	Nil	x
Mar. 67	15	228-299	65-200	4	26.7	11	73.3	2	13.3	Nil	x	Nil	—	Nil	x
Apr. 67	Data not collected														
May 67	Data not collected														
June 67	18	220-298	157-200	13	72.2	6	33.3	3	16.7	Nil	x	2	11.1	Nil	x
July 67	17	206-322	55-220	12	70.6	10	58.8	3	17.7	3	17.7	Nil	x	Nil	x
Aug. 67	15	201-285	55-150	5	33.3	6	40.0	3	20.0	6	40	6	40.0	Nil	x
Sep. 67	19	200-280	50-153	6	31.6	3	15.8	3	15.8	7	36.8	3	15.8	1	5.3
Oct. 67	7	200-325	60-195	5	71.4	4	57.2	1	14.3	2	28.6	2	28.6	Nil	x
Nov. 67	11	260-340	120-210	10	90.9	8	72.7	3	27.3	5	45.5	2	18.2	Nil	x
Dec. 67	11	200-327	50-195	8	72.7	4	36.4	1	9.09	5	45.5	4	36.4	Nil	x
Jan. 68	14	224-312	67-200	11	78.6	6	42.9	2	14.3	2	14.3	Nil	—	Nil	x

for this host, has been encountered only twice during the period of survey.

The digenetic trematode, *D. brevicolle* has been found infesting as many as 10 in a sample of 11 hosts examined during November, but during March only 4 hosts out of 15 have been noticed to be infested by this parasite. The other trematode, *H. platycephali* has been obtained from all the 13 hosts examined during February. The nematode parasite *Philometra insidiatrix* is reported all through the year and it is exclusively found in female fish infesting the ovary. Of the two copepod parasites, *P. platycephali* has not been found during March and June; and *A. bulbosus* during March, July and January. The low incidence of the isopod parasite, *C. krishnai* is presumably due to its ectoparasitic life and the profuse mucous secreted by the host does not provide a secure anchorage to the parasite. This parasite has been found to infest only the chin region of *Platycephalus insidiatrix*, while in other fishes, it infests the buccal cavity.

In Table 4, the percentage infestation of all the 137 infested fish (including both the juveniles and the adults) for each species of the parasite is given. Of the species of parasites studied, the digenetic trematode *D. brevicolle* is the most common one occurring in as many as 86 hosts out of 137 (62.8%). The least common parasite is *C. krishnai* infesting only a small number of the hosts (1.5%).

In Table 5, the degree of infestation or the 'worm burden' in all the 137 infested fish has been analysed. The trematodes *D. brevicolle* and *H. platycephali* occur frequently in small numbers between 1 and 5, in each host. The nematode *P. insidiatrix* occurs mostly singly (Table 6). The copepod *P. platycephali* has been obtained twice numbering always above 25. The other copepod *A. bulbosus* also occurs in large numbers and the number is never more than 15, in each host.

TABLE 3. *Percentage infection in hosts harbouring three or more different species of parasites*

Month	Total Number of fish	Number of hosts infected with 3 and more species of parasites	Percentage of Heavy infection
February 1967 ..	13	3	23.1
March ..	14	nil	0
April ..	Data not collected		
May ..	Data not collected		
June ..	18	1	5.6
July ..	14	4	28.6
August ..	13	3	23.1
September ..	14	2	14.3
October ..	7	2	28.6
November ..	14	5	35.7
December ..	13	3	23.1
January 1968 ..	17	1	5.9

Parasites and their probable modes of infestation

The incidence of the aforesaid parasites all the year round indicates that *Platycephalus insidiatrix* is an ideal host. The extent to which a host can get infested may mainly depend upon its contact with the parasites either directly or indirectly. The pattern of life-cycle of the parasites also has a profound influence on the degree and mode of infestation.

The copepod and isopod parasites by virtue of their simple or direct life cycles seem to have an easy access to the hosts. In contradistinction, the digenetic trematodes have complicated life-cycles involving intermediate hosts. The successful completion of their life-cycles, to a very great extent, depends upon the frequency of association between the intermediate hosts and final hosts.

In the lake, the penaeid prawns are relatively abundant in all seasons of the year. They form the major bulk of food of the host fish. This makes one to reasonably speculate that the penaeid prawns are the intermediate hosts for the digenetic trematodes *D. brevicolle* and *H. platycephali*. It is of ecological interest to note that both the host fish and the *Penaeus indicus* are equally sedentary and essentially bottom dwelling. The high incidence of the digenetic trematodes in the fish, may be due to this cohabitation of the intermediate host and the definitive host.

TABLE 4. *Percentage infection of fish for each species of the parasite.*
(Total Number of infected fish : 137)

Name of the parasite	No. of hosts infected	Percentage infection
Didymozoon brevicolle ..	86	62.8
Helicometrina platycephali ..	74	54.01
Philometra insidiatrix ..	27	19.7
Parataeniacanthus platycephali	34	24.8
Acanthochondria bulbosus ..	23	16.8
Cymothoa Ktishnai ..	2	1.5

The digenetic trematodes find two ideal hosts in the fish and prawn which live in close proximity with each other in the same stratum of the lake and further the prawn is the major food item of the fish.

At what stage of the life-cycle, these trematodes leave the intermediate hosts for establishment in the definitive hosts is a matter of conjecture. In the present study, examination for encysted metacercaria in the prawns yielded negative results, and the exact stage of the larva at which it gains entry into the fish-host could not be fixed. It can also be reasoned, that there is yet another intermediate host, besides the prawn (mysids or gastropod molluscs) involved between the larvae of the parasites and the fish-host *Platycephalus insidiatrix*.

Parasite populations in the hosts and their co-existence

In almost every monthly sample of the adult fish collected, there are atleast two host fishes on an average, found to be infested by more than three different species of parasites. The percentage of infestation with respect to the number of different species of parasites is furnished in Table 3.

From the Table it is evident that on an average, for every 14 hosts (13.7), there are two hosts (1.9), infested with more than three different species of parasites. This suggests

TABLE 5. *Analysis of the 'worm burden' in 137 infected Fish*

Parasite	Number of Parasites	Number of Hosts	Number of parasites					
			1-5	6-10	11-15	16-20	21-25	26+
Cymothoa krishnai ..	2	2	2	—	—	—	—	—
Philometra insidiatrix ..	29	27	27	—	—	—	—	—
Acanthochondria bulbosus	115	23	15	6	2	—	—	—
Didymozoon brevicolle ..	399	86	61	19	4	2	—	—
Helicometrina platycephali	297	74	59	9	4	1	1	—
Parataeniacanthus platycephali ..	344	34	9	13	5	3	2	2

the degree of co-existence among the different groups and species of parasites exploiting a single host. It is of considerable interest to note that in *Platycephalus insidiatrix*, all the six different parasites reported here are located in six different parts of the body, namely, (*a*) gills ; (*b*) buccal floor ; (*c*) stomach wall musculature ; (*d*) epithelium of the stomach and intestine ; (*e*) gonad and (*f*) external body surface.

Each of these six different parts of the host body provides sufficient ecological localization for a particular species of parasite in question, reducing to a reasonable extent the chance of any competition with other species of parasites. The relative numbers of each species of the parasite in each part of the host fish all the year found indicate the delicate natural balance of association operating between the parasites themselves on one hand and the parasites and the host on the other.

Sex of the host and parasitic infestation

In a total of 80 females and 60 males, 90% of the females and 88.3 per cent of the males have been found to be infested by the various species of parasites. This equally proportionate infestation in the two sex groups of the host fish suggests that the parasites apparently do not exhibit any choice over the sex of the host fish. In Table 6 the number of females and males infested by each species of parasite and the percentage of infestation monthwise are given. The percentage of infestation in each sex group of the host, by each parasite, is also proportionate stressing the aforesaid point. Only the nematode parasite *Philometra insidiatrix* seems to be an exception. It infests only the females, the site of infestation of its choice being the ovary. This parasite has been found to infest as much as 33.7 per cent of the females examined in the present study. The isopod *C. krishnai* being a very rare parasite, finds no place in the present context.

Biology of the parasites of Platycephalus insidiatrix.

Didymozoon brevicolle : This trematode parasite occurs mostly in pairs and rearly singly within cysts in the stomach wall of the fish. The cysts are commonly confined to the stomach region. The live worms are bright yellowish, ranging between 5.0 and 8.0 mm. in length. This parasite occurs all through the year infesting 48.3 per cent of the fish.

Helicometrina platycephali : This parasite is as common as *D. brevicolle* occurring in large numbers. The worms are pinkish and active. They have been found to infest 41.5 per cent of the fish.

Philometra insidiatrix : Occurs all the year round infesting the ovary of the fish. It is strictly restricted to adult females. It is found only singly in either of the gonads (right or left). Its body is much coiled and it occupies the entire space of the ovary. In certain cases, the worm is obtained in a dead and degenerate condition. From this it is presumed that the host tissue in the gonad secretes certain substances which are hostile to the parasite. The infested gonad in the fish is much enlarged and is almost 1½ times larger than the uninfested gonad. The nematode resembles *Philometra rajani* Mukherjee (1966) in several respects, but is reddish brown in colour reaching only a maximum length of 120 mm.

Parataeniacanthus platycephali : This copepod parasite infests the gills and inner surface of the operculum. It occurs in large numbers in a single host. The parasite ranges from 2.0 to 2.5 mm in length and infests 9 per cent of the fish.

Acanthochondria bulbosus : Occurs on the buccal floor of the host. The head of the parasite is buried in a vesicle which has to be ruptured to release the parasite. Heegard

TABLE 6. *Number of males and females infected by each species of parasite monthwise*

Parasite	Sex	Number of individuals infected each month										Total	% of infection
		Feb.	Mar.	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.		
D. brevicolle ..	Female	8	3	8	5	2	5	2	5	4	2	44	55.0
	Male	—	1	5	7	3	1	3	5	4	9	38	63.3
H. platycephali ..	Female	11	8	5	4	6	1	x	5	2	1	43	53.7
	Male	2	3	1	6	—	2	4	3	2	5	28	46.6
P. insidiatrix ..	Female	6	2	3	3	3	3	1	3	1	1	27	33.7
	Male	—	—	—	—	—	—	—	—	—	—	—	—
P. platycephali ..	Female	1	—	—	—	5	5	1	2	2	1	17	21.2
	Male	—	—	—	3	1	2	1	3	3	1	14	
A. bulbosus ..	Female	1	—	1	—	5	2	1	1	—	—	11	13.7
	Male	—	—	1	—	1	1	1	1	4	—	9	15.0
C. krishnai ..	Female	—	—	—	—	—	1	—	—	—	—	1	1.2
	Male	—	—	—	—	—	—	—	—	—	—	—	—

(1943) makes no mention of this nature of the parasite. The parasite is whitish ranging between 3.0 and 7.0 mm in length. The egg sacs are yellowish and easily shed. This copepod infests 12.9 per cent of the fish.

Cymothoa krishnai : This is the least common parasite occurring singly on the outer body surface of the fish. This parasite has been found to infest 1.1 per cent of the fish.

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