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Sessions II-VI

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

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National Seminar on Shellfish Resources and Farming

Session II

SHELLFISH CULTURE TECHNIQUES AND PRODUCTION

45. CULTURE TECHNIQUES AND PRODUCTION RATES OF MOLLUSCS IN INDIA

—Theme Paper

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INTRODUCTION

The estimated world production through aquaculture in 1975 was 6.1 million tons, of which the molluscs formed 16.2% (Pillay, 1979). The production of oysters in the above was 591,386 t, mussels 328, 517 t, clams 38,851 t, scallops 62,600 t, and cockles and other molluscs 29,987 t, totalling to 1,051,341 t. In 1980, the estimated world aquacultured production was 8,707,363 t to which the molluscs contributed 3,196,308 t or 36.7% of the total production (Alagarswami, 1986). The production of molluscs in a five-year period appeared to have trebled, whereas the overall increase of fish, shellfish and seaweeds put together has been only 42.7%. The world aquaculture production figures have been cited here only to indicate the aquaculture species group, on which the scope lies for future expansion. Nutritionally speaking, the yield of high-quality protein by bivalves per hectare of surface sea water far exceeds the protein that could be produced on a hectare of land by any known terrestrial plant or animal (Hulse, 1982). But economically speaking, culture of bivalves may not be as attractive as shrimp farming or culture of some choice finfish species.

BACKGROUND OF EXPLOITATION OF MOLLUSCS IN INDIA

Considering the poor attention paid to the development of molluscan fisheries before or since Independence of the country, the conclusion that, with exception of pearl oyster and chank, these resources were not thought of as something to merit a place among the fishery resources of India, is inescapable. The one to whom these resources appealed most was the British biologist James Hornell who had contributed the most to our knowledge on these resources and had even indicated the culture potential of some of the species, particularly the oyster (Hornell, 1949). Rao (1939) recorded the fishery for *Turbo* and *Trochus* in the Andaman and Nicobar Islands and suggested certain measures for regulation. The biological and fishery aspects of many of the oyster, clam and mussel resources exploited at subsistence level by the coastal fishermen have been given by several workers (Rai, 1932; Rao, 1941; Rao, 1958; Durve, 1960; Joshi, 1963; Ranade, 1964; Jones and Alagarswami, 1973; Alagarswami and Narasimham, 1973 and others). These works were fishery management oriented rather than culture

oriented. However, the information contained in these publications were found immensely useful when the importance of mollusc farming was realised in the early 1970s and some experimental programmes were initiated.

DEVELOPMENT OF RESEARCH IN MOLLUSC CULTURE IN INDIA

In the year 1972, the Central Marine Fisheries Research Institute commenced for the first time a research project under the major title "Miscellaneous Investigations" and project title "Aquaculture, its potential and practical applications". The plan of work included culture of clams and oysters to be undertaken in suitable areas of Tuticorin and Mandapam. The experimental programme on pearl culture was initiated the same year at Tuticorin as a later addition. The project was expanded in 1973 under the revised title "Mariculture, its potential and practical applications", to include mussel culture at Vizhinjam and Madras, transplantation of clams and edible oyster at Tuticorin and Mandapam, and pearl culture at Tuticorin. In the subsequent period, with the esiablishment of the Molluscan Fisheries Division at the CMFRI, major thrusts were given to programmes of culture oysters, mussels, clams, pearl oyster and pearl culture at several centres of which Tuticorin developed itself as a strong centre of research for pearl culture and oyster culture. Having developed the basic techniques of production of these bivalves and experienced high levels of production rates, it became important to concentrate on seed production by hatchery technology which was achieved for pearl oyster in 1981, edible oyster in 1982 and mussel in 1983.

Concurrent to the above developments, the National Institute of Oceanography developed a research programme on mussel culture in Goa. The Konkan Krishi Vidyapeeth implemented a project on mussel culture at Ratnagiri. Several short-term experiments on oyster culture have been carried out sporadically in some of the estuaries by some university departments.

The fact remains that, in spite of the rapid strides made in research and successful experimental farming of molluscs obtaining high production rates, commercial farming remains a non-starter except in the case of pearl culture. The situation, therefore, needs a critical look at the constraints that hold up the progress and chalk out a practical plan of action to overcome the hurdles, keeping in view the nutritional potential of molluscs, economics of production and utilisation and the socio-economic goals aimed to be achieved by the action plan.

FARMING TECHNIQUES AND PRODUCTION RATES

Oyster culture

Spat of oyster *Crassostrea madrasensis* is collected in Tuticorin bay and creek by laying lime-coated roofing tiles in the oyster spawning areas. The spat that settle on the tiles are scrapped and reared in trays under the rack culture system (Nayar and Mahadevan, 1983). The estimated production is 119 tonnes of whole oysters per hectare per annum. In Vaigai estuary near Mandapam spatfall of the same species has been observed on several experimental collectors and culture duration has to be restricted to avoid floods in the estuary due to north-east monsoon (Rao *et al.*, 1983). Some short-term experimental work on spatfall and growth has been done in Cochin backwater (Purushan *et al.*, 1983). Mulki estuary (Joseph and Joseph, 1983) and Bheemunipatnam backwater (Reuben *et al.*, 1983).

Mussel culture

Seed of the green mussel *Perna viridis* and brown mussel *Perna indica* are collected from the intertidal rocky beds in their region of natural distribution. Both species are farmed by the raft culture method by seeding the ropes with the seed mussels using the standard techniques. The harvest is taken generally after about 5—6 months growth in the sea. Besides culture in the open sea and bay, experimental success has been achieved in growing green mussel by pole culture in the salt water lagoon at Muttukad near Madras.

The experimental production rates achieved are as given below :

P. viridis :

Calicut (open sea)	:	4.4—12.3 kg/m rope/ 5 months (Kuriakose, 1980)
Dona Paula Bay	:	6 kg/m rope/6 months (Qasim *et al.*, 1977)
Ratnagiri (open sea)	:	7 kg/3-m rope/ 6 months (Ranade and Ranade, 1980)
Kovalam (open sea)	:	2 t/raft/4 months (Rangarajan and Narasimham, 1980)

P. indica :

Vizhinjam Bay	:	10-15 kg/m rope/ 7 months (Appukuttan *et al.*, 1980)
Vizhinjam (open sea)	:	15 kg/m rope/ 5 months (Appukuttan *et al.*, 1980)

Based on average production rates obtained in raft culture, some authors have estimated production per hectare, *e. g.* 480 t/ha for green mussel (Qasim *et al.*, 1977) and 150 t/ha for brown mussel (Adpukuttan *et al.*, 1980).

Pearl oyster culture and pearl production

The technology for pearl culture was developed in India in 1973 (Alagarswami and Qasim, 1973; Alagarswami, 1974). Pearl oysters have been collected from the natural beds in the Gulf of Mannar and farmed by raft culture in the open sea at Veppalodai (since discontinued) and in the harbour basin. Nucleus implantation operation is done on oysters of suitable size and farmed again under raft culture. Gross pearl production rate is an average 60%. Pearl oyster farming is done for the pearls and not for the meat as in the case of edible bivalves such as oysters and mussels.

Clam culture

Simple transplantation of clam seed into manageable areas in the estuaries and bays has been done. In Kakinada Bay, consistent production results were obtained in the culture of the blood-clam (cockle) *Anadara granosa*. The production was 0.39 t/100 m^2/5 months, 2.6 t/625 m^2/5½ months, and 6.1 t/0.16 ha/7 months respectively representing production rates per hectare of 39 t, 41.6 t and 38 1 t (Narasimham, 1980). Short-term transplantation of the backwater clam *Meretrix casta* has been carried out by other workers in Mulki estuary Vellar estuary (vide Silas *et al.*, 1982).

Cephalopod culture

Some amount of success has been achieved in experimental rearing of cuttlefish *Sepia pharaonis* at Mandapam by collection of egg capsules, hatching them and nurturing the hatchlings to adult (Sivalingam and Pillai, 1983).

Hatchery production of bivalve spat

The development of technology for production of spat of pearl oyster (Alagarswami *et al.*, 1983), edible oyster (Nayar *et al.*, 1984), green mussel (Rangarajan, 1983) and brown mussel (Appukuttan *et al.*, 1984) have given a new dimension to shellfish farming in India. Both the pearl oyster (*P. fucata*) and oyster (*C. madrasensis*) spat are produced in large scale at the experimental hatchery of the Central Marine Fisheries Research Institute at Tuticorin.

Post-harvest technology

Simple chlorination technique has been used to purify the farm produced oyster *C. madrasensis* (Nayar *et al.*, 1983). Balachandran and Prabhu (1980) have summarised the development in post-harvest techniques for mussels. Balachandran and Nair (1975) developed a process for canning clams and mussels in hot, refined groundnut oil. Balachandran and Prabhu (1980) reported a method for preparing mussel pickle having a shelf life of upto 6 months. The Integrated Fisheries Project of Government of India is successfully engaged in oyster product development and trial marketing in India.

Toxicological problems in mussel have been studied by Menon *et al.* (1983) and Wesley and Raj (1983). An overview of molluscan toxicology and shellfish sanitation, referring also to the recent instances of death of people

due to consumption of contaminated clams (*Meretrix casta*) at Vayalur in Tamil Nadu and Arikadu in Karnataka as likely cases of paralytic shellfish poisoning (Ray and Rao, 1984).

TECHNOLOGICAL PROBLEMS

It has briefly been seen that the basic technology for culture of molluscs has been developed and the technical feasibility can be stated to have been established in the case of oyster, pearl oyster, mussel and the cockle through repeated experimental trials which have given consistent results. Production rates are fairly high and comparable with those obtained elsewhere adopting similar techniques. Culture duration is considerably less in the tropical waters. Oyster culture in Europe, U. S. A. or Japan requires 2 years or more but in India it takes only a year to get the marketable size. Mussel needs only 5-6 months. Growth of the species being faster, the time to reach marketable size is reduced.

There has been no major problem with the cleanliness and hygiene of the products from the experimental farms. Pollution levels are still low in the areas of production. The only disaster has been the two cases of suspected PSP deaths reported in Vayalur in Tamil Nadu and Arikadu in Karnataka after consuming contaminated clam *M. casta* collected from natural beds. However, there is a warning in this to be taken note of.

Technology has developed so far on its own momentum, but I am afraid that this cannot be taken to greater levels of production or perfection without a challenge from the development sector. There would be no incentive for further rsearch unless the demand is created by the industry or common producer. In other words, the utility value of research can be stated strongly only when there is concomittant use of the results. We are reaching towards a stage when decisions will have to be taken and directions given both to research and to development. If there is a gap between the two, it should be bridged *via* the extension link.

The technological problems that require immediate attention may be identified. The base of operation in terms of species, areas, ecosystems and techniques has been very narrow. Farming and production results have been shown for oyster *Crassostrea madrasensis* at Tuticorin, green mussel *Perna viridis* at Calicut, brown mussel *P. indica* at Vizhinjam and cockle *Anadara granosa* at Kakinada. Green mussel culture at Karwar and Madras, though seriously attempted, had to be suspended due both to technical and logistic reasons, such as seed non-availability or operational problems of rafts in rough sea conditions or poaching. With the diversity of ecological situations along the long coast line, perhaps greater thrusts are needed in diversifying the candidate species and techniques of culture to show production results even on a short-term experimental basis. A few points to be borne in mind are that (i) open-sea mariculture is beset with technological and logistic problems and the earlier we go in for appropriate technology the better would be the results; (ii) the estuarine or the backwater ecosystem is also dynamic subject to seasonal and annual variations controlling natural settlement and production of molluscs with an added dimension of indiscriminate exploitation of living resources and shell deposits; and (iii) the Andaman and Nicobar Islands and Lakshadweep which offer greater scope for mariculture in terms of suitable areas and species are as yet out of the mainstream of technological development.

Another important area for technological innovation is to reduce cost of production or to work out an acceptable cost-benefit ratio. In terms of available technology, this is a job to do. Raft culture and rack-tray culture require capital investment and involves short-term replacement costs and recurring maintenance expenditure. Farming technology should aim at reducing cost of inputs and increase production. This is essential as, in the Indian situation, the molluscs are not a luxury food as in the West or in Japan, and, therefore, the value of produce from the farm cannot go up beyond what the consumer is prepared to pay for it at present in the local markets selling the produce from the wild. This applies for the culture of oysters as well as mussels.

Production techniques require to be so improved as to yield a higher meat/total weight ratio. Mussel under culture gives a better ratio than what is obtained in the wild. In the case of oyster, the meat yield in fresh condition is a maximum 10%, but when processed the net yield ratio is reduced to less than half of this. Increase in yield ratio can improve the economics of oyster culture.

ECONOMIC DATA BASE

Admittedly, an economic data base for mollusc culture, based on pilot-scale operations is yet to be developed. Some authors have given projections based on estimates of several variables which may or may not be the true situations. The methods of estimating profitability or return on investment have been quite different. A cost-benefit study of oyster culture by the rack-tray method on 0. 25 ha, producing 3 t of oyster flesh annually, has been made. With cost of production at Rs. 19.00/kg flesh, and at a selling price of Rs. 28.00/kg, the net income before tax would be Rs. 27,000 —about a 30% return on invesiment (*vide* Silas *et al.*, 1982). A simpler estimate on oyster culture shows the per-annum cost of Rs.800/rack and gross income of Rs. 920/rack based on production of 4600 oysters/rack and selling cost at Rs. 20 per 100 oysters. On the above basis 250 racks in 1 ha area can produce 140 t of whole oysters grossing Rs. 30,000 a year (Nayar and Mahadevan, 1983).

For mussel culture, there are several projections. Qasim *et al*, (1977) have given the rate of return on investment as 181% for the green mussel in Goa. Ranade and Ranade (1980) have visualised a return of 168% in Ratnagiri. Achari (1980) projected a return of 76.71% on capital for single-raft production of brown mussel in Vizninjam Bay. Appukuttan (1980) calculated a net profit rate of Rs. 1480-2680 for a single raft for the same species in the same area. Kuriakose (1980) projected a profit of Rs. 4750 per raft at the end of 3 years on an investment of Rs. 14,000 for green mussel culture at Calicult.

For *Anadara* culture in Kakinada Bay, Narasimham (1986) projected a profit of Rs. 2550 on an investment of Rs. 7450 over 6 months in 1 ha area, showing a return of 34.2% on investment.

DEVELOPMENT PROBLEMS AND CONSTRAINTS

The only technology which has been taken up for commercialisation is pearl culture. A joint venture company, M/s. Tamil Nadu Pearls P. Ltd, by Tamil Nadu Fisheries Development Corporation and Southern Petrochemical Industries Corporation was established in 1983. It is worthwhile analysing why the other technologies, particulary oyster culture and mussel culture still remain on the shelves of the laboratory.

Coastal aquaculture development is new to the country and there is no awareness of its potential. Even when the scientists were directly involved in the transfer of technology to the fishermen, as in the case of the Lab-to-land programme (CMFRI, 1979) on mussel and oyster and the Operational Research Project on mussel, the results were not encouraging. The constraint analysis pointed out certain basic issues: part-time occupation in farming cutting into their period of essential rest is not ideally suited to their temperament; they would not invest; and they cannot afford to wait for a period of 6-12 months to realise the revenue from farming operations. The situation would hardly change with the fishermen unless these valid constraints are removed.

The entrepreneurs who prepared to invest need lot more information than what is currently available. They would like to have risk-proof project proposal for appraisal and investment. Mariculture is risk-prone and would need all support, particularly insurance, subsidy, soft loan, longer gestation period and other incentives.

Marketing is the major constraint if production is established. Eating habits of people hardly change. Except in small pockets in the coastal areas, mussels, oysters and clams are not known as wholesome food items. The situation would improve only with a major thrust in popularising mollusc sea food through appropriate nutrition extension programme. The Integrated Fisheries Project has been

fairly successful in trial marketing of oyster products in a few centres. But this effort is not adequate for popularising these food items so as to make an impact. Market promotion can be done only when there is an assured supply of production. The gap between production and marketing efforts can be linked only through a well planned strategy for simultaneous action on both the fronts. Export marketing was a good potential but supplies and quality standards will have to be assured.

Land and water use policy in the coastal sector for aquaculture is yet to be developed on a firm footing and the beneficiary groups for leasing will have to be identified on a realistic basis taking into consideration the effectiveness of such leases. Unless the farm sites come under the control of the lessees for appropriate period of time, investments will not be forthcoming.

In the present context, fisheries development organisations in the centre and States/ U.T.s will have to play a large and effective role in breaking the Ice. Fisheries is a highly supported and subsidised industry and it has grown with such support from the government. Mollusc culture is an area which deserves all the support that can be extended in view of the high production potential it offers. It needs setting of objectives and priorities right for providing the development support.

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46. POSSIBILITIES OF GREEN MUSSEL CULTURE IN THE SOUTHWEST COAST OF INDIA

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ABSTRACT

A simple and viable technology has been developed for the culture of green mussel *Perna viridis* on ropes suspended from floating rafts in the open sea at Calicut and Karwar along the west coast of India. Rafts varying in size from 5 x 5 m to 8 x 8 m were constructed using teak and bamboo poles and moored in the open sea at 8-10 m depth. Collection of seeds for the culture was done during October-December from the intertidal and submerged mussel beds. The average seed size for farming was 15-30mm and 0.5-1.0 kg seeds are required for seeding one meter length of the rope. Synthetic and coir ropes of 15-20 mm diameter were found suitable for growing mussels from the rafts. The seeds were placed around the rope and securely wrapped with knitted cotton cloth. The seeded portion of the rope varied from 5-8 m and the ropes were suspended from the rafts 0.5-1.0 m apart. Growth of mussels in the farm at Calicut ranged 11.6-12.9 mm in lenth and 5.9-7.3 g in weight per month. At Karwar the growth ranged 7.6-10.0 mm in length and 3 18-3.5 g in weight per month. A production rate of 12.3 kg per mater length of rope at Calicut and 10 kg per meter length at Karwar was obtained. Harvesting was done at the end of five months. The possibilities and constraints of mussel farming in the open sea conditions are discussed in the paper.

INTRODUCTION

The green mussel *Perna viridis* though found along the west coast of India from Quilon to Ratnagiri, is densely distributed along the rocky areas of Malabar coast. Jones and Alagarswami (1973) have given a detailed account of its resources and magnitude of the fishery. The distribution and extent of mussel beds and the exploited resources of this species has been studied from 1981-84 along the Kerala coast from Calicut to Cannanore and Karnataka coast from Bhatkal to Majali by the present authors. The average annual exploited resources was around 3500 metric tonnes.

Mussel culture by various methods is widely practiced in Spain (raft culture), France (Pole culture) and the Netherlands (Bottom culture) and elsewhere (Mason 1972, 1976, Korringa 1976, Lutz 1974, 1979 and Hulburt 1974). Mussel farming in Europe and other parts of the world is limited to bays and other protected areas which are ideally suited for culture, but the configuration of the Indian coast line is such that ideal bays or protected areas are limited for farming mussels on commercial scale. Experiments on the culture of green mussel were initated in the open sea at Calicut for the first time in India in 1975 and continued till 1980 and later at Karwar The possibilities of farming green mussel in the open sea condition following the raft culture technique and its production potential has been given by Kuriakose (1980), Quasim et al (1977), Silas (1980) and Pai and Kuriakose (1981). The paper deals with the observations made at Calicut and Karwar about the possibilities of mussel farming in the open sea conditions and also the adoption of the same in suitable areas along the Indian coast.

FARM SITE AND ENVIRONMENTAL CONDITIONS

At Calicut the mussel culture farm was located in the open sea about 2.5 km away from the shore having a depth of 8-10 m. The area is a good fishing ground and is free from industrial pollution and fresh water influx from rivers. The bottom is sandy near the shore and muddy at the farm site. During the experimental period October to May, the salinity of the farm site ranged from 32.44°/$_{oo}$ to 33.68°/$_{oo}$ at the surface and from 31.99°/$_{oo}$ to 33.45°/$_{oo}$ at the bottom. The sea water temperature at the farm site for the period varied from 27.44° C to 30.66° C at the surface and from 26.70° C to 30.26° C at

the bottom. The dissolved oxygen content of the surface water was almost constant and ranged between 4.43 ml/l and 4.90 ml/l and that of the bottom was slightly lower from 3.79 ml/1 to 4.32 ml/l.

At Karwar the culture farm was located off Karwar bay about 2 km away from the shore having a depth of 8-10 m. The bottom is muddy at the farm site. During the experimental period October to May of 1981-84, the salinity ranged from 34.62°/$_{oo}$ to 35.0°/$_{oo}$ at the bottom. The sea water temperature varied from 28.5° C to 30.5° C at the surface and from 28 2° C to 30.2° C at the bottom. The dissolved oxygen content of the surface water varied between 3.53 ml/l and 4.93 ml/l and that of the bottom was from 4.16 ml/l to 4.9 ml/l.

TECHNIQUE

The raft culture or suspended culture technique suitable for west coast conditions was followed for farming mussels. Rafts varying in size from 5 x 5 m to 8 x 8 m (Tables 1&2) were constructed using teak wood and bamboo poles lashed together with coir and nylon ropes. The rafts were mounted over 5-6 metallic floats of 200 l capacity, painted with anticorrosive and antifouling paints. Three iron anchors

TABLE - 1 *Details of mussel culture work carried out at Calicut from 1975-76 to 1980-81*

Particulars	1975-76	1976-77	1978-79	1979-80	1980-81
Number of rafts used for mussel culture	1	10	24	10	3
Size of the rafts	7 x 5m	8 x 8m	8 x 8m	8 x 8m	5 x 5m 6 x 6m 7 x 7m
Depth of the farm site	5m	9m	8m	7m	8m
Period of seeding	Nov 85	Nov & Dec 78	Nov & Dec 79	Nov & Dec 79	Nov & Dec 80
Seeded length of the rope	4m	8m	7m	6m	6m
Weight of seed used for seeding 1m length rope	700g	500g	600g	750g	1kg
Average size of the seed used for seeding	26.7mm	21.7mm	20.4mm	20.4mm	24.2mm
Number of ropes suspended from one raft	3.5	5.5	100	100	65
Total number of ropes seeded during the year	35	533	2400	1000	195
Average length of the harvested mussels	80.0mm	89.22mm	84.6mm	82.00mm	72 8mm
Average weight of the harvested mussels	37.3g	41.0g	26.8g	36.4g	25.24g
Meat yield of the harvested mussels	40.1%	40.2%	40.5%	36.3%	34.72%
Production rate per meter length of rope	5.1kg	4.4kg	12.3kg	11.3kg	10.5kg
Total number of ropes harvested	35	176	145	393	100
Total number of ropes lost in the rough sea	—	375	2255	607	95
Total quantity of mussel harvested	706.4kg	6164kg	12500kg	13400kg	652kg

TABLE - 2 *Details of mussel culture work carried out at Karwar from 1980-81 to 1983-84*

Particulars	1980 81	1981-82	1982-83	1983-84
Number of rafts used for mussel culture	4	3	1	1
Size of the rafts	7 x 7m, 6 x 6m, 5 x 5mm	6 x 6m, 5 x 5m	5 x 5m	5 x 5m
Depth of farm site	8m	9m	9m	9m
Period of seeding	Jan '81	Nov & Dec '81	Dec '82	Nov & Dec '82
Seeded length of the rope	4m	5, 6 & 7m	6m	6m
Weight of seed used for seeding one meter length of the rope	1 kg	1 kg	700 g	500 g
Average size of the used for seeding	17.5mm	26mm	18.2mm	19.6mm
Number of ropes suspended from one raft	48, 41, 33 & 32	29, 38 & 26	12	32
Total number of ropes seeded during the year	154	103	12	32
Period of harvest	June '81	May '82	—	May '84
Average length of the harvested mussels	62 6mm	78mm	—	80.6mm
Average weight of the harvested mussels	14.7g	33.7g	—	36.4g
Meat yield of the harvested mussels	27.89	34 0	36.5	35.9
Production rate per meter length of rope	7.6kg	10kg	—	8kg
Total number of ropes harvested	120	42	—	8
Total number of ropes lost due to poaching	34	61	12	24
Total quantity of mussels harvested	3751kg	2520kg	—	300kg

weighing 100 kg each were used for mooring the rafts in the sea attached to iron chain links of 13 mm diameter. The rafts were anchored at depth ranging from 8-10 m in the open sea about 2-2.5 km away from the shore (Fig 1 A) The rafts could withstand wind and wave action in the sea for a period of 7 months from October to April.

SEED COLLECTION AND SEEDING

The breeding season of the green mussel along the west coast extends for a period of five months from July to November with peak spawning activity in August and September. Juvenile mussels were found carpeting all over the intertidal and submerged rocks (Fig 1 B) reaching a density of 6225 per meter

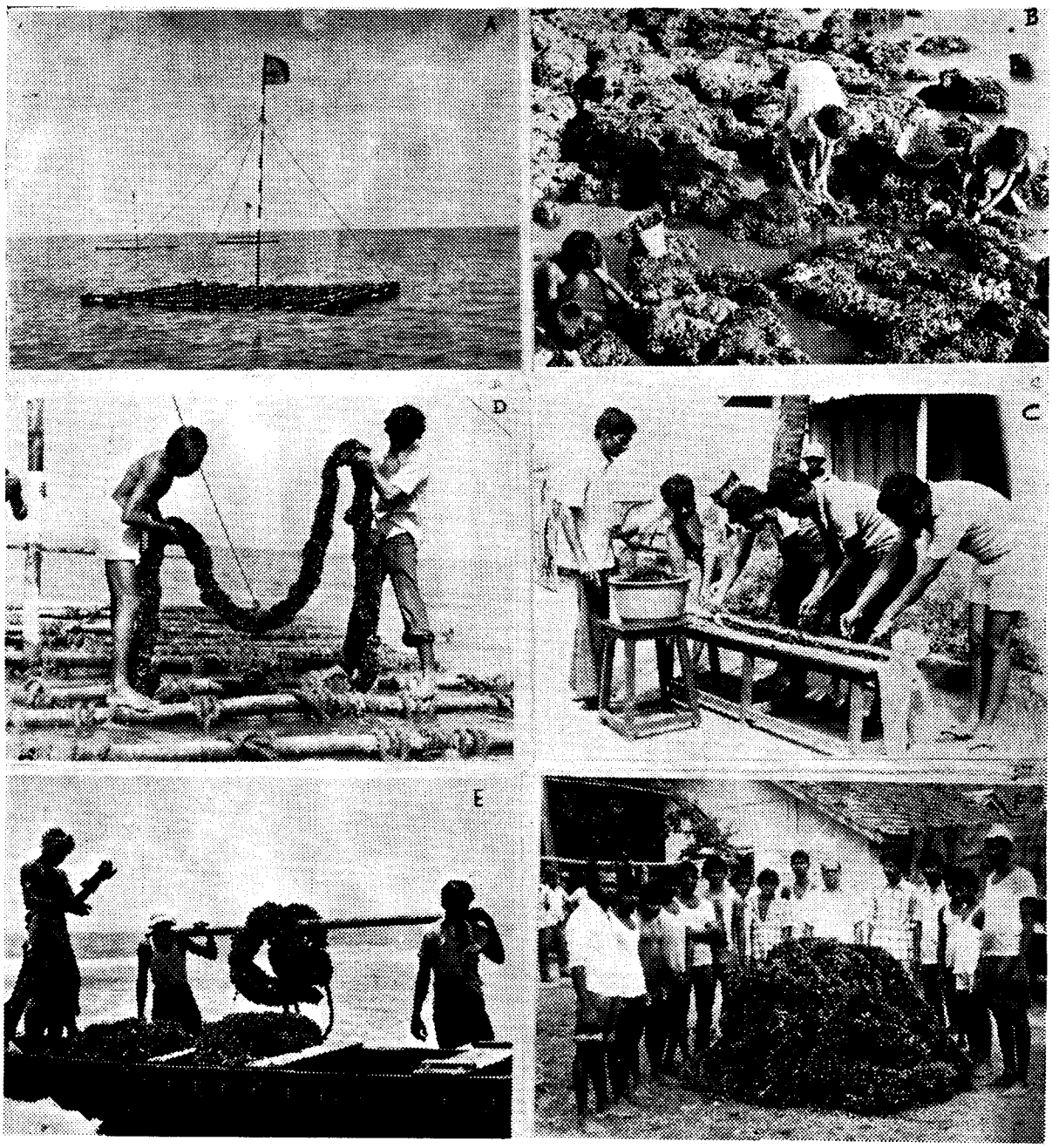

Fig. 1 Mussel culture on ropes at Calicut and Karwar. A. The rafts in the sea; B. Mussel seeds in the natural bed; C. Seeding the rope; D. Growth and Production of mussels on rope; E. Harvested mussel; F. A day's Harvest

square area in centre like Elathur. The collection of seed for the culture at Calicut was made from the intertidal and submerged natural beds at Elathur, Thikkodi and Mahe.

At Karwar, the collection was made from the submerged natural bed at Karwar, Chendia and Harwada. Immediately after the collection the seed were cleaned to remove the adhering mud and epifauna. The size of the seed used for seeding ranged from 15-30 mm and 0.5-1.0 kg seeds were used for seeding one meter length of the rope. Synthetic and coir for ropes of 15-20 mm in diameter were used for growing mussels from rafts. The seed mussels were secured around the rope by enclosing and stiching in knitted cotton cloth of 25 cm width (Fig 1 C). The seeded portion of the rope

varied from 5-8 m at Calicut and 4-7 m at Karwar (Tables 1 & 2). The seeded ropes were suspended from the rafts 0.5-1.0 m apart, with the lower free end about 2 m above the bottom. The seeded mussels got attached to the ropes by means of freshly secreted byssus threads within 2 to 3 days and the cloth disintegrates in sea water within about 10 days (Fig 1 D).

GROWTH OF MUSSELS IN THE FARM

Growth rate of mussels in the farm at Calicut from 1975-76 to 1980-81 is presented in Figs 2 & 3. Seeds having an average length

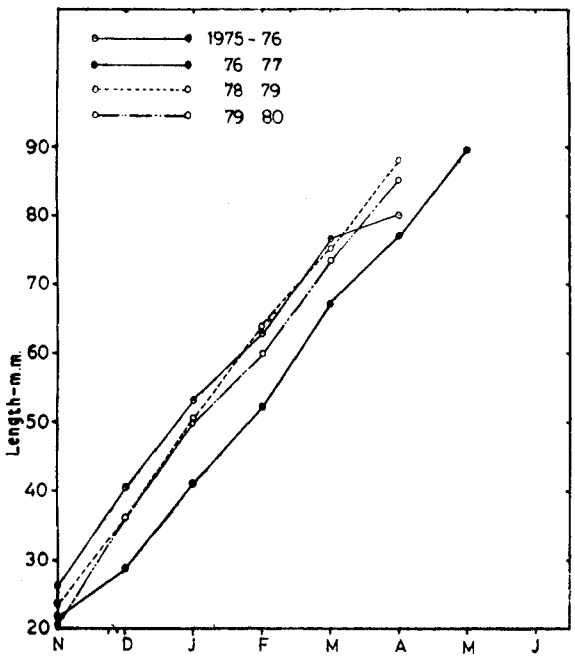

Fig 2 Growth rate of mussels in the farm at Calicut

of 20.4-26.7 mm, weighing 0.8-1.92 g transplanted in the middle of November grew to a size of 80.0-88.2 mm in length weighing 36.4-37.5 g in the second week of April, within a period of 5 months. The average monthly growth ranged from 11.6-12.9 mm in length and 5.9-7.3 g in weight. The percentage of meat yield at the time of the harvest in April ranged from 34.82 to 40.1 (Fig 4).

Growth of mussels in the farm at Karwar is presented in Figs 5 & 6. The monthly growth rate was 10.0 mm in length and 3.18 g in weight (1980-81), 7.6 mm in lenath and 3.5 g in weight (1981.82), 8.3 mm in length and

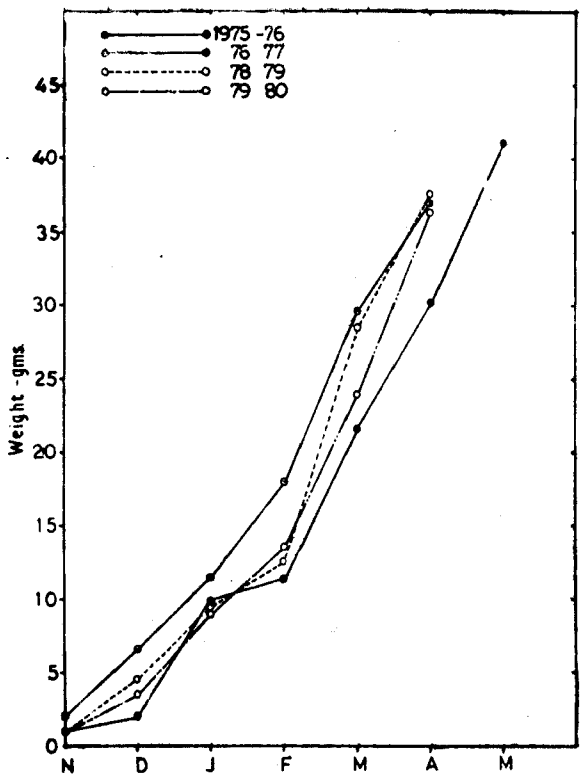

Fig 3. Monthly average weight of mussels in the farm at Calicut.

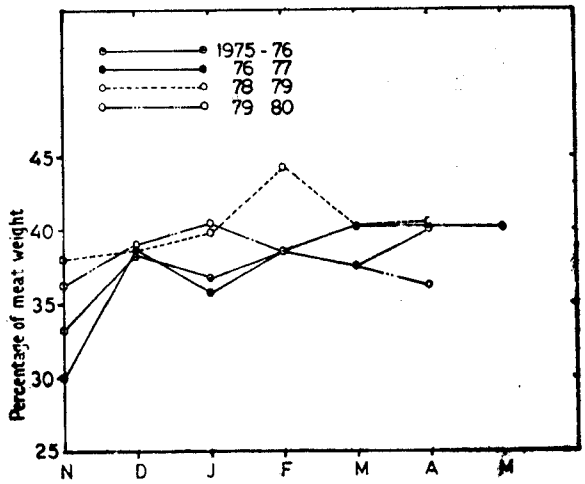

Fig 4. Monthly average meat yield of cultured mussels at Calicut.

3.8 g in weight (1983-84). The percentage of meat yield for the above periods were 27.9, 34.0, 36.5 and 35.9 respectively (Fig 7).

PRODUCTION

Details of the harvest and the production from the mussel culture experiments at Calicut

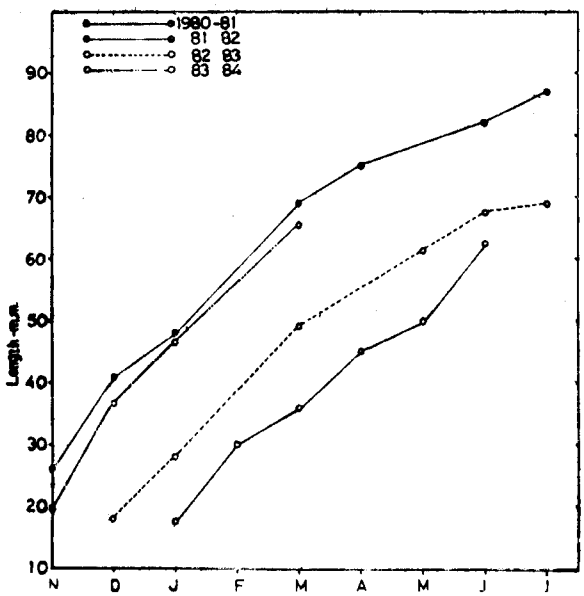

Fig 5. Growth rate of mussels in the farm at Karwar

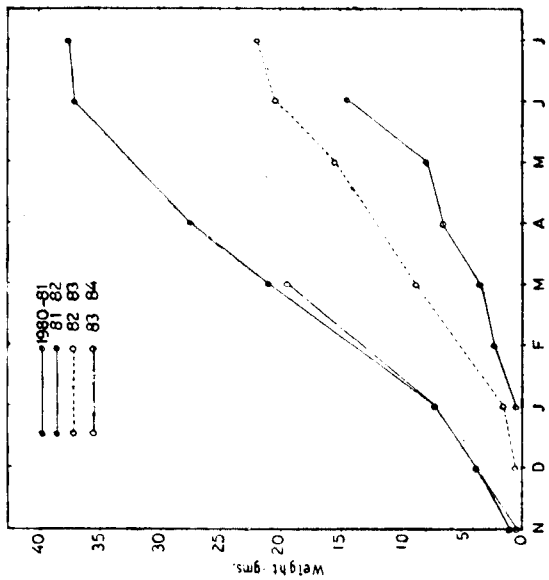

Fig 6. Monthly average weight increase of mussels in the farm at Karwar

from 1975-76 to 1980-81 are presented in Table 1. The average production per meter length of rope in 1975-76 was 5.1 kg mussels by using 0.7 kg seeds. In 1976-77, the production rate was 4.4 kg per meter length from 0.5 kg seed. The highest production of 12.3 kg per meter length of rope was obtained in 1978-79 which is 21 times the seed used for culture (Fig 1 E). The production rate in 1979-80 was 11.3 kg mussels per meter length

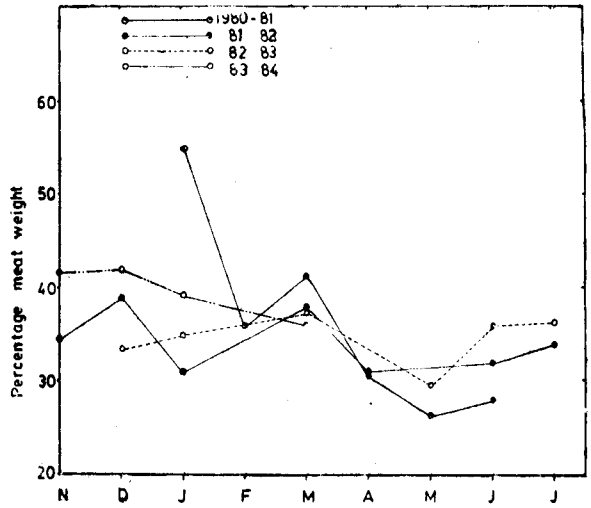

Fig 7. Monthly average meat yield of farm mussels at Karwar

registering an increase of 15 times of the seed weight. During 1980-81 the production rate was 10.5kg per meter length of rope.

The results of harvest and production from the mussel culture experiments at Karwar from 1980-81 to 1983-84 is presented in Table 2. The production rate of mussel per meter length of rope during 1980-81 and 1981-82 was 7.6 kg and 10.0 kg from an initial weight of 1.0 kg seeds (Fig 1 F). In 1983-84, the production from an initial seed weight of 0.5 kg was 8.0 kg mussels registering an increase of of the seed used.

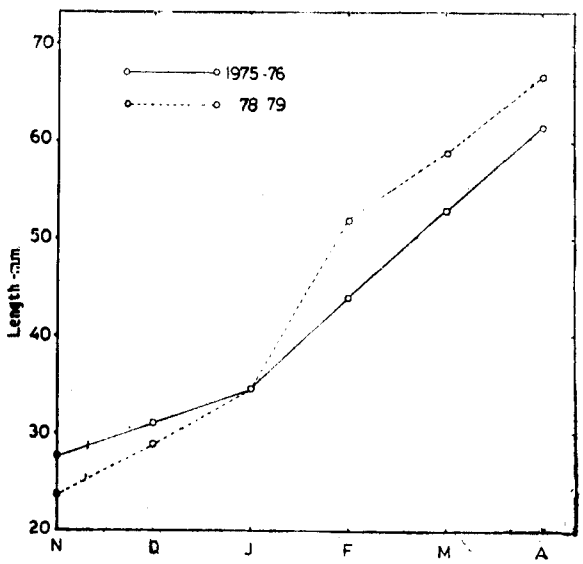

Fig 8. Growth rate of mussels in the natural bed at Calicut

DISCUSSION

The results of the experiments conducted in the open sea conditions along the west coast showed that the growth of mussels in the farm is very fast, 10.6-12.9 mm in length and 5.8-7.3 g in weight per month at Calicut. Growth of mussels of the same brood in the natural bed was only at the rate of 6.9, mm in length and 3.6 g in weight in 1975-76 and 6.8 mm in length and 3.8 g in weight in 1978-79. (Figs 8&9). The farm muasels gave a better meat

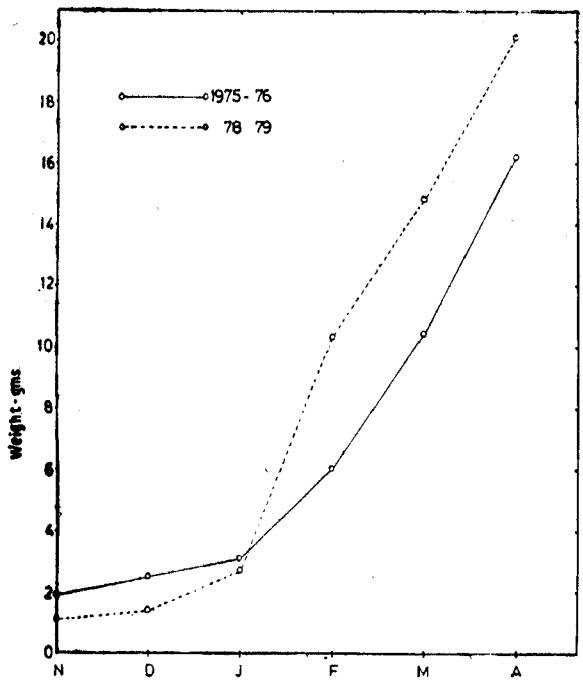

Fig 9. Monthly average weight increase of mussels in the natural bed at Calicut.

yield than the mussels in the natural beds (Fig 4 & 7). The average wet meat yield ranged from 34.82-40.5 percent of the total weight at Calicut and 27.89 to 36.5 percent at Karwar. Whereas, in the natural mussels at Calicut the meat yield was only 27.2-32.9 percent (Fig 10).

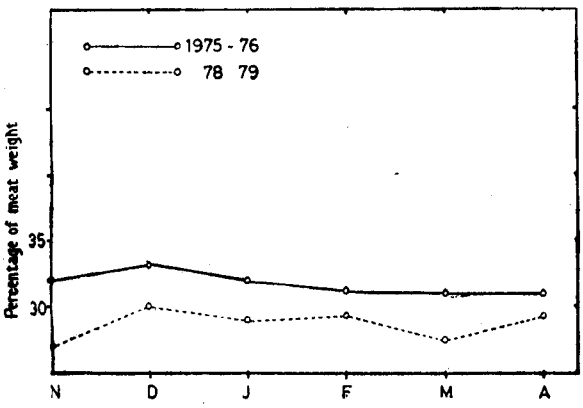

Fig 10. Monthly average meat yield of mussels in the natural bed at Calicut

The seed mussels transplanted from the natural bed to the culture rafts in the open sea at Calicut in November, showed signs of gonad development in December within a period of 30 days and 100 percent of the mussels in the farm was in the developing stages. In January 100 percent was in the matured condition (Table 3). Spawning of mussels in the farm started in Febuary, within 90 days. In the culture farm 65-100 percent were in the maturing, matured and spawning stages (Table 3). This is quite encouraging because mussel seed can be easily collected from the farm on suitable spat collectors. In the natural beds at Calicut, gonad development commenced only in April and only 47 percent was in the early developing stages in 1975-76 (Table 4). In 1976-77 gonad development did not commence till April and 100 percent was in the indeterminate stage. During 1978-79, gonad development started in March when 6 percent was in the developing stages. In April, 6 percent was in the developed condition and 10 percent in the developing stages.

At Karwar, in the seeds transplanted from the natural beds to the farm in November, gonad maturity started in December and 100 percent of mussels were in the developing stages (Table 5). Spawning started within 90 days and 40 percent spawned in January. In March 100 percent completed the spawning and were in the indeterminate stage. Re-development of the gonad commenced in farm in April with 5 percent in the developing stages, 41 percent in the fully developed condition and 54 percent in the spawning stage (Table 5).

The green mussel attained harvestable size of 80-88 mm in length within 5-6 months, as against 15-18 months in Spain and 24-36 months in the Netherlands and France (Korringa 1979, Mason 1976). A production rate of 12.3 kg mussels per meter length of rope was achieved within 5 months and this is much more than the production rate in the Galician bays of Spain, the leading mussel producing country in the world.

Availability of seeds in the wild is restricted to a few rocky patches along the coast, that too only for a short period from October-December every year. To overcome this possible

TABLE - 3 *Percentage of indeterminate, maturing, matured and spawning stages of mussels in the farm at Calicut*

Months	No. of mussels in sample	Indeterminate	Male			Female		
			% maturing	% matured	% Spawning	% maturing	% matured	% Spawning
			1975–76					
Nov	100	100	—	—	—	—	—	—
Dec	100	17	47	—	—	36	—	—
Jan	100	—	—	47	—	—	53	—
Feb	100	—	—	32	15	—	36	17
Mar	100	30	—	9	22	—	11	28
Apr	100	15	—	14	20	—	18	33
			1976-77					
Nov	100	100	—	—	—	—	—	—
Dec	200	32	37	—	—	31	—	—
Jan	200	3	16	30	—	15	36	—
Feb	200	—	—	45	—	1	54	—
Mar	200	9	—	36	9	—	37	9
Apr	200	—	—	24	18	—	29	29
			1978-79					
Nov	200	100	—	—	—	—	—	—
Dec	150	—	42	—	—	58	—	—
Jan	150	—	16	25	—	14	45	—
Feb	150	3	—	32	11	—	31	23
Mar	100	19	—	5	34	—	5	37
Apr	100	28	—	24	5	—	35	8
			1979-80					
Nov	100	100	—	—	—	—	—	—
Dec	100	—	38	13	—	28	21	—
Jan	100	—	—	46	—	—	54	—
Feb	100	—	—	18	28	—	21	33
Mar	100	—	—	13	32	—	22	33
Apr	100	35	5	13	12	1	16	18

shortage of seed it appears desirable to develop methods to collect seed from the farm by using suitable spat collectors. Non-availability of required quantity of seed may pose problems for future farming operations. At present we have very little information as to the extent of mussel spat availability along the west coast of our country. A detailed survey to identify

TABLE 4. *Percentage of indeterminate, maturing, matured and spawning stages of mussels in the natural bed at Calicut*

Months	No of mussels in sample	Indeter-minate	Male % maturing	Male % Matured	Male % Spawning	Female % maturing	Female % matured	Female % Spawning
			1975—76					
Nov	100	100	—	—	—	—	—	—
Dec	100	100	—	—	—	—	—	—
Jan	100	100	—	—	—	—	—	—
Feb	100	100	—	—	—	—	—	—
Mar	100	100	—	—	—	—	—	—
Apr	100	53	30	—	—	17	—	—
May	100	47	25	1	—	27	—	—
Jun	100	19	39	4	—	37	1	—
			1976—77					
Nov	100	100	—	—	—	—	—	—
Dec	100	100	—	—	—	—	—	—
Jan	100	100	—	—	—	—	—	—
Feb	100	100	—	—	—	—	—	—
Mar	100	100	—	—	—	—	—	—
Apr	100	100	—	—	—	—	—	—
			1978—79					
Nov	200	100	—	—	—	—	—	—
Dec	100	100	—	—	—	—	—	—
Jan	100	100	—	—	—	—	—	—
Feb	100	100	—	—	—	—	—	—
Mar	100	94	1	1	—	1	3	—
Apr	100	84	4	2	—	6	4	—

TABLE - 5 *Percentage of indeterminate, maturing, mature and spawning stages of mussels in the farm at Karwar*

Months	No of mussels	Indeterminate	Male % of maturing	Male % of matured	Male % of Spawning	Female % of maturing	Female % of matured	Female % of Spawning
			1981-82					
Nov	100	100	—	—	—	—	—	—
Dec	100	—	43	—	—	57	—	—
Jan	100	2	—	30	20	—	28	20
Feb	100	2	—	10	40	—	6	42
Mar	100	100	—	—	—	—	—	—
Apr	100	—	3	28	25	2	13	29
May	100	—	—	40	—	2	58	—
Jun	100	—	—	32	19	2	33	30

these areas and knowledge about the season of availability is very necessary.

Mussel farming is done only from November to April and the rafts are beached in the unfavourable season. Modifications of the rafts is needed for the year round culture in the open sea Long line culture has to be tried to overcome the limitations of raft culture. The coastal areas of the west coast are good fishing grounds. Floating rafts in the active fishing zones comes in conflit with the interest of the traditional coastal fisheries. Demarcation of farm site using suitable light fittings can overcome this constraint to a certain extent. At present mussel meat is relished only along the narrow coastal belt. Popularisation of mussel meat in cities and interior places will act as an incentive to production by mussel farming.

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47. BROWN MUSSEL *(PERNA INDICA)* RESOURCES ON THE SOUTHWEST COAST OF INDIA AND THE RESULTS OF FARMING EXPERIMENTS AT VIZHINJAM

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ABSTRACT

The distribution, abundance and fishery of the brown mussel *(Perna indica)* along the southwest coast of India are dealt with in this account. The annual production of brown mussel was estimated around 500 t and the total stock about 1500 t This shows that there is scope for increased production from the natural beds. The results of mussel farming experiments done in the Vizhinjam Bay by raft culture method are given. The prospects of mussel farming and the problems encountered are discussed.

INTRODUCTION

The brown mussel, *Perna indica* and green mussel, *Perna viridis* contribute to the mussel fishery along Indian coasts. The brown mussel occur in the southernmost part of east and west coasts. Jones (1950), Jones and Alagarswami (1973), Alagarswami et al (1980), Appukuttan and Nair (1980) and Silas et al (1982) have given details of distribution, abundance, fishery, utilization and marketing of this species. Experiments on brown mussel culture were taken up at Vizhinjam in 1971 (Achari 1975, Anon 1978, Appukuttan and Nair 1983) and basic technology for farming this species was evolved In this paper the distribution of the brown mussel *Perna indica*, its fishery, exploitation and total stock based on the survey during 1982-84 period and results of farming experiments in 1980, 1981 and 1983 are given.

MATERIAL AND METHODS

The results indicated in the present study are based on the survey during 1982-84 period from Quilon to Muttom. The estimation of total stock and exploited stock are made for major areas of mussel beds by regular visits to the centres twice a month and collection of daily landings and also random sampling of settlement in the beds. The effort is represented here as the total man power employed every month. The meat weight percentage, condition index, details of spawning and growth rate were taken for farm grown mussels for 1980, 1981 and 1983. By tracing the peak modes, growth was estimated and growth was also observed directly by keeping mussels in cages from floating rafts.

Distribution

Jones and Alagarswami (1973) have indicated the distribution of *Perna indica* from Varkala to Kovalam (Kanyakumari) along the southwest coast of India. The natural beds of brown mussel are located mainly in the intertidal rocky area and also in the nearshore submarine rocks (Fig I A). At Muttom and Enayam there are a few mussel beds on the submarine rocks, 2-3 km away from shore at 5-6 m depth. The mussels occur even upto 15m depth. The important mussel fishing centres on the southwest coast are Kovalam, Avaduthura, Vizhinjam, Mulloor, Pulinkudi, Chowarah, Enayam, Colachal, Kadiyapatnam and Muttom (Fig. 2). Besides these occasional fishing is practiced at Kappil, Chilakkoor, Papanasam, Vettoor (near Varkala), Kodimuna, Vaniyakudi, Kurumpanai, Enayam Puthenthura, Ramanthurai and Kovalam (Kanyakumari). There is also brown mussel settlement in the harbour breakwaters at Sakthikulangara (Quilon) and harbour pilings in Valiathura (Trivandrum) which is exploited seasonally.

Fishery and Abundance

Brown mussel fishery along the southwest coast is of sustenance nature. The fishing

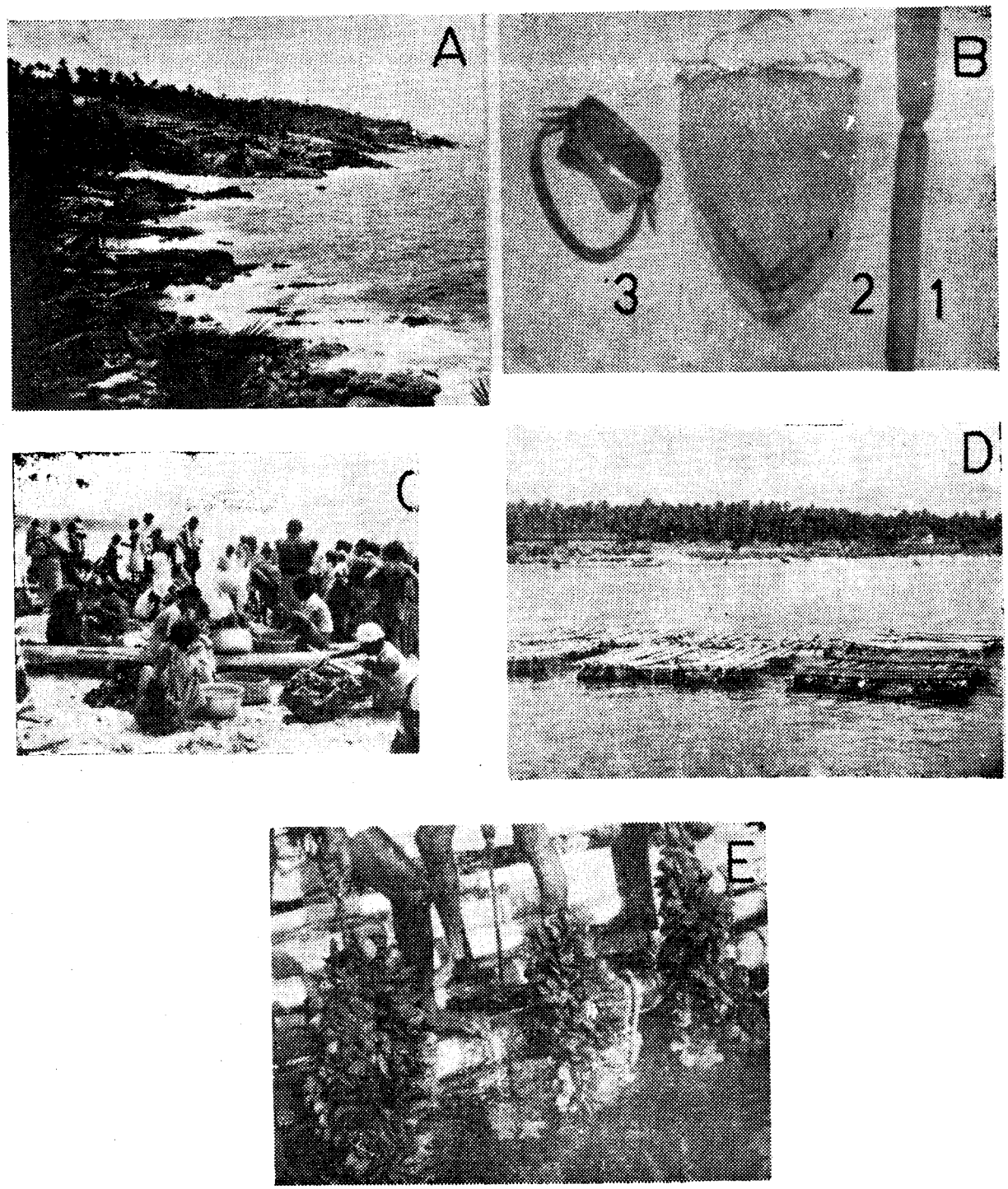

Fig 1 A Mussel beds in the intertidal area at Vizhinjam; B 1. Chissel used for mussel exploitation - 'Chippikathi'; B 2. Nylon bagnet used for mussel collection; B 3. Locally made mask used by divers engaged in mussel picking. C Grading the mussels brought from natural bed for marketing; D Mussel culture rafts inside Vizhinjam Bay; E Harvestable sized mussels on ropes.

methods have been described by Jones (1950) and Jones and Alagarswami (1973). Appukuttan and Nair (1980) have given the seasons and the magnitude of the fishing at Vizhinjam from 1976 to 1979. The fishermen reach the mussel bed by swimming or in catamarans and collect the mussel using iron chissel with wooden handle locally known as *Chippikathi* (Fig I. B 1) and keep

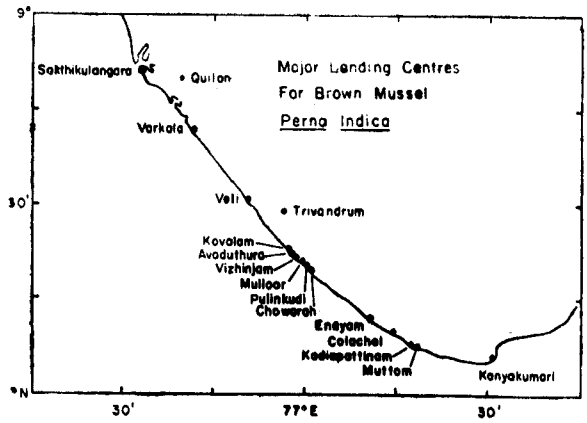

Fig. 2. Important brown mussel beds along southwest coast of India

them in nylon net bag (Fig I. B2) tied around their waists. For collecting mussel from deeper waters, most of the fishermen use locall made masks (Fig I. B3), which helps in locating the mussel settlement in the submarine rocks. Fishing is generally done during sunny days between 9 am to 4 pm in all the major centres. The major areas of mussel beds along southwest coast are Vizhinjam area (Kovalam to Vizhinjam). Mulloor-Chowarah and Colachal-Muttom. The annual landings at important centres from Vizhinjam to Muttom for 1982-83 and 1983-84 and the catch per effort of exploited mussel for corresponding period are given in Table-1. Fishing commences in all the centres by September and lasts till March with peak landings during November-January period. The present exploitation of mussels from all the centres together amount to 500 t annually. The catch per effort varied from 3 to 17.28 kg, the highest during November and lowest in March. The catch per effort shown in Table-1 indicates that

TABLE 1. *Showing total exploited quantity of brown mussel from important centres for 1982-83 and 1983-84 with the catch per effort for each month.*

Months	1982-83 Catch (kg)	1982-83 Effort	1982-83 C/E	1983-84 Catch (kg)	1983-84 Effort	1983-84 C/E
			VIZHINJAM			
Sep	13,000	1100	11.80	—	—	—
Oct	16,469	1126	14.60	26,350	1736	15.18
Nov	21,128	1050	20.12	42,000	2430	17.28
Dec	15,655	775	20r20	19,995	1829	10.93
Jan	8,060	806	10.00	5,704	713	8.00
Feb	2,380	476	5.00	2,893	406	7.12
Total exploited quantity	76,692			96,142		
			ENAYAM			
Nov	800	120	6.70	26,000	2080	12.50
Dec	26,000	2000	13.00	22,000	2000	11.00
Jan	15,000	1500	10.00	20,800	2080	10.00
Feb	12,500	1850	6.90	5,625	750	7.50
Mar	4,800	800	6.00	2,600	520	5.00
Total exploited quantity	59,100			77,025		
			COLACHAL			
Nov	4,875	450	10.83	23,400	3120	7.50
Dec	13,000	1250	10.40	36,400	3640	10.00
Jan	7,000	700	10.00	19,500	2600	7.50
Feb	9,000	1200	7.50	10.500	1750	6.00
Mar	5,400	720	7.50	2.184	728	3.00
Total exploited quantity	39,275			91,984		

TABLE 1 Contd.

Months	1982-83 Catch (Kg)	1982-83 Effort	1982-83 C/E	1983-84 Catch (Kg)	1983-84 Effort	1983-84 C/E
			KADIYAPATNAN-MUTTOM			
Nov	3,375	400	8.44	11,400	1040	10.96
Dec	10,000	600	16.67	9,750	780	12.50
Jan	5,490	624	8.65	4,600	624	7.37
Feb	3,600	480	7.50	3,500	600	5.83
Mar	1,440	240	6.00	1,400	312	4.49
Total exploited quantity	23,815			30,650		
			MULLOR-CHOWARAH			
Oct				52,000	3120	16.66
Nov				52,475	2850	18.41
Dec		No data available		9,250	1050	8.80
Jan				5,000	600	8.33
Feb				—	—	—
Total exploited quantity				15,6065		

C,E was highest at Mulloor-Chowarah during 1983-84 period. The estimated production during 1983-84 shows that 21% was from Vizhinjam area, 34.5% from Mulloor-Chowarah area and 44% from Colachal-Muttom area. The average number of fishermen engaged in mussel fishing is estimated as 790, of which 520 are active fishermen. The number of catamarans engaged in fishing annually in this region is around 295. Table 2 shows the estimated total stock of mussel, extent of mussel bed and the average weight of mussels per square metre from important mussel beds. The total stock estimated was highest at Vizhinjam area, Mulloor-Chowarah ranking second and Colachal-Muttom ranking third in abundance. Observations on the natural settlement in Vizhinjam area during October-November 1982 by random sampling (Table 3) showed that the average number of spat/m² was 4794 and weight 7 kg/m². The size of the spat ranged from 15 mm to 35mm with monthly average of 1-15 mm in July, 10-20 mm in August, 15-25 mm in September and 15-35 mm in October.

TABLE 2. *Showing total stock of mussel P. indica along southwest coast of India*

Places	Extend of bed (in sq. mtr.)	Av. Wt. per sq mtr. (in kg)	Total estimated stock (in tonnes)
1) Vizhinjam area (Kovalam, Avaduthura, Vizhinjam and Kottappuram)	1,11,500	6	669.0
2) Mulloor-Chowara (Pulinkudi, Mullor, Karimpally)	71,000	6	426 0
3) Enayam	22,500	8	180.0
4) Colachal (Kurumpana, Veniakudi, Kodimuna and Colachal)	42,500	6	225.0
5) Kadiapatnam-Muttom	10,000	6	60.0
6) Varkala	2,000	5	10.0
7) Kappil	400	5	2.0
8) Sakthikulangara	1,800	8	14.4
Total	2,61,700		1586.4

TABLE 3. *Showing the number and weight of spat settlement around Vizhinjam during October-November 1982.*

Place	No- of observation	Total No of spat/sq. mtr.	Wt of spat/sq. mtr (in kg)
Vizhinjam (Oct.)	5	5132	7.3
Kovalam (Oct.)	4	4500	6.5
Avaduthura (Oct.)	5	5048	7.0
Vizhinjam (Nov.)	3	4680	7.0
Kovalam (Nov.)	3	4036	7.4
Avaduthura (Nov.)	4	4560	7.0
	Average	4794	7 0

The mussel catches landed during peak season are disposed off at landing centres to the local consumers and merchants. The mussel brought to shore are cleaned to remove encrusted fouling organisms and seaweeds and they are graded and sold (Fig I A-E). From Vizhinjam area and Mulloor-Chowarah area mussels are taken on bycicle to Trivandrum and nearby markets. During November to January period truck loads of mussels with shell are taken from Muttom to interior markets. The price of mussel at Vizhinjam ranges from Rs 3 to 7/100 numbers during peak season and at Muttom it is Rs 3-5/100 numbers. During 1985 1120 kg of mussels collected from Sakthikulangara were sent to Kuwait in forzen condition on trial basis.

Farming Experiments

The results of the mussel farming experiments at Vizhinjam were given by Achari (1975) and Appukuttan and Nair (1983). Experiments during 1981-82 and 1982-83 have shown large scale slipping of seed when transplanted to ropes. Seeds of 20-30 mm size collected from submerged rocks showed minimum slipping during 1984 experiments. The environmental parameters of the mussel farm recorded during 1980-83 are shown in Fig. 3. As indicated by Appukuttan and Nair (1983) decline in salinity and temperature was recorded during May to October coinciding with the monsoon. The minimum salinity was recorded during May-July period and temperature was low during May to August. Dissolved oxygen varied from 4.02 to 5.51 ml/l during 1980-83 period. Meat weight percentage of farm grown mussels

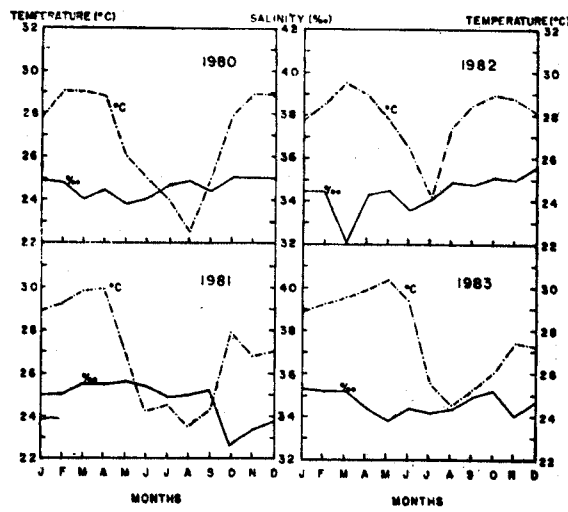

Fig. 3. Temperature and salinity for 1980-83 inside the Bay.

ranged from 21.35 to 39.83 in 1980, 35.66 to 41.50 in 1981 and 36.96 to 43.87 in 1983 (Fig.4)

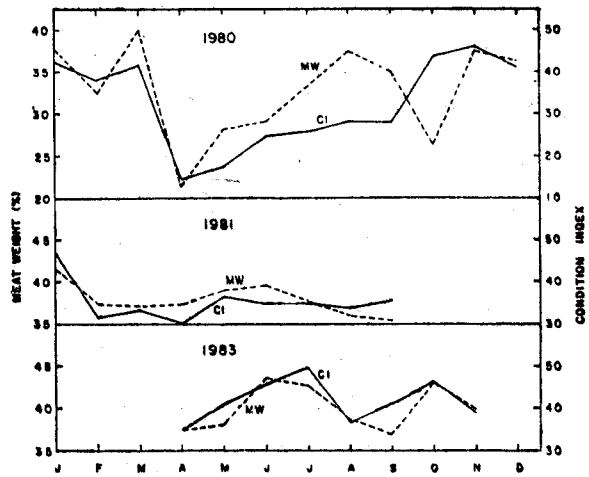

Fig 4. Meat weight percentage and condition index of mussel cultured in the Bay for 1980, 1981 and 1983.

and the condition index from 13.9 to 45.33 on 1980, 30.0 to 46.6 in 1981 and 35.27 to 45.79 in 1983. The high meat weight was noted during October-March period and the lowest in April. An identical trend was noticed for condition index. The meat weight and condition index show sharp decline after the spawning and usually spawning commences with the onset of southwest monsoon.

The growth observed from direct observation of mussels kept in rearing cages is shown in Fig 5. Samples collected from mussel ropes during 1980 showed that the peak mode in January was 40-44 mm and by September it has reached 60-64 mm, indicating a 20 mm growth in nine months at an average of 2.2 mm/month. In 1981 it was 2 mm/month and in 1983 2.5 mm/month. Direct observation also showed 2.5 mm growth per month. In the earlier experiments during 1976-79, Appukuttan and Nair (1983) found that the growth rate of mussels cultured on rope was 2.9 mm/month in the Bay and 5 mm/month in the open sea. Increase in meat weight during this period for farm grown mussel was 0.32 g/month in in the Bay and 0.9 g/month in the open sea.

Spawning commences by the end of of May and lasts till September with peak during June to August. Natural settlement of mussels was noticed from July onwards with maximum settlement in September through November every year.

The price of mussel at Calicut was Rs 1.25/kg, at Goa Rs 3/kg, at Ratnagiri Rs 4/kg and at Vizhinjam Rs 1 50/kg. In recent years the demand for brown mussel has increased and as a result the price has gone upto Rs 3 to 4/kg at Vizhinjam and neighbouring areas.

REMARKS

The present study has shown that the exploitation of brown mussel is around 500 t annually and estimated total stock is roughly 1500 t. It is quite evident that the exploitation can be increased. The landings during 1983-84 period reveal that the maximum exploitation is at Colachal-Muttom area, which accounts for 50% of the estimated total stock of that area. At present mussel picking is done as a part-time occupation during fair season in most of these centres. When there is good fish landing at Vizhinjam, fishermen do not go for mussel picking. Recently most of the fishermen engaged in mussel fishing in the Colachal-Muttom area go to the east coast for chank fishing during November-January period and thus active mussel picking is not done during this season. At present there is no Government assistance to encourage mussel picking. This

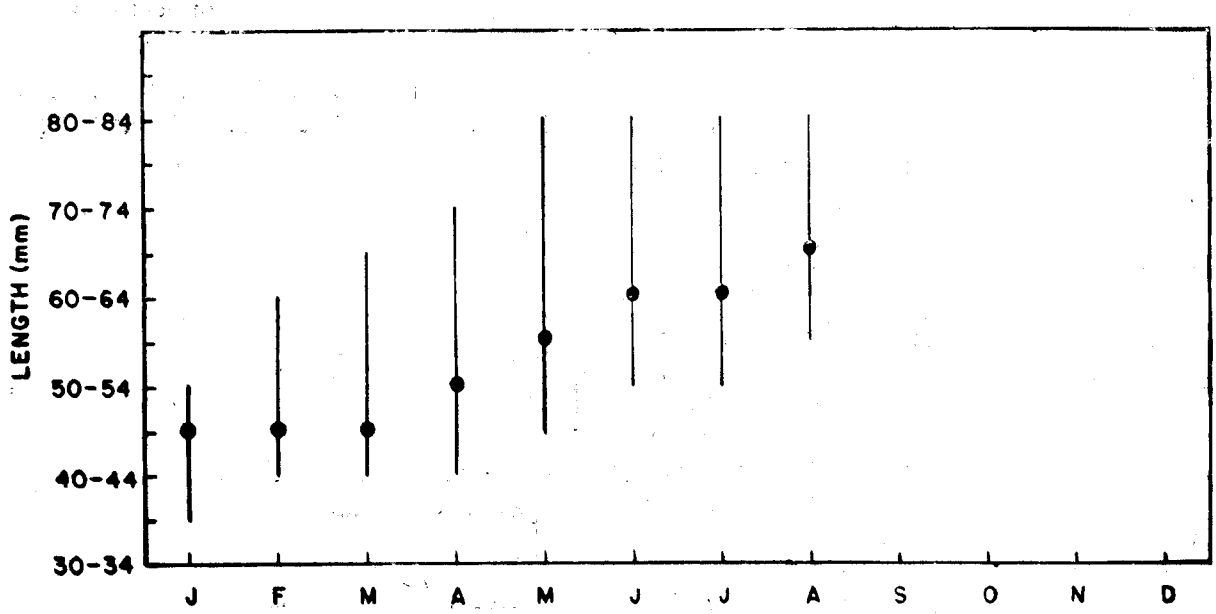

Fig. 5, Growth rate of mussels kept in rearing cages inside the Bay during 1980 for direct growth observation. The bar represents the size range and dot indicates the peak modes in different months

and the poor demand are two factors which keep the exploitation at low level. At present, mussel consumption is limited to the coastal belt and a few interior towns and villages near the landing centres.

The present study indicates slower growth rate for mussel inside the Bay compared to that observed in 1976-79 period. The reasons can be due to increase in the number of rafts in a limited area and also due to heavy silting inside the Bay caused by recent breakwater construction. Seed slipping noted during 1982-83 can also be due to the heavy silting inside the Bay. Though the mussel farming techniques have been developed and demonstrated through extension programmes and culture projects of various Government agencies, no mussel farming of commercial proposition has been taken up in India. Some of the aspects yet to be studied are the methods for increased seed collection from the wild and also production through hatchery techniques. Experiments revealed that farming in the open sea is more productive (Appukuttan and Nair 1983) and thus it is felt that improved techniques for mooring rafts in the open sea have to be developed. In European countries it takes 15-24 months for mussels to reach harvestable size, whereas in India it reaches this size within 6-3 months after seeding (Fig 1. E). Availability of mussel seed in the east and west coasts, high rate of production by farming in floating rafts and low cost technology for farming are factors conducive to large-scale mussel culture in India.

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48. EXPERIMENTAL STUDIES ON THE PATTERN OF SPATFALL OF THE GREEN MUSSEL, *PERNA VIRIDIS* AT ENNORE, MADRAS

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ABSTRACT

The green mussel, *Perna viridis* spawns throughout the year at Ennore near Madras. This assures continuous availability of mussel seed at frequent intervals almost throughout the year. The length at first maturity is 16 mm (age: about 16 months). Experiments conducted to understand the spatfall pattern at Ennore reveal that, on average, 112 spat/month settle in an area of 56.25cm^2 of granite stone collector. The maximum settlement of 669 spat/month has been recorded during June. The effects of biotic and abiotic factors on settlement pattern of spat are discussed.

INTRODUCTION

For successful implementation of mussel culture programme, a knowledge on the availability of spat in the vicinity of culture area is of foremost importance. The need for experimental studies on mussel availability has been emphasised repeatedly by many authors (Alagarswami 1980; Nayar and Mahadevan 1980; Silas 1980); In Kovalam (near Madras), the Central Marine Fisheries Research Institute has demonstrated that there is considerable scope for culture of mussels on rafts. The present investigation was undertaken to understand the mussel spat recruitment pattern in Ennore (also near Madras) and to ascertain the availability of mussel spat for culture practices in this area.

MATERIAL AND METHODS

Ennore, a coastal village, 15 km north of Madras (13° 14' N and 80° 20' E) was selected as the study area. For experimental purpose, the concrete platform extending about 250 m into the sea was used for suspending the test panels.

Four kinds of test panels namely weather-proof-roofing tiles, wooden planks, concrete plates and granite stones of various sizes were experimented with. Among these, the granite stone panel measuring 53 cm x 38 cm x 7.5 cm was selected since it withstood even harsh environmental conditions. Two 50 mm diameter holes were made on top and bottom of the panel. Iron chain of 9 mm thickness was passed through the holes. The chain from the upper hole was tied to the platform pillar and the chain passing through the lower hole was shackled with a 35 kg, five pronged iron anchor which minimized the swinging action of the panel.

The test panel was suspended from the platform in July 1981. On completion of every four week immersion, the organisms that settled on the two sides of the panel were scraped off in an area of 7.5 cm x 7.5 cm and counted. The scraped off area on completion of first 4 week immersion period was designated as Area I (Fig 1, A1). The panel with the rest of the unscraped

FIG. 1

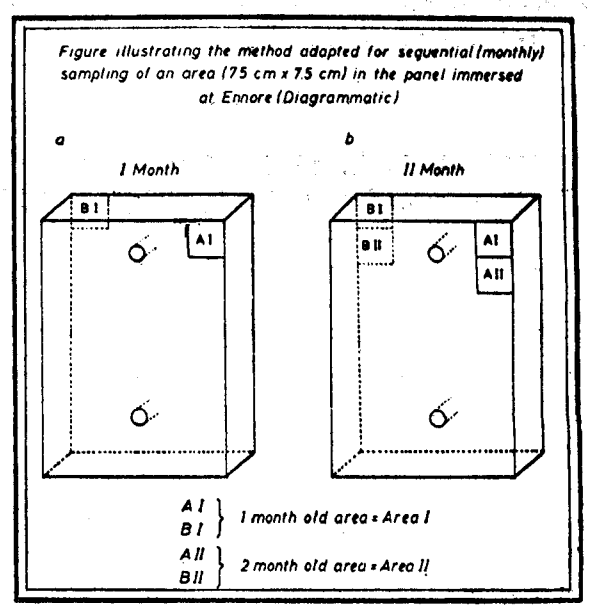

Fig. 1 The Experimental Panel

organisms was again suspended in the sea water. After a period of another four week the panel was lifted up and all the organisms that had settled in Area I as well as an adjacent new area of 7 5 cm x 7.5 cm were scraped off and counted (Area II). This gave data on the fresh settlement of organisms in 4 weeks time on a previously settled and scraped off area as well as on settlement during a 8 week of undisturbed period. This sampling was continued up to March 1983.

Based on the numerical abundance of mussel that had settled in a given area (56.25 cm^2), the intensity of spat recruitment was classified into the following four categories: 1. Intensive spatfall: When the settlement intensity exceeded 300 individual mussel spats in an area of 56.25 cm^2, it was taken to denote as intensive spatfall. 2. Moderate spatfall : Mussel spat density ranging from 101 to 300 was considered as moderate spatfall. 3. Poor spatfall; Mussel spat numbering between 20 to 100 was taken as poor spatfall. 4. Very poor spatfall: This category included spat settlement of 19 or less number in 56.25 cm^2 area.

During this period, the surface water temperature ranged from 25.4°C to 29.2°C and salinity varied from 25.5 ppt to 34.4 ppt. The dissolved oxygen ranged from 3.8 to 5.2 ml/l.

RESULTS

Mussels settle on a given substratum during the pediveliger larval stage when the shell length is 2 mm (Bayne 1976). These young mussels are generally termed as spats. Dare (1973) used the term 'spat' to specify young *Mytilus edulis* of 10 mm in length. In the present paper, the term 'spat' is used to denote mussels measuring <14 mm in length. A cut off at 15mm was felt necessary because, in *P. viridis* of Madras coast, the onset of maturity was noticed in mussels of 15 mm length. Young mussel took about one month from the time of settlement, to attain a length of 14 mm.

Table 1 illustrates the monthly variation in mussel spat settlement. Intensive spatfall was observed during June and early October 1982, the density being 659 and 631 respectively In September 1981, September 1982, March 1982

TABLE 1. *Monthly variation in mussel spat settlement on experimental panel (56.25 cm^2 area) at Ennore.*

Year & Month	No. of spat
August '81	34
September	115
October I	22
October II	3
November	6
December	Nil
January '82	Nil
February	90
March	282
April	11
May	5
June	659
July	33
August	12
September	244
October I	631
October II	9
November	73
December	10
January '83	19
February	15
March	199

and March 1983, moderate spatfall ranging from 115 to 282 individuals was recorded. Poor spatfall with a range of 22 to 90 spats was recorded during August 1981, February 1982, July 1982, November 1982 and early October 1981. Very poor spatfall was noticed in the remaining months. In these months, the spat recruitment was from nil to 19 mussels per 56 25 cm^2 area.

DISCUSSION

The average spatfall during the present investigation is 112 spat/month in 56.25 cm^2 area on a granite stone panel. This observation is comparable with the results recorded by earlier workers. On an average, in one sq. cm. area 1.4 mussel spat at Kovalam (Selvaraj 1984), 1.5 at Vizhinjam (Appukuttan *et al.* 1980) and 2.34 between Shertalai and Cochin (Nair *et al* 1975) have been reported. However, along the

Brazilian coast, Fernandes and Seed (1982) recorded a high mussel spat density of 117/cm². In the present study, the maximum spat density/ cm² was 11.7.

TABLE 2. *Average mussel spat settlement/cm² area*

	Ennore	Kovalam	vizhi-njam	Sherta-lai to Cochin
Average (No/cm²)	2.0	1.4	1.5	2 34
Maximum (No/cm²)	11.7	14.56	1	2.20
(month)	Jun '82	Oct '82	—	—
Minimum (No/cm²)	0.05	0 0	21.5	2.48
(month)	Late Oct 1981	Apr '81 Nov '81 Apr '82 May '82	—	—

Environmental factors may play a vital role in mussel spat settlement. Investigations on spawning period and occurrence of mussel larvae in plankton revealed that during September 1981, for instance, 68% of mussels were found to be in spawning condition and high planktonic larvae count of 236 was recorded in 20 l sea water. However, a meagre 22 and 8 mussel spat settled in the panel in October 1981. The occurrence of low level in spatfall may be due to the turbulent sea condition coupled with severe underwater currents that prevailed during north-east monsoon in October. It is possible that the currents transported the larvae away from the coastal zone (Easterson and Mahadevan 1980; Silas 1980). Other abiotic factors such as salinity and dissolved oxygen (Harger 1970) and wave action (Harger 1969) are also known to influence the spat abundance.

Favourable conditions for successful spawning and spat settlement may provide abequate mussel seed for culture operation on a commercial scale. It is suggested that the peak spatfall during June may be utilized for raft culture operation so that marketable size mussel could be harvested before the onset of north-east monsoon in Madras coast.

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49. OPEN SEA MUSSEL FARMING AND ITS PRACTICAL ASPECTS

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ABSTRACT

This paper briefly recapitulates some of the experiments carried out by the Central Marine Fisheries Research Institute at its various research centres along the east and west coasts in culturing mussels in the open sea and sheltered bays. Variations in the technology of mussel farming, principally rope culture and raft culture have been experimented under field conditions. Local fishermen were involved under the Operational Research Project and Lab to Land Project with the main objective of developing mussel farming into an industry and to provide additional income to the fishermen. In the light of our experience, the problems involved and the constraints in the effective implementation are objectively reviewed. The possible remedial measures for overcoming some of these constraints are presented in this account.

Marine mussels feed on primary producers and non-living organic materials, and with a short food chain and low position in the food web, are efficient converters of these organisms into edible flesh; hence their production potential is immensely vast. An analysis of mussel farming around the world may reveal that the mussel fishery and farming have centred Europe and the major mussel producing countries are Spain, the Netherlands, France and Italy. In Spain, the cultivation of mussels on rafts has developed as a family business, each family owning on an average, two to three rafts for the operation (Bardach et al 1972). Larger operators may own up to 25 rafts and employ as many as ten people. The culture grounds are owned by the Spanish Government and leased out to the private entrepreneurs (Hurlburt and Hurlburt 1980, Wallace 1980) Wallace 1980).

The natural distribution of mussels along the Indian coast is patchy. While dense settlement of the green mussel, *Perna viridis*, is recorded between Calicut and Cannanore, it is scanty along Karwar, Goa, Ratnagiri, Visakhapatnam, Kakinada, Madras, Pondicherry and Cuddalore. The brown mussel, *P. indica* is restricted to the south-west coast between Quilon to Cape Comorin. Limited mussel fishery along Vizhinjam (Appukuttan and Nair 1980), Malabar coast (Kuriakose 1980) and Kakinada (Narasimham 1980) has been reported. The open sea mussel farming practices were initiated

at Vizhinjam in the early seventies. Since 1978, various experiments were carried out along both east and west coasts on the open sea mussel farming. The raft culture technology originally borrowed from Japan and experimented by Spanish workers (Bardach et al 1972) was considered to be best suited for mussel culture since it offers an excellent three dimensional environment for better survival and faster growth rate (Andreu 1968). The brown mussel, *P indica* were cultured on rafts in Vizhinjam bay (Appukuttan et al 1980) and green mussel at Calicut (Kuriakose 1980), Kakinada and Kovalam near Madras (Rangarajan and Narasimham 1980).

With the research experience on mussel farming, it was decided to implement it on a large scale through Operational Research Project and Lab to Land programmes which were carried out as a natural sequel to the National Demonstration Programmes that were being successfully carried out in the agricultural sector. The focal theme in these projects is to put to test the economic feasibility of the laboratory developed technology for a commercial-scale production, involving the local fishermen and in that process to identify the various constraints to evolve the most suitable technology for deriving full benefit for the participant fishermen.

Kovalam, a fishing village, 36 km south of Madras, where the Field laboratory of CMFRI has been carrying out experimental studies on mussel culture, was selected for introducing the Operational research project. Karikattukuppam, an adjacent fishing village, about 30 km south of Madras was identified for launching Lab to Land programme. Prior to implementation, a bench mark survey on the various socio-economic structures was carried out. Under the Operational research project mussel culture work was initiated on the French-style pole culture. Though the seeded mussels grew to a size of 45 mm (total length), the fishermen could not reap the fruits of their hard labour as unexpected cyclone that crossed the coast near Kovalam in November 1978 uprooted all the poles. Floating rafts were used for undertaking mussel culture at Karikattukuppam. The fishermen, in the initial phase, undertook mussel seeding operation very enthusiastically. Learning by experience, the culture techhology was partially modified to suit the turbulent sea conditions. The first prototype submerged raft was fabricated and launched for mussel farmiag at Kovalam On two occasions, marketable-size mussels to the tune of over 1t (shell-on weight) were harvested. In the course of implementation of these programmes slated for the economic uplift of the local fishermen, the essential R & D inputs needed are categorised as follows:

Need for a modified culture technology

During both the monsoon regimes south west and north-east formation of depressions and cyclones are not unusual along Bay of Bengal (Easterson and Mahadevan 1980, Mukherjee al at 1982, 1983, Ramasastry et al 1984). Due to the turbulent sea conditions and strong underwater currents caused by such depressions, the culture ropes hung from the raft and occasionally the rafts also were partially or completely damaged. Similar constraint has also been reported from the west coast of India (Kuriakose 1980). Hence, the entire system of raft culture should be improved and rendered efficient to withstand the rough monsoon conditions of the open coastal waters so that year-round culture operation could be made. Shifting of operations from one locality to another according to change in weather conditions is a possible way of circumventing this problem.

Seed resource

A basic requirement for continual success of mussel culture is a consistent supply of mussel seed. A steady supply of mussel seed may be obtained through well organized hatcheries. Pending development of such hatcheries, the seed requirement may be met with from the natural spatfall since mussels in this area spawn almost throughout the year. The spat collectors have to be carefully selected and suspended from the culture raft synchronizing with the mussel spawning period. In a recent study, it has been recorded that an average of 10,000 spats may settle on a tile panel in an area of 15 cm x 15 cm (Selvaraj 1984). Cosiderable research efforts in this direction are needed so that proper hatcheries could be established. It is an advantageous factor that there is no dearth of seed resource from the wild. In this context, it may be pointed out that the leading

mussel producers in Europe have not faced any crisis of seed shortage due to abundant natural supply (Korringa 1976).

Capital input

Open sea mussel culture involves capital investment on raft and other ancillary materials. These are costly inputs which the common fishermen are unable to afford even if the project is subsidised. Further, the risks involved in maintaining the structure in the open sea are great, especially in areas prone to natural calamities. Under such circumstances, repayment of loans becomes extremely difficult. Above all, the fishermen are naturally reluctant to venture again into the sea for looking after the rafts, after their day's toil in the sea for their traditional fishing. Unlike agriculturists, the mental attitude of the fishermen is basically different. They are accustomed to immediate disposal of the catch and realisation of money.

Marketing

The problem of disposal of the cultured mussels at an economic price is a matter of serious concern. A detailed marketing survey showed that there is a low demand for mussel meat, especially on Sundays in most of the markets in Madras, and is yet to become a popular food item even amongst the meat eating population. The retail price varies from Rs. 5 to Rs. 8 per hundred mussels (Tampi and Selvaraj 1983). However, it must be mentioned that there is a good demand for mussel meat in Malabar coast.

Mussel cooking demonstration programme was organised by the Operational research project members and the fisherwomen at Kovalam were trained in cooking various mussel dishes. A pamphlet containing various cooking receipe also was released. Stuffed green mussels were fried and sold with the help of Tamilnadu Fisheries Department at the All India Tourist's Trade Fair at Madras. It indicated a sound response from the public who tasted the mussel flesh for the first time.

Need for short-term culture and adequate publicity

Mussel culture may be carried out on a short term of 3-4 months by which time it attains marketable size (total length 60 mm). Such a venture could easily avoid harsh climatic conditions prevailing during south-west and north-east monsoon. The culture technology also needs improvisation.

Adequate publicity along east coast of India on the value of mussel as a nutritive food item may be given as that of the U. S. Government which carried out a wide spectrum of publicity campaign on mussel value during World War I and mussel had become a regular item in popular diet (Miller 1980). The present day mass communication media such as Radio and Television may be effectively used to popularise the importance of this low cost but protein rich food commodity.

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50. RECENT TRENDS IN OYSTER CULTURE IN INDIA

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ABSTRACT

Rack and tray method of culture of the oyster *Crassostrea madrasensis* has been developed initially at Tuticorin and oysters have been cultured successfully Recently Innovations have been made in the methods of collection of oyster spat and techniques of rearing them. The development of hatchery techniques for large-scale production of oyster seed has led to reorientation of culture techniques. Oyster seed are produced in the hatchery by employing different types of spat collectors depending on the kind of culture practice in which they will be used. Prospects for ren, stake and bottom sowing methods of culture have been studied.

INTRODUCTION

Although Hornell (1910) attempted experimental oyster culture and indicated the possibilities for oyster farming as early as at the beginning of the present century, there was revival of interest in the subject only recently when the Central Marine Fisheries Research Institute took up a research project on developing techniques for collection of oyster spat and rearing them in suitable grow out systems As a result of the studies carried out in this project, methods for large scale collection of spat of the oyster *Crassostrea madrasensis* have been evolved and the spat thus obtained were cultured to marketable size by a rack and tray method (Mahadevan et al. 1980, Nayar and Mahadevan 1983). Subsequently experimental research in oyster culture has been done in different institutions at different places on the east and west coasts of India. Rao et al (1983) collected spat of *C. madrasensis* on different types of spat collectors and cultured them in Vaigai esturay. The work done by Dhulked and Ramamurthy (1983) and Joseph and Joseph (1983) has indicated the possibilities for culture of *C. madrasensis* in Mulki estuary, Karnataka. Purushan et al. (1983) studied the setting and growth of oyster in Cochin backwater. Reuben et al (1983) carried out culture experiments on the same species in Bheemunipatnam backwater. Parulekar et al (1983) have reported the feasibility of culture of *C. gryphoides*.

It has been felt that it is necessary to make some modifications in culture techniques for reducing the investment required for oyster farming. New types of spat collectors and methods of rearing oysters have been developed. Hatchery techniques for production of seed of *C. madrasensis* in laboratory have also been developed. The Central Marine Fisheries Research Institute has established at Tuticorin, a oyster hatchery where oyster seed are produced using different types of spat collectors depending on the kind of culture system that will be used. Ren, stake and on bottom methods of culture of *C. madrasensis* have been tried and they have given encouraging results.

SPAT COLLECTION TECHNIQUES

Previously various kinds of spat collectors such as lime coated tiles, asbestos sheets, mussel shells and oyster shells were used for spat collection (Mahadevan et al., 1980, Thangavelu and Sundaram 1983). Spat settlement was found to be higher on the lime coated tiles than other spat collectors. Laying of spat collectors in all the months of the year indicated that there are two peak periods of spawning on Tuticorin coast, one in April-May and another, a secondary spawning period in August-September during which there was only limited spawning. Large scale spat collection was attempted by employing 30,000 to 50,000 lime coated tiles during a season and good number of oyster spat were collected. Spat collectors were laid in different areas viz., Karapad creek, near natural bed and intertidal part of Tuticorin Bay and it was found that spat settlement in the bay was 316/m² on lime coated tiles. In the near natural bed area and in the creek, the

settlement was comparatively less 92/m² and 76/m² respectively. This indicated the potentiality for large scale collection of oyster spat in the shallow inshore area of the Tuticorin Bay. Since use of lime coated tiles involved much labour for giving lime-coating to the tiles and scraping of seed oysters from them, oyster shells on rens, PVC pipes and velon screen encircled on a metal frame were tried as spat collectors. The rens of oyster shell and PVC pipes were found to be effective for collection of spat.

Oyster shell rens

Twenty to twentyfive shells are centrally punctured and strung on a No. 10 Galvenized iron wire of length of 1.5 m. These rens are laid horizontally on a rack. When the seed oysters attain a size of 15-20 mm, separate rens are prepared by stringing 5-6 oyster shells with spat, on a 3 mm thick synthetic rope with PVC spacers allowing an interspace of 10-15 cm between successive shells. The rens thus prepared are suspended from a rack till the oysters grow to harvestable size of 80-90 mm (length).

PVC pipes

PVC pipes of 2.5 cm diameter and 1 m length are used as spat collectors. Nine such pipes are made into a bundle fixing the ends of the pipes in a wooden circular board with grooves. Twenty such bundles are placed on a rack. On an average 30 spat are collected per single pipe. The ribbed PVC pipes are being widely used as spat collectors in France along the Britanny coast. The advantages of using this as spat collectors are easy handling of the material and quick removal of spat from the pipes which is possible by slightly twisting the tube.

HATCHERY PRODUCTION OF SEED

It has been realised that for establishing oyster culture as an industry in the country, development of hatchery techniques for production of oyster seed in laboratory is quite essential. It may not be possible to collect sufficient quantity of seed for stocking in farms as intensive spawning period is limited to short duration. Further spatfall in nature is often erratic as it is influenced by hydrological factors which are variable in different years. Natural spat collection is also labour intensive. A molluscan hatchery has been established at Tuticorin with necessary infrastructure facilities like filtered seawater, microalgal culture, aeration system and larval and spat rearing tanks (Nayar and Easterson 1983, Nayar et al. 1984). It has been possible to induce *C. madrasensis* to spawn in the laboratory by conditioning them for maturation and artificial spawning. The larvae obtained from the spawnings have been successfully reared in favourable condition and the oyster seed are being produced on a large scale in the hatchery. The hatchery techniques have been streamlined and it is now possible to produce oyster seed on a mass scale at any period of the year (Nayar et al 1984).

Oyster seed have been collected in the oyster hatchery on different types of spat collectors taking into consideration the kind of culture method which will be employed. Spat settled on oyster shells are being used in the stake or ren method of culture. Cultchless spat which are made to set on shell-grit or polythene liner sheet are used in bottom method of culture or rack and tray system.

CULTURE TECHNIQUES

Stake method

Oyster spat set on oyster shells have been nailed to a stake of 1.5 m length with two shells on the side and one at the tope of the stake. These stakes are erected in the shallow intertidal region. Usually oyster seed of size 1-2 mm produced in the hatchery have been used in stake culture. For initial rearing of 2 to 3 months in order to avoid predation by crabs, shells with oyster spat could be covered with a velon screen. With relatively low maintenance expenditure, the oysterlings can be grown to marketable size of 80-90 mm in one year when they could be harvested. The production rate by this method varies from 10 to 15 t/ha. The stake culture method is commercially employed in British Columbia (Quayle 1969) and Taiwan (Chen 1976).

Bottom culture

The cultchless spat and some of the spat which set on oyster shells have been broadcast on the hard bottom in the Karapad creek and Korampallam canal and they have exhibited good growth. Wherever shallow coastal areas with a firm bottom are available, culture could be undertaken by this method on a large scale. The oysters grew to a mean size of 75 mm at the end of twelve months in bottom culture. This method of culture is widely employed in U.S.A and U.K.

Ren culture

In this method oyster shells with oyster spat are strung on a 3 mm thick synthetic rope, the ren. On each ren five to six oyster shells have been strung with interspaces of 15 cm. About 25-30 rens are suspended from a rack which is constructed by erecting six vertical casuarina poles of 3 m length at a distance of 2 m between them At a height of 2 m, two long casuarina poles 6 m in length are tied from which shell rens are suspended. The oysterlings are cultured on the rens for one year when they grow to an average size of 85 cm.

DISCUSSION

Keen interest is being evinced by some entrepreneurs in India in taking up oyster culture. Oyster resources are distributed at several places along the Indian coasts (Alagarswami and Narasimham 1973, Mahadevan 1987). This indicates that it may be possible to culture the shellfish if appropriate techniques are used. *Crassostrea madrasensis* is a rapidly growing oyster species attaining 80-90 mm length in one year and is thus highly suitable for farming. The technical know-how developed by the Central Marine Fisheries Research Institute in oyster farming techniques and possibilities for large scale production of oyster seed by hatchery techniques will be of immense help to enterpreneurs who wish to carry out oyster culture.

Oysters have to be cultured in unpolluted waters and depuration of oysters has to be carried out as they may accumulate pathogenic microorganisms in the course of filter feeding. The Central Marine Fisheries Research Institute has developed a simple method of depuration of oysters in which the oysters are first cleaned, hosed with a jet of seawater and they are kept in trays in running seawater in a tank for twenty four hours. In recent years seawater used in depuration is treated with chloride, ozone or ultraviolet light. Regular qualitative and quantitative bacteriological monitoring of oysters as well as oyster growing waters is essential for determining the safety of shellfish for human consumption.

The oysters may accumulate shellfish toxins as a result of feeding on toxin bearing dinoflagellates. A well known shellfish poisoning is paralytic shellfish poison (PSP) caused by the dinoflagellate *Gonyaulax* sp (Ray 1984). Monitoring shellfish toxicity and blooms of toxic dinoflagellates in oyster growing waters is necessary to ensure the safety of shellfish. The Central Marine Fisheries Research Institute is regularly monitoring the plankton in Tuticorin Bay where oyster culture is carried out for the occurrence of toxic dinoflagellates in plankton.

Except in a few coastal cities and towns the food value of oysters is not known in our country. For creating marketing possibilities three consignments of oyster meat each of one ton obtained by shucking oysters cultured by the Central Marine Fishheries Research Institute at Tuticorin were supplied to Integrated Fisheries Project, Cochin and the latter processed and canned the meat and marketed it in several cities in the country. The response to the trial marketing has been very good which indicates that there are marketing possibilities for the sea food if steady supplies could be ensured (Samuel et al 1982). Sale of oyster shells as raw material to Calcium carbide industry and for preparation of shell grit for use in poultry will yield additional income. Extension programmes such as publication and distribution of pamphlets and articles and screening of documentary films highlighting aspects on oyster culture and value of oysters as food have to be organized to promote oyster utilization and farming. In exhibitions held at A. I. R. Science Festivals, Tourist Fair and Farmers Fortnight Celebrations, exhibits relating

to various aspects of oyster resources and culture have been arranged and explained,

The Central Marine Fisheries Research Institute has recognized the importance of transfer of technology of mariculture of oysters and has organized oyster farming as part of Lab to Land programme of I. C. A. R. In this programme fifteen fishermen were given orientation training in oyster farming as well as infrastructure facilities. The fishermen carried out oyster culture successfully and produced 12 tons of oysters. This programme generated 323 man-days without affecting the regular avocation of the fishermen as they attended to oyster culture during their spare time.

Training programmes in oyster culture are being conducted by the Central Marine Fisheries Research Institute from time to time for the technical personnel from fisheries departments of maritime States, Fisheries corporations and Fisheries Colleges and other institutions to impart training in the technology of oyster culture and allied aspects.

An Ad-hoc Research Scheme is proposed to be taken up in Central Marine Fisheries Research Institute to survey the Indian coasts for identification of potential sites for oyster farming and experimental introduction of oyster culture in selective representative ecosystems for assessing their suitability and estimating the production potential. At present research is carried out in CMFRI to make innovations in culture techniques which will result in reduction of inputs. Breeding experiments are being conducted in hatchery to evolve oyster strains with desired qualities like more rapid growth and high meat content.

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51. DEVELOPMENT OF OYSTER CULTURE IN PULICAT LAKE AREA – PROSPECTS AND PROBLEMS*

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ABSTRACT

Pulicat lake is bestowed with rich natural oyster beds. There has not been any concerted effort at culturing oysters on scientific lines, probably because of lack of sustained demand and lucrative regular remuneration.

After a preliminary study of the oyster beds, a suitable location was selected for conducting experiments on oyster culture. Asbestos sheets were found to be by far the best cultch among the materials tried. Tray culture method proved to be appropriate for the area. The rate of production of oyster meat during the course of the study was 224.4 g/5 months/0.75 m^2 area. Incidental to the production of oysters, the trays were found to harbour a variety of fishes of prime quality adding to the production by 1.8 kg/5 months 0.75 m^2.

This study points to the possibility of developing a system of oyster-cum-fish culture' as a profitab'e proposition in the area. The suitability of the area for the venture is also discussed.

INTRODUCTION

In India no organised culture is being done worth its name (Durve 1974) except for the attempts made by Hornell (1910 b) to culture oysters in Pulicat Lake and the experimental work at Karapad creek oyster farm of Tuticorin centre of Central Marine Fisheries Research Institute, Tuticorin (Anon 1977) and in Mahim creek near Bombay. Also the efforts made by the Department of Fisheries, Government of Tamil Nadu at culturing oysters in Pulicat lake were sporadic and preliminary in nature. Devanesan and Chacko (1955) outlined the importance and possibility of culturing them in the area. Chidambaram and Dinamani (1951) made observations on spat fall and setting of *C. madrasensis.*

* Formed part of the thesis submitted to the Andhra University for the award of ph.D. degree.

RESULTS

Selection of site Ramakrishna and Ganapathy (1979) conducted a survey of natural oyster beds of the Pulicat Lake with a view to selecting a suitable site for conducting oyster culture experiments taking into account the nature of substratum, hydrographical conditions, water currents, spat setting and retentivity. Accordingly a site in the vicinity of Ice-plant at Pulicat village was selected for the purpose where the present experiments were carried out.

Selection of cultch material In this study, wooden planks, asbestos sheets and glass panels were used simultaneously with replicates of 8, 7 and 6 respectively during the spawning season The details of replicates, area of the cultch, number of spat on either side and the average number are shown in Table 1.

It is noticed that the spat have settled down on all asbestos sheets (100.0%) whereas only 4 out of 6 glass panels (66.7%) and 3 out of 8 wooden planks (37.5%) had spat settlement. Of the three cultch materials tried, the density of spat settlement on asbestos was 2.53/100cm² followed by wooden planks, 1.38/100cm² and glass panels, 1.02/100 cm² indicating the preference of spat to the asbestos sheets for attachment.

Positional influence of cultch on spat fall Only two positions namely one vertical and the other horizontal have been tried. The cultch used was asbestos sheets.

Asbestos sheets were placed vertically in the improvised slots in a dealwood box keeping the box along the tidal flow. The side facing the lake mouth was designated as 1st side and

TABLE 1. *Comparative statement of spat fall on different cultch materials between 28-12-1979 and 18 1-1980.*

Sheet No.	Asbestos sheets (Size: 45 x 30 cm)					Glass panels (Size: 50 x 26 cm)					Wooden planks (Side: 47 x 27 cm)				
	1st side		2nd side		Average	1st side		2nd side		Average	1st side		2nd side		Average
	T. No.	No. per 100cm²	T. No.	No. per 100cm²	No. per 100cm²	T. No	No. per 100cm²	T. No.	No. per 100cm²	No. per 100cm²	T No.	No. per 100cm²	T. No.	No per 100cm²	No. per 100cm²
I	43	3.2	25	1.9	2.6	24	1.85	—	—	0.93	—	—	—	—	—
II	18	1.3	12	0.9	1.1	—	—	—	—	—	—	—	—	—	—
III	59	4.4	18	1.3	2.9	16	1.23	8	0.62	0.93	35	2.76	11	0.87	1.81
IV	43	3.2	25	1.9	2.6	—	—	—	—	—	—	—	—	—	—
V	56	4.1	40	3.0	3.5	18	1.38	10	0.77	1.08	—	—	—	—	—
VI	39	2.9	20	1.5	2.2	18	1.38	12	0.92	1.15	21	1.84	6	0.52	1.18
VII	48	3.6	30	2.2	2.8						—	—	—	—	—
VIII											22	1.57	10	0.71	1.14
Av. No./ 100 cm² per side		3.24		1.81	2.53		1.46		0.58	1.02		2.06		0.70	1.38
Average number/100 cm² of cultch :					2.53					1.02					1.38

Note: 1st side is the side facing the lake mouth and the 2nd side is the opposite side of the 1st side.

TABLE 2. *Positional influence of cultch : Density of spat on vertically positioned asbestos sheets (Average number per 100 cm² area of cultch)*

Expt. No.	Date	Asbestos sheet		Average number of spat		Average number of spat/100 cm²
		No.	Size (cm)	1st side	2nd side	
1	15-12-'75	8	55.0 x 25.0	7.70	2.40	5.10
2	15-10-'77	3	60.0 x 30.0	3.03	0.37	1.70
3	11- 1-'78	3	60.0 x 30.0	3.90	1.40	2.70
4	14-12-'78	5	45.5 x 40.5	5.64	3.70	4.70
5	18- 1-'80	7	45.0 x 30.0	3.24	1.81	2.53
Average number per 100 cm² of cultch				4.70	1.94	3.35

* The side facing the lake mouth.

the other as 2nd side. The lake mouth remained open throughout the period of this study. A total of five experiments were conducted, details of which are shown in Table 2.

From the Table it is seen that the spat fall was heavy and varied from 5.1 to 3.03 no/100 cm² with an average of 4.70 no/100 cm² on the lake side. On the other side it varied from 0.37 to 3 7 no/100 cm² with an average of 1.94/100 cm². On the whole, inclusive of both sides the average number was 3.35 per 100 cm² It is clear that the area facing the lake mouth attracted more spat in all the experiments.

Asbestos sheets, two in numbers for each set, were horizontally tied to casuarina poles with nylon ropes in a tier fashion one above the other in such a way as to leave sufficient space for the flow of water in between. These sets were positioned inside dealwood boxes. Twelve such sets were prepared (Table-3).

From the table it is seen that out of 24 sheets 8 sheets (33.3%) were found with spat on lower surface while 3 sheets (8.5%) were found with spat on upper surface. The range of the number of spat per 100 cm² attached on lower surface was between 0.61 and 5.39 with an average of 1.38; while it was 0.06 to 0.39 on the upper surface with an average of 0.26. This indicated that the spat preferred lower surface for attachment.

TABLE 3. *Positional influence of cultch : Density of spat on horizontally positioned asbestos sheets (Average number per (100/cm² area of cultch)*

Set No.	Sheet No.	Number of Spat			
		Upper surface		Lower surface	
		Total	No./100cm²	Total	No/100cm²
I	1	—	—	—	—
	2	—	—	—	—
II	1	—	—	14	0 78
	2	6	0.33	24	1.33
III	1	—	—	11	0.61
	2	—	—	12	0.67
IV	1	—	—	—	—
	2	—	—	11	0.61
V	1	—	—	—	—
	2	7	0.39	17	0.94
VI	1	—	—	—	—
	2	—	—	12	0.67
VII	1	—	—	—	—
	2	1	0.06	97	5.39
VIII	1	—	—	—	—
	2	—	—	—	—
IX	1	—	—	—	—
	2	—	—	—	—
X	1	—	—	—	—
	2	—	—	—	—
XI	1	—	—	—	—
	2	—	—	—	—
XII	1	—	—	—	—
	2	—	—	—	—
Average number per 100cm²/side		0.26		1.38	

TABLE 4: *Spat settlement consequent to the Secondary in March-April 79*

Date	Cultch size (cm)	No. of spat both sides	No/ 100 cm^2	Height (mm)		Length (mm)	
				Range	Average	Range	Average
March'79	46x40	5.0	0.27	3-11	6.9	3-12	7.1
Apr. '79	,,	5 5	0.30	5-10	7.3	5-10	7.9
Average			0.29	3-11	7.1	3-12	7.5

Spawning and setting The spawning periods and setting of the spat were observed by studying the spat settlement on the cultch provided. It was found that the peak periods of spawning were between October and December when spat settlement was 4.7/100 cm^2 (Table 2). Secondary spawning was noticed during March-April and the spat settlement during this period was 0.29 no/100 cm^2 as shown in Table 4.

During the peak spawning season in October December (monsoon), the spat settlement noticed during the first half of the monsoon (.i.e) before the middle of November (1-9 no/ 100 cm^2) did not survive whereas the spat settlement seen subsequently during December survived and attained marketable size in due course of time.

Growth and survival of oysters To find out the rate of growth of the spat, those settled on asbestos sheets during the later half of the monsoon were studied till an average height of about 60.0 mm was reached within a period ranging from 4 to 7 months. In another experimen,t the spat from the asbestos sheets were removed and transferred to wooden trays after they attained an average size of about 40.0 mm in height and were cultured till they attained an average size of about 80.0 mm in about 3 to 5 months.

Three experiments were conducted on asbestos sheets commencing after the monsoon (Table 5). From the Table it is observed that the average height increase per month in these three experiments ranged from 6.8 to 7.7 mm and in length the range was from 5.1 to 6.6 mm with maximum increase in the first two months. In subsequent months the rate of growth slows down. The percentage of survival was poor in summer months (June : 73.5, May : 61.7, March : 56.5 and March : 60.0). The cumulative percentages of survival were 34.5, 23.8, 22.0 and 15.7 at the end of 7, 7, 4 and 6 months respectively. It has also been noticed that the oysters grown on asbestos sheets generally reached a height of about 30 to 35 mm in about three months and 40 to 50 mm in about 5 months. It is also clear that the growth in height and length are almost comparable till a height of 40 to 45 mm was reached from whence increase in height surpassed that of length resulting in oblong shape.

The results of the four experiments in wooden trays are shown in Table 6. The experience has been that the experiments initiated before monsoon have been vitiated due to severe monsoon resulting in heavy mortality.

The average increases in height and length ranged from 1.7 to 5.0 mm and 1.4 to 5.1 mm respectively. The growth have been generally slow and steady in almost all the months. The fall in the average size noticed during the course of the experiments No. II and IV might be due to the death of bigger specimens during summer period. Similarly during the third experiment, the fall in average height might be due to the death of larger specimes during monsoon. From the Table it is seen that the percentage of survival was poor in monsoon months when heavy mortality occurred. Summer

TABLE 5. *Growth of oysters grown on asbestos sheets.*

Date	Total number on both sides	Height (mm) Range	Height (mm) Average	Length (mm) Range	Length (mm) Average
Experiment I					
15.12.75	139	7-10	8 0	7-9	7.5
23. 3.76	88	28-67	47.3	23-83	47.5
19. 5.76	68	37-85	57.4	35-72	48.4
25. 6.76	50	40-82	59.7	35-68	51.1
16. 7.76	48	45-85	61.6	35-68	53.8
Experiment II					
17.1.77	80	2-12	6.8	3-10	6.3
16.2.77	68	10-30	17.6	10-25	13.6
29.3.77	56	18-65	36.2	20-62	35 6
19 4.77	47	18-70	39 7	20 66	39.3
16.5.77	29	25-60	48 1	25-60	42.8
16.6.77	24	30-70	48.7	25-60	41 1
18.7.77	21	35-80	52.5	30-60	44.5
7.8.77	19	40-75	58.3	40-65	48.7
Experiment III					
14.12.78	172	2-5	2.5	2-4	2.2
17. 2.79	100	15-47	30.9	15-48	33 1
14. 3.79	60	15-60	31.9	15-56	33.2
18.4.79	52	30-58	37.9	25 55	39 6
16.5.79	45	30-60	43.4	30-62	43.5
14.6.79	27	30-60	4ε.3	30-51	40.5

TABLE 6 *Growth of oysters grown in wooden trays*

Date	Total number per tray	Height (mm) Range	Height (mm) Average	length (mm) Range	length (mm) Average
Experiment I					
28.4 76	50	27-80	45.9	25-60	38.6
19.5.76	40	32-89	50.2	30-75	43.8
25.6.76	28	40-92	60.1	35-86	49.7
16.7.76	22	45-95	65.1	32-70	50.7
14.9.76	19	60-105	67.3	48-92	64.3
Experiment II					
17.1.77	50	35-80	58.7	30-90	57.2
16.2 77	32	35-98	61.5	30-65	48.4
29.3.77	24	50-98	80.2	35-80	65.8
19.4.77	16	60-105	78.0	38-89	56.4
16.5 77	13	60-110	78.5	48-90	62.9
Experiment III					
15.10.77	150	40-85	61.7	40-80	51.9
16.11.77	120	50-100	67.2	32-75	51.8
14.12.77	80	45-100	66.0	35-75	50.0
11.1.78	46	48-100	66.9	37-75	51.8
Experiment IV					
15.2.78	68	30-105	62.0	30-95	52.0
15.3.78	50	35-105	65.0	35-82	57.5
18.4.78	40	52-88	70.0	33-68	49.0
11.5.78	29	45-99	59.3	35-74	44.4
14.6.78	24	45-89	62.5	39-75	51.9
18.7.78	19	60-105	80.2	45-80	63.7

months also experienced poor survival (66.7% and 70.0% experiments II and I respectively). The cumulative percentage of survival at the end of 5, 4, 3 and 5 months in experiments I to IV are 38.0, 26.0, 30.7 and 27 9 respectively.

Oyster culture Of the several methods like stick culture. bottom culture, longline culture, raft culture and tray culture the last mentioned two culture methods have been tried in the present work

The raft culture technique was found unsuitable since the growing oysters dropped to the bottom as the galvanised wires were broken due to rusting and the nylon ropes damaged by crabs.

The tray culture was found suitable in the area. Wooden trays of 60x40x10 cm size with 7 to 8 reapers of 5 cm width fixed at the bottom of the trays were arranged in a suitable box one above the other The oysters have been reared in these trays/boxes in the Pulicat Lake.

The selected cultch (asbestos sheets) were kept in vertical position in the boxes during September, about a month before spawning and setting of spat took place. At the end of December, spat measured about 5 to 10 mm in size. They reached an average height of 30 to 35 mm by the end of March/April and are designated as 'Oysterlings'. When these oysterlings reached a height of 40-50 mm on an average in about 5 to 6 months i. e. by May/June, these were removed carefully with the help of a chisel and were transferred to the wooden trays of the size mentioned earlier. The removal of oysterlings from the cultch may inflict some damage to them to the tune of about 15 to 20%.

The number per tray was maintained at around 50. Five such trays with oysterlings were stacked in each dealwood box and these were arranged one above the other in line with the tidal flow of water. These boxes were periodically cleaned of the silt and macrophytes which were brought down by the floods and tides. While cleaning the trays and boxes the associated fish, crabs and prawns were collected and recorded.

Oysterlings in trays reached an average height of 80.0 mm after a period of 2 to 2½ years with an average meat weight of 6.8 g/oyster. The production of marketable size oysters worked out to 224.4 g/5 months/0.75 m^2 at 33.0% survival level (Table 6). Since these boxes were kept in the open lake, fishes, crabs and prawns entered into these boxes. The harvested figures for these associates worked out to be about 4.3kg/0.75 m^2. Fishes included perches, catfishes eels and gobids and accounted for 3.36 kg followed by crabs, 0.89 kg and prawns. Among the fishes, perches accounted for 2.67 kg.

Experiments conducted to find out the positional influence of the cultch on the intensity of spat-fall reveal that the under surfaces of the horizontally positioned cultch attract more spat. This is in agreement with the results obtained by Hopkins (1935) Similar observations were made by Schaefer (1937) who attributed the setting behaviour of *C. gigas* to the upward position of the foot of the swimming larvae and also possibly due to negative geotaxis. The same may be true in the case of this species also.

The delineated spawning seasons of this oyster in Pulicat lake especially of the heavy spawning during October-December period coincide with those of the same species at Ennore and Adyar (Hornell 1010a; Devanesan and Chacko 1955 and Rao and Nayar 1956)

Of the methods tried in this study, tray method of culturing oysters at mid-water level has been found to be suitable for Pulicat Lake.

Observations on the oysters cultured on asbestos sheets and in wooden trays revealed that the latter is better. Although the growth in the former was slightly slow, in the percentage of survival was better in the latter. In general heavy mortalities of oysters observed during monsoon might be due to sudden lowering of salinity, water temperature and heavy load of silt which were the result of influx of rain water from the catchment area during north east monsoon.

Harvesting of oysters during pre-monsoon has been found to be ideal since they reach marketable size and are in best condition.

The average meat weight of 6 8g/oyster at harvestable size obtained in this study is less than the 10 g obtained at Karapad (Anon 1977). The results obtained in this study indicate the possibility of taking up oyster culture in the Pulicat lake. The advantages for taking up oyster culture in the pulicat lake are the existence of natural oyster beds in the lake, the perennial communication of the lake with the sea, the natural spawning and settlement of spat inside the lake, availability of several hactares of land suitable for oyster culture in lake, the easy accessability by road and the proximity Madras to City which facilitate marketing.

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52. ON SOME EXPERIMENTS ON THE PEARL OYSTER, *PINCTADA MARGARITIFERA* (LINNAEUS) FROM ANDAMANS

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INTRODUCTION

During the course of a general survey of various organisms such as mussels, oysters and sea cucumbers around Port Blair (Andamans) in 1975-'78 the author came across a bed of pearl oysters belonging to the species *Pinctada margaritifera* on the Blair Reef near Port Blair. This species has been reported from the Andamans by Prashad and Bhaduri (1933), Rao (1970) and Rao (1974). Recently Alagarswami (1983) reported on the resource of *P. margaritifera* and its potential for pearl culture in Andaman and Nicobar Islands.

Pinctada margaritifera is the most common species in Andaman and Nicobar Islands. It chiefly occurs in the intertidal region from the mid-littoral zone and beyond to a depth of 10 m They are found attached to dead coral stones On the Blair reef in an area of 100 square metres 20-25 oysters varying in length from 20 to 120mm were found.

MATERIAL AND METHODS

The oysters collected were kept alive in nylon net bags (Fig. 1) beyond the low water mark. No rafts were used they being costly to instal and difficult to maintain. The net bags used are of the usual type with a handle. They are 600 mm long with a mesh size of 20 mm. In each bag four or five oysters depending on the size are arranged in a single row without stretching the bags wide Between two oysters a rubber band is put to keep them in the same place. Four or five such bags are tied together near the handle with a nylon rope to which a weight is attached to serve as an anchor. A suitable rock crevice is selected beyond the low water mark and the nylon net bags are kept concealed inside the crevice. A number of

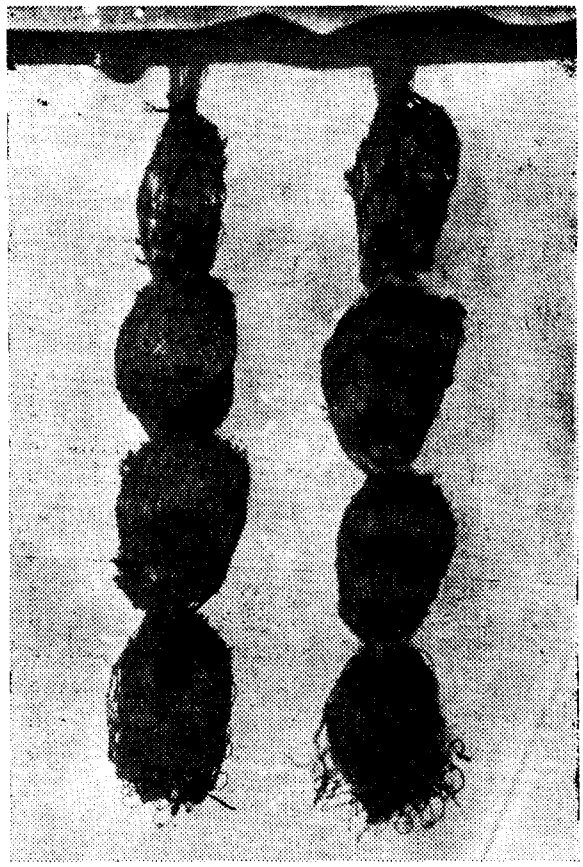

Fig. 1. Pearl oysters suspended from nylon net bags

oysters were kept in net bags from August 1977 onwards and they were regularly watched every week. About 30% of the specimens examined had a commensal shrimp. In some specimens two or even three shrimps were found to live at the same time.

EXPERIMENTS

Two methods were tried to produce culture pearls by using ordinary pierced plastic beads which are sold in the market and used for necklaces etc. They were 3 mm in diameter. Besides using the mantle grafts other methods

were also tried and the results of the experiments are presented below.

In the first method plastic beads were pasted inside the shells, by quickfix. The live oysters when kept out of water in a tray, slightly open their valves. A small wooden peg is introduced between the valves like a wedge. When the mantle is touched with needle it withdraws slowly exposing a wide area of the inner surface of the shell. The moisture on shell is removed with the help of a blotting paper and the beads were pasted at different levels right from the edge of the shell to the base of the aductor muscles. After pasting the beads, the oysters are kept outside for about half an hour for firm setting. Subsequently they are put back into the net bags and returned to the sea. The beads were found to attach well to the shell. The mantle constantly moves over the beads and secretes the nacreous substance over them. After a period of three months it has been found that the whole bead was covered with a thin layer of nacre. The coating, however, was thin and extremely fragile.

In the second method some mantle graft operations were performed as described by Alagarswami (1970) to induce pearl formation. The oysters were first narcotised and arranged on a tray before operation Fig. 2. On 1-1-78, twelve oysters were operated. During the post operative period three of them died. Again on 12-12-'78, sixteen oysters were operated. Of these four died during the post operative period. The two lots of oysters were deposited at different places and regularly watched After one month the first lot of oysters operated on 1-1-78 were lost presumably removed by some one. It may be mentioned here that the Nicobaris regularly collect the pearl oysters for eating. The second lot was immediately shifted to a more secure place. Four more oysters died during the course of observation leaving only eight oysters. These were opened on 26-4-78 after 75 days. Three nuclei were recovered from the oysters. One of them was found to be partially coated with nacreous substance. Another was found to be coated with chalk-like material and the third one had no coating at all.

Fig. 2. Pearl oysters arranged in a tray before operation

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53. ON SOME EXPERIMENTS ON PEARL PRODUCTION AT OKHA AND SIKKA IN THE GULF OF KUTCH

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ABSTRACT

Considerable progress has been made since 1956 in the field of pearl culture by the Gujarat State Fisheries Department at Okha and Sikka in the Gulf of Kutch. Earlier attempts on pearl production did not yield desired results. Refinement in this field was achieved on receiving the technology on pearl culture perfected by the Central Marine Fisheries Research Institute. Of the various materials tested as nuclei, the Japanese nuclei was found to give quality pearls The pearls produced by agate beads, though reflected the colour of beads, experienced problem in uniform drilling while making strings. Analysis of structure of pearl by X-ray method revealed no distinction between the core material and nacre coating. Use of artery forceps and electroacutry in sealing the site of incision was tested. Straining of nucleus and pearls were attempted.

INTRODUCTION

Gulf of Kutch is one of the areas in India where the pearl oyster (*Pinctada fucata*) is available in the intertidal zone extending upto 5 km from coastaline. Based on the pearl oyster resources the work was initiated to produce cultured pearls since 1956. Hornell (1909) laid foundation for the work by establishing a pearl oyster farm with stone enclosures near Sikka Easwaran (1972) reported that a pearl was produced in Sikka Station. In the subsequent years several attempts were made to produce cultured pearls using different materials as nucleus (Desai et al 1977; Pathak et al 1981 and Anon 1983). This paper reviews the earlier attempts on pearl production and the latest techniques developed in various aspects of pearl production both in *P. fucata* and freshwater mussel.

MATERIAL AND METHODS

Before nucleus implantation, *P. fucata* brought from the pool owned by Gujarat State Electricity Board were conditioned for 12 h. The pearl culture techniques perfected at the Tuticorin Research Centre of Central Marine Fisheries Research Institute were followed here (Alagarswami and Dharmaraj 1984). Different sizes of surgical artery forceps were procured for the experiments in sealing the incision after nucleus implantation. The lips of incision was held together by the artery forceps till the incision was closed. A mild electric shock was given to incision in order to coagulate the muscles at the site by means of electrocautry. The battery used for the purpose has 3-6 volts of current.

The plastic experimented here were blue, purple, green and yellow in colour having the diameter of 2-3 mm The agate and akik beads were obtained from M/s. Mutual Industrial Corporation, Sabli Pole, Cambay 388,620, Gujarat State. The colour of the beads were grey, green jet, amethis, blue jet, carmellian, rose quartz, blood stone and light jet. The diameter of the beads varied from 4 to 6 mm.

The structure of pearl was examined by X-ray photography at the Civil Hospital, Ahmedabad and at District Health Centre, Jamnagar. Straining of nucleus and pearl was done in the medium containing 0.5 gm eosin, 20 ml of edible oil and 50 ml of obsolute alcohol. To ensure nucleus rejection by individual oyster the bottom of aquarium tank was partitioned into compartments.

The live freshwater mussels, the species of which not confirmed, were collected from the down streams of Sinhan River, 33 km away from Sikka on Jamnagar-Sikka highway and from the water logging areas around Lingda fish farm, 19 km away from Nadiad near

Ahmedabad. The size of mussels was 90-99 mm in length and 45-50 mm in breadth. They were transported in wet gunny bag by road and kept in natural environment near Sikka. 50 mussels of the batch were implanted with 2 mm Japanese nucleus. The surgical instruments meant for pearl oyster surgery work were used here except the oyster clamp. Instead of oyster clamp a wooden box was prepared for holding mussels during operation. The mussels were implanted fresh without narcoticing.

RESUME OF EARLIER WORKS ON PEARL PRODUCTION IN GULF OF KUTCH

Experiments on pearl prodction in *P. fucata* were commenced in 1956 by implanting 60 pearl oysters with imported nuclei. The technique employed at that time during the operation was to drill a hole from outer side of the shell just to reach the mantle and place nucles in the hole and seal it. The portion of nucleus touching mantle was found to have received a thin coating of nacre (Pandya 1974). During 1972, various materials like plaster of paris, glass beads, freshwater mussel bead and plastic bead were tried as nuclei in a few oysters. Of these materials the freshwater mussel bead received a partial coating of nacre. According to Easwaran (1972) out of 200 oysters operated an oyster yielded a pearl. Desai et al (1977) reported that preliminary work on implantation was done during January 1975 using Japanese nuclei, which they found at that time, was not suitable for pearl production in *P. fucata*.

EXPERIMENTS ON PEARL PRODUCTION AT OKHA AND SIKKA

According to Pathak et al (1981) nucleus implanatation in *P. fucata* at Okha during February 1979 yielded 172 free spherical pearls. Of this 115 were single pearls 38 twin, 2 triplet and 17 plastic pearls. The colour of pearls by Japanese nuclei were silver white, ivory and golden yellow. The pearls produced by plastic beads were not as good as the pearls of Japanese nuclei. In another set of experiment 6 plastic pearls, 6 twin pearls and 2 triplet pearls were produced.

The results of nucleus implantation carried out at Sikka from the year 1979-80 to 1984-85 were reported by Anon (1983) (Table 1). Jani (1981) gave his results of nuclei implantation done during the year 1979-80, 80-81 and 81-82. According to him percentage of pearl formation was 24.8%, 30.5% and 21.9% in the respective years. The mortality was found to increase 17.9%, 28.1% and 43.6% whereas the percentage of nucleus rejection decreased form 43.3% to 23.9% The colour of pearls produced here at Sikka was similiar to that of pearls at Okha.

TABLE 1. *Results of nucleus implantation as reported by Anon (1983).*

Year	Pearl No. of oysters operated	No. of nuclei implanted	No. of pearls harvested
1979-80	507	1027	255
1980 81	442	799	244
1981 82	1412	2593	569
1982-83	982	1507	314
1983-84	3809	8178	1715
1984-85	745	863	98

IMPROVEMENTS IN POST-OPERATIVE CULTURE

Some improvements were made during post-operative culture by keeping individual oyster in a compartment made at the bottom of tank to ensure nucleus rejection. Farm rearing of seeded oysters was done in cages covered with velon screen to prevent the loss of pearl and nucleus.

STAINING OF NUCLEUS AND PEARL

Japanese nuclei were stained in the medium prepared by dissolving 0.5 gm eosin 20 ml edible oil and 50 ml absolute alchohol (modified after Cahn 1949). The pearls obtained from these nuclei were pink in colour. In the same way cultured pearls were also strained at different durations namely 12 h, 24 h, 36 h upto 72 h. Depending upon the duration the pearls were stained light pink to dark pink colour.

USE OF COLOUR PLASTIC BEADS AND AGATE/AKIK BEADS IN PEARL PRODUCTION

Plastic beads of different colours namely blue, purple, green, yellow were used as nuclei. A total of 181 *P. fucata* were implanted with 253 plastic beads. 13 numbers of plastic pearls were recovered which reflected the colour of beads. The quality of these pearls were not comparable to the pearls of shell bead nucleus. The study indicated 5.1% of pearl production, 70.2% mortality and 20.2% nucleus rejection.

The use of agate or akik beads were tested in pearl production during the year 1981-82 and 82-83. The source of availability of these beads was already mentioned elsewhere in the text. The beads resulted in 38.2% of pearl formation with a mortality of 24.3% and 21.9% nucleus rejection. The pearls obtained by these beads were lustrous in nature and reflected the colour of beads.

USE OF ARTERY FORCEPS AND ELECTROCAUTRY IN NUCLEUS REJECTION

A new device was employed in sealing the incision point after nucleus implantation. An artery forceps was used to hold the lips of incision together. This facilitated the closure of incision thus preventing the slipping of nucleus. A method of electrocautry was also employed to coagulate the muscles at the site of incision after nucleus implantation. It gives a mild electric shock of 3-6 volts. The oysters treated with electrocautry showed no rejection of nucleus both in the laboratory and farm.

X-RAY PHOTOGRAPHY OF CULTURED PEARLS

An attempt was made to examine the structure of cultured pearls by means of X-ray photography. The study showed no distinction between the core material and nacre coating.

PEARL PRODUCTION IN FRESHWATER MUSSEL

A total of 50 freshwater mussels were implanted, each with 2mm size Japanese nucleus. Two white pinkish colour pearls were produced after 177 days of culture. It indicated only 4% pearl production; mortality of seeded mussels was as high as 88%.

DISCUSSION

Experimental pearl production started in the year 1956 in the Gulf of Kutch which was considered to be the second important place in India with respect to the availability of pearl oyster resources. Panda (1974) reported that by adopting an old method of drilling the shell of a live oyster from outside and keeping the nucleus in touch with the mantle inside and finally sealing the hole, a thin coating of nacre was noticed on a portion of nucleus during 1956. Desai et al (1977) expressed that no pearl was produced due to high mortality of seeded oysters. Till then the progress was rather slow. By this time the Central Marine Fisheries Research Institute developed the technology of pearl production and imparted the technique to personnel of different maritime states through training courses. The active participation of Gujarat State Fisheries Department in acquiring the technology resulted in the production of more pearls. According to Pathak et al (1981) a total 58 pearls were produced, of which 39 pearls were by Japanese nuclei, 7 by 'Patharia moti' and 12 by plastic beads during the year 1979-80 and the production rate obtained was 21.4% 38.9% and 60.0% respectively. Anon (1983) reported that 3195 pearls were harvested between 1978-80 and 1984-85 with a maximum of 30.5% production during 1980-81.

Experimentation of various materials as nuclei revealed their suitability in pearl production. Though the coloured pearls produced by agate beads have reflected the colour of nucleus, the problem of drilling the pearls was experienced. The use of plastic beads as neclei resulted in poor quality pearls. The results indicated that the Japanese nuclei are more suitable for pearl production. Similarly the suitability of indegenously made chank beads in pearl production was reported by Alagarswami (1987).

The study on the structure of pearl through X-ray might be usefull to assess the size of

pearl *in situ* in the seeded oysters and accordingly by noting initial size of nucleus the schedule time for harvesting of pearl might be fixed.

A method of sealing the site of incision by artery forceps and electrocautry has decreased the percentage of rejection of nucleus from 43.3% to 23.7%. But it has increased the mortality rate considerably from 17.9 to 43.6% during the years 1979-80, 80-81 and 81-82. The percentage pearl production was 24.8, 30.5 and 21.9 in the respective years. It clearly indicated that the method is effective in the retension of nucleus rather than the production of pearl and mortality.

A pearl was produced in freshwater mussel by Tamil Nadu Fisheries Department at Tuticorin and the mortality reported here was 30% (Nazarene and Dev/1984). Freshwater pearl production was attempted in Bangladesh using eyeball of small fishes and a piece of mantle as core material. The data showed 90% mortality (Masud Ahmed 1982). In the present study a pearl produced out of 50 freshwater mussels operated. The percentage of mortality was 80%. Japanese nucleus was used for this work.

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54. ON SOME ASPECTS OF TRANSPORTATION OF SEED OF PEARL OYSTER *PINCTADA FUCATA* (GOULD)

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ABSTRACT

The object of mass production of pearl oyster seed in the hatchery at Tuticorin Research Centre of Central Marine Fisheries Research Institute (CMFRI) is to ensure adequate supply of seed needed by the culture indutry and also to meet the demands of the future requirement of different maritime states and other establishments. To ensure adequate supply of healthy seeds, experiments were conducted to perfect the technique of transport of seed oysters. The paper highlights some significant results which will facilitate transport of pearl oyster seed over long distances.

INTRODUCTION

Seed oysters produced at Miyagi and Kumamoto Prefectures in Japan are exported to Hong Kong and North America in ships (Imai 1971). History shows that oysters were introduced to new environs when there was total mortality and destruction of the local species due to epidemics. Chidambaram in 1950 had attempted transportation of pearl oyster by air from Persian Gulf and introduced them to the Tuticorin oyster beds and Krusadai farm, Gulf of Mannar (Devanesen and Chacko 1958). In Japan, the pearl oysters are taken in large vessels from place where the conditions are unfavourable to places where suitable environmental conditions exist (Alagarswami 1970).

Vast fluctuations exist in the production of pearl oyster in the pearl oyster beds of the Gulf of Mannar (Alagarswami et. al 1987) and hence dependance on the natural population for the commercial pearl culture operations becomes a nonguaranteed venture. By the recent success in the production of pearl oyster (Alagarswami et. al 1983), required quantity of pearl oyster seed can be produced by hatchery method. To ascertain the suitability of the spat for tranpsorting them to the culture sites, cheapest and efficient means of transportation methods are to be evolved and hence these experiments.

MATERIAL AND METHODS

Hatchery produced pearl oyster spat belonging to different batches were reared in the farm at Tuticorin Harbour. The spat of different size groups were taken for the experiment from the above batches. They were divided into 5 mm size groups, viz 5-10, 10-15 and so on upto 35-40 mm. Prior to the experiment, the spat were conditioned for 24 h in the laboratory by keeping them in filtered seawater under aeration, No food was supplied to the spat during conditioning.

Tolerance limit of the spat in room condition, controlled temperature condition and refrigerated condition are found out. For this, each group was arranged separately in trays. The time of exposure to various conditions varied from 3 to 24 h in the size groups 20-25 mm, 25-30 mm, 30-35 mm and 35-40 mm. The experiment commenced at 10.00 h and continued upto the the next day. The room temperature was recorded regularly. After the stipulated time, 10 spat from each size group were removed and placed in filtered and well aerated seawater in tanks. survival rate of spat was estimated at the end of 24 h of immersion in water.

The survival rate of the different size groups of the spat in wet condition was also studied. The experiment was conducted in room temperature. The gunny bag, prior to the experiment was washed thoroughly in fresh water and finally soaked in seawater. The gunny bag was spread inside a plastic basin of 50 cm dia and the spat were placed over it, covered by another piece of gunny bag. To keep the spat in wet condition, seawater was sprinkled over

it as and when required. Care was taken not to accumulate seawater at the bottom of the basin. The time for this experiment varied from 5 to 25 h in the size groups 5-10, 10-15 and 15-20 mm and from 10 to 35 h in the other size groups (20-25, 25-30, 30 35 and 35-40 mm). At 5 h interval, 10 spat from the size groups 5-10, 10-15 15-20 mm and 25 spat from 20-25, 25-30, 30-35 and 35-40 mm size groups were removed and put in filtered and aerated seawater to find out their survival. The room temperature was recorded at every two hours.

Seaweeds, in the place of gunny bags, were used in another experiment. The seaweeds collected freshly were washed well in seawater before use. Seawater was sprinkled to keep them moist throughout the experiment. The results were recorded.

The time limit to which the spat of the size groups 5-10, 10-15 and 15-20 mm remain in a limited quantity of water was determined. 50 spat in each size group were placed separately in polythene bags of 55x30 cm size which contained 1 l of filtered seawater. Tne bags were tied on both ends. These bags with the spat were kept in the room away from light. The duration of the experiment ranged from 12 to 72 h. The dissolved O_2, pH, salinity and temperature of the water were recorded prior to and after the experiment. The bags with the spat were removed at the intervals of 12 h, 24 h, 36 h etc. upto 72 h of immersion. The survival rate of these spat was determined as in the earlier cases.

In order to find out the effect of oxygenation in spat survival under packed condition, a similar experiment as in the previous one was conducted. Oxygen was filled to the capacity of the polythene bag The duration of the experiment was from 24 to 108 h. The bags were lifted at the interval of 24 h upto 72 h, 12h upto 84 h and 6 h upto 108 h The resuts were recorded.

The optimum number of spat that can be transported safely in a known quantity of water was tried in another experiment. The size groups of spat experimented were 10-15, 15-20, 25-30 and 30-35 mm. In 10-15 mm size group, 500 spat were kept in 2.5 l of water and 1000 spat in 5 l. The experiment was terminated after 122h. 250 spat (15-20 mm) were kept in 2.5 l of water and 750 in 5 l and were dismantled after 99.5 h. 250 spat (25-30 mm) and 500 spat of the same group were kept in 2.5 l and 5.0 l of water respectively, the former was terminated after 66 h and the latter after 75.55 h. 100 spat and 200 spat of the 30-35 mm group were kept in 2.5 l and 5 l respectively and were removed after 72 h and 96 h. The survival of the spat was estimated after 24 h of immersion in normal seawater under aeration. The water used for the experiment was analysed for its hydrological parameters prior to and after the experiment.

RESULTS

Exposure to room temperature

Fifty per cent mortality occurred in spat of the size group 5-10 mm between 15 and 18 h. In 18 h exposure, this group suffered 80% mortality (Table 1). The tolerance limit for the size group 10-50 mm was 21 h. The size group 15-20 mm withstood 24 h exposure suffering only 10% mortality. During the experiment, the room temperature ranged from 26.7 to 30 5°C with an average of 28.4°C. The size groups 25-30, 30-35 and 35-40 mm survived 21 h of exposure beyond which heavy mortality exceeded 64% in the 20-25 mm group in 21 h which was quite abnormal when compared to the other groups During the second phase of experiment, the ambient temperature ranged from 27.2 to 32.3°C with an average of 29.2°C.

Exposure to controlled temperature conditions

The size group 5-10 mm showed mortality upto 80% whereas in the size group 10-15mm, it was 50% in 18 h of exposure. The larger size groups (15-20mm to 35-40 mm) withstood exposure for 24 h causing negligible mortality. In the size group 20-25mm, 29.2% mortality was seen which seemed abnormal (Table 2). The range in temperature when the 5-10 and 10-15 mm group experimented was from 24.0 to 27.6 °C (average 25.2 °C) and when the higher size groups were experimented, it was from 19.0 to 24.9°C (average 22.6°C).

TABLE 1. *Percentage mortality of spat - exposure to air at room temperature*

Size group (mm)	Exposure (h) 9	12	15	18	21	24
5-10*	11.1	20.0	25.0	80.0		
10-15*	—	10.0	20.0	30.0	50.0	70 0
15-20*	—	—	—	—	10.0	10.0
20-25@	—	—	—	20.00	64.0	83 0
25-30@	—	—	—	—	4.2	37.5
30-35@	—	—	—	—	10.0	66.7
35-40@	—	—	—	—	5.0	52.6

* : Temperature range : 26.7 - 30.5°C (Average 28.4°C)
@ : Temperature range : 27.2 - 32.3°C (Average 29.2°C)

TABLE 2. *Precentage mortality of spat - exposure to air at controlled temperature condition*

Size group (mm)	Exposure (h) 9	12	15	18	21	24
5-10*	10.00	20.00	20.00	80.00	—	—
10-25*	—	—	44.4	50.0	—	—
15-20*	—	—	—	—	—	Nil
20-25@	—	—	—	—	—	29.2
25-30@	—	—	—	—	—	4.4
30-35@	—	—	—	—	—	11.1
35-40@	—	—	—	—	—	Nil

* : Temperature range : 24.0 - 27.6°C (Average 25.2°C)
@ : Temperature range : 19.0 - 24.9°C (Average 22.6°C)

TABLE 3. *Precentage mortality of spat—gunny bag soaked in seawater.*

Size range (mm)	Exposure (h) 10	15	20	25	30	35
5-10*	—	—	—	11.1	No	No
10-15*	—	—	—	10.0	No	No
15-20*	—	—	—	—	No	No
20-25@	—	—	12.0	84.0	92.3	96.3
25-30@	—	—	12.0	13.3	79.0	84.2
30-35@	—	—	—	30.0	100.0	100.0
35-40@	—	—	—	66.7	73.3	80.0

* : Temperature range 26.3 - 28.3°C (Avdrage 27.1°C)
@ : Temperature range 29.0 - 30.6°C (Average 29.9°C)
No Not Observed

TABLE 4. *Percentage mortality of spat - seaweed soaked in seawater*

Size range (mm)	Exposure (h) 10	15	20	25	30	35
5-10*	—	—	10.0	8.3	No	No
10-15*	—	—	—	10.0	No	No
15-20*	—	—	—	—	No	No
20-25@	—	4.6	15.4	85.7	100.0	100.0
25 30@	—	—	—	35.0	90.9	95.7
30-35@	—	—	—	16.7	50.0	75.0
35-40@	—	—	33.3	25.3	50.0	58.8

* : Temperature range : 28.4 - 30.0°C Average 29.1°C)
@ : Temperature range : 25.9 - 28.5°C (Average 26.7°C)
No Not Observed

TABLE 5. *Percentage mortality of spat - 50 spat in 1 litre seawater*

Size range (mm)	Exposure (h) 36	42	48	54	60	66	72	Final pH
5-10	—	—	—	—	—	—	6.4	7.54
10-15	2.0	—	—	26.0	100.0	—	—	7.34
15-20	4.2	92.0	100.0	—	—	—	—	6.88

Mean temperature : I day : 28.2°C
II day : 28.3°C
III day . 27.9°C
Initial pH of the medium : 8.0

TABLE 6. *Percentage mortality of spat - 50 spat in 1 litre seawater with oxygen*

Size range (mm)	Exposure (h) 24	48	72	84	90	96	102	108
5-10	—	—	2.0	4.0	—	—	—	—
10 15	—	2.0	—	2.0	—	—	4.0	—
15-20	—	2.0	—	2.0	—	—	4.0	—

Mean temperature of the days : 28.9°C, 28.5°C, 28.8°, 29.0°C, 28.7°C

Tolerance limit in refrigerated condition

The size groups 20-25, 25-30, 30-35 and 35-40 mm subjected for refrigerated condition resulted in heavy mortality ranging from 62 to 100%, even in 6 h of exposure. The temperature varied from 7 to 20°C (average 15.3°C)

Survival of spat in wet condition

The spat kept covered in wet gunny bag tolerated exposure to a maximum of 24 h wherein only 10% to 11% mortality could be seen in the size groups 5-10 and 10-15 mm. No mortality occurred in 15-20 mm group during the period. The ambient temperature ranged between 26.3 to 28.8°C with an average of 27.1°C during the experiment. In the larger size groups higher rates of mortality occurred between 25-30 h (Table 3).

When the seaweeds were used in the place of wet gunny the mortality was negligible for the spat of the size groups 5-10, 10-15 and 15-20 mm upto a period of 25 h. In the size groups 20-25, 25-30, 30-35 and 35-40 mm, substantial mortality was observed in 30 h. The temperature range was from 28.4 to 30.0°C (average 29.1 °C) when the size groups 5-20mm were experimented and 25.9 to 28.5°C (average 26.7°C) when the size groups 20-40 mm were experimented (Table 4).

Survival of spat in aqueous condition

The smaller size group (5-10 mm) survived with negligible mortality of 6.4% in 72 h. 100% mortality occurred for the size group 10-15 mm in 60 h whereas it was 92% in 42 h in the 15-20 mm size group (Table 5). From the initial pH of 8.0, it had gone down to 7.54 for the 5-10 mm size group, 7.34 for the 10-15 mm size group and 6.85 for the 15-20 mm size groups in a period of 72 h. The average temperature for the first through third day was 28.2, 28.3 and 27.9°C respectively (Table 5).

Under the influence of oxygen, the spat of the size groups 5-10, 10-15 and 15-20 mm could withstand very well for a period of 108 h till the observation was made (Table 6). The pH of the water at the end was 7.65, 7.50 and 7.50 in the three size groups from the initial value of 7.95. The dissolved oxygen was 3.6 ml/l in the smaller size group and it came down to 1.35 and 1.92 ml/l for the immediate larger size groups. The initial oxygen content of the water was 3.6 ml/l. The temperature of the experimental water increased to 31.2°C, 31.8°C and 29.4°C from the initial temperature of 27.0°C. The averages of the atmospheric temperature during the period of experiment (108 h) ranged from 28.5 to 29°C.

Spat density vs volume of water

The size group 10-15 mm at a density of 500 spat in 2.5 l of water showed no mortality upto 122 h of immersion whereas at a density of 1000 in 5 l of water, a mortality of 37.5% had occurred. The pH in this experiment decreased from 8.2 to 7.91 in the first case and 6 74 in the second one and the dissolved oxygen from 3.60 to 3.39 ml/l and 2 88ml/l in the above two densities.

The size group 15-20 mm in a density of 250 spat in 2.5 l of water suffered 28.8% mortality in 99.5 h. In the size group 25-30mm a negligible mortality (0.8 and 1.0%) in concentrations of 250 and 500 spat in 5 l of water in a period of 68 h and 75.5 h had occurred. In size group 30-35 mm, 100 spat in 2.5l of water and 200 spat in 5 l of water kept for 72 h and 96 h gave similar rates of mortality (Table 7).

DISCUSSION

Chidambaram in his experiments at the Krusadai farm, found that pearl oyster can remain out of water for 36 h. He had succeeded in keeping *Pinctada margaritifiera* out of water for 60 h at Bahrain. The air-lifting of different sizes of 600 *P. margaritifera* from Bahrain to Tiruchirappally in 16 h 45 m was accomplished by him in 1950 (Devanesen and Chacko 1958). According to him, the mortality

TABLE 7. *Spat survival vs volume of water and oxygen*

Size range (mm)	No of spat	Quantity of water (l)	pH final	Oxygen (ml/l) final	Observation time (h)	Mortality %
10-15	500	2.5	7.91	3.39	122.0	Nil
10-15	1000	5.0	6.74	2.88	122.0	37.5
15-20	250	2.5	6.81	3 95	99.30	28.8
25-30	250	5.0	6.83	1.13	66.0	0.8
25-30	500	5.0	6.82	—	75.30	1.0
30-35	100	2.5	6.85	3.05	72.0	2.0
30-35	200	5.0	6.80	1.07	96.0	2.6

Initial pH : 8.2
O_2 : 3.60 ml/l

set in only subsequently and out of 124 oysters introduced to Krusadai farm 79 could survive and out of 179 oysters kept at Tholayiram paar only 38 could survive.

Fifty pearl oysters (25 *P. fucata* and 25 *P. sugillata)* taken by train by one of us (A. Chellam) during December 1976 and again in January 1977 had withstood the transportation from Tuticorin to Bhubaneshwar for about 43 h. In this transportation, the oysters were packed in gunny bag sprinkled with seawater for most part of the transport. In between they were kept in seawater in plastic basins for a while. After keeping the oysters in seawater under aeration for 3 days, they were packed as before and taken back to Tuticorin without mortality. The time taken for this trip was 52 h. In his experiments, Dharmaraj (1983) could keep exposed the *P. fucata* upto 21 h.

The present observations indicate that when the ambient temperature remains around 29°C the spat ranging in size from 15-40 mm can tolerate upto 24 h of exposure and if the temperature is less than 25°C (controlled) they can tolerate the conditions for more than 24 h with negligible mortality (Table 1 & 2). But spat of 5-15 mm were safe only for 12 h in the above temperatures (Table 1 & 2).

Under wet conditions both gunny bag and seaweed are equally good in the transportation of pearl oyster seed (Table 3 & 4) about 24 h. Spat of 5-10 mm size group are suitable for transportaion in seawater for about 72 h whereas the size group 10-15 mm and 15-20 mm can tolerate upto 48 h and 36 h respectively (Table 5) in water. The suitable way of transportation of spat upto 20 mm is by keeping them in seawater with oxygen (Table 6). During the experiments, the mean atmosphere temperature never exceeded 29°C.

Chidambaram Devanesen and Chacko (1958) opined that the high rate of mortality to the *P. margaritifera* transplanted from the Persian Gulf to the Gulf of Mannar may be due to the low salinity and their inability to stand the change in conditions. Dharmarj (1983) observed that the pearl oyster could withstand exposure upto 21 h whereas in anaerobic condition (in water) the mortality set in from 19th hour. This, he said may be due to the organic products excreted by the oyster into the water. The excretory products and carbondioxide released in the water medium may decrease the pH (Taylor 1976). A noted decrease in the pH was found to have resulted in the mortality of spat (Table 5).

The survival time after exposure differs for the bivalves. At room temperature (30°C), *Donax cuneatus* could survive 69 h after exposure

and *D. faba* 94 h (Rao and Kutty 1968). *Ostrea edulis* could withstand upto 24 days of exposure and complete recovery after 18 days of exposure at low temperature (Korringa 1952). To transport seed oysters from Japan to Hongkong and North America, they are loaded in ships, covered with straw mats to prevent drying during transportation. To prevent mass mortality, the straw mats are sprayed with seawater two or three times daily during the 10 day voyage to North America where the seed oysters are then released into the growing beds and reared (Imai 1971). Hardened seed oysters of *Crassostrea madrasensis* withstood transportation in semiarid condition upto 120 h with 76% survival whereas the survival rate of non-hardened seed for the same period was 22% (Muthiah 1987). Jones (1987) in his preliminary experiments found that the brown mussel seed can be kept in viable condition for several days in the lower shelves of a domestic refrigerator.

The pearl oyster seed which settle and grow in deeper water, could tolerate exposure to air only for a limited time (20-24 h). Under wet condition, this could be extended a little more (25-30 h). In water, spat upto 15 mm could be safely kept for about 48-54 h and if oxygen was supplied spat upto a size of 30-35 mm could withstand the condition upto 72 h (observed) with negligible mortality.

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55. ON THE GROWTH OF THE PEARL OYSTER, *PINCTADA FUCATA* IN COMMERCIAL FARM AT KRUSADAI ISLAND

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ABSTRACT

Growth on two different size groups of the pearl oyster *Pinctada fucata* reared in farm at Krusadai Island was studied for the period from October 1985 to October 1986. Good growth was observed from October '1985 to January 1986 and poor growth was recorded from March 1985 to May 1986 in both the size groups. The growth increment was correlated with rain fall and temperature parameters. Oysters cultured in permanent piling structures at a depth of 4 m, exhibited faster rate of growth compared to the oysters in raft culture at the same depth In velon screen stitched box cages the growth rate of oysters of 20 mm and above was less compared to those reared in cages without velon screen. The stocking density of oysters in a cage and the mortality were found to be directly proportional.

INTRODUCTION

In 1916 James Hornell acquired Krusadai Island for rearing pearl oysters and did some works on pearl oyster and pearl culture. Later in the year 1938 a pearl culture farm was established by Sundararaj and conducted experiments (Devanasan and Chacko 1958). Subsequently the pearl culture farm at Krusadai island was again revived on research scale by the Tamilnadu States Fisheries Department (Nalluchinnappan et al 198?)

A commercial pearl oyster farm belonging to Tamilnadu Pearls Limited came into existance from September 1983. In the farm, the Indian pearl oyster *Pinctada fucata* (Gould) were reared for the production of cultured pearls on commercial scale. The growth of pearl oyster was monitored with reference to different culture systems, size groups, rainfall and temperature and different stocking densitities.

MATERIAL AND METHODS

The pearl oyster *P. fucata* collected from natural grounds off Tuticorin during September 1985 and transported to Krusadai farm were taken for the study. The oysters were reared in box cages (40x40x10 cm) in the Kundugal channel near the shore of Krusadai island (Lat 90° 14 'N, Long 73° 13'E). The cages were suspended at a depth of 3-4 m from the wooden rafts (5x5 m) and permanent teak pole structures (30x15 m) 35 m away from the shore.

In all the experiments the cages contain 30 numbers of oysters except in the last experiments with different stocking densities. The growth measurements of oysters viz. dorso-ventral measurement (DVM), hinge line (HL) and thickness (T) were recorded every month. The above oysters and cages were cleaned monthly, oysters accounted and the dead oysters were removed. The growth recorded was correlated with the meteorological data. The observation was made for a period of one year from September 1985 to September 1986.

OBSERVATIONS

The smaller size group of 6.8 mm in DVM in average and the larger size group 30.1 mm in average exhibit good growth from October 1985 to January 1986 and in June-July 1986. Maximum growth (average) of 4.2 mm in DVM was recorded in December 1985 in the former group and 2.9 mm growth was recorded in the latter group. Both the size groups exhibted fairly faster rate of growth during June and July 1986 (Table-1.) Comparatively poor growth was observed during August and September 1986 in both the size groups.

Spats exhibited a total of 26.1 mm growth in DVM for the one year period and the bigger

TABLE 1. *Growth of* Pinctada fucata *in the box type cages (increment) in mm.*

Ex. No.	Dimensions	Initial Sep '85	Oct	Nov	Dec	Jan '86	Feb	Mar	Apr	May	June	July	Aug	Sept
	DVM	6.8	9.1	12.0	16.2	19.7	22.0	23.8	25.0	26.2	28.4	30.1	31.6	32.9
			(2.3)	(2.9)	(4.2)	(3.5)	(2.3)	(1.8)	(1.2)	(1.2)	(2.2)	(1.7)	(1 5)	(1.3)
1	HL	6.7	10.1	13.5	16.6	20.1	23.5	25.0	26.1	28.0	29.5	31.0	31.5	31.8
			(2.4)	(2.4)	(3.9)	(3.5)	(3.4)	(1.5)	(1.1)	(1.9)	(1.5)	(1.5)	(0 5)	(0.5)
	W	2.1	3.3	4.6	5.5	6.5	7.1	7.6	8.0	8.8	9.1	10.0	10.6	11.9
			(1.2)	(1.3)	(0.9)	(1.0)	(0.6)	(0.5)	(0.4)	(0.8)	(0.3)	(0.9)	(0.6)	(1.3)
	DVM	30.1	31.8	34.3	37.2	39.1	40.0	41.1	41.8	42.9	45.0	46.9	47.4	47.8
			(1.7)	(2.5)	(2.9)	(1.9)	(0.9)	(1.1)	(0.7)	(1.1)	(2.1)	(1.9)	(0.5)	(0.4)
2	HL	32'0	32.9	33.7	34.3	36.7	36.8	37 0	37.6	37.8	38.2	38.6	40.2	40.6
			(0.9)	(0.8)	(0.6)	(2.4)	(0.1)	(0.2)	(0.6)	(0.2)	(0.4)	(0.4)	(1.6)	(0.4)
	W	10.7	10 9	11.6	12.8	13.6	14.1	14.4	14.5	14.7	15.1	15.3	15.5	15.6
			(0.2)	(0.7)	(1.2)	(0.8)	(0.5)	(0.3)	(0.1)	(0.2)	(0.4)	(0.2)	(0.2)	(0.1)

TABLE 2. *Meterological data of the Kundungal Channel*

	Oct 85	Nov	Dec	Jan 86	Feb	Mar	Apr	May	June	July	Aug	Sept
Rainfall in mm	160.4	360.5	87.1	34.2	40.5	11.7	25.2	28.2	Nil	42.6	2.3	12.9
Temperature °C Average	29.0	27.4	26.1	26.0	26.5	28.1	31.0	31.3	30.6	28.6	29.0	28.8

TABLE 3. *Variation of growth rate of* P. fucata *in raft and permanent teak pole structures (Value in mm).*

Month	Raft						Permanent teak pole structures					
	No of oysters	DVM	x	HL	x	W	No of oysters	DVM	x	HL	x	W
Sept 85	30	30.1	x	32.0	x	10.7	30	32.0	x	33.4		11.4
Sept 86		47.8	x	40.7	x	15.5		51.3	x	44.6		18.9
Annual increment		17.7	x	7.3	x	4.8		19.3	x	11.2		7.8

TABLE 4. *Differential growth rate observed with* P. fucata *in ordinary box cages and velon screen stitched box cages.*

Month	Box cages						Box cages in velon screen					
	No of oysters	DVM	x	HL	x	W	No of oysters	DVM	x	HL	x	W
Sept 85	30	30.1	x	32.0	x	10.7	30	29.3	x	29.5	x	9.4
Sept 86		47.8	x	40.7	x	15.5		39.7	x	38.4	x	13.9
Annual increment		17.7	x	7.3	x	4.8		10.4	x	8.9	x	4.5

TABLE 5. *Growth of* P. fucata *in different stocking densities.*

S. No.	Stocking density		% of Mortality	Growth in mm (DVM)		Annual increment in mm
	Initial (Sep '85)	Final (Sep '86)		Initial (Sep '85)	Final (Sep '86)	
1	200	134	33	28.4	40.2	11.8
2	150	112	25	27.8	39.4	11.6
3	100	88	12	28.0	42.3	14.3
4	75	64	12	27.4	44.2	16.8
5	50	42	16	29.2	45.8	16.6
6	30	28	6.7	28.4	46.4	18.0
7	20	20	Nil	26.9	47.2	20.3

oysters showed 17.7 mm annual growth rate (Table 1).

Maximum rainfall was recorded during the period October 1985 to December 1985 and July 1986 and the surface temperature was low during November 1985 to February 1986. The above periods of maximum rainfall and lower temperature coincided with the period of conspicuous growth (Table 2).

In the raft culture system the annual growth increment of oysters was 17.7 mm in DVM and it was 19.3 mm in the permanent teak pole structures (Table 3).

The oysters reared in ordinary box cages with nylon webbing showed an annual increase of 17.7 mm in DVM and the oysters cultured in the same box-cages stitched with Velon screen (P=32) exhibited 10.4 mm annual growth rate (Table 4).

A distinct trend of increase in the rate of oysters was observed at low densities. At the stocking density of 200 oysters (28.4 mm DVM) per cage, the average growth increase was 11.8 mm for the whole year and it was 20.3 mm at the density of 20 oysters (26.9 mm) per cage. The stocking density and the mortality of oysters were directly proportional. At the density of 200 oysters per cage the mortality was as high as 33% for the whole year. However it was nil and 6.7% in cages with stocking densities of 20 and 30 oysters respectively (Table 5).

DISCUSSION

In the spat of *P. fucata* the hinge line (HL) was more than the dorsoventral measurment (DVM). Alagarswami and Chellam (1977) related the morphometric correlates viz. DVM, HL and W of the pearl oysters collected from different pearl banks of Tuticorin. According to them the DVM increased faster than the HL when the oysters grow. In our present study the growth of the oysters in DVM was more pronounced than HL. On simultaneous comparison of annual growth, the spats of 6.8 mm reached 37.9mm in DVM while the bigger oysters attained 47.8 mm in DVM from 30.1 mm (Table 1).

Earlier works by Devanesan and Chidambaram (1956) in Krusadai pearl oyster farm, showed that the growth was inversely proportional to the age of the spats. Nalluchinnappan et al (1982) reported that in adult oysters (30 91 mm) increment was upto 18.2 mm within a period of seven months. The reduction in growth rate of adult oysters in Krusadai island in the present study may be due to crowding in a restricted area and the spats of 6.8 mm DVM, grow to the size of 40 mm only after 18 months period (Table 1).

In the Gulf of Kutch, the growth of Indian pearl oyster *P. fucata* was under the influence of extrinsic factors such as water temperature and salinity (Gokhale et al (1954). The growth of pearl oysters in the Gulf of Mannar was high

during the period when the water temparature is low (Jeyabaskaran et al 1983). The two growth peaks coincided with the north-east and south-west monsoon. Jeyabaskaran et al., (1983) also observed a peak period of growth from November 1977 to February 1978.

Water current movements from Pamban pass might have influenced the growth of the pearl oysters at the Kundugal channel. Drift water current and more flow of water during north-east monsoon with lower salinity level enhanced the growth of the pearl oysters at Tuticorin (Jeyabaskaran et al 1983).

The ever oscillating rafts and the cages seemed to cause poor growth of oysters than the oysters reared in the permanent teak pole structures where the conditions remained static and calm (Table 3).

Accumulation of silt and other organisms on the velon screened cages resulted with poor growth of pearl oysters than in the unscreened boxes (Table 4).

The stocking density at the rate of one oyster per 80 cubic cm showed mortality as high as 33% with an annual growth of 11.8 mm and at the rate of one oyster per 800 cubic cm the mortality was nill with a higher annual growth rate of 20.3 mm the optimum stocking density was found to be 100 oysters (28 mm in average) per box cage where the mortality was 12% and beyond which it was doubled (see Table 5.) Pollution free calm areas with periodical replenishment of water by reasonable flow of currents will help oysters to grow faster in such a commercial farm.

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56. MANAGEMENT OF MOLLUSCAN FISHERIES

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The development of molluscan resources in our country involves two problems, the first being creating of demand and the second improved and rational exploitation of the resources.

MUSSEL FISHERIES

Mussels are gregarious and sessile and favour damp ledges and platforms rather than verticals. They grow on rocks, shingle and mud flats of mid littoral. There is a marked increase in number and size towards the submerged lower levels.

In the shallow coastal and shelf waters, the amount of organic matter reaching the bottom and thus available to the attached forms like mussels is high for three reasons:

1. high phytoplankton production
2. distance through which it has to sink is less with less opportunity for consumption in the middle layer and
3. lateral transport from the areas intensely high, primary productivity in sea weed beds, estuaries and marshes.

With heavy rainfall in Kerala, Karnataka and Maharashtra, the 'Mytilus line' is in line with mean high water neap and immediately below the line, the mussel population is dense. Temperature plays a vital role in the reproduction of mussels.

Mortality during the free swimming larval period has been reported to be considerable, even upto 99%. The main mortality factors have been identified as predation, excessive dispersal to areas, where suitable sites for post larval survival do not exist and death due to extreme physical factors.

Production of seed or young ones is one of the vital aspects of any farming activity. In the culture of green mussels, where considerable advances have been made on the techniques of farming, the basic seed material has always been obtained from the wild. Removal of seed mussel from the beds for farming comes in conflict with the interests of natural fishery. The natural seed resources on the beds cannot support mussel culture industry of some magnitude. These factors make it imperative to develop techniques for seed production. At present, for the mussel culture operation in India, seed collected from the natural grounds is used and these cannot meet the requirements of expansion of mussel culture as an industry.

Profuse spatfall takes place on granite embankments and groynes laid along the coast of central Kerala for prevention of sea erosion. Spatfall occurs in the mussel culture farm itself at Vizhinjam/Calicut. Possibility of production of seed in the farm by keeping a breeding stock of mussels as in Madras, will have to be examined and developed The above three possibilities need further considerations and experimental work. Economic consideration will weigh upon such attempts, although technical feasibility may be established.

Induced spawing can be effected by rough handling, chemical stimulation and thermal stimulation.

In handling the larvae through development to settlement, success would depend on several factors of water quality, larval food and disease control. The sea water used for larval rearing has to be assessed for suspended matter, pollutants, temperature, salinity and pH range and nutritional value. Feeding the bivalve is a major constraint in the hatcheries—to give optimal nutritional support that is efficient and economical for culturing under controlled conditions.

There are potential dangers to be foreseen from different sources. It is therefore, important to take steps to prevent ill effects of pollution and outbreak of diseases The following points deserve attention.

1. Selection of farm site free of biological and chemical contamination;
2. Selection of disease resistant seed for culture;

3. Avoiding overcrowded stocking to minimize ill effects of epizoites;
4. Care in handling cultured stock to avoid contamination;
5. Periodic inspection on the larvae of pathoginic organisms in the culture systems to assess the status of the stock;
6. Eliminating other sources of contamination and pollution; and
7. Timely harvesting of stock.

At present in a few centres like Tellicherry, Kozikode, Vizhinjam, Colachel and Goa, mussel is liked by the local population, but in other centres, it is consumed as food by fishermen. It is a common belief on the west coast that mussels are unwholesome/poisonous during the S. W. monsoon and possibly due to turbidity, mud, sand and refuse.

Treatment of mussels for sanitation and flushing of material from the digestive system and in the mantle cavity is essential, before marketing the mussels. This is highly essential and important.

Mussels, clams & Oysters, though in demand and as luxury items in the West & Far East they are not in much demand in the country. The production at present is from natural/wild stocks. Though technically, culture is possible, and that too only from wild seed stock, the economics and commercial feasibility studies are still to be made as also market promotion.

CHANK FISHERY

Chank Fishery *(Turbinella pyrum)* is commercially important in the Gulf of mannar and Palk Bay, contributing to landing of 8 to 10 lakhs a year, valued at about Rs 3 million and offering employment to 2000-3000 divers, during the season.

The Chank fisheries were crown monopolis, enjoyed from time immemorial by the rulers of the region and became a state monopoly vested with the State Govt. under powers, conferred under Sec 6 of the Indian Fisheries Act 1897 under which fishing for Chank will be regulated under license or lease.

In 1971, it was decided to open Chank fisheries in all districts except in Tirunelveli District considering that it might give benefit to the divers and improve their socio-economic condition, except that divers should take a license with a fee of Rs 10/- per year. But a review after a period of five years showed that this system did not contribute to the desired effects, but led to undesirable results and it was felt that the conservation of the fisheries will face problems and the earlier system was restored. The management of the fishery is with the state Department of Fisheries.

PEARL OYSEER FISHERY

The Gulf of Mannar has pearl banks of some magnitude in the country. In 1909 the management of the fishery came under of the Department of Fisheries and it is conserved, managed and exploited by the Fisheries Department. There has been fluctuations in the fisheries and it is not an annual feature. As pearl oysters (Young ones) could be collected in large numbers in the Gulf and considering the potential, a Pearl Culture Project has recently been established as a Public Sector operation, based on the technology developed by CMFRI.

The reasons attributed for the oysters not reaching the fishable size in the natural beds are biological and physical viz. growth of *Modiolus* on oyster beds, abundance of fish browsing on oysters, of sea-stars, migration, natural sand drift, fierce underwater currents, etc.

As a large number of factors influence the spat fall and their growth in the pearl banks away from the coast, the management becomes difficult but they can be grown in sheltered bays & among coral Island and there is scope for culture pearl operation, the establishment of commercial farm is encouraging.

SQUIDS AND CUTTLEFISH FISHERY

Cephalopod fishery, comprising of squids, cuttle fish and octopus account for 1 to 1.5 million from all oceans. More than half of the total catch is at present taken in the northwest and northeast, Pacific and Atlantic Oceans. In

1981 Japanes fishing vessels accounted for over 7,00,000 t and Japan also is a major consumer.

The potential yield of squids in the Indian Ocean has been esimated as several hundreds of thousands of tonnes and that Bay of Bengal accomodates the largest nursery for squids in the Indian Ocean. The production potential of the region has been estimated to be 5,00,000 t. George et al (1977) assessed the exploitable production from the continental shelf waters of around 1,80,000 t of which 66% is from the east coast of India. As against this potential, the landings of cephalopods, especially squid & cuttle fish in India were about 20,000 t in 1984.

There is scope for increasing landings of squids and cuttlefish by introducing squid jigging and intensifying the efforts in the inshore waters and by collaboration with selected foreign companies for adopting new and improved technologies for fishing in the EEZ and for handling them to meet the demands of selected markets. This activity should be monitored by a study, survey and rational exploitation with bases in Veraval, Malpe, Tuticorin, Vizag and Port Blair.

MANAGEMENT

Based on a thorough knowledge of the resources and their biological and environmental aspects, the management and conservation of these resources will have to be formulated (directed) for recommending a biological minimum size for exploitation for each of the commercial species closed areas and seasons for fishing after taking note of the peak spawning. These steps are necessary not only for collection of adult oysters, clams and mussels but also for the production of the seeds from wild stock for culture purposes.

Further, molluscs except cephalopods, are sedentary with restricted mobility and are therefore, more prone to depletion than fishes but this factor enables us to observe in advance the indication of depletion and resort to conservation measures on time.

57. STUDIES ON THE SETTLEMENT OF BARNACLES AT DIFFERENT DEPTHS IN THE PEARL OYSTER FARM AT TUTICORIN

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ABSTRACT

Fouling on the pearl oyster cages in the farm by barnacles and other organisms is considered a big nuisance and also at times retards the growth rate of oysters leading to mortality. Removal of the barnacles is a labour intensive work. To avoid this, experiments were conducted to find out at what depth the intensity of barnacle fouling is minimal so that the cages can be lowered to that depth. It has been found that there is considerable reduction in the number of barnacles settled at 5 m depth even during the peak barnacle settlement season. It is considered to be advantageous to position the cages lower down the water column. The paper gives an account of barnacle fouling intensity on pearl oyster cages in different months and different depths in the pearl oyster farm.

INTRODUCTION

In the normal condition the oysters reared in the farm are subjected to fouling and boring by different organisms. Fouling is a menace to the oysters as reported by Alagarswami and Chellam (1976), Dharmaraj and Chellam (1983) and Velayudhan (1983) in the pearl oyster

farm. Kuriyan (1950) had observed a dense settlement of organisms in the pearl oysters at Krusadai Island in the Gulf of Mannar. Arakawa (1980) has given a comprehensive account of the prevention and removal of fouling on cultured oysters in Japanese waters. Mizumoto (1964) and Yamamura et al (1969) have listed the major fouling organisms in the pearl oyster farms of Japan. The present study has been conducted in the pearl culture farm in Tuticorin Harbour basin on the settlement of fouling organisms on the glass panels suspended at different depths. The major fouling is barnacle, and other fouling organisms form a small percentage on the panels. This work has been carried out to study the sequential settlement of barnacles at different depths and find out steps to avoid the attachment of these organisms on the pearl oysters and to reduce the manpower in cleaning to reduce the mortality.

MATERIAL AND METHODS

In the present study four sets of each containing five ground glass panels of size 20x20x5 cm with 5 mm dia. hole at 4 corners and 4 mm synthetic rope was fixed at depths of every 1 m upto 5 m. Of the total of 20 panels suspended at each fortnight period, 10 numbers were suspended horizontally and the remaining 10 vertically at each depth. The pearl culture raft was moored in the Harbour basin at a depth range of 5-7 m. The sea bottom is muddy with coral pieces and silt materials. A total of 960 number of panels were suspended during the study from April, 1982 to March, 1983. For counting fouling organisms a metal frame of 20x20 cm in size divided into 4 cm x 5 cm rectangular sub areas was used. The countings were made by placing the metal farme over the panel. The total count of barnacles and foulers in each randomly selected sub area were noted by using the random tables. The weight of foulers was determined from the intensity of their occurrence on the panels. The total weight and volume of barnacles as well as the total weight and volume of other fouling organisms were noted The total weight of barnacles and other fouler settled per month in 3,200 cm^2 was also calculated.

RESULTS

FOULING AT DIFFERENT DEPTHS

In order to calculate the mortality of pearl oysters at different depths five frame nets of size 65x45 cm made of 5 mm dia iron rods each with 5 compartments were used. A total of 50 pearl oysters of size 45 mm in DVM were kept in each frame net and suspended vertically from the raft at 0.5, 2, 3, 4 and 5 mm depths. The mortality of oysters and the intensity of fouling organisms on these oysters were also studied from December, 1980 to November, 1981.

A. *1 Metre depth*

The highest settlement of foulers barnacles, hodrozoans, compound ascidians, *Avicula*, algae and amphipods was during the months of June, May, April, September and May respectively. These organisms cause serious damage to oysters, especially the barnacle the density of which was 661 per 100 cm^2 weighing 117.68 g per 3,200 cm^2. The average number of barnacles which settled was 149 per 100 cm^2. The average monthly weight of barnacles which settled was 26.70 g per 3200 cm^2 during the year. The monthly average weight of compound ascidians settled was 1.73 g, bryozoans 0.04 g, hydrozoans 6.16 g, silt 5.45 g, algae 1.09 g, *Avicula* 1.19 g and amphipods 1.97 g per 3,200 cm^2. The total fouling load during June was 133 50 g per 3.200 cm^2 (Table 1).

B. *2 Metres depth*

The maximum settlement of foulers, barnacles, *Avicula*, hydrozoans, compound ascidians, amphipods and tubiculous polychaetes were during the month of June, May, February, April, February and June respectively. Barnacles which are the major fouling organisms were observed during June and showed a density of 1,115 per 100 cm weighing 159.85 g per 3,200 cm^2. The average monthly density of barnacles per 100 cm^2 was 302. The monthly average weight of compound ascidians was 2.18 g, bryozoans 0.23 g, hydrozoans 3.96 g, silt 5.48 g, algae 0.15 g, *Avicula* 1.15 g and amphipods 0.75 g per 3,200 cm^2 were observed during the period. The total weight of fouling organisms during June was 210 gper 3,200 cm.

TABLE 1. *Average weight and number of barnacles and weight of other fouling organisms and silt on the panels suspended at different depths in the pearl oyster farm at Tuticorin during the period from February, 1982 to March 1983.*

Depth (m)	Wt of barnacle/ 3200 cm²	No. of barnacle/ 3200 cm²	Compound ascidian 3200 cm² (g)	Bryozoan 3200cm² (g)	Avicula 3200cm² (g)	Hydro-zoan 3200cm² (g)	Amphi-pods 3200cm² (g)	Algae 3200cm² (g)	Silt 3200cm² (g)	Barnacle/3200cm² Max. no.	Min. no.	Max. Wt. (g)	Min. Wt (g)
1	26.70	149	1.73	0.40	1.19	6.16	1.97	1.09	5.45	661 June	7 Feb.	117.68	0.59
2	36.24	302	2.18	0.23	1.15	3.96	0.75	0.15	5.48	1115 June	23 Feb.	159.85	0.81
3	34.03	346	0.10	0.10	5 56	9.50	1 86	0.01	10.31	12321 June	57 Feb	179.52	0.60
4	18.40	263	0.10	0.50	2.85	11.33	0.93	—	9.04	938 June	6 Feb.	63.85	0.01
5	16.37	116	0.50	0.37	2.74	10.41	0.48	—	14.77	276 June	2 Feb.	73.30	—

C. *3 Metres depth*

At this depth the pattern of settlement of fouling organisms was similar to that in 2 meters depth and the highest settlement of barnacles, hydrozoans, *Avicula*, amphipods and tubiculous polychaetes noted was during the months June, May, May June and June respectively. The other forms like simple ascidians, isopods and Anomia were negligible on the panels for quantitative study. The density of the major fouling organisms viz., barnacles was very high in June, 12,321 per 3,200 cm², weighing 179.52 g. The average monthly density of barnacles setting on the panels during the period of study was also high, 346 per 3,200 cm². The total number of barnacles observed on the panels during June was 1,540 per 100². The average weight of compound ascidians 0.06 g, *Avicula* 5.56 g, tubiculous polychaetes 0.49 g and amphipods 1.86 g per 3,200 cm² were observed during the period. The total weight of fouling organisms during June was 225.5 g per 3,200 cm².

D. *4 Meters depth*

The fouling oganisms settling on the panels at this depth are barnacles, *Avicula*, hydrozoans, tubiculous polychaetes and amphipods which settled in highest numbers during June, May, May, June and September respectively. The most prominent fouling organisms at this depth also were barnacles, 938 per 100 cm weighing 63.68 g per 3,200 cm². The minimum number of barnacles observed during February was 6 per 100 cm². The average weight of compound ascidians was 9.09 g, bryozoans 0.57 g, hydrozoans 11.33 g, silt 9.04 g, algae nil, *Avicula* 2.85 g and amphipods 0.93 g per 3,200 cm² were observed during the period.

E. *5 Meters depth*

The highest settlement of fouling organisms barnacles, hydrozoans, *Avicula*, amphipods and bryozoans was during the months of June, May, July, March and November. The maximum number of barnacles attached during October was 492 per 100 cm² weighing 49.64 g per 3,200 cm². The average monthly number of barnacles settled during the whole period was 116 per 100 cm². The total monthly weight of barnacles attached was 196 per 3,200 cm² and the average weight during the whole period was 16.37 cm² and average weight during the whole period was 16.37 g per 100 cm². The intensity of settlement of barnacles at different depths shown in the Table 2, clearly indicates that the fouling by barnacle as well as total fouling load is lowest at 5 m depths. The average weight of compound ascidians 0.4 g, bryozoans 0.37 g, hydrozoans 10.41 g, silt 14.77 g, algae nil, Avicula 2.74 g and amphipods 0.48 g per 3,200 cm² were observed during the period. The depth wise settlement of these fouling organisms is given in Table 2.

TABLE 2. *Depth and monthwise weight of barnacles settled on the panels suspended in the pearl culture farm during the period from April, 1982 to March, 1983.*

Depth	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
(m)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)	(g)
1.	7.00	0.89	117.69	37.16	30 75	20.76	28.25	38.28	22.30	16.24	0 59	0.64
2.	35.70	5.89	159.85	20.99	23.32	48.08	55.90	47.23	25.64	10.68	0.81	0.82
3.	48.36	1.50	179.52	18.13	38.39	42.62	50.83	47.53	15.27	2.84	0.60	0.70
4.	15.92	0.11	63.86	11.38	15.24	28.73	40.75	34.17	10.15	0.32	negli-gible	0.19
5.	3.52	0.10	73.30	5.39	15.43	3.19	49.64	32.08	13.50	0.26	,,	0.01

TABLE 3: *Total fouling volume on ten numbers of oysters suspended at different depths in the pearl oyster farm from December, 1980 to November, 1981.*

Depth (m)	Dec. Vol (ml)	Jan. Vol (ml)	Feb Vol (ml)	Mar. Vol (ml)	Apr. Vol (ml)	May. Vol (ml)	June Vol (ml)	July Vol (ml)	Aug. Vol. (ml)	Sep. Vol (ml)	Oct. Vol (ml)	Nov. Vol (ml)	Average Vol (ml)	Average Vol (ml)
0.5	65	86	180	100	140	60	260	80	65	180	94	138	121	2.67
2.0	45	54	108	92	100	55	250	55	70	170	90	132	102	4.1
3.0	40	65	93	57	65	50	180	50	60	92	92	149	86	2.8
4.0	30	45	26	19	55	45	175	75	45	96	96	148	73	4.5
5.0	25	12	5	5	50	15	10	5	5	46	46	120	28	2.5
Total	205	262	412	273	410	225	875	265	245	632	418	684		
Mortality %	2.8	0.4	2 8	2.0	1.6	—	2.4	2.8	4.8	4.4	6 4	9.6		

FOULING ON THE LIVE OYSTERS

The average monthly settlement of fouling organisms were 121,108.86,73 and 25 ml respectively at 0.5, 2.0, 3.0, 4.0 and 5.0 m depths. During this period of observation, studies on the percentage of mortality of oysters at these different depths indicated that at 5 m depth it was as low as 2.5 whereas it was 2.67 (at 0.5 m), 4.1 (2.0 m), 2.8 (3.0 m) and 4.5 (4.0 m). Perhaps the mortality of oysters could be related to the fouling intensity, particularly the settlement of barnacles. It is of interest to find that during the month of May where there was very little of barnacle settlement, there was no mortality of oysters at all.

Intensity of fouling on live pearl oysters, ten numbers each, kept suspended in the same area at depths 0.5, 2.0, 3.0, 4.0 and 5.0 m depth showed identical result in the year 1980-1981.

During experiments conducted in the year 1982-1983 in the New Major Harbour area to study the intensity of fouling in different months at defferent depths (1.0-5.0 m) on glass panels suspended vertically and horizontally, it was noticed that settlement of foulers was more on the panels upto 4 m depth whereas those that were lower down showed less fouler settlement (Table 1). It is of interest to notice that glass panels kept horizontally attracted greater fouler settlement than thoae suspended vertically.

DISCUSSION

The volume of fouling organisms on the live oysters was least at 5 m depth than at

other depths. Survival percentage appears to be more at this depth. The weight of fouling organisms on the panels lowered to different depths varied but the lowest level of fouling was always maintained at the 5 m depth. In the pearl culture farm at Tuticorin Harbour the maximum monthly average settlement was observed as 346 numbers per 100 cm^2 at 5 m depth. On the live oysters the maximum fouling volume was noticed at 1 m depth (120 ml) and lowest at 5 m depth (28 ml) per 10 numbers of live oysters. The total fouling volume was found decreasing with depth. According to Daniel (1956) that if only blue or green colours which do not contrast against the background were used in the antifouling paints it will have greater effect in successfully preventing settlement of larvae of foulers for a long period. It was found that on the ground glass panels used, the maximum barnacle settlement was observed at 1-3 m depth while the number decreased at 5 m depth in the pearl culture farm. It was observed that the silt deposition increase in Tuticorin Harbour with depth. This might have reduced the light penetration. This silt load not only might have also clogged the gills of barnacles larvae settling at 5 m depth but also affects the slime film formation also at this depth. In the Harbour farm the vertical clarity of water was found to range from 1 to 3.5 m.

According to Dharmaraj and Chellam (1983) great settlement of branacles was observed at Veppalodai in their experimental farming done during the period from June-November. In the present study also intense settlement of fouling organisms and higher rate of mortality of oysters was also noticed during June to November (Table 3). The monthly average percentage of mortality of oysters during this 6 months period was 2.4, 2.8, 4.8, 4.4 and 9.6 respectively guided by the results of this experience in the pearl culture farm at Tuticorin Harbour, fouling by barnacle in the pearl culture farm at Tuticorin Harbour, fouling by barnacles was substantially avoided by suspending culture frames at 5 m depth. Manpower employment for keeping off the intensity of fouling to a minimum by periodical cleaning of cages was brought to a minimum level by resorting to this avoidence technique.

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58. OBSERVATIONS ON THE BIO-FOULING IN PEARL OYSTER FARM AT KRUSADAI ISLAND, GULF OF MANNAR

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ABSTRACT

Emphasis was laid mainly to identify the dominant groups of biofoulers on pearl oysters and cages in commercial farming during the year 1985-86. The rate of biofouling observed in Krusadai farm was less compared to the observations made at Tuticorin. Comparatively more of fouling was observed during the south west monsoon and north east monsoon periods. During the south west monsoon, barnacles contributed more and during the north east monsoon silt deposition was found to increase the quantum of fouling. Barnacles, bryozoans, molluscan spat, tunicates, decapods, crustaceans and sea weeds were found on pearl oysters and cages througout the year in varying quantities. Boring by sponges and spionids were practically nil.

INTRODUCTION

First attempt to culture pearl oysters in India dated back to 1864 by Phipps, as is evident from Markham's (1865) letter to the British Government in India. A pearl oyster nursery at Tuticorin near Hare Island was established for the first time in 1864. Successful pearl oyster farming and a break through in cultured pearl production were achieved by Central Marine Fisheries Research Institute in 1972 (Alagaraswami 1974). Earlier, attempts made to rear pearl oyster in captivity to produce cultured pearl at Krusadai Island were reported by Devanesan and Chidambaram (1956) and Nalluchinnappan et al (1982). A commercial cultured pearl producing farm is successfully established at Krusadai Island in the Gulf of Mannar in 1983 for the first time in India.

Biofouling on pearl oysters and cages is one of the major problems faced in pearl oyster farming which requires periodical cleaning of oysters and cages. Kuriyan (1950) and Ananthanarayanan (1967) had also observed such settlement of fouling organisms on pearl oysters and cages at Krusadai Island. Detailed studies on the fouling and boring organisms on pearl oysters in the farm at Tuticorin were made by Alagarswami and Chellam (1976), Dharmaraj and Chellam (1983) and Velayudhan (1983). Here an attempt is made to identify the different fouling organisms, month of occurrence and the intensity of settlement of dominant foulers on oysters and cages.

MATERIALS AND METHODS

The live pearl oyster *Pinctada fucata* and the box cages (40 x 40 x 10 cm) used to rear them, themselves provide the substrate for the various fouling communities. The cages were suspended at a depth of 3-4 m from unit wooden rafts (5 x 5m) floated 50 m away from the shore. The bottom of the farm site is hard with a mixture of mud and sand. Ten cages containing 150 *P. fucata* each were taken for the study. The oysters ranged 40 mm and 45 mm in dorso ventral measurement (DVM). The pearl oysters and cages were cleaned by scrapping off the encrusting fouling organisms. Such encrusting forms and other free living organisms found inside the cages were then sorted out and identified to the extent possible and the data is furnished in Table 1. The volume of important fouling groups found on pearl oysters collected from one cage (150 oysters) was estimated every month by volume displacement method. The fouling load per oyster was determined by weighing the scrap from 100 oysters of the above size group every month which is given in Table 2. The observation covered a period of twelve months.from July 1985 to June 1986.

TABLE 1. *Fouling organisms observed on oysters and cages and the month of occurrence at Krusadai farm from July 1985 to June 1986.*

Sl. No.	Name of organisms	observed in cage (c)/oysters (o)	month observed
1.	*SPONGES*		
	Cliona sp	0	Nov - Jan
2	*COELENTERATES*		
	Companularia sp	0	Nov - Feb
	Obelia sp	C & 0	Nov – Feb
	Sertularia sp	C & O	Sept, Dec - Jan
	Lytocarpus sp	C & O	March
	Clavularia sp	C	Dec, Jan
	Sarcophytum sp	C & O	September
	Bunodactis sp	O	September
3.	*BRYOZOANS*		
	Membranipora sp	C & O	Oct – Dec
	Thalamoporella sp	C & O	Nov - Dec
	Bugula sp	C	Mar - June
4.	*ANNELIDS*		
	Dasychone sp	C & O	Oct - Jan
	Polydora sp	O	Dec, Jan
	Perineris sp	O	Throughout the year
	Eunice sp	C	Aug, Sept, Mar - May
5.	*ARTHROPODS*		
	Balanus sp	C & O	Throughout the year
	Lystamata sp	C & O	Aug, Sept, March - May
	Gonodactylus sp	C	April, May
6	*ISOPODS*		
	Sphaeroma sp	C & O	Throughout the year
	Cilicaea sp	O	Throughout the year
7.	*DECAPODS*		
	Pinnotheres sp	C & O	Throughout the year
	Matuta sp	C	June
	Charybdis sp	C	Throughout the year
	Thalamita sp	C	Throughout the year
	Panulirus sp	C	April - June
8.	*PYCNOGONIDS*		
	Nymphon sp	C	August, September
9.	*MOLLUSCS*		
	Pinctada sp	C & O	January, May, June
	Cyprea sp	C	August, September
	Drupa sp	C	May, June
	Pyrene sp	C	May, June
	Cymatium sp	C	August, September
	Doris sp	C	April
	Modiolus sp	C & O	June, July
	Murex sp	C & O	September

Sl. No.	Name of organisms	Observed in cage (c) oysters (o)	month observed
	Avicula sp	C & O	May, June
	Pinna sp	C	October, November
	Cymatium sp	C & O	February - June
	Crassostrea sp	C & O	April – June
	Oliva sp	C & O	May
	Martesia sp	C & O	April, Aug & Sept
10.	*ECHINODERMS*		
	Antedon sp	C & O	November - January
	Salmacis sp	C	June - September
11.	*TUNICATES*		
	Ascidia sp	C & O	May, June, Aug., Sept.
	Rhabdocynthia sp	C & O	March - July
	Dicarpa sp	C & O	Throughout the year
	Botrylloides sp	C & O	April, June
	Diplosoma sp	C & O	Throughout the year
	Leptoclinum sp	C & O	March - April
12.	*PISCES*		
	Acanthurus sp	C	April - June, August
	Blennius sp	C	Throughout the year
	Pterocrites sp	C	May
	Gobius sp	C	Throughout the year
II. 1.	*SEA WEEDS*		
	Gracilaria sp	C	Throughout the year
	Cladophora sp		October - December
	Enteromorpha sp	C & O	September - December
	Dictyota sp		November, December
	Ceramium sp		September - January
	Gelidium sp		December, January
	Sargassum sp	C	Throughout the year.

TABLE 2. *Seasonal variation of fouling intensity (%) of predominant group of fouling organisms and the fouling load on oyster in the pearl oyster farm at Krusadai Island.*

Period	Barnacles (%)	Annelids (%)	Bryozoans (%)	Molluscs (spat) (%)	Tunicates (%)	Sew weeds (%)	Fouling load (Min-Max) per oyster (g)
1985 July-Sept	70.8	5.6	3.1	13.2	6.3	1.0	3.6 - 6.8
Oct - Dec	58.0	12.1	9.7	8.2	4.9	7.1	2.8 - 6.6
1986 Jan - March	62.5	10.0	9.8	5.6	6.1	6.0	1.3 - 4.9
April - June	74.8	3.0	5.4	10.6	4.5	1.7	3.8 - 6.4

OBSERVATIONS

Emphasis was laid mainly to identify different fouling organisms, dominant groups and their seasonal occurrence on pearl oysters and cages in the pearl oyster farm at Krusadai Island. The different biofoulers in pearl oyster cages and on pearl oysters identified during the period of observation is shown in Table 1. Fouling intensity of important groups is given in Table 2.

Barnacles were found to be the most important constituent of the fouling organisms. The volume of barnacle load was very high (74.8%) during April-June 1986. Though dominant, barnacle load was comparatively less (58.0%) during October-December 1985. The other conspicuous group that increased the volume mainly was molluscan spat. They were abundantly seen during the periods July-September 1985 (13.2%) and April-June 1986 (10-6%). Between October 1985 and March 1986 annelids were represented in fairly good numbers. The volume was 12.1% (October-December) and 10.0% (January-March). Bryozoans were well represented from October to December 1985 (9.7% and from January to March 1986 (9.8%). The tunicates were found in large numbers during July-September 1985 (6.3%) and January-March 1986 (6.1%). Sea weeds were found abundantly during the periods October-December 1985 (7.1%) and January-March 1986 (6.0%) (Table 2).

Among others, decapod crabs and some species of fishes were also observed throughout the year. Very rarely, instance of boring by the sponge *Cliona* sp, polyclad worm *Polydora* sp and pholad *Martesia* sp were observed (Table 1).

The maximum fouling load was observed during July-September 1985 and the minimum was recorded in January-March 1986. During October-December 1986 silt deposition was found on oysters and cages.

REMARKS

Balanus spp was the dominant fouling organism on both oysters and cages throughout the year. though their presence varied during different periods. Peak settlement was recorded during July-September 1985 and April June 1986. Among the others annelids, molluscan spat, bryozoans and tunicates were the dominant groups (Table 2). This concurred with the observation of Alagarswami and Chellam (1976). Molluscan spat occur in large numbers on oysters during July-September and April-June. The spat were mainly of *Pinctada* spp, *Crassostrea* spp. *Modiolus* sp. and *Avicula* sp. The bryozoans *Membranipora* sp, *Thalamporella* sp, and *Bugula* sp were found to spread all over the cages and oysters. The tunicates, *Dicarpa* sp and *Diplosoma* sp were recorded throughout the year. Crabs of several genera are found althrough the year, mainly inside cages. Juveniles of *Panulirus* sp were also occasionally found (Table 1). Similar above observations were made by Alagarswami and Chellam (1976).

Sea weeds (Table I) were significantly seen from October to December 1985 and in January and February 1986. During the period October-December 1985 heavy silt deposition on oysters and cages was observed. This period coincides with the north east monsoon which results in change in direction of wind and water current in Kundugal channel. The silt brought by the current deposit on cages and oysters and the growth of sea weeds on oysters help the deposited silt retained which ultimately add to the fouling.

Boring by the annelid worm *Polydora* sp and sponge *Cliona* sp was very negligible when compared to the observations made by Velayudhan (1983) at Tuticorin and Veppalodai. From the Table 2, It can be seen that the fouling load per oyster at Krusadai farm ranged from 2.3 to 7.8 g during the one year period. But Jeyabaskaran et al (1983) reported that the weight of foulers per oyster varied between 3.5 and 32.0 g at Tuticorin farm.

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59. ON THE LARGE SCALE PREDATION BY THE GASTROPOD, *(CYMATIUM CINGULATUM)* ON PEARL OYSTERS

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ABSTRACT

The predatory gastropod *Cymatium cingulatum* was found to occur in large numbers in the pearl oyster farm at Krusadai from February to July, 1986. They feed mainly on spat and young oysters below the size 40 mm in DVM and thereby causing large scale mortalities of pearl oyster stock. This menace was eradicated by periodical checking and hand picking manually. In all 50,901 oysters were found dead in the 4,010 cages inspected and 934 predators were collected and destroyed. The gastropods ranged between 21 and 88 mm in length.

INTRODUCTION

Certain predators pose serious threat to commercial molluscan culturist all over the world leading to considerable economic loss. Hence, effective checks and control measures have to be developed to eradicate the predators. Some known enemies of pearl oysters are drills, star fishes, crabs and fishes. Hornell (1922) has reported about the destruction of pearl oysters by the carnivorous molluscs belonging to the genera *Purpura, Nassa* and *Sistrum*. Presence of predatory gastropod *Cymatium* sp. in the pearl oyster beds in the Gulf of Mannar and pearl oyster farm at Tuticorin was reported by Jeyabaskaran et al (1983). In the present note, an observation on the occurrence of the predatory gastropod *Cymatium cingulatum* and its effect on pearl oyster farming near Krusadai Island in Gulf of Mannar is reported.

MATERIAL AND METHODS

Pearl oysters belonging to the species *Pinctada fuctada* are being farmed at Krusadai Island for the purpose of producing cultured pearls on a commercial scale. These are reared in box type cages of size 40 x 40 x 10 cm and suspended from wooden rafts and permanent structures erected with teak poles. During periodical cleaning of oysters and cages the presence of *C. cingulatum* was detected in February, 1986. Mortality of oysters in these cages was found to be high. Data on number of cages cleaned, number of oysters examined and number of oysters found dead were recorded daily to assess the extent of the damage. The predators were totally eliminated by the end of July, 1986 by repeated and intensive checking of cages and by hand picking.

OBSERVATIONS

It is observed, during predation *C.cingulatum* sits on the oysters and its proboscis gland secretes an acidic fluid which paralyses the oyster, as a result the shell valves remain agape to enable the whole of fleshy portion to be fed by the predator as reported by Thangavelu and Muthian (1983). As a result, the valves were found to remain open without damage to the shell, but the entire flesh devoured by the predator. Details of cages cleaned, oysters examined etc. are given in Table 1. From February to July, 1986 a total of 4,010 cages were cleaned and 6, 09, 680 *P. fucata* were examined. In all 934 *C cingulatum* were collected and destroyed. 50, 901 oysters were found dead ranging in Dorso Ventral Measurement (DVM) between 20 and 40 mm. The rate of mortality was found to be high during February (18.2%) and May (12.2%) followed by April (9.4%) and March (7.4%). The average mortality recorded for the entire period of observation was 8.3%. A maximum number of 425 *C. cingulatum* was

TABLE 1. *Particulars of the number of pearl oyster cages cleaned, oyster examined and* Cymatium cingulatum *recorded at Krusadai Pearl oyster farm from February to July, 1986.*

Month	No. of cages cleaned	No. of oysters examined	No. of oysters dead	No. of *Cymatium cingulatum* present	Percentage of mortality
February'86	434	65,190	11,875	172	18.2
March	1,241	1,86,199	17,435	425	7.4
April	1,002	1,50,295	4,756	92	9.4
May	685	1,01,604	13,162	147	12.2
June	408	70,392	2,574	70	3.7
July	240	36,000	1,090	28	3.1
Total	4,010	6,09,680	50,901	934	8.3

picked up in March. The size distribution of *C. cingulatum* collected from the farm is given in Table 2 Among the 934 predators collected,

TABLE 2. *Size distribution of* Cymatium cingulatum *observed in Krusadai pearl oyster farm from February to July 1986.*

Size range in mm	21-40	41-60	61-88
	Numbers present in each size group		
February'86	81	64	27
March	143	216	66
April	32	41	19
May	59	73	15
June	22	28	20
July	4	15	9
Total	341 (36.5%)	437 (46.8%)	156 (16.7%)

21-40 mm size group (341 nos.) constituted 36.5%, 41-60 mm size group (437 nos.) consisted of 46.8% and 61-88 mm individuals (156 nos.) were 16.7%. The maximum length of *C. cingulatum* observed was 88 mm and the minimum size was 21 mm. Comparatively young oysters less than 40 mm in DVM were found to be susceptible for predation.

REMARKS

Cymatium cingulatum is found to be the principal predator inflicting heavy casuality on pearl oysters in the farm at Krusadi Island. The maximum mortality of 18.2% caused by the predator was in February, 1986 and the average mortality for the period of observation was 8.3% vide Table 1. This appears to be less in comparision with the 13% mortality observed in Tuticorin edible oyster farm by Thengavelu and Muthiah in 1983, 17.4 to 40% mortality recorded in the pearl culture farm at Tuticorin by Jeyabaskaran et al (1983) and 30% mortality caused by oyster drills in Atlantic coasts (Adams, 1947).

Oysters of smaller size group (below 40 mm DVM) were found to be affected mainly and the rate of mortality was found to increase as the number of *C. cinglatum* increased. The fact that smaller size groups were mostly affected was observed earlier by Jeyabaskaran et al (1983) also. By repeated checking and hand picking manually, the predators can be eliminated,

It is a probability that these predators occurring in pearl oyster beds off Tuticorin (Jeyabaskaran *et. al*, 1983) might have found entry into Krusadai farm along with the stock of oysters collected at Tuticorin and transported to Krusadai. But there is every possibility of the local stock of *C. cingulatum* found in

Krusadai Island area (Satyamurthy, 1952) invading the pearl oyster farm and causing destruction.

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60. ASPECTS OF THE BLOOD CLAM, *ANADARA GRANOSA* (LINNAEUS) CULTURE IN KAKINADA BAY

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ABSTRACT

A. granosa of mean length 25.2-25.9 mm, when grown in boxes for about 4½ months did not reveal any disparity in the growth rate at densities of 50-100/0.25m² but at 125-150/0.25m² the growth rate is significantly reduced. Growth in weight showed similar reduction. It is shown that in the Kakinada Bay, a stocking density of 100 clams/0.25 m² of about 7 g average weight gives the maximum production of marketabla size (25 g) *A. granosa* in about 4½ months. In the absence of a pen enclosure, field culture of *A. granosa* gave a production rate of 21 t/ha/6months with 41.5% retrieval. Although the clams have restricted movements their mobility is large enough to reduce both the retrieval and production rates by about 50% if pen enclosure is dispensed.

INTRODUCTION

The results of pen culture experiments conducted on *A. granosa* during 1979-80 in the Kakinada Bay on growth, production and retrieval were published (Narasimham 1980, 1983). It is of practical importance to determine the optimum stocking density in order to obtain the maximum production of marketable clams. Also, of importance is how the production was affected when culture is undertaken without pen enclosure. The results of a study undertaken during 1981-82 to throw light on these aspects are dealt in this paper.

MATERIAL AND METHODS

The details regarding the topography of the culture site, preparation of the ground, method of seed collection, stocking and harvesting are given by Narasimham (1983). The condition index, determined as percentage of wet flesh weight in total weight, was studied in a sample

of 25 clams, collected at monthly intervals from the clam farm and clam bed.

The effect of density on growth and production was studied by growtng clams of narrow length range in 5 dealwood boxes. Each box measured 50 cm x 50 cm x 15 cm. The boxes were filled to about 2/3 depth with sediment obtained from the clam bed from the top 10cm depth. After introducing the measured clams, the boxes were covered with synthetic webbing of 1 cm mesh. The boxes were positioned close to the eastern boundary of the clam culture site in the subtidal region. Once in a month all the clams were measured and reintroduced into the boxes after changing the sediment. Based on weekly observations, the monthly average temperature, salinity and dissolved oxygen of the waters over the clam culture site were calculated.

RESULTS

Environmental conditions In the clam culture site during May-October 1981 and March-September 1982, the temperature varied from 28.0 to 33.5°C and salinity from 15.06 to 34.40°/$_{oo}$. The maximum values for both these parameters were obtained during summer in May. With the onset of the south-west monsoon in June both the values declined by September/October. The dissolved oxygen was high and ranged from 5.18 to 6.80 ml/l.

Effect of density on growth and production Clams measuring 24.0 - 27.2 mm length (mean lengths 25.2-25.9 mm, mean weights 7.01-7.68 g) were stocked on 3-5-1981 in the boxes 1-5 with 50, 75, 100, 125 and 150 numbers/box respectively (Fig 1). In June and July the mean length of clams in any box was within one standard deviation of the mean length of clams in any other box. In August the mean length of 34.1 mm in box 5 was below one S. D. of the mean of clams in other boxes. On 16.9.81, when the experiment was terminated, the mean lengths in different boxes varied from 35.9 to 40.2 mm and mean weights 19.06 to 26.64 g; the mean lengths in boxes 4 and 5 at 37.3 and 35.9 mm respectively were below one S. D. of the mean lengths (39.6 to 40.2 mm) of clams in the other 3 boxes. Analysis of variance (Table 1) showed that the mean lengths attained by the clams in different boxes, at the termination of the experiment, were significantly different at 5%. The 95% confidence limits for 39.6 mm mean length (box 1) worked

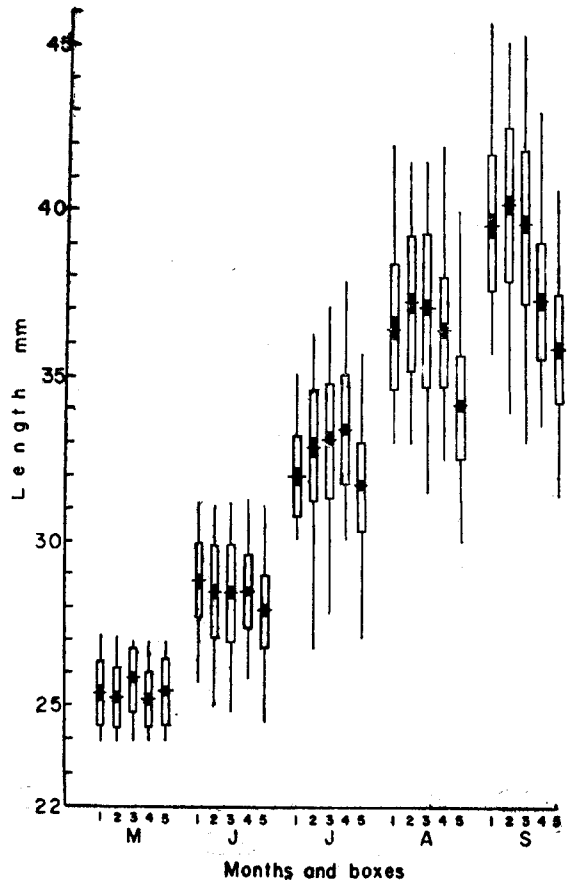

Fig. 1. *A. granosa* : Study of growth by placing clams in boxes during May-September 1981. The vertical line (not depicted in the area showing S.E and S.D) shows the range, the small horizontal line the mean, the shaded and open boxes together one standard deviation and the shaded boxe alone one standard error on either side of the mean. The numerals 1-5 in each month indicate the box numbers.

TABLE 1. *Analysis of variance of mean lengths of* A. granosa *in boxes as on 16-9-1981*

Sources of variation	d. f.	S. S.	M S.	F
Between boxes	4	1424.66	356.1650	92.573
within boxes	473	1819.83	3.8474	
Total	477	3244.49		

F. (d. f. 4. 473) 5% = 2.39

out to ± 0.6724; the mean lengths obtained in boxes 2 and 3 are within these limits while those recorded in the boxes 4 and 5 are outside the 95% confidence limits. This indicates that the slow growth observed in boxes 4 and 5 is significant when compared to the growth in the other boxes. On termination of the experiment, in boxes 1-3, the mean weight varied from 25.95 to 26.64 g whereas in boxes 4 and 5 it was low at 21.82 and 19.06g respectively. Thus the growth in weight also showed reduction in boxes 4 and 5. In the course of this study mortality of the clams was 11 in box 1, 2 in box 2, 1 in box 3, 2 in box 4 and 6 in box 5 and this could be due to predation by the crab, *Charybdis* sp (carapace length 5-7 cm) as inferred by their presence in the boxes which they obviously entered by damaging the webbing, covering the boxes.

To study the effect of density on production the data pertaining to box 1 was excluded from analysis since the mortality was 22%. In the remaining 4 boxes survival rate varied from 96-99% and it is assumed that the slight mortality of the clams observed is not significant to affect production. The production increased from1944.7 g in box 2 to 2744.6g in box 5 (Table 2) suggesting higher production with increase in density. However, the clams attained the marketable size of 25 g only at densities 75-100/0.25m²; at higher densities of 125-150/0.2 m² they did not reach the marketable size. In an earlier experiment (Narasimham 1983) it was shown that clams stocked at densities 10-60/0.2m² did not show any disparity in the growth rate. It is concluded that in the Kakinada Bay, under the prevailing conditions, maximum production of marketable size *A. granosa* can be obtained at a density of 100/0.25m².

TABLE 2. *Initial density (no/0.25 m²),survival, survival rate, average weight attained and production of* A. granosa *grown in boxes.*

Box no.	Initial density	Final no	Survival rate %	Mean wt g	Total wt g.
1	50	39	78.0	26.15	1019.9
2	75	73	97.3	26.64	1944.7
3	100	99	99.0	25.95	2569.0
4	125	123	98.4	21.82	2683.9
5	150	144	96.0	19.06	2744.6

Field culture: An estimated 1 million clams of the length range 17-25mm (mean length 21.8mm, mean weight 5 68 g) were transplanted in a 0.5 ha area between 22 and 31-3-1982 (Table 3).

TABLE 3. *Stocking, growth and harvesting particulars of* A. granosa *in 5000 sq. m during 1982.*

		Size range(mm)	Mean length	Mean weight g
Stocking:				
Dates 22 to 31-3-82		17-25	21.8	5.68
Estimated no	10 00,000			
Weight	5688 kg			
Density (No)	200/m²			
Grow out phase				
	30-4-82	21-31	26.1	10.00
	29-5-82	28-37	31.8	14.03
	29-6-82	30-39	33.6	17.02
	27-7-82	30-42	35.4	20.34
	31-8-82	32-44	37.8	23.81
Harvesting:				
Dates 20 to	30-9-82	34-50	39.7	25.33
Estimated no	4,15,000			
Retrieval rate	41.5%			
Production	10.51 t/0.5 ha/6 months			

This gave density of 200/m². Pen enclosure was not used. The clams were harvested between 20 and 30-9-1982 and an estimated 4,15,000 clams were retrieved (retrieval rate 41.5%). At harvest the mean length was 39.7 mm and mean weight 25.33 g. A production of 10.51 t/0.5 ha/6 months was obtained.

The condition index of the transplanted clams varied from 15.6 to 24.4 during May-September and this compared well with those studied from the clam bed (Table 4).

TABLE 4. *Monthly average condition index in* A. granosa *from the farm and clam bed*

Month	Condition index	
	Culture site	Clam bed
May'82	15.6	17.3
Jun	17.5	19.8
Jul	19.7	20.0
Aug	22.4	22.0
Sep	24.4	23.3

DISCUSSION

Broom (1982) stated that density and exposure are the main factors controlling the growth of *A. granosa* in Malaysia. It is shown that in the Kakinada Bay, densities of 75 and 100 clams/0.25m² did not affect the growth whereas growth rate is reduced at densities of 125-150/0.25m². Overcrowding may result in reduced food supply which in turn adversely affects the growth.

In Malaysia, *A. granosa* is stocked at high densities in the commercial farms and thinned more than once to attain final densities of 300 to 600/m² (Bardach et al 1972). In the pen culture experiments conducted at Kakinada (Narasimham 1980, 1983), the clams were stocked at densities 30 to 175/m². The present study suggests that in the Kakinada Bay, a stocking density of 400/m² is optimum for maximising the production of commercial size *A granosa*.

A. granosa has restricted movements and in the commercial culture operations in China and Malaysia, pen enclosures are not used (Zhong-Qing 1982, Oon et al 1982). However, in Taiwan for the nursery rearing of the spat of the same species, fencing by nylon netting is used (Chen 1976) and in Thailand, during the grow-out phase bamboo fences are erected to prevent the movement of *A. granosa* from the farm area (Saraya 1982). In the U. S. A., fencing was found to be necessary to exclude predators (chiefly crabs) in the experimental plots where the hard clam *Mercenaria mercenaria* was grown (Bardach et al 1972). In the earlier studies at Kakinada, when pen enclosure was used, a retrieval rate of over 83% and production rates of 38.5-41.6 t/ha in 5 to 5½ months were obtained for *A. granosa* (Narasimham 1980, 1983), whereas in the present study the retrieval and production rates came down to 41.5% and 21:0 t/ha/6 months respectively when the pen was not used. This suggests that under the local conditions, the movemements of the clams away from the farm area are substantial so as to reduce the retrieval and thereby production within the farm by about 50% when the pen enclosure was not used. In other words, although the clams have restricted movements, their mobility is sufficiently large so as to affect the production. In these studies a few crabs were observed in the boxes in which *A. granosa* was grown and they never occurred in abundance in the farm to warrant attention.

Considerable variation in the duration of the culture and production rate of *A. granosa* was reported from different countries. From China production rates of 23 5-60 t/ha/4.5 years were given (Zhong-Qing 1982). In Malaysia, this species reaches marketable size in 6-10 months (Bardach et al 1972) and a production rate of 40 t/ha/year was reported (Oon et al 1982). In Thailand the duration varies from 5 to 12 months depending on the size of the seed stocked and production rate of 31-109 t/ha/year were mentioned (Saraya 1982). The production figures obtained for *A. granosa* in the Kakinada Bay compare well with those reported from Malaysia and Thailand while in China, under the temperature conditions, the growth is slow requiring longer time to reach marketable size.

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61. SETTLEMENT OF SPAT OF THE BACKWATER OYSTER, *CRASSOSTREA MADRASENSIS* (PRESTON) IN PULICAT LAKE

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ABSTRACT

Spawning of the backwater oyster *Crassostrea madrasensis* (Preston) and settlement of its spat on the cultch material have been observed from April 1980 to November 1982 at Pulicat Lake. The intensity of spat settlement on the cultch was correlated with the abundance of veliger larvae in the plankton. Settlement of spat was found to be high during May and low during November when the salinity was high and low respectively in the lake. The salinity of the lake during the summer months seems to be favourable for the growth and settlement of the larvae.

INTRODUCTION

The basic need in any culture practice is a steady supply of seed. Seed production in the natural beds is not always dependable and fluctuates due to various factors in the environment. In most of the industrialised countries' water pollution has wiped out large areas of natural oyster beds and even destroyed the coastal fisheries. To prevent depletion of stocks, of new methods of fish and shellfish cultivation are being developed. Some work has been carried out in India on collection of oyster spat. Hornell (1910, 1922) reported the the use of roofing tiles for spat collection in the Pulicat Lake. Devanesan and Chacko (1955) tried casuarina twigs and oyster and cockle shells at Ennore, but did not obtain encouraging results. Sundaram and Ramadoss (1978) reported on the suitability of lime-coated tiles at Tuticorin. The other important works on oyster spat are of Rao (1951) and Rao and Nayar (1956) in Adyar estuary, Dhulkhed and Ramamurthy (1980) and Stephen (1980) in the Mulki estuary, Purushan et al (1981) at Cochin backwaters, Thangavelu and Sundaram (1983), Nayar and Mahadevan (1983) in Tuticorin bay and Rao et al (1983) at Athankarai estuary.

MATERIAL AND METHODS

In order to investigate the intensity of spat settlement and frequency of larval abundance a sampling station opposite to the Estuarine Biological Laboratory was established. A small experimental rack of size of 2 m x 1.5 m was constructed by driving the casuarina poles into the muddy bottom. Poles were tied horizontally just below the surface of water and perpendicular to these poles transverse poles were tied to form a rack in such a way that the gap between them was sufficient to prevent the tiles falling from the rack. Curved roofing tiles (22 x 12 cm) were procured locally, cleaned and then coated with lime as described by Thangvelu and Sundaram (1983). After ascertaining the ripeness of the gonads of oysters by periodically examining some oysters in every season 50 tiles were arranged on the rack in the form of a crate. In addition to the tiles, weathered oyster shells (100 numbers) were also placed in a 45 x 30 cm bag made out of 2 mm synthetic twine with mesh size of 20 mm and the bag was suspended from the rack. The tiles and shells were examined after a period of 15 days and the number of spat settled on the cultch was noted.

Plankton samples were collected from the sampling station by filtering 200 l of water through a hand net made with fine shed bolting silk. Plankton collections were preserved in 2% formalin and analysed by using the plankton counting chamber and the number of bivalve veligers present in 100 l were calculated. Salinity, temperature and dissolved oxygen were also recorded from the spat collecting site regularly.

RESULTS

Relation between the ripe oysters and number of larvae in plankton

The percentage of ripe male and female oysters in the samples throughout the period of study is illustrated in Fig 1. Maximum number of fully ripe oysters of both the sexes were found during April and October during three years of study from 1980 to 1982. Immediately after the outbreak of the north east monsoon, due to freshwater influx the salinity of Pulicat Lake decreased to a low level during October/ November, which probably made the oysters to spawn. The rise in water temperature during April induces the animals to liberate their gametes into the water.

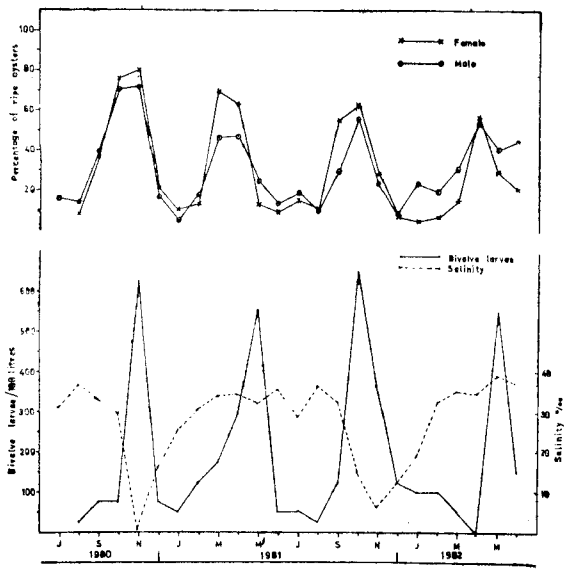

Fig. 1. Seasonal variations in the abundance of bivalve larvae/100 litres observed during July, 1980-June, 1982 and correlation with the salinity and percentage of ripe oysters.

The maximum percentage of ripe males and females during October 1980 was 75.7% and 70.5% respectively, which rose to 80% and 72% in November 1980. Since there was a delay in the onset of the monsoon during 1980 in the Pulicat Lake, spawning was also delayed and it was observed in the middle of November. Another peak of ripe ones was observed during April 1981 and it was 46.5% in females and 64.1% ih males respectively. It was found to decline during May. The same trend was observed during the corresponding months of the subsequent year also.

Immediately after spawning in November and April, there was a major peak of larval abundance in water indicating the major spawing during this period. The number of larvae was found to decline slowly during the next fortnight. In the subsequent month, the occurrence of oyster larvae was noted in the plankton samples but not in significant numbers.

The maximum occurrence of veligers in the plankton which are predominantly those of *C. madrasensis* coincided with the maximum percentage of spent oysters in the population. The peak occurrence of veliger larvae was observed in the lake during November soon after spawning which triggered by the low saline conditions as a result of northeast monsoon rain. In April, another peak of larval occurrence was observed in the lake.

Relative abundance of veligers in relation to spatting

The average number of spat collected on the tiles and shells during different periods are given in the Table 1. Oyster spat settled during April 1980 on the lime-coated tile and oyster cultch were 33 and 4 respectively. In October 1980, the average number of spat settled on a single tile was 3 whereas settlement was totally absent on shells. In April 1981, the average settlement was 19 and 2 on tiles and shells respectively. The spatfall during this period was less when compared with the previous year of the same period. In October '81, the average settlement of spat was 27 per tile and 3 per oyster shell and the number of veligers in 100 l of water was 650. Salinity was slightly higher than in the previous year. There was very good spat settlement both on the tiles and shells during April 1982. On considering the data for three years, the setting of oyster spat was considerably high during May and poor during November.

TABLE 1. *Number of spat collected in two types of spat collectors during the period April 1980 to November 1982.* (each value represents the mean (± S. D).

Type of spat Collector	Number of tiles/shells used.	Period of spat collection Apr/May, 1980	Oct/Nov 1980	Apr/May 1981	Oct/Nov 1981	Apr/May 1982	Oct/Nov 1982
Lime-coated tiles	50	33 ± 9.9	2.6 ± 2.29	19.04 ± 10.98	27 ± 20.42	51.5 ± 16.51	2.4 ± 2.37
Oyster shells	100	4.46 ± 2.23	0.0 ± 0.00	2.04 ± 1.88	2.29 ± 2.48	3.71 ± 2.90	0 0 ± 0.00

Salinity and setting of spat

Salinity is an important ecological factor in the lake which shows diurnal, seasonal and annual fluctuations in the environment. The time of spawning and the peak occurrence of oyster larvae are probably regulated by the seasonal salinity patterns. The seasonal variations in relation to the abudance of larvae in plankton are illustrated in Fig 1. Major spawning peak was observed during November '80 and relative abundance of larvae in the lake was also found to be high but the settlement of spat on the spat collectors was very poor. This may be due to poor larval development in the low saline conditions prevailing in the lake. There are changes for the mortality of veliger larvae in the lake during the low saline conditions. During the minor peak of spawning in April, the salinity was found to be 34.83 °/₀₀ and the larval abundance in the plankton was also moderately lesser than in October. Since there was no significant change in the salinity of water during April, there was no possibility of mortality of the larvae and the settlement of spat was also considerably high. In October 81, the salinity was 6.83°/₀₀ which was considerably higher than the previous year, the settlement of spat was also considerably higher during this period. It is obvious that this salinity was conducive for larval development and the settlement was on an average of 27 per tile and 3 per shell. Again in April 1982, the settlement of spat was high when compared to earlier months' but in October 1982, the settlement was very poor as it was for October/November 1980. By and large, the settlement was high during May 1982 when the salinity was moderately high.

Other factors regulating the rate of setting of oyster spat

The settlement of oyster spat on the spat collectors is greatly influenced by biological

TABLE 2. *Monthly variations in salinity, temperature and dissolved Oxygen observed over the oyster bed at Pulicate Lake*

Months		Salinity ‰	Water Temp. (°C)	Dissolved Oxygen (ml/1)
Jul	1980	31.06	30.0	4.65
Aug		36.56	29.3	4.14
Sep		32.95	30.0	4.03
Oct		29.56	29.5	7.43
Nov		0.37	29.5	4.99
Dec		16.02	25.8	4.42
Jan	1981	25.74	26.0	4.70
Feb		30.39	27.5	5.22
Mar		34.14	29.0	4.20
Apr		34.83	31.0	3.97
May		32.21	30.5	4.65
Jun		35.42	30.0	3.91
Jul		29.20	29.8	5.16
Aug		36.53	27.8	4.31
Sep		32.63	27.0	4.76
Oct		14.99	29.0	5.57
Nov		6.83	26.0	4.48
Dec		12.41	24.0	8.83
Jan	1982	18.99	23.0	3.19
Feb		32.84	23.0	5.22
Mar		35.29	29.0	3.19
Apr		35.29	29.5	3.82
May		39.24	29.0	4.71
Jun		37.19	29.0	6.49

and environmental conditions. There are favourable conditions such as extensive oyster beds, with sexually mature adult stock, a sharp fall in salinity during the northeast monsoon which triggers the rapid spawning of oysters, suitable physical factors like tides, waves and winds which contribute to the dispersal or accumulation of these larvae, suitable rise in water salinity and temperature during the summer months which facilitated a healthy growth of the larvae, suitable substratum for good settlement (Table 2). There are certain other factors which by direct or indirect means do not favour the settlement. The reason for the poor settlement is due to poor growth of the larvae in lower saline conditions, or mortality might have occurred due to silting or lack of larval food in the water. Mortality might have been due to predation, turbidity or the fast flow of water and these factors have considerably impeded the settlement after peak spawning of oyster,

DISCUSSION

Salinity, temperature and other factors are of utmost importance to induce spawning, successful development of embryos to the veliger stage and to promote setting of oyster spat (Loosanoff and Davis 1952). Based on the examination of oysters the percentage of ripe oysters in the population, the quantity of larvae produced and the number of seed collected; the efficiency of seed collection was determined. Ambient temperature does not seen to play much role in the spawning of oysters in the tropical regions. Salinity is the main factor that influences the spawning. The fall in salinity during the northeast monsoon on the contrary, is the chief stimulating factor in the spawning of the Madras oysters on the east coast backwaters of South India (Hornell 1910, 1910a, 1922 and Rao 1951). The percentage of ripe ones in October, decline considerably in November indicates the major spawning of oysters as a result of low saline conditions prevailing soon after northeast monsoon rains. The presence of early stages of oyster larvae in plankton also indicates the recent spawning, and their number will indicate whether it was a minor spawning.

In the present study on oysters of Pulicat Lake, the intensity of spawning was found to be considerably high during October/November as indicated by the presence of a large number of veliger larvae in the plankton, but mortality of veliger larvae is also moderately high due to low saline conditions (0.37%) and prevalence of heavy silting in the lake. Though the spawning intensity of oysters was low during April/May when compared with October/November in the three years of study, the setting of spat on tiles and shells was most intense. This was mainly attributed to the optimum salinity (34.83°/$_{oo}$) conditions prevailing for the larval growth and settlement. From this, it is clear that the larval development, growth and settlement of oysters are influenced by the salinity in the lake. Below the 5°/$_{oo}$, salinity level oysters cease to feed and hence the growth gets inhibited (Galtsoff 1964). The larval development, growth and settlement were moderate in salinity ranged between 32.21°/$_{oo}$ and 33.24‰ Mortality of larvae during their free swimming life is obviously high but assessing the causes for this mortality is very difficult. Predation and dispersion are probably the major causes although mortality due to disease has not been adequately evaluated. The relation between larval transportation are also poorly understood in Indian coasts.

Both roofing tiles and weathered oyster shells seem to be effective for the collection of oyster spat. Andrews (1971) mentioned that in high salinity of the eastern shores of Virginia, Carolina and Georgia there is intensive spatfall due to moderately high tidal amplitude. Hopkins (1931) found correlation between the periods of setting and the periods of high salinity in *Ostrea. (Crassostrea) virginica* of Galveston Bay, Texas and considered that this larvae depend on the salinity either directly or indirectly to develop to the setting stage. According to Pritchard (1952) both the James River and the Delaware Bay have low saline areas with high production of seed oysters but the recruitment level was poor. The findings in the precent study agree with the views of Andrews (1971).

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62. CONSTRAINTS IN IMPLEMENTION OF FARMING TECHNIQUES IN COMMERCIAL MOLLUSCAN SHELLFISH CULTURE

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ABSTRACT

In the past nearly two decades elaborate and unfailing techniques have been developed at some of the Research Centres of the Central Marine Fisheres Research Institute for the culture of oysters, clams, mussels etc. among the molluscan shellfish. Culture of pearls of perfect form in the pearl oyster species using indigenously developed techniques has also been initiated. The farming operations so far undertaken have been only on an experimental scale in pilot demonstration farms run by governmental effort in restricted areas. There are many constraints for conducting culture on a commercial scale, the chief among them being the acquisition of suitable farming sites with a right to ownership on lease. The availability of adequate seed resources of the species of consumer preference and facilities for transporting production to marketing centres or processing establishmants are items which need careful examination. Infrastructural facilities should include provision for depuration of the harvested production. The need for technical manpower to supervise and monitor operations and offer advice and guidance is essential. At the initial stages substantive financial support is also expected. The nature of the problems and the need to solve them to make molluscan culture commercially feasible and remunerative are outlined in the paper.

INTRODUCTION

Marine molluscs such as clams, cockles, edible oysters and mussels inhabiting wide areas both along the east and west coasts of India are being exploited from early times by coastal populations almost entirely from natural stocks. However, in a few places in the vicinities of big cities oysters are transported from natural beds or relaid in shallow hardened grounds for a little growth before they are supplied to interested parties on demand. The pearl and chank beds are under the monopolistic rights of the State Governments and their fisheries are regulated by suitable legislative measures. The chank fisheries are regular and annual but the pearl fisheries have serious setbacks, the grounds remaining barren for prolonged periods. Interest was envinced in oyster culture and pearl culture experiments by the Department of Fisheries of the Government of Tamil Nadu about fifty years back but the work was subsequently suspended. In short, earlier to the seventies of this century, none of the

molluscan species were under propagation by culture in this country. The Central Marine Fisheries Research Institute has realized the importance of developing methods of farming molluscs and evolved the techniques for the culture of oysters, mussels, clams and pearls (Silas et al 1982). The techniques have been repeatedly tested by the Institute by conducting culture on an experimental scale and the feasibility of undertaking large scale culture operations of chosen species of molluscs to achieve substantial increase in production both for use within the country and for supporting export trade besides creating employment for a large section of rural population has been indicated.

In experimental farming of oysters and massels the cost-benefits worked out have shown high rates of profits on investments. Pearl culture techniques worked out by the Central Marine Fisheries Research Institute have already been put into operation by the Southern Petro-Chemical Industries Corporation in collaboration with the Department of Fisheries of the Government of Tamil Nadu.

There is vast scope for carrying out culture of different groups of molluscs in suitable localities at commercial level of production by private entrepreneurs. However, this being a new line of industry in India there are some forseeable constraints which have to be removed to achieve progress.

ACQUISITION OF SUITABLE SITES FOR FARMING

The basic requirement for culture is a suitable farming site. As it exists, now, the coastal tracts and adjacent water areas are not marked out into plots to be leased out to shellfish farmers. Suitability of farm site is determined by the high productivity of waters and favourable hydrological conditions for growth and breeding of the species under propagation. The site has to be away from regions of heavy siltation and free from the menace of pests and predators. The location of the farm should be such that the farmer can carry out his avocation without hindrance to navigation or capture fisheries or any other activities in the area. Coastal waters are often contaminated with domestic, agricultural and industrial wastes and it is imperative that the waters of farming site should be free from such pollutants. The environs where different molluscan species thrive in respect of substrata supporting them as also the salinity tolerance levels etc. are varied and specific. It is therefore, necessary to select sites to meet the special requirements of the particular species to be cultured and these involve intensive preliminary investigations.

AVAILABILITY OF SEED

The shellfish farmers should be able to procure adequate quantities of seed from the natural beds in the open waters or from hatcheries. Hatchery production of seed is expensive and may not be within the means of a small scale farmer. Collection of seed from closeby natural beds may not be large enough to meet the farm requirements. There is lack of information on the distribution and magnitude of seed resources in different grounds. In respect of some oyster, mussel and clam species this information is gathered by the Central Marine Ftsheries Research Institute and other government organisations especially in some of the southern states but the work has to be extended to other coastal areas. Such information will enable establishment of a network of low cost seed collection centres. If the seed is to be collected from far off grounds the transport and proper handling of them present some difficulties. However, if the resource is large, the seedlings can be used to support export trade. The seedlings such as those of oysters can be hardened adopting methods in practice in other countries so that they can withstand the strain of transport over long distances. It may be mentioned here that hardening for relatively shorter duration is also advantageous to reduce mortality rates for culture within the same country as observed in Taiwan. If only a detailed distribution pattern of shellfish seed for all areas is available, much can be done to plan out transplantation techniques from one locality to another where it is required to

augment production with relatively less expense. Clams of several species lend themselves well for the purpose.

CULTURE TECHNIQUES, FARM EQUIPMENTS, SERVICE FACILITIES FOR FABRICATION AND MAINTENANCE OF RAFTS ETC.

Culture techniques employed should have a bearing on the extent of demand and utilisation of the production obtained. The present level of utilisation of molluscan shellfish for food purposes in the country is low to moderate being confined to restricted zones where the natural productlon is almost sufficient to meet the local requirements. There is, however, a growing awareness that the products are nutritious and that the potential resources should not be neglected but exploited by culture practices for improving the quality for wider acceptability and increase in quantity to support export trade after processing suitably. The techniques generally used broadly fall into two categories, one for cultute on substrata at bottom level and the other in the water column at various levels. The relative efficiencies of the two types of methods are well-known. The first type is relatively less expensive than the second which involves floatation devices, suspension gadgets etc. obtainable at no small investment. Conditions for off bottom culture of shellfish during monsoon months being not favourable due to rough condition of the seas or heavy gales, rafts and other devices have to be beached with the result that the duration of the culture operations have to be reduced to a period of about six months. The advantage of bottom culture operations is that they could be carried out continuously round the year.

The types of culture methods well tried and currently in practice at the experimental farming stations mainly make use of the following: 1) Durable wooden racks holding trays with oysterlings and shell rens or stakes in oyster culture, 2) Floating rafts with suspended ropes with attached seedlings in mussel culture, 3) Rafts with similar designs holding seeded pearl oysters in cages or frames for culture, 4) In clam culture for *Anadara, Meretrix* etc. seed are simply broadcast on sandy mudflats with equal success in raising good crops and 5) The hatchery techniques for raising the the seed of edible oysters, mussels and pearl oysters are necessarily elaborate in conditioning the adult shellfish for gonad maturation, in inducing them to spawn and in rearing the larvae to size of their settlement by feeding them on chosen cultures of microalgae. The pearl culture techniques are highly sophisticated in *seeding* of oysters with mantle grafts, the beads for this purpose being imported from Japan.

In general the techniques developed are being improved upon and refinements constantly made. The technologies developed by research are included in various training programmes to interested scientific and technical personnel. In locations where the farms are situated transfer of technology is carried out and the local small scale fishermen are given opportunities to actively participate in operational procedure of shellfish farming.

NEED FOR INFRASTRUCTURAL FACILITIES, EXTENSION, DEPURATION TECHNIQUES AND FINANCIAL ASSISTANCE

The infrastructural facilities required are varied. Of much importance is the availability of the services of a well trained technical person for offering advice and guidance to the shellfish farmer, at the initial stages in organising the farm, in fabricating specialised equipment and in providing basic amenities.

In the later stages he should supervise operations with managerial ability, until the farm production reaches the consumer in a suitable form. His role as an extension worker in popularing the shellfish as highly nutritious and health giving food is no less important.

Mussels, oysters or clams and the like are filter feeders which take in pathogens and accumulate harmful chemicals etc. from the ambient aquatic medium which gets contaminated by domestic, agricultural and industrial discharges. Shellfish from polluted waters may cause health hazards and instances are on record of shellfish poisoning in human beings

Sudden appearance of rich plankton blooms of some species like the dinoflagellate, *Gonyaulax* etc. result in shellfish toxicity. Molluscan shellfish at present in this country do not pass through inspection tests to certify to safety of their use as food items as it is done in some advanced countries. Depuration techniques using sea water treated with chlorine, ozone or U. V irradiation are effective in removing pathonic bacteria etc. to a considerable extent. The infrastructural facilities should necessarily include those for depuration.

As the molluscan shellfish culture is altogether a new venture, adequate financial support should come from governmental or other organizations as loans, subsidies etc. in the initial stages. Institutions like NABARD and I. D. B. I. could give financial assistance to entrepreneurs taking up large scale molluscan culture and scheduled and co-operative banks to small scale shellfish farmers by giving loans at concessional rates of interest.

In experimental farms commendable work has been done so as to initiate commercial production of shellfish. Constraints may be varied and many but once a beginning is made in commercial farming, solutions will be found to remove them. There are countries which have adopted advanced techniques for successful propagation of shellfish and this should go a long way to achieve success.

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Session III

HATCHERY DEVELOPMENT FOR SHELLFISH SEED PROUCTION

63. HATCHERY DEVELOPMENT FOR SHELLFISH SEED PRODUCTION

—Theme Paper

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The evolving of hatchery techniques for producing seed of marine molluscs of economic importance is one of the important achievements in marine fishery research in this century. This field of reserch had its origin in the efforts of scientists who attempted towards the close of the last century and the early period of the twentieth century. Some of the earliest work in the subject is that of Brooks (1880) on the eggs and early larval stages of the American oyster *Crassostrea virginica* and the attempts by Ryder (1883) and Winslow (1884) to grow oyster larvae to metamorphosis. There was much skepticism and also severe criticism by experienced biologists like Nelson (1921) of the utility of the efforts. In the early twenties Wells (1926, 1927) succeeded for the first tme in rearing the larvae of *Crassostrea virginica* to spat in glass jars. Cole (1937, 1939) reared the larvae of larviparous *Ostrea edulis* in tanks or small ponds and laboratory conditions.

The failure of the earlier workers in rearing the bivalve larvae up to seed stage was due to the poor quality of sea water used, the type of materials used like metal screens which were toxic and the absence of proper phytoplankter food for the larvae. Bruce *et al* (1940) have set up the first functional laboratory for rearing the larvae of the European oyster *Ostrea edulis*. In the middle of this century Loosanoff and his colleagues have investigated carefully hatchery techniques for culture of bivalve larvae and juveniles and contributed much to the subject by developing suitable techniques which could be adopted for large scale production of oyster larvae. Loosanoff (1945) found that if *Crassostrea virginica* are reared in warm water in winter season, maturation of gonads takes place and the oysters could be induced to spawn. This technique of obtaining sexually ripe oysters was a major breakthrough which led to the evolving of the Loosanoff-Davis method of effecting breeding of oysters and rearing oyster larvae successfully alround the year (Loosanoff and Davis, 1963). It has also been shown that spawning could be delayed in mature oysters by keeping them at low temperature.

Hatchery techniques have been developed in other species of oysters, clams, mussels, scallops, pearl oysters and abalones and this has led to the establishment of hatcheries for molluscs in various countries like U.S.A., U.K., France and Japan. Some of the hatcheries have been established by Government or Universities and the rest by private companies.

The selection of site for a hatchery is an important aspect. The hatchery should be located at a place where the temperature, salinity and other hydrological conditions are favourable for culture of the larvae. Areas with wide fluctuations in hydrological conditions, high levels of suspended matter or blooms of harmful phytoplankters are unsuitable for the setting of a hatchery. The molluscan hatchery should have all the necessary infrastructural facilities viz., filtered sea water, aeration system, temperature controlled rooms for induced maturation of gonads and stock and mass cultures of selected species of microalgae and tanks for larval and spat rearing.

The hatchery production of molluscan seed consists of six phases viz., selection and maintenance of broodstock, conditioning of the molluscan species for maturation of gonads, induced spawning, fertilization, rearing of larvae to seed in optimum conditions in laboratory and mass culture of microalgae for feeding the larvae and spat.

CONDITIONING OF MOLLUSCS FOR MATURATION OF GONADS

In temperate countries where water temperatures are low marine molluscs are conditioned for maturation of gonads by rearing the animals in laboratory at higher than normal temperatures and feeding them with a rich supply of diet (Loosanoff and Davis, 1950). Loosanoff and Davis (1952) have shown that *Crassostrea viriginica* and *Mercenaria mercenaria* could be made to reproduce repeatedly in a year if ecological conditions especially temperature are controlled. In the tropical water where the water temperature is higher than in temperate regions immature *Crassostrea madrasensis* are fed with adequate quantities of mixed phytoplankton especially diatoms and reared at a few degrees below normal temperature for conditioning the oysters for maturation (Nayar *et al.*, 1987). The oysters were found to attain several maturity in ten to twenty days.

INDUCED SPAWNING

Marine molluscs could be induced to spawn artificially by giving different kinds of stimuli like raising temperature, addition of sperm suspension to a tray in which ripe females are kept, mechanical stress or chemical stimuli by the addition of Hydrogen peroxide, Ammonium hydroxide, sodium hydroxide or tris buffered sea water (Galtsoff, 1930, Loosanoff, 1954, Loosanoff and Davis, 1963). *C. madrasensis* has been induced to spawn by raising the ambient temperature to 29°-34°C, addition of milt or 5 moles hydrogen peroxide.

FERTILIZATION

In oysters eggs are fertilized within 45 minutes after they are spawned, from a pooled sperm suspension obtained from different males (Dupuy *et al.*, 1977, Nayar *et al.*, 1987). A delay in adding sperms to freshly spawned eggs is harmful.

LARVAL REARING

Molluscan larvae are reared in filtered sea water in rectangular or circular shaped tanks. The larvae are fed with microalgae like *Isochrysis galbana, Pavlova lutheri, Dicrateria* sp., *Chromulina, Pyramimonas virginica, Pseudoisochrysis pavadoxa, Chlorella* spp , *Tetraselmis* sp or *Synachocystis* after determining the acceptance of the particular species by the larvae (Dupuy *et al.*, 1977). During the course of larval rearing culling is done at different stages of development and slow growing ones are segregated and reared separately. The feeding density of the algal cells/larva/day is determined by trial feedings. In the case of sedentary species when the larvae grow to the creeping stage spat collectors are provided in the tanks for setting. The kind of spat collectors suitable for the purpose varies in the case of different species.

MASS CULTURE OF MICROALGAE

The microalgae mentioned above are isolated from sea water collections, the particular species selected is isolated and pure cultures are obtained by culturing them in controlled conditions in test tubes in Conway's or Walne's medium (Walve, 1974) and using these stock cultures in Haufkin's flasks and subsequently mass cultures in perspex tanks, glass carbuoys or polythene bags are carried out.

RELEVANCE OF MOLLUSCAN HATCHERIES

It is considered by some that development of molluscan hatchery systems is not of much significance but this is not correct. The establishment of a hatchery requires heavy expenditure but hatcheries have a very important role and are essential. The marine environment is polluted very much along several coasts and collection of seed from nature is often difficult. In this context, production of seed in hatchery

systems will be of great help to those intending to culture a particular molluscan species. By conducting breeding experiments in a hatchery it is possible to evolve strains of molluscs which are fast growing, are of high quality and disease resistant, characteristics which are looked for by the culturists and consumers.

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64. INDUCED MATURATION AND SPAWNING OF *CRASSOSTREA MADRASENSIS*

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ABSTRACT

One of the constraints in the development of hatchery techniques for the production of the seed of oysters on a year round basis is the difficulty in getting spawners from the natural stock throughout the year. In order to overcome this, attempts were made for induction of maturation of gonads of *Crassostrea madrasensis* and to make them spawn. After conditioning the oysters in laboratory, gonads matured within fifteen to twenty days. Spawning was effected by administering thermal stimulation. The conditioning *C. madrasensis* for maturation of gonads and effective spawning are described.

INTRODUCTION

One of the problems experienced in the operation of oyster hatchery is the difficulty in obtaining sexually ripe oysters from natural beds throughout the year for the production of viable gametes required to run the hatchery. Hence, this study was undertaken to evolve laboratory techniques for conditioning and spawning the oyster *C. madrasensis* in this region.

Similar studies were carried out by Loosanoff (1945), Loosanoff and Davis (1963), Don Maurer and Price (1968) and Dupuy et al (1977) in the American oyster *Crassostrea virginica*. These authors succeeded in inducing the precocious development of the gonads of oysters by subjecting them to higher temperature medium. They were also able to withhold the spawning of ripe oysters by lowering the temperature medium. Don Maurer and Price (op. cited) were able to hold the oyster in healthy ripe condition for 248 days.

Loosanoff and Davis (op. cited) conditioned the oysters and a turned them into potent spawners within a period of 2 to 3 weeks. In our present studies the oysters have been conditioned by keeping them at water temperature below the normal sea water temperature and by intensively feeding them with mixed phytoplankters and corn meal which enabled the oysters to become sexually mature within a period of 10 to 20 days. Various techniques involved in this process and the laboratory facilities required for these experiments have been presented in this paper.

MATERIAL AND METHODS

Oysters which appeared healthy and comprised of different age groups were collected from Tuticorin bay and used as broodstock. The physical factors such as salinity, pH and temperature of the water in the natural bed were comparable to those in the hatchery. This feature eliminates the need for acclimatising the oysters before conditioning in the hatchery. The ambient water temperature of the Tuticorin bay has been taken as the basis for the manipulation of the temperature protocol for conditioning and spawning of oysters.

Around 750 oysters of the size ranging from 60 - 110 mm, representing "0" to "2" year old oysters were selected as brood stock for conducting 3 sets of experiments at a time. It has been observed that males are dominant, among the oysters of "0" age group and females around 60% in 2 year old oysters. The brood-stock was so selected that it included atleast 30% "0" and one year age groups.

Oysters thus selected were cleaned and placed in sea water in 100 l fibre glass tanks (75 x 50 x 25 cm) on nylon knitted `P. V. C. frames Six to eight such tanks were used and in each tank 25 oysters were held. The water temperature was maintained at 22 to 24°C by using 2 units of 1.5 ton air conditioners in a 20' x 24' room. The tanks were adequately

and continuously aerated by using an air compressor. Air stones were provided to air tubes placed in each tank to filter the air. The required filtered sea water wes drawn from the main filtered sea water supply system of the hatchery (25,000 l overhead tank). A storage tank (1000 l) was kept in the air conditioned room with filtered sea water for preconditioning the water temperature before use in the experiments.

The oysters were fed with mixed phytoplankters viz. the diatoms, *Chaetoceros affinis, Skeletonema costatum, Thalassiosira subtilis* and *Nitzschia closterium* and phytoflagellates, *Isochrysis galbana* and *Pavlova* spp at the rate of 3 l per oyster per day. The cell concentration of the algal diet was on an average one million cells per ml. Some batches of oysters were fed exclusively with the microgreen algae *Chlorella salina* in similar quantity with a cell concentration of 1 to 1.2 million cells per ml. Artificial feed such as corn flour suspension was provided for some batches of oysters. The corn flour was dissolved in water, boiled and cooled and preconditioned to the temperature of the conditioning room before feeding the oysters. 400 mg of corn flour was provided as feed per oyster per day.

The tanks in which the oysters were reared were cleaned daily to remove dirt and faeces and filled with fresh sea water before commencing the feeding. At the start of the experiments a sample of 5 to 10 oysters were opened and the stages of maturation determined by smear studies. After a period of ten days a few oysters were opened to determine the maturity stage. If the gonads of oysters did not reach desired mature stage the conditioning process was continued.

When the oysters were found to be sufficiently mature they were transferred to a 100 l perspex tank (spawning module - Fig 1) containing filtered sea water with the temperature maintained at 2 - 4° C above the ambient level viz. 4 - 8°C above the temperature maintained during conditioning process. The water temperature in the spawning tank was regulated

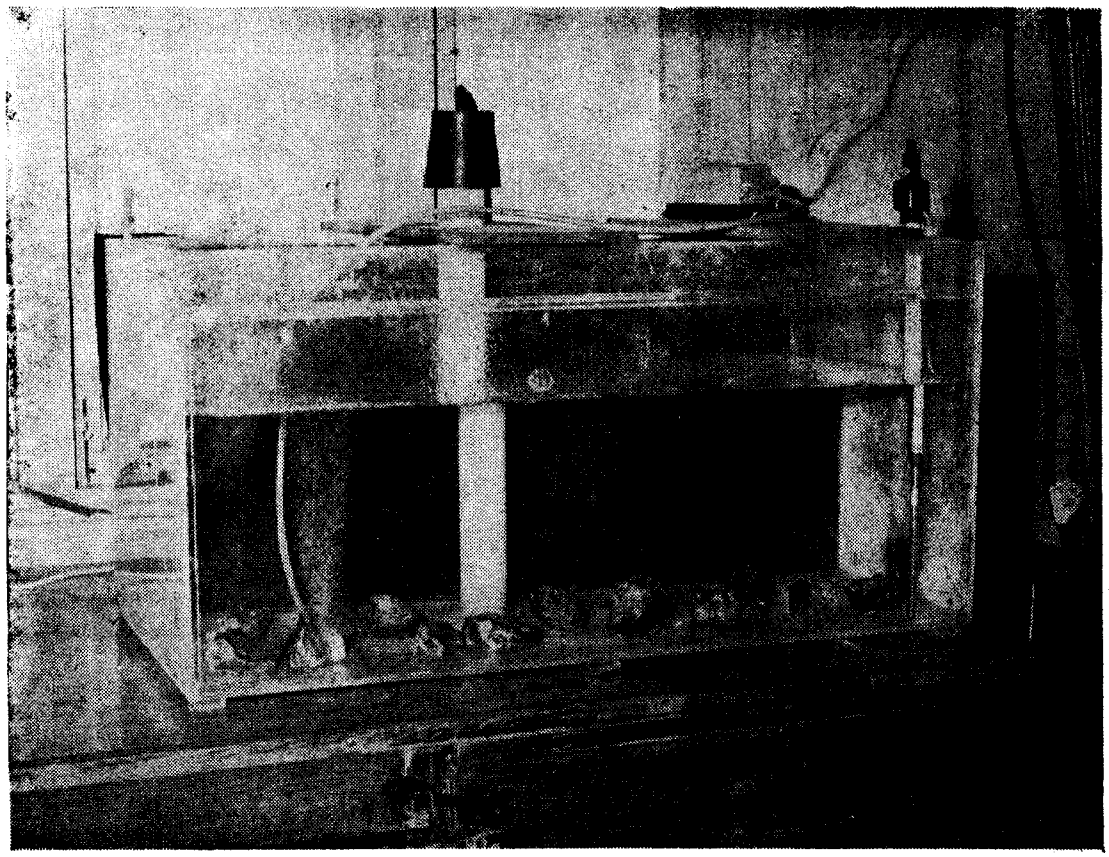

Fig. 1 Spawning module

to the desired higher level with the help of an insulated electrical heater controlled by a thermostat. The tank was also well aerated. In lees than one hour stimulated by the sudden rise in temperature the oysters spawn. Other methods for inducing spawning oysters like manipulating the pH of water adjusted from 4.5 to 5.0 or at higher levels from 9 to 10 did not produce desirable results. However, introduction of sperm suspension obtained from a ripe male oyster into the tank helped to induce spawning in 20 to 30% oysters.

RESULTS AND DISCUSSION

Seven hundred and fifty oysters in maturing and spent stages were utilised for these studies. On conditioning for 10 to 20 days the oysters showed matured gonads. Three sets of experiments involving 10 batches for each set, were conducted between April 1986 to September 1986. The different sets of experiments were carried out in order to assess the relative efficiency of the diets in conditioning the oysters. Tables 1, 2 & 3 show the incidence of spawning in the conditioned oysters during these experiments.

TABLE 1. *Spawning of* Crassostrea madrasensis *conditioned by feeding with mixed phytoplankton*

Sl. No. of expt	Period of condition-ing in days	No. of oysters tested	No. of oysters spawned		% of oysters spawned
			Male	Female	
1	20	25	8	3	44
2	15	25	4	2	24
3	17	25	5	2	28
4	12	25	7	4	44
5	16	25	3	0	12
6	11	25	9	3	48
7	10	25	8	5	52
8	16	25	9	4	52
9	10	25	7	4	44
10	18	25	9	5	56
Average value	14.5	25	6.9	3.2	40.4

TABLE 2. *Spawning of* Crassostrea madrasensis *conditioned by feeding with microgreen algae* Chlorella salina

Sl. No. of expt.	Period of condition-ing in days	No. of oysters tested	No. of oysters spawned		% of oysters spawned
			Male	Female	
1	17	25	3	0	12
2	13	25	4	0	16
3	18	25	8	3	44
4	17	25	0	0	0
5	10	25	3	1	16
6	13	25	4	1	20
7	16	25	0	0	0
8	13	25	2	0	8
9	11	25	0	0	0
10	15	25	2	3	20
Average value	13.3	25	2.6	0.8	13.6

TABLE 3 *Spawning of* Crassostrea madrasensis *conditioned by feeding with corn flour*

Sl. No. of expt.	Period of condition-ing in days	No of oysters tested	No of oysters spawned		% of oysters spawned
			Male	Female	
1	10	25	0	0	0
2	15	25	3	5	32
3	12	25	0	0	0
4	17	25	4	2	24
5	20	25	7	4	44
6	10	25	0	0	0
7	20	25	5	2	28
8	10	25	2	0	8
9	15	25	2	1	12
10	17	25	5	2	28
Average value	14.6	25	2.8	1.6	17.6

Among the conditioned oysters the ones which were fed with mixed phytoplankton registered high percentage of spawning (40.47%). The oysters which were fed with the microgreen algae *Chlorella salina* and corn flour have registered very low pecentage of spawning when compared to to the former. It

looks advisable to resort to mixed phytoplankton feeding of oysters while conditioning.

Stimulating the conditioned oysters to spawn appears to be best done by thermal stimulation process. As is universally known and practised, introduction of sperm suspension in holding tank containing ripe females will activate the squirting of matured eggs.

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65. INFLUENCE OF SALINITY AND DIFFERENT ALGAL DIETS ON REARING OF LARVAE OF *CRASSOSTREA MADRASENSIS* IN HATCHERY

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ABSTRACT

The larvae of *Crassostrea madrasensis* were reared in various salinities and fed with different algal diets. The influence of the two factors on the growth and setting of the larvae has been studied. Larval rearing experiments conducted in salinities 20 ppt, 25 ppt, 30 ppt, and 35 ppt indicated that growth as well as setting were higher in salinities 25 ppt and 30 ppt than in the other two grades. Four species of phytoflagellates such as *Isochrysis galbana*, *Pavlova lutheri*, *Chromulina freiburgensis* and *Dicrateria inornata* were accepted as food by the oyster larvae and of these, *Isochrysis galbana* gave better growth and setting.

INTRODUCTION

It is characteristic of oysters of the genus ***Crassostrea*** to thrive in estuarine environments although they can very well tolerate marine conditions. Korringa (1957) reviewed the reports of the distribution of ***Crassostrea*** sp. and stated that many of them were uryhaline and some species especially *C. rhizophorae* were found in salinities of 44 ppt at Puerto Rico. *C. margaritacea* thrives in South African intertidal zone in salinities of approximately 36 ppt. Seed of *C. gigas* grow in the creeks of Japan at 32-33 ppt. *C. madrasensis* occur along east coast of India at 32-37 ppt. More recently Stephen, (1980) reported *C. madrasensis* to be surviving in Mulki estuary with an annual salinity range of 3-33 ppt. However, the survival and growth of larvae in different salinities depends on the salinity level experienced by the parents during gametogenesis (Davis) 1958)

Dupuy et al (1977) found that the optimum development of the larvae of *C. virginica*

occurred at salinities of 17.5 ppt to 20 ppt. Nayar et al (1984) observed that the larvae of *C. madrasensis* could be successfully reared in salinities of 30.5 ppt to 36.3 ppt. In order to assess the optimum salinity conditions for the growth of larvae and setting of spat several experiments have been conducted at different salinities during April '85 to June '86. The details of the experiments and results are dealt in the present paper. Further in assessing the food requirements of oysters, experiments on feeding the larvae with four phytoflagellates belonging to the families, Haptophyceae and Chrysophyceae have been conducted and details of the experiments and the results are given in this account.

INFLUENCE OF SALINITY

Six experiments were conducted from April 1985 to June 1986 in four salinity media, 20 ppt 25 ppt 30 ppt and 35 ppt. The experiment involved conditioning and spawning of adult oysters, rearing of larvae and setting of spat in respective salinity media

Conditioning

30 oysters in each salinity media were conditioned at temperature below 2° C from ambient temperature and intensively fed with mixed phytoplankters ranging in size from 4 μ to 15 μ. Fibreglass tanks of the size 75 x 50 x 25 cm with a capacity of 80 l were utilised. The oysters exhibit ripe gonadal stages in 15-20 days.

Spawning

The matured oysters were suddenly transferred to the respective salinity media in temperature of 2-4° C higher than the ambient temperature levels This triggers spawning of the oysters. Once the spawning is initiated the oysters were transferred to spawning trays at normal water temperature levels. The egg and sperm of oysters were mixed in 1 : 3 ratio and mixed well to effect optimum fertilization. The fertilized eggs were kept in 10 l glass beakers for first 20 h with mild aeration.

Rearing

The straight-hinge or D-shell larval stage was obtained at the end of 20 h. The actively swimming larvae were separated from the container and transferred to fibreglass tanks (size 75 x 50 x 20 cm) containing filtered seawater of respective salinity media. The larval density in each of the experimental tank was maintained at 2 larvae/ml throughout the rearing period. The larvae were fed with *Isochrysis galbana* at the rate of 3000 to 4000 cells/larvae/day initially and the number of algal cells was increased upto 10,000-12,000 cells/larva/day when the larvae were about to settle.

The growth of larvae at different salinity media were recorded and furnished in Table 1. The growth has been observed to be high in 25 ppt and 30 ppt. At 20 ppt the growth rate is slightly better than at 35 ppt.

TABLE 1. *Rate of growth of larvae of Crassostrea madrasensis per day at different salinity media (in micromillimeter).*

Duration of Expt.	*20 ppt*	*25 ppt*	*30 ppt*	*35 ppt*
17.4.85-3.5.85	19.3	21.4	21.2	—
16.6.85-2.7.85	17.9	19.9	18.0	15.9
15.10.85-28.10.85	19.0	21.8	21.6	16.8
15.5.86-6.6.86	16.6	18.5	17.9	16.2
28.6.86-11.7.86	17.2	18.7	19.0	16.6
Mean	18.0	20.1	19.5	16.4

Setting

The percentage of settlement of spat ranged from 0.33 to 17.71. The settlement has been observed to be high in 25 ppt and 30 ppt followed by 20 ppt and 35 ppt. The details of the percentage of settlement in different experiments are given in Table 2.

TABLE 2. *Settlement of spat of C. madrasensis in different salinity media in percent.*

Duration of Expt.	*20 ppt*	*25 ppt*	*30 ppt*	*35 ppt*
17.4.85-3.5.85	0.24	2.2	0.15	—
16.6.85-2.7.85	4.6	6.8	5.8	2.1
15.10.85-28.10.85	0.67	2.8	2.9	0.35
15.5.85-6.6.86	2.18	6.98	2.36	0.33
28.6.86-11.7.86	6.77	17.71	10.42	4.85
-Do-	6.25	10.94	7.81	5.25
Mean	3.5	7.9	4.9	2.6

The temperature during the course of the experiments ranged between 29.1° C to 32.4° C. However each experiment has been conducted at different prevailing temperature regimes with minimum variation.

The period of settlement in each experiment varied between 13-21 days. During the course of each experiment, the variation in the tempe rature was negligible. No pronounced variation has been observed in the pH of the seawater. The algal food provided to the larvae during the course of these experiments was *Isochrysis galbana* and standard feeding protocol has been followed. (Table 3).

TABLE 3. *Feeding protocol of different experiments on larvae of* C. madrasensis.

Stages of larval development	*Cells per larva per day.*
'D' Shape	3000-4000
Early umbo	4000-5000
Umbo	5000-8000
Late umbo	8000-10,000
Eyed stage	10,000-12,000
Pediveliger	10,000-12,000

RESULTS

From these experiments under normal temperature and feeding, growth and settlement of spat have been observed to be good in salinities of 20 ppt to 30 ppt. However salinity range of 25 ppt and 30 ppt has been found to provide better results. The salinity range above 30 ppt provided low values. Coeroli et al (1984) conducted several experiments on the hatchery production of spat of *Saccostrea echinata* in Tahiti. They have observed slow growth and high mortality of the larvae at 15 ppt and recorded best results in salinity range between 20-30 ppt.

INFLUENCE OF ALGAL DIETS ON GROWTH OF LARVAE

The food requirement of the larvae of some marine bivalves have been studied by Walne (1964, 1965 and 1970). Some other workers have demonstrated that the size and habitat of the phytoflagellates are of vital importance in diagnosing the suitability as the food of larvae. Phytoflagellates with the size range from 5 to 8 μ m with greater mobility are preferable. They are found in the surface and column waters and are easily filtered by the oyster larvae. Loosanoff and Davis (1963), Dupuy et al (1977), and Brube et al (1940) roported that *Isochrysis galbana* had resulted in the best growth of the larvae of *Crassostrea virginica*.

Dupuy et al (1977) isolated three algal species namely *Pyramimonas virginica*, *Psuedo-isochrysis paradoxa* and *Chlorella* sp as food for the larvae of *C. virginica* from the York river in Virginia and these algae were observed to be growing optimally in salinities of 10 5 to 25 ppt. Similarly four algal species namely *Isochrysis galbana*, *Pavlova lutheri*, *Dicrateria inornata* and *Chromulina freiburgensis* have been isolated from Tuticorin bay. These phytoflagellates have been used in the experiments. The generation doubling time of these flagellates during the growing phase varies from 14 to 18 h. Further it has been observed that all flagellates can tolerate the salinity of 20 ppt to 36 ppt in laboratory conditions and tolerate the temperature fluctuations from 22° to 30°C. The optimum salinity and temperature conditions for the growth of these flagellates have been observed to be 32 ppt and 25° C respectively. In the mass culture of these flagellates the growing phase will continue for 6-8 days and harvesting of the culture is done during the growing phase.

DISCUSSION

The aim of this investigation is to make an assessment of the food value of the four flagellates and to study the maximum growth and settlement of the oyster larvae. With each food it was hoped to obtain the maximum growth possible and to compare that with the growth in a standard control. As far as *C. madrasensis* is concerned, all the four flagellates can be used as suitable feed. However, the local strain of *Isochrysis galbana* (Tuticorin strain) is more suitable as larval feed when compared to others. This species is employed as the standard food for bivalve larvae at Conway (Walne 1965, 1966) and its use has therefore received a good deal of attention. The only suggestion for this

type of food preference by the oyster larvae is that *Isochrysis* enjoys a thin slimy cellular cell wall and greater amount of amino acids when compared to other flagellates (Walne 1970).

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66. LARVAL REARING AND SPAT PRODUCTION OF THE BROWN MUSSEL *PERNA INDICA* AT VIZHINJAM

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ABSTRACT

The brown mussel *Perna indica* was spawned in the laboratory and larval rearing experiments were conducted. The larvae undergo early development and metamorphose into veliger, eyed stage, pediveliger and spat. Settlement commences between the 15th and the 20th day. Various stages from fertilized egg to spat are described. Laboratory cultured phytoflagellates like *Isochrysis galbana* and *Pavlova* sp are given as food for larvae till settlement. Details of larval rearing, spat settlement and post-set growth were studied and the results are given.

INTRODUCTION

Very little work has been done on the rearing and spat production of mussels from Indian waters. Rao et al (1976) described spawning, fertilization and larval development of green mussel *Perna viridis* from Goa coast. Attempts have been made to produce brown mussel seeds in laboratory conditions at Vizhinjam (Appukuttan et al 1984). Loosanoff and Davis (1963) have successfully reared *Mytilus edulis* larvae in the laboratory using phytoplankton as larval food. Recently the aquaculture team of Centre Oceanologique due Pacifique. French Polynesia have carried out larval rearing and spat production of the mussel *Mytilus viridis* in the tropical conditions. In the present paper details of early development, larval rearing, spat settlement and post-set growth of *Perna indica* are given.

MATERIAL AND METHODS

Experiments were done from June to September in 1983, 1984 and 1986 and larval settlement was studied in the laboratory and post-set growth in the farm at Vizhinjam Bay. One year old mature mussels of 45-60 mm were used in all the experiments. Mussels collected from natural bed, culture ropes and hatchery produced seed reared to adult stage in the farm were used as spawners. Induced spawning by thermal stimulation was tried successfully. Induced spawning method adopted was that of Nayar et. al. (1984) in edible oysters. A 4°C jump in temparature gave good results. During peak spawning period (June-August) mussels spawned in the laboratory at temperatures ranging from 26 to 29°C, without any external stimulii. One or two spawners were kept in spawning trays (Fig. 1 A) or six or ten mature mussels were placed in 50 l fibre glass tanks. Males expell milt as a jet and subsequently females eject eggs rythmically 3 to 4 times within 3h. Eggs were removed from the spawning tanks immediately to 5 l glass beakers and fresh sperm was added and stirred well. Fertilized eggs sink to the bottom of the beaker. Supernatant water containing the sperm and unfertilized eggs was removed and fresh filtered sea water was added to the beaker. The morula stage is reached in four hours after fertilization and healthy larvae aggregate at the surface. Early 'D' shaped larvae were siphoned out from the beaker and transferred to 50 x 50 x 40 cm fibreglasss rearing tanks with 50 l filtered sea water. Water was changed daily from tanks and continued till the apperance of settting stage and the tanks were changed on alternate days till the eyed stage appeared in the tanks. Aeration was given to all the rearing tanks.

The sea water for larval rearing was initially drawn from the Bay, but later water from open sea near Kovalam was brought in plastic bins and filtered through 30 μ bolting silk and then passed througn sand filters and stored in 1500 l capacity fibreglass tanks. Before transferring

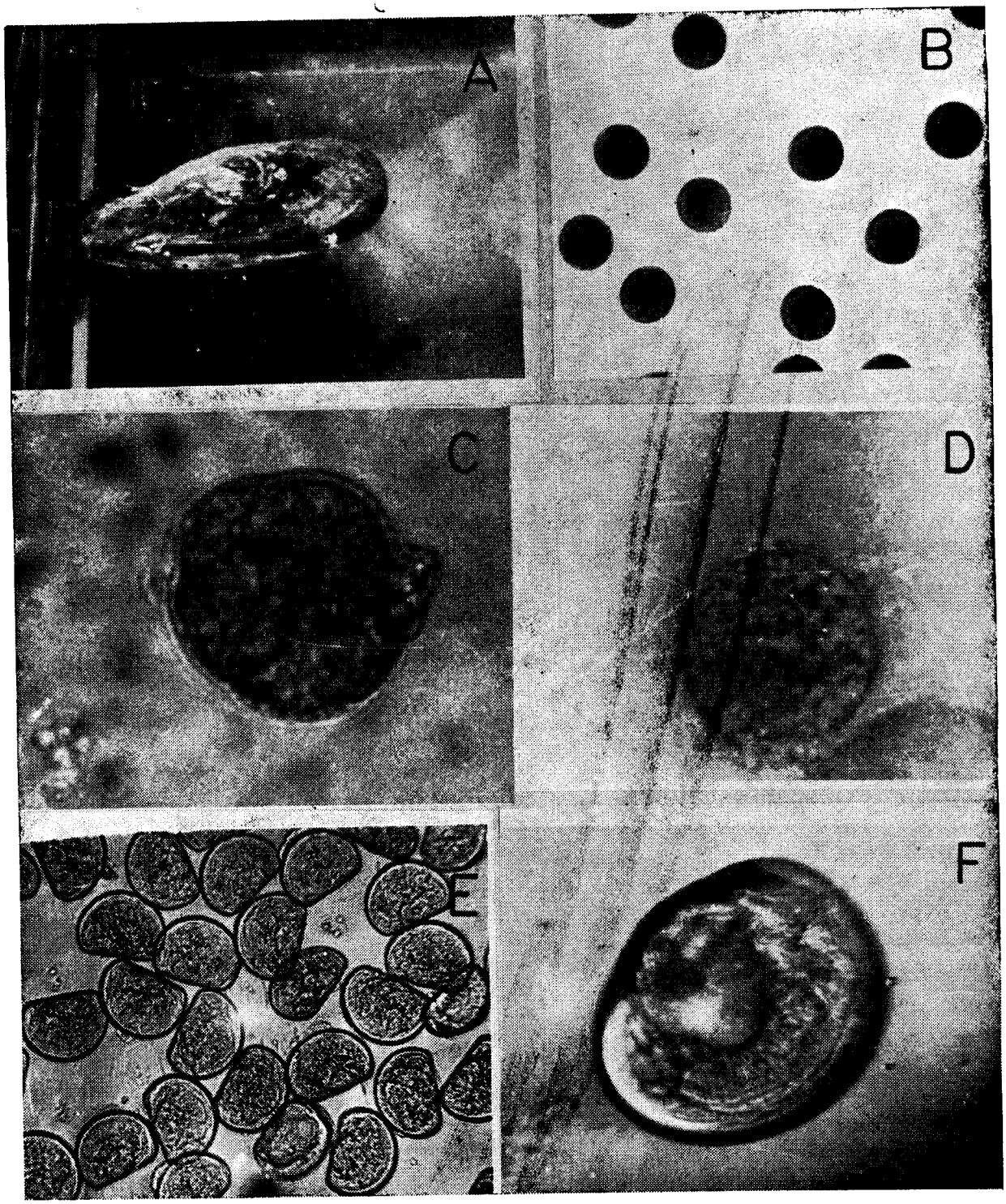

Fig. 1 A Mature male *Perna indica* kept in spawning tray ejecting sperm.
B. Spherical eggs of *P. indica* C. Fertilized eggs with polar bodies. D. Trochophore larvae.
E. D-shaped veliger F. Early umbo stage.

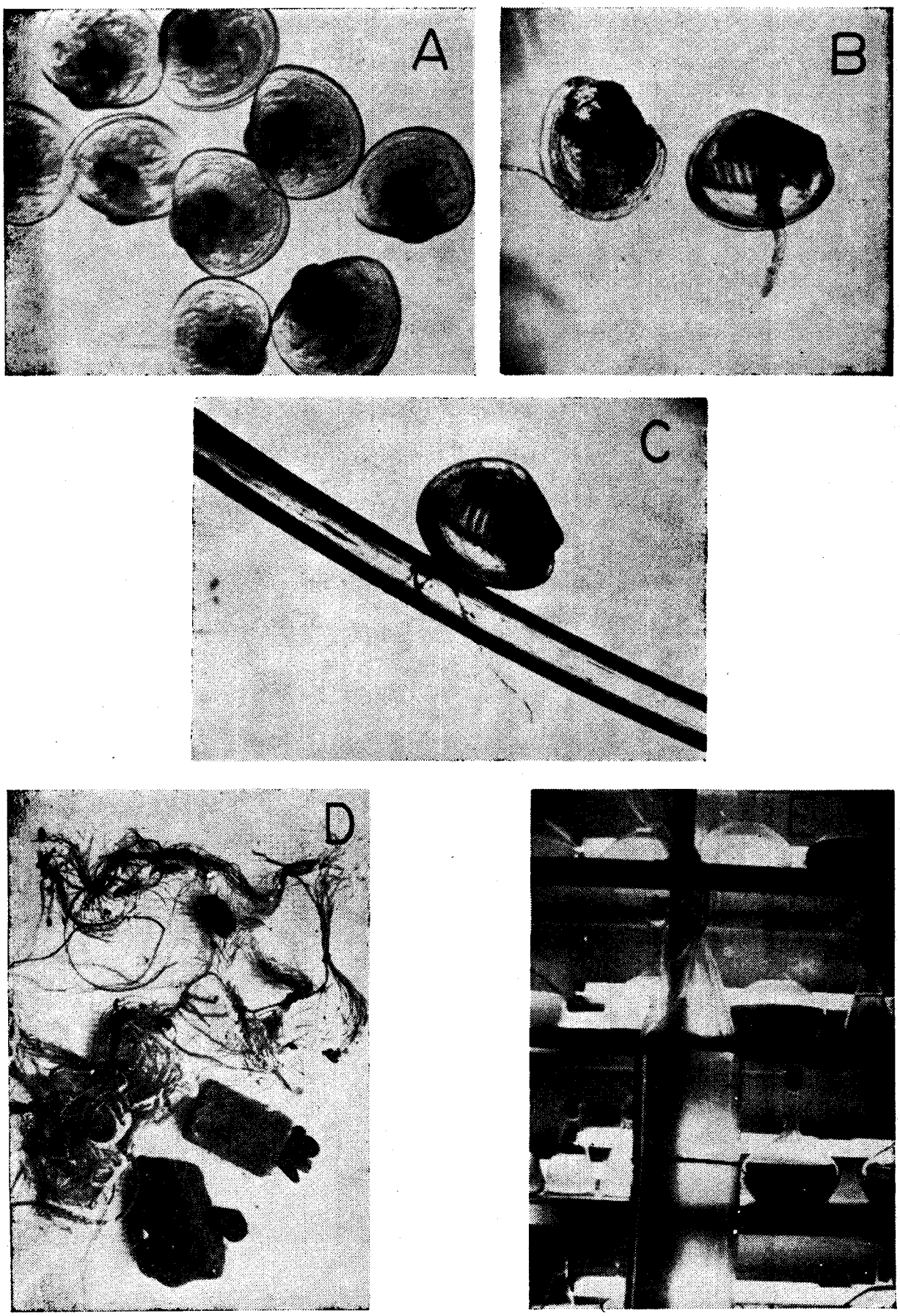

Fig. 2. A Eyed stage; B. Pediveliger stage C. Spat settled over polyethylene monofilament by weak byssus threads. D-Spat settlehd over polyethylene monofilament and granite ctones. E. Mass culture of *Isochrysis galbana* in polythene tubings.

to rearing tanks the water was filtered through surgical cotton to remove smaller particles entering into tanks.

The ambient temperature during June to August ranged from 25.5°C-28.5°C in 1983, 25.5°C-27.5°C in 1984 and 25°C-29°C in 1986. The salinity had a range of 34-34.44 °/$_{oo}$ in 1983, 30-10-33.97°/$_{oo}$ in 1984 and 33.35-34.39°/$_{oo}$ in 1986. Dissolved oxygen in the rearing tanks ranged from 4.03-4.95ml/l and pH from 7.8-8.2 during the experiments.

Yellow-brown flagellate *Isochrysis galbana* was used as larval food in most of the experiments. *Pavlova* sp in addition to *Isochrysis galbana* was given to three batches of larvae in 1984 experiments. Pure cultures of these flagellates were stocked in the laboratory throughout the year by reculturing. Mass culture of algae in 50 l perspex tanks and 30 l polythene tubings (Fig 2 E) was done to meet the larval food requirements. Filtered and heated sea water enriched with Walne's medium was used for stock culture. Flurescent lights were used to provide illumination. The peak growth phase was observed from 3rd to the 6th day. Open culture in sun light in perspex tanks of 50 l capacity was also successfully tried. Temperature below 30°C was maintained by providing shade over the culture tanks. Good bloom was obtained within 4-5 days.

The shell length and width of the larvae were measured in the antero-posterior axis and the dorso-ventral axis respectively. The mean lengths were taken for growth studies.

RESULTS

Rao et al (1976) have described the early development of *Perna viridis* from egg to spat stage in the laboratory. The present observations show that the development of *Perna indica* is very much identical. Healthy eggs are brick-red in colour and spherical (Fig 1 B). They are heavily yolked and measure between 45 and 50μ m. The first and second polar bodies are formed within 20 minutes after fertilization when segmentation commences (Fig 1 C). Oval shaped morula with minute cilia all over the body was observed in four hours after fertilization and these larvae measure 58-60μ m in the longer axis and 52-55μ m in the shorter axis. Trochophore larvae measuring 65-70μ m long and 52.5-55 μ m wide (Fig. 1 D) with an apical tuft of cilia and a long flagellum were noticed within seven hours after fertilization.

Early straight-hinged or D-shaped veliger appeared in the tanks within 17-20 h (Fig 1 E.) The veliger has two transparent valves, a well developed velum, a velar hood with small cilia all around with a strong flagellum at the centre which helps in active movements of the larvae. These larvae measured 70 - 76 μ m in the anteroposterior axis and 62-65μ m in the dorsoventral axis. Feeding of larvae with flagellates began at about this stage. The third day veliger has adductor muscles and a well developed alimentary canal. The early umbo stage (Fig. 1. F) was noticed from the 7th day. The larva is oval in shape with well developed umbo in the mid-dorsal part of the velum. It measured 120-140 μ m in the antero-posterior axis and 95-110μ m in the dorso-ventral axis. A 9 day old larva measured 200μ m in the antero-posterior axis and at this stage the rudimentary gill folds, foot and the yellow food mass in the antero-dorsal region are clearly visible.

The eyed stages (Fig 2 A) measuring 208-260μ m in the antero-posterior axis and 200-260 μ in the dorsoventral axis are seen in tanks between the 13th and 14th days. This stage is characterised by the presence of a black, pigmented rounded spot below the food mass. A much developed adductor muscle, concave valves and reduced functional velar hood are unique features of this stage.

Pediveliger stage (Fig 2 B) could be seen from the 16th day onwards. A light brownish and slight oblique shell with 280-320 μ m length in the antero-posterior axis is characterestic of this stage. Foot becomes functional, labial palps and gill filaments are well developed. Shell has weak radial striation. The larvae crawl on the bottom of the tanks with the help of foot and temperory attachment is made with the help of weak byssus secretion.

Large-scale spat settlement is noticed from the 20th day onwards. The young ones bear all unique features of adult in shape and structure. Shell is brownish in colour with radial striation and the functional foot protruded

through the gaping shells and establish as temperory settement (Fig 2 C) with the help of weak byssus thread. Spats show aggregating tendency and settle on the smooth surface of tanks or on spat settlers. The largest spat found in the tanks on the 20th day was 490 μ m in the antero-posterioraxix and 440 μ m in the dorso-ventral axis

The larval density in rearing tanks varied in each experiment. The number of larvae was estimated while transferring the D-shaped larvae to the rearing tanks. Initial stocking density in tanks ranged from 5000 to 15000/l. Estimation of larval density for advanced stages was done while changing the water in the tanks. Though initial stocking density was 5/ml to 15/ml in rearing tanks, at settling stage it came down to 2-3/ml. The tanks with initial stocking density of 5/ml showed good settlement.

Larval feeding commenced the day when D-shaped veligers were transferred to 50 l rearing tanks. *Isochrysis galbana* was used as larval food. The cell concentration of mass cultures ranged from 7 lakhs/ ml to 12.5 lakhs/ ml with a mean of 9.75 lakhs/ml. The average cell count of feed for different stages are 5850/ larvae, for D-shaped larvae, 11,700/ larva for eyed stages and 17,550/ larva for pediveliger stage. Mixed pytoplankton fortified with *Isochrysis galbana* at about 30,000 cells/ml was given to the spat in the laboratory. In tanks with high larval density the quantity of food supplied was increased by two to three times more than what was given in tanks with 5000 larvae/l.

The D- shaped veliger reached the umbo within seven days and the average growth increment in antero-posterior axis was from 73 to 135.5 μ m. This shows a growth of 62.5μm at the rate of 10.4μm/day. On the 13th day, the eyed stage had a mean length of 234.5 m with a growth rate of 16.5 μm/day. On the 16th day the mean length of pediveliger was 300μm showing a growth rate of 21.8 μ m/ day. The measurments given are based on the averages of 100 larvae per day and the days of appearence of various stages are noted by observing maximum number of that stages available in the tanks.

Spat settlement commenced on the 20th day though in a few experiments it was noticed from the 15th day onwards. Fibreglass tanks of 75 x 50 x 50 cm dimension were used for spat setting. Filtered sea water was used in these tanks under good aeration, and the water was changed on alternate days Bunches of polyethylene monofilament, pieces of granite stones, plastic sheets, tile pieces and glass plates were used as spat settlers. Among these the monofilaments (Fig 2 1) and granite stones showed good settlement. The sides and bottom of the spat rearing tanks also provided good substratum for settlement. The setting process continued for 5-9 days in these tanks. When the spat reached 2-3 mm size, they were transferred to the farm and kept in nursing cages for studying further growth.

Growth of spat was traced for 52 days in the laboratory, and for 16 months in the farm. The results are presented in Fig-3. with the bars represents the range of shell length and the dot, peak modes in each month. In the laboratory the spat grew to 690μ m in 25 days at the rate of 43.3μ m/day. On the 35th day the shell length was 1390.3μ m at 73.18 μm/day, on the 45th day 3630μm growth at 363μm/day and on the 52nd day 4190μ m at 198μm/day. In the farm, spat with peak model size of 6-10mm reached 46-50 mm within six months showing a 6.6 mm growh rate per month; after six months it was at 66-70mm, with a growth rate of 3.33 mm/months. In the next four months the peak mode observed was at 76-80 mm indicating a growth rate of 1.66 mm/month.

DISCUSSION

Among bivalves, larvae of *Mytilus edulis* from European waters have been extensively studied and frequently referred to in the literature. The work of Loosanoff and Davis (1963), Hrs-Brenko (1973) Bayne (1976) and Morse et al (1978) have described successful methods of induced spawning, studies on morphology and metamorphosis, spat settlement and mass production of spat of temperate and tropical species of mussels. Rao et al (1976) have studied induced spawning, fertilization and larval development of the green mussel *Perna viridis*.

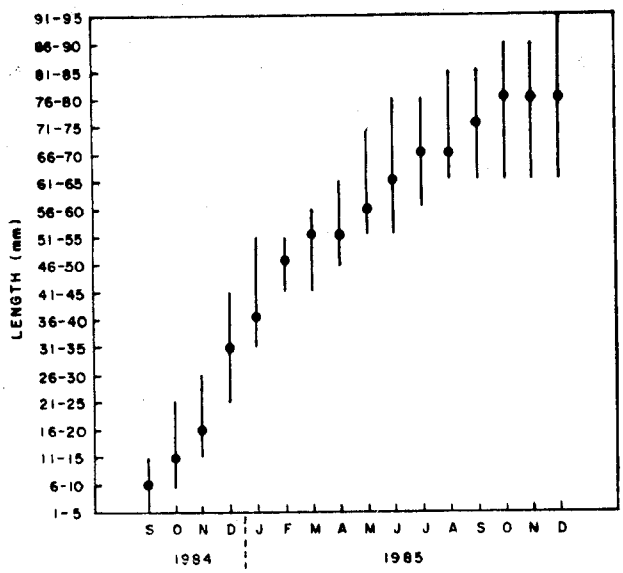

Fig. 3. Growth of *Perna indica* spat in the rearing cages inside the Bay for 16 months. Bars represent the range of shell length and dot peak modes present in each month.

Sea water used for rearing was sand filtered and further filtering through bolting silk and cotton wool has given good results. Aquacop (1983) has treated the water used for rearing *Mytilus viridis* with Treflan, chlorine and sulfadimerazine to prevent fungal attack and control bacterial action. Changing of water daily and changing of rearing tanks on alternative days till settlement gave good results.

Ukeles (1975) reviewed the nutritional requirements of bivalve larvae and suggested that the best food for rearing larvae of oysters and other bivalves are some of the yellow-brown flagellates of the family Chrysophyceae. Rao et al. (1976) used *Tetraselmis gracilis* as larval food for green mussel larvae. Alagarswami et al (1983) and Nayar et al (1984) used *Isochrysis galbana* and *Pavlova* sp. successfully. Aquacop (1983) has given *Isochrysis* sp and *Monochrysis lutheri* as food for mass production of green mussel *Mytilus viridis* in French Polynesia, and after metamorphosis *Skeletonema costatum* was added to the larval diet. *Chaetoceros gracilis* was also used as larval food in French Polynesia. At Vizhinjam *Isochrysis galbana* fed larvae showed good growth, metamorphosis and settlement. Amixture of *Isochrysis* and *Pavlova* was tried for advanced larval stages.

The smallest normal straight-hinge larva of *Mytilus edulis* measured approximately 93 x 64μ m (Loosanoff and Davis 1963). According to Rao et al (1976) the smallest D-shaped veliger of *Perna viridis* measured 73 x 50.9μ m. In this study the early D-shaped veliger of *Perna indica* measured 58 x 52μ m, thus indicating that the early veliger of this species is smaller than that of other mussels studied. D-shaped veliger appeared within 24 hours, umbo stage on the 7th day, eyed stage on the 13th day, pediveliger on the 16th day and settling stage on the 15th to 20th day in the present observation. As noted by Rao et al (1976) large variation in the growth rates was observed among the larvae of the same batch. In *Perna viridis* (Rao et al 1976) early veliger appeared within 18 h after fertilization,eyed stage on the 14th day, pediveliger on the 16th day and settling stage on the 19th day. This closely agrees with the present observations on *Perna indica*. Spat esttlement over bunches of polyethylene monofilament, granite stones and on the bottom and sides of rearing tanks was good. The growth rate studies showed that spat when transferred to farm at a size of 2-3 mm length grew faster than that kept in the laboratory.

Alagarswami (1980) indicated the need for mass production of mussel seed, since large scale removal of seed from the natural bed for farming comes in conflict with the interest of traditional mussel fishery as the mussel beds in India are limited and scattered. Thus it is imperative to develop suitable techniques for mussel seed production in India. The present work deals with the basic techniques for larval rearing and spat production of *Perna indica* at Vizhinjam and further studies are required to determine the optimum larval density in rearing tanks, critical cell concentration and spat settlement rate for initiating mass production of mussel spat.

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67. INDUCED BREEDING AND EARLY DEVELOPMENT OF *VILLORITA CYPRINOIDES* VAR *COCHINENSIS* WITH COMMENTS ON HATCHERY SYSTEM

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ABSTRACT

Villorita cyprinoides is an important resource which can be developed in low saline conditions of the estuarine systems. *Villorita cyprinoides* var *cochinensis* is induced to spawn in the laboratory by adjusting the hydrogen ion concentration. The eggs measuring 55 μ develop into trochophore stage by 19 h after fertilisation and become 'D' shaped larvae (95 μ) by 29h. By about 11 days the larvae (140 μ) show signs of settlement but continue planktonic life up to 26 days when they (450 to 500 μ) settle at bottom.

The laboratory temperature ranged from 27.5°C to 34°C and the salinity ranged from 17.2‰ to 18.35‰. Eventhough the larvae could survive in almost fresh water condition during late stage of development salinity above 19‰ is found to be detrimental to the larvae. The advantages of using hapa system for hatchery purpose is also presented in the paper.

INTRODUCTION

Villorita forms a major resource of clam in low saline conditions and even in fresh water bodies. In Vembanad lake 25,000 t of this clam are landed annually (Achary 1986). Nothing is known about its early development and breeding habits. Considerable work has been done on the hatchery production of other bivalve species in India and elsewhere and the detailed works by Loosanoff et al (1963 and 1966) have presented the problems involved in such studies. The works of Rao et al (1976) on *Mytilus viridis* Alagarsami et al (1983) on *Pinctada fucata*, Nayar et al (1984) on *Crassostrea madrasensis* and of Appukuttan et al (1984) on *Perna indica* are the recent studies on the rearing of commercial bivalves from India which are worth mentioning.

METERIAL AND METHODS

Adult *Villorita cyprinoides var. Cochinensis* are brought to the laboratory and conditioned in fibre glass tanks by keeping them in water collected from the same locality of their beds during April 1982. They are given regular feed developed from the same water along with the plankton blooms stimulated by adding nutrients. Mickel solution A & B are used as nutrients to develop the bloom. After two to three weeks the clams are kept in glass containers and induced for breeding by increasing the pH from 6.5, to 7.5 by adding very dilute solution of KOH in a very slow process. Saturated solution of 0.5ml KOH is mixed with 100 ml of water taken from the parent animals tank and this solution is added drop by drop and the desired pH is developed in the medium.

Males started releasing sperms by sudden closing of the valves in the initial period and subsequently by ejecton by the same process. This gives stimulation to the female clams and slowly they release fully mature translucent eggs within one hour. Eventhough few eggs remain at the bottom of the container, by slight disturbance of water the eggs remain in suspension.

The eggs and sperms are transferred to other containers, mixed well and further observations made.

FERTILIZATION AND FORMATION OF TROCHOPHORE

Immediately after mixing the eggs with the sperm the eggs are fertilized. Spawned eggs measure 55 microms in diameter, are spherical and the yolk is uniformly distributed giving a translucent appearance (Fig 1 A). The first division starts within half an hour (Fig 1 B),

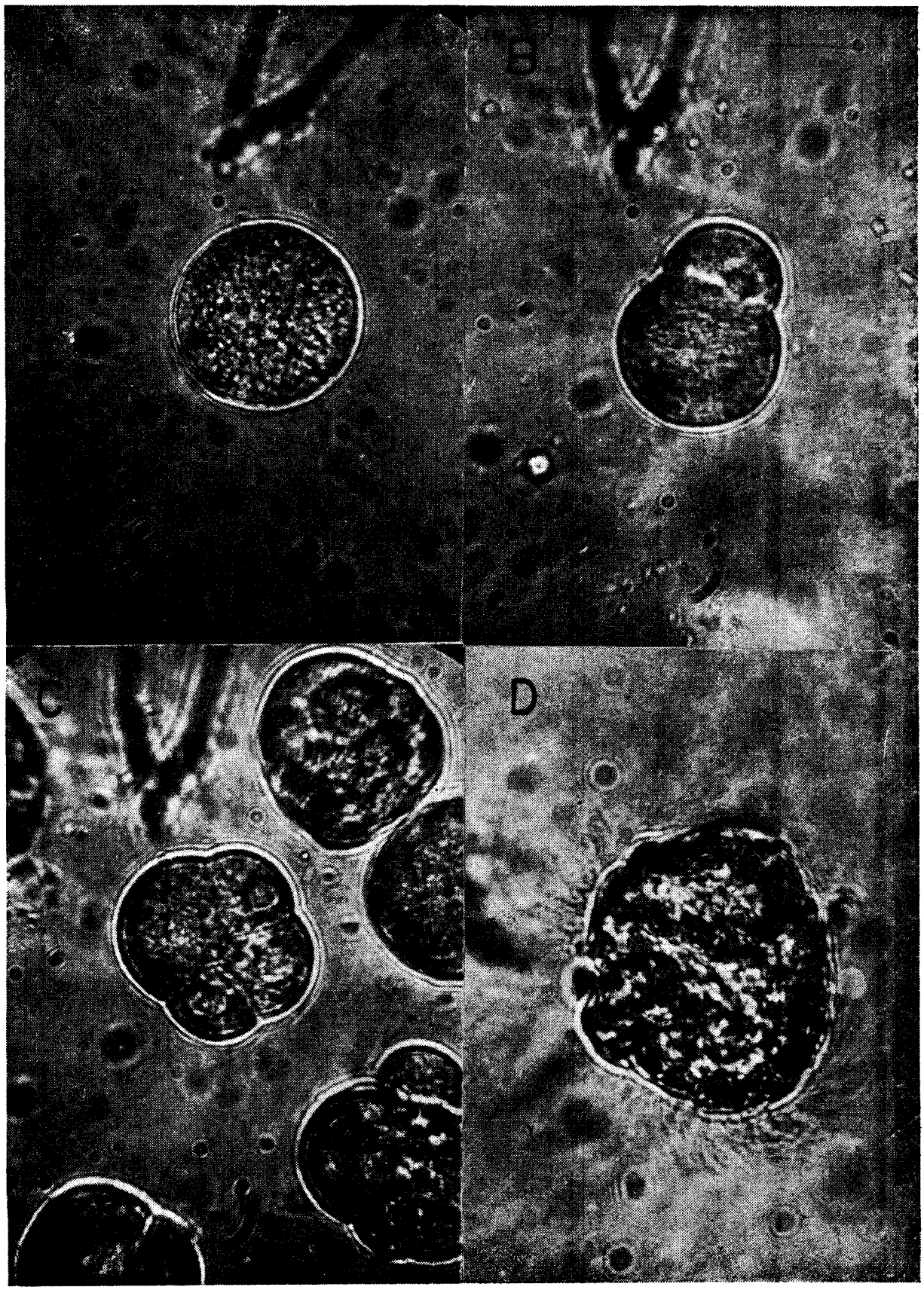

Fig. 1. Early development of *Villorita cyprinoides* var *Cochinencis*, A Egg, B Stage of first division, C. Stage of second division, D Trochophore larva

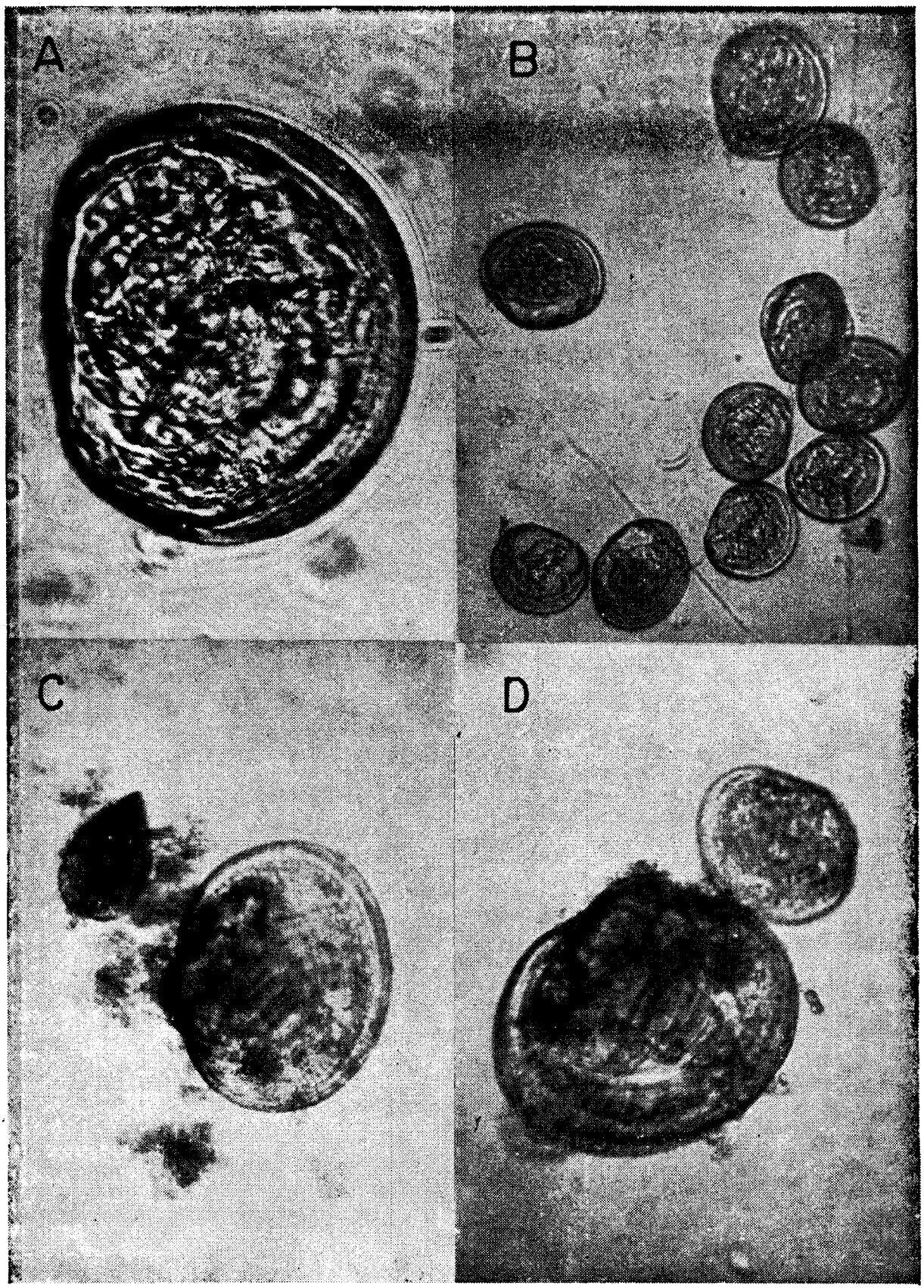

Fig. 2. Early development of *Villorita cyprinoides* var *Cochinencis* (A 'D' shaped larva; B Larva 11 days old; C & D Larva 26 days old-settlemen stage)

and the second division in another 30 minutes (Fig 1). Further cell division is at a very fast rate (Fig 1). Eggs show rotatory movement during the time of first division and blastula is formed in another five hours. By this time cilia also are noticed around the periphery and active rotatory movement was observed. The eggs reach trochophore stage by 19 h after fertilisation (Fig 1 D). The trochophore is more or less anterio-posteriorly elongated and the apical tuft of cilia are typical as found in other bivalve larvae. The larvae move in a clock-wise direction and are fast moving. Heavy ciliation is noticed at the anterior and posterior ends and circum oral cilia are comperatively large. Shell started forming during the eight hour period of growth of the trochophore larvae. Velum also starts developing and subsequently they reach 'D' shaped stage (95 μ) by 29 h (Fig 2 A).

EARLY AND LATE VELIGER STAGES

The straight hinged larvae or the 'D'-shaped larvae are found to be very active and the velum is better developed as the metamorphosis is advanced. After two days, the development of the intestine, other internal organs and musculature could be noticed. Within five days the late 'D' shaped larvae are found to show charactoristic rotatory movement in the clockwise direction and by the sweeping action of cilia, algal particles are taken in, A slight distrubance in the microscope is giving stimuli to the larvae for contracting the velum and fall towards the left side. Again by expansion of the velum, movement is gained in the clock-wise direction.

The larvae reach 140μ in 11 days (Fig 2B) and the umbo is well developed with progress in the development of soft parts. By this time the larvae actively feed on algae and the movement is slowed down. In another two days the velum gets reduced and shows sluggish movement when the larvae touch the bottom of the container. Intestine, adductor and other internal organs are demarcated and seen through the shell. Behind the remnant of the velum the foot is just forming and the planktonic life style is still continued.

SETTLEMENT OF LARVAE

In 26 days the larvae grow to 450 to 500μ (Fig 2 C & D) The same algal diet was given. The foot is well developed, velum completely absorbed, gills are also well formed and the larvae crawl at the bottom of the container. The foot is extended to almost equal length of the anterio-posterior margin and shows signs of selection at the bottom. When micro sand and silt particles are given as substrate the crawling movement is reduced. The larvae are very active in filtering and prefer lower salinities. The crawling movement continues upto 30 days.

OPTIMUM CONDITION FOR LARVAL DEVELOPMENT

The larvae are found to survive well in a salinity range of 17.2°/$_{oo}$-18.35°/$_{oo}$ and while the feed from fresh water culture is added to some of the batches of larvae the salinity is lowered and they are found to survive even in the level of fresh water condition as mentioned earlier. But when the salinity is raised above 19°/$_{oo}$ it was found to be highly detrimental to the larvae. No mortality of the larvae were observed when the salinity remained below 19°/$_{oo}$. In natural conditions also settlements occur and clam beds are formed in fresh water condition to the above range which is also substantiating the laboratory findings. The mixed feed developed using the water from the clam bed is found to be dominated by *Clamydomonas* sp and *Chlorococcum* sp and these algae are found to be good diet for the clam larvae as well as for the adult clams.

ADVANTAGE OF USING HAPA SYSTEM

A few batches of larvae are released in miniature hapa made of bolting silk (40μ mesh) suspended in the tank and a flow of water is maintained from inside the hapa to the container tank. The hapa measured 25 cm x 25 cm x 25 cm and two hapas are suspended in each of the laboratory tanks. Water is flown by gravity from a higher level tank to the inside of the hapa and the additional water flowing to the hatchery tank is siphoned out to a lower tank.

No mortality of larvae are noticed by using this hapa system while in a control tank maintained under similar conditions and without using the hapa, the larvae did not metamorphose to the settlement stage because of heavy ciliate attacks. The density of feed (2,000 cells/ml) is maintained in proportion to the consumption rate of the larvae which can be detected from time to time by periodic sampling of the medium in which the larvae are kept. The hapa system is used throughout the experimental period. It is found that this system helps to wash out additional quantity of the planktonic algae and ciliates in the medium The hapa are to be changed every three days to avoid clogging of the mesh and the larvae can be released to fresh hapa (which is washed and dried if it was used earlier) and fresh feed could be added subsequently. Eventhough this was conducted only on an experimental basis to evaluate the suitability of the system, the system is found to be very useful and this method can be adopted for large hatchery system. The contamination by ciliates and other organisms also can be minimised if a permanent flow of water is maintained in hapa.

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68. GROWTH OF THE LARVAE OF *SACCOSTREA CUCULLATA* (BORN)

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ABSTRACT

The present study on the growth of the larvae of the rock oyster *Saccostrea cucullata* is intended to provide some basic information for the efficient operation of commercial oyster hatcheries. The effect of algal concentration on the growth of the larvae were measured. Algal concentration can be optimized to provide for maximal larval growth and efficient use of algal food

INTRODUCTION

Study of the growth of oyster larvae provides some basic information necessary for the efficient operation of commercial oyster hatchery. The food requirements of the larvae of commercially important bivalves from other regions of the world were examined and reviewed by Loosanoff and Davis (1963), Walne and Spencer (1968), Ukeles (1975) and Bayne (1983). Studies on the growth rates of bivalve larvae from Indian waters are scanty. Hence the present study was undertaken to measure the growth rate of the larvae of *Saccostrea cucullata* under laboratory conditions.

MATERIAL AND METHODS

The oysters were collected from the natural population of Porto Novo and they were thoroughly cleaned before subjected to induced spawning. Gonadial smears were taken to ascertain the condition of the gonad. Batches of 8-10 oysters were taken at a time and spawning was induced by increasing the water temperature and addition of sperm extract as suggested by Loosanoff and Davis (1963).

Filtered and sterilized seawater was used for the larval rearing. Pipettes and 1 l beakers used for the larval rearing were sterilized chemically (using chlorinated water) and washed with distilled water.

After the spawning, the bivalves were removed from the trough. The eggs were screened by bolting silk of fine mesh (40 μ) and placed in beakers containing sterilized seawater. The developing larvae were screened through bolting silk of fine mesh (40 μ) and resuspened in another beaker containing sterilized water. One ml of sample was pipetted to sedgewick rafter counting cell and the larval number was counted. The average number was calculated after 4-5 counts.

The density of the larvae was adjusted to 5 larvae/ml. The pure cultures of *Isochrysis galbana* were enumerated using a Haemocytometer. The effect of different concentrations of the algal food, *I. galbana*, such as 5, 10, 20, 80 cells/μl on the growth of the bivalve larvae was determined. The medium water was changed daily and the required volume of algal cultures were added to this medium contained in the rearing containers. The growth of the larvae was monitered on the 4th and 8th day and the shell length of 30 larvae was measured by means of an ocular micrometer, for comparing the same with measurements taken on a sample of larvae, at the start of the experiment. The growth coefficient (K) value was calculated using the formula of Helm, (1977) :

$K = \log_e l_4 - \log_e l_0$ where l_4 is the length of the larvae after four days of the experiment and l_0 is the length of the larvae at the start of the experiment.

RESULTS

Table 1 shows the growth of larvae (expressed as the coefficient K_4) for the larvae of *S. cucullata* recorded after feeding with different concentrations (5,10,20,40,80 cells/ μl) of *I. galbana*. Growth increased with increasing

algal density upto 40 cells/ µl and declined at the algal density of 80 cells/ µl. Maximum growth was achieved at a concentration of 40 cells/ µl

TABLE 1. *The growth of larvae (expressed as the coefficient K_4) between days 0.4 and 4 8 when fed with different cell concentration of* I. galbana.

Days	Cells/µl				
	5	10	20	40	80
0 4	0.143	0.268	0.325	0.431	0.208
4-8	0.125	0.057	0.201	0.337	0.118
Mean	0.134	0 168	0.263	0.384	0.163

DISCUSSION

Much of the work was concerned with unicellular algal cultures as potential source of food supply for the larvae of commercially important bivalves of other regions of the world. This work has been comprehensively reviewed by Loosanoff and Davis (1965) and Bayne (1983).

Maximum growth Increment in the bivalve larvae was recorded at an algal density of 40 cells/ µl and it decreased at 80 cells/ µl. Reduction in the growth of the larvae at high algal density of 80 cells/ µl may be due to mechanical disturbances of food cells on the larval swimming and feeding mechanisms and also by producing external metabolites which are toxic to the larvae. Similar conclusions were made by Davis and Guiliard (1958), Loosanoff and Davis (1963), Walne (1966) and Malouf and Breese (1977).

Loosanoff and Davis (1963) reported that high concentrations of certain food organisms, such as *Chlorella* sp affect the larvae of *M. mercenaria,* as well as those of several other species, both by mechanical interference of the food cells with larval swimming and feeding mechanisms, and chemically by producing metabolites which are toxic to larvae. Malour and Breese (1977) observed that the important cause of reduced growth at high algal densities might be due to excessive formation of pseudofeces. Davis and Guillard (1958) found that *Isochrysis* is known to produce substances toxic to bivalve larvae under certain conditions.

ACKNOWLEDGEMENTS

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69. EXPERIMENTAL REARING OF LARVAE OF THE WEDGE CLAM, *DONAX CUNEATUS* LINNAEUS IN THE LABORATORY

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ABSTRACT

The wedge clams *Donax cuneatus* Linnaeus are found in great abundance along the surf beaten sandy beach of Parangipettai. Fertilized eggs of *D. cuneatus* developed into straight-hinge stage larvae with a shell length of 110 μ. The larval shell developed umbo at about 140 μ. The description of the larval stages is presented in this paper.

INTRODUCTION

Donax cuneatus occurs in the surf beaten sandy beaches of both the east and west coasts of India. There is no regular fishery of these clams for food or for any organised lime making industry, with the result that these valuable resources are neglected (Nayar and Mahadevan 1974). Very few works have been carried out on its biology (Nayar 1955; Rao 1967). There is no information on the larval development of this species. The present study describes the development of the larval stages of *D. cuneatus* under laboratory conditions with a view to facilitate larval identification in the plankton and predict spatfall.

MATERIAL AND METHODS

Clams were collected from the surfline of the sandyshore of the Porto Novo coast (Lat. 11°29'N; Long. 79°46' E) and were kept in plastic troughs containing seawater. The clams were fed with unialgal cultures of *Thalassiosira* sp, *Skeletonema costatum* and *Amphipora* sp. Gonadial smears were taken to ascertain condition of the gonad. Spawning was induced in batches of 10 clams by increasing the temperature and by addition of stripped sperm as suggested by Loosanoff and Davis (1963).

The seawater was filtered through cotton and then sterilized. The sterilized water was used throughout the experimental period. Fingerbowls and pipettes were washed with tapwater, sterilized chemically and washed with distilled water.

The spawned eggs were placed in fingerbowls and fertilization effected by adding sperm suspension. Early development was not studied in this investigation. The developing larvae were screened and placed in fingerbowls containing sterilized water. A pure culture of *Isochrysis galbana* was added to the container as food after changing the seawater daily. The larvae grew upto 200 μ but further development was inhibited due to ciliate attack. The terminology used in the present study for larval descriptions was after Chanley and Andrews (1971).

RESULTS

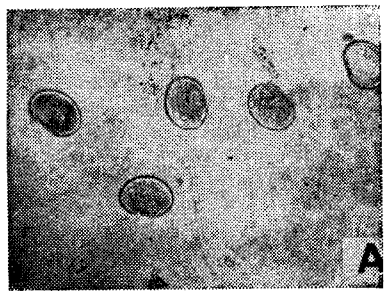
Egg

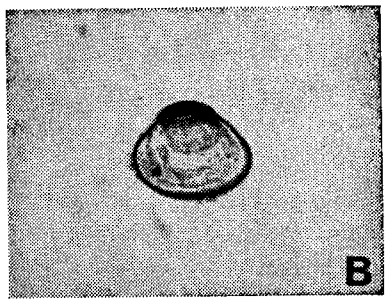
The diameter of the unfertilized egg is 70 μ.

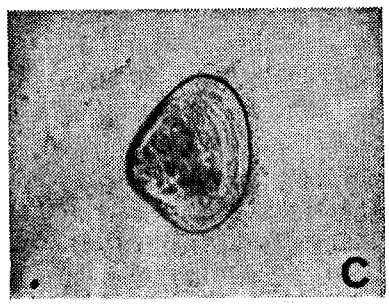
Larval development

Straight-hinge stage (Fig 1A)

The fertilized eggs develop into straight-hinge stage larvae in about 25-30 h with a minimum length of 110 μ and height of 80 μ. The hinge line measures 60 μ in length. The velum is the chief organ of locomotion. By means of their cilia, the larva swim actively in all directions and crowd near the surface of water.







A. Straight hinge larva of size 110 x 80 μ
B. Umbo stage larva of size 140 x 100 μ
C. Late umbo stage larva of size 200 180 μ

Umbo stage Fig. 1B & C)

On the 4th day, the umbo begins to obscure the hinge line when the larvae attain 140 μ in length and 100 μ in height. The shape of the umbo is broadly rounded and it becomes knobby at 200 μ in length. The height is 20 μ less than the length. The ends are equally rounded while the shoulders slope gradually at the 140 μ length. The ventral margin is well rounded, forming a semicircle with ends, shoulders and umbo about 1/3rd total height.

DISCUSSION

The larval development of *Donax vittatus* (Rees 1950), *D. venustus* (Zakhavatkina 1959), *D. variabilis* (Chanley and Andrews 1971) from other regions of the world have been reported, but information on larval development of the species under study is lacking.

The induced spawning in *Donax cuneatus* was effected by increasing the water temperature (32-34°C) and addition of sperm suspension. Rao et al. (1976) and Rao (1983) carried out induced spawning in *Perna viridis* and *Crassostrea madrasensis* with thermal, mechanical and chemical stimuli. Alagarswami et al (1983) reported various methods for induced spawning in the pearl oyster *Pinctada fucata*. Nayar et al (1984) carried out induced spawning in *Crassostrea madrasensis* by using thermal stimulus or thermal stimulus with the addition of gonad extract.

The straight-hinge larva of *D. cuneatus* is 110 μ in length, whereas in the larva of *D. variabilis* (Chanley and Andrews 1971) is 70 μ in length. The shape of the umbo in the larvae of *D. cuneatus* is similar to that of *D. variabilis* i.e., broadly rounded umbo in the early umbo stage and knobby umbo in the late umbo stage. The rearing of *D. cuneatus* larvae upto metamorphosis could not be carried out because of attack by ciliates and flagellates. However, the present study provides descriptions from which it would be possibie to identify the larvae of *D. cuneatus* in plankton samples, to find out the spwning period and predict spatfall.

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70. MICROENCAPSULATED DIET FOR LARVAE AND SPAT OF *CRASSOSTREA MADRASENSIS*

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ABSTRACT

Edible oyster larvae and spat were fed with *Isochrysis galbana* supplemented with microencapsulated diet prepared from oyster, clam or fish oil extracts. In the experiments conducted with oyster larvae, spat setting was higher in the larvae fed with algal diet supplemented with oyster oil extract encapsulated diet than those fed with algal diet. Better growth and more weight increase was observed among the spal fed with algal diet supplemented with microencapsulated diet containing oyster oil and fish oil, compared to that in oyster spat fed with algal diet alone.

INTRODUCTION

Seed production of edible bivalves is one of the prime requisites for carrying out large-scale farming. Study on the mass production of oyster seed through hatchery system was initiated by the Central Marine Fisheries Research Institute and successful production of seed oysters has been achieved at the Shellfish hatchery at Tuticorin (Nayar et al 1984). In the larval rearing and rearing early spat in the hatchery, cultures of microalgae such as *Isochrysis galbana* and *Pavlova lutheri* are maintained. Though mass culturing feed algae is cumbersome and has many drawbacks over suitable formula feed, at present no suitable feed for molluscan larvae is available. Microparticulated diets such as Carrageenan microbinding diet and Zein microcoated diet which have been successfully used as alternate diet in Prawn larval rearing (Kanazawa et al 1982), was tried for the edible oyster larvae and spat. Since the particle when soaked in water swells up and enlarges in size it was found to be too large for the molluscan larvae and so was not useful for feeding larvae and spat. As the oesophageal diameter of molluscan veliger is about 5 μm, the optimum particle size for the molluscan larval feed is μm.

Keeping in view the usefulness of microencapsulated diets in the larval rearing of marine prawns (Jones et al 1979), these diets were prepared in the present study from edible oyster extract, clam extract and fish oil and were tried alongwith regular algal diet. Helm et al (1973) and Holland and Spencer 1973) demonstrated the importance of lipid in the early development of oysters.

MATERIAL AND METHODS

Preparation of Capsule

Gelatin capsules were prepared by the method given by Langdon and Waldock (1981). At 40°C in an atmosphere of nitrogen 1 ml of lipid was emulsified in dark for 2 minutes in 40 ml of 2% W/V aquous gelatin solution using an homgenizer maximum speed (14,000 rpm). The emulsion was then transferred to a flask and stirred at 500 rpm for 1 min. The pH of the mixture was reduced to 3.9 by adding 0.01 M-HCl, causing a gelatin wall to form around each lipid droplet. The rate of stirring was then reduced to 100 rpm and the mixture was kept at 40°C, for 40 min. After stirring, the pH was raised slowly to 9.3 by adding 1M-NaOH dropwise. This capsule suspension was poured into 300 ml distilled water at 5°C for at least 1h to harden the capsule walls. The capsules then were autoclaved at 115°C for 15 min without any adverse effect on wall stability. The suspensions were stored at 5°C until required. The mean diameter of the capsules was 3μm.

Edible oyster and clam extracts were prepared by using Chlorofom Methanol mixture (2:1) after Bligh & Dyer method. The oyster and clam meats were collected and homgenised using high speed blender. The homogenate was treated with large quantity of solvent mixture and the soluble fraction was concentrated by

rotary vaccum evaporation. The final concentration was carried out by drying the concentrate over nitrogen gas. The concentrated extract was used as the diet ingredient for the preparation of microencapsulated diets. Cod liver oil (available in the market under the trade name Seven Seas) was directly used as the fish oil diet. The diets were prepared and stored in the refrigerator under nitrogen for a number of days.

Edible oyster larvae of 70μm belonging to the same brood were used in the study. They were fed with *Isochrysis galbana* supplemented with one of the microencapsualted diets prepared from edible oyster extract (OOD) and clam extract (COD). (Larvae were reared in 3 l glass beakers in a concentration of 4 larvae per ml. Filtered seawater was changed daily.) Larvae were fed with *I. galbana* @ 5000 cells/larva/day and supplementary diets OOD and COD at two levels viz, 10,000 capsules and 20,000 capsules per larva per day (Table 1). Experiments were conducted in triplicate and the rate of settlement of spat between the diet groups was compared with the control which were fed only with *I. galbana*.

For the spat growth experiments spat of 1 to 2 weeks old of same brood were starved for 24 h before the experiment, cleaned, blotted dry and weighed. Experiments were conducted in triplicate for a particular diet with 50 or 100 spat kept in a 5 l beaker. Filtered seawater was changed daily. *I. galbana* @ 20,000 cells/ spat and supplementary diets of OOD, COD and FOD/20,000 to 60,000 capsules were given daily.

RESULTS

Larval feeding experiments

The number and percentage of spat settled in the two experiments are given in Table 1. In experiment No. 1, one set of oyster larvae was fed with *I. galbana* alone for 25 days and average settlement was 5.9%. In the larvae fed with *I. galbana* and 10% OOD the percentage of settlement was 3.5% and for 20% OOD, the percentage of spat settled was 8.4. The clam lipid extract diet supplemented with *I. galbana* fed larvae, the spat settlement was 1.8%.

In the second and third experiment also the percentage of spat settled in the larvae fed with *I. galbana* supplemented with 10% and 20% OOD was found to be more than for the larvae fed with *Isochrysis galbana* alone or *I. galbana* supplemented with 10% COD.

Spat growth experiments

In Table 2, the weight increase of spat fed with *I. galbana* and microencapsulated diets supplemented with *I. galbana* are given for the three experiments conducted.

In the Experiment I, the weight increase for the spat fed with *I. galbana* supplemented with 20,000 cells of OOD/spat was 97% and with

TABLE 1. *The percentage of larvae* (C. madrasensis) *setting, fed with artificial supplimental diet.*

Expt. 1 22.6.84 to 9-7-84	No. of spat settled	% of settlement.
I. galbana + OOD 10%	286	3.5
I. galbana + OOD 20%	674	8.4
I. galbana + COD 10%	149	1.8
I. galbana only	475	5.9
Expt. 2 25.9.84		
I. galbana + OOD 10%	220	1.8
I. galbana + OOD 20%	136	1.1
I. galbana + COD 10%	75.6	0.6
I. galbana only.	0	0

OOD = Oyster oil diet; COD = Clam oil diet

TABLE 2. *The growth rate of the spat of* C. madrasensis *fed with supplimentary artificial diet.*

Initial wet wt of spat : 0.092 gm Mean length of spat : 1.16 mm Duration of the expt : 19 days	increase in in length (mm)	Wet weight increase (%)
Expt. 1. 23.12.83 to 11.1.84		
1. *I. galbana* + OOD (20,000 cells/spat)	1.13	97.0
2. *I. galbana* + OOD (40,000 ,,)	1.03	122.0
3. ,, + FOD (20,000 ,,)	1.06	85.0
4. ,, + FOD (40,000 ,,)	1.16	93.0
5. ,, + FOD (80,000 ,,)	1.02	86.0
6. *I galbana* only	0.67	69.0
Expt. 2.		
Duration 24 days. 7.1.84 to 30.1.84		
1. *I. galbana* + OOD (20,000 ,,)	—	133.0
2. ,, + OOD (40,000 ,,)	—	140.0
3. *I, galbana* + FOD (20,000 ,.)	—	100.0
4. ,, + FOD (40,000 ,,)	—	85.9
5. ,, + FOD (60,000 ,,)	—	97.6
6. *I. galbana* only	—	121.0

Expt. 3.				
23.4.84 to 22.5.84				
Initial length : 2 4 (mm)				
1A *I. galbana* + 20% (capsules)	0.134	0.396	0.262	195.0
1B	0.154	0.460	0.306	198.0
2A *I. galbana* + 40% OOD ,,	0.134	0.356	0.216	161.0
2B	0.155	0.350	0.195	125.0
3A *I. galbana* + 10% COD ,,	0.200	0.587	0.387	193.5
3B	0.162	0.402	0.240	148.1
4A *I. galbana* + 10% FOD ,,	0.197	0.616	0.419	212.0
4B	0.163	0.586	0.423	259.0
5A *I galbana* only —	0.120	0.341	0.229	184.0
5B	0.134	0.381	0.247	184.0

OOD = Edible oyster oil diet; COD = Clam oil diet; FOD = Fish oil diet (cod liver oil)

40,000 cells of OOD/spat was 122%. The Fish oil supplemented at the rate of 20,000, 40,000 and 80,000 cells/spat along with *I. galbana* registered an increase of weight 85%, 93% and 86% respectively. The control spat fed with *I. galbana* alone had weight increase of 68%. In the second experiment also, the spat fed with the micro algae supplemented with OOD had achieved higher percentage of weight increase than those fed with *I. galbana* alone and the other set of spat fed with *I galbana* supplemented with fish extract.

In the third experiment one set of spat was fed with *I galbana* supplemented with 10% COD and the weitht increase was 170%. The control sets, the percentage of weight increase was 184%. But the spat fed with algal diet supplemented with 20% OOD registered a weight increase of 198%.

DISCUSSION

The algal diets used in bivalve larval and spat rearing are varied in their food quality. Walne (1970) has given the food value of various micro algae used as feed for bivalve larvae. Trider and Castell (1980) indicated that polyunsaturated fatty acids are essential to oysters for growth and maintenance. In the hatchery experiments larvae fed with *Dunaliella salina* have not grown well indicating that the deficiency of 22:6W3 as a growth limiting factor as reported by Langdon and Waldock (1981).

Further it was demonstrated by Langdon and Waldock (1981) that the mixture of 20:5W3 (ecosa pentaenoic acid) and 22:6W3 (docosa hexfaenoic acid) support better growth than individual acids. The growth of *C. gigas* was enhanced by adding supplements of either solvent extract of oyster high in 20:5W3 and 22:6W3. The experiments in the larval rearing supplemented with OOD showed more spat settlement percentage than the larvae fed with algal diet alone and solvent extract, clam extract diet supplemented with *I. galbana* (Table 1). In spat growth experiments also, the seed oysters fed with OOD registered more weight increase than those fed with Fish oil diet and clam extract, as observed by Langdon and Waldock (1981) the improved growth in oyster spat when oyster lipid extract capsulated diet of 22:6W3 along with *D. tertiolecta* or *I. suecica*.

Of the OOD, FOD and COD microencapsulated diets OOD yielded better spat settlement, improved growth of spat indicates that the essential fatty acid of linolenic (W3) may be more than linoleic (W6) type fatty acids. Further studies need be carried out on the quality and quantity of the essential fatty acids in the capsules containing solvent extracts of oyster, clam and fish oil and also the fatty acid composition of the spat experimented with the above mentioned diets.

In hatcheries, one or two cultured algal species are being used as diet for larvae and spat. These algae in laboratory culture conditions may be unable to produce long-chain fatty acids of the W3 which is essential for the growth of bivalve larvae and spat. So further study is needed on the amount essential fatty acids composition in these algae so as to supplement with the lipid extracts and to obtain better growth of seed oysters.

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71. MICROENCAPSULATED DIET AS SUPPLEMENTAL FOOD FOR LARVAE AND SPAT OF THE PEARL OYSTER *PINCTADA FUCATA*

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ABSTRACT

The flagellate *Isochrysis galbana* was found to be the best natural food for the pearl oyster larvae. To supplement this, artificial microencapsulated diet was prepared using edible oyster oil, fish oil and Soybean lecithin with a view of enhancing the growth of pearl oyster larvae and spat. Different concentrations of edible oyster oil diet, fish oil diet and lecithin diet were tried by keeping a control wherein *I. galbana* was alone given as feed. The control with *I. galbana* gave good results. Among the artificial diets tested the edible oyster oil diet showed better results on the growth of larvae and spat while the fish oil diet promoted weight gain in the spat. The suitability of the microencapsulated diet for the larvae and spat is discussed in this paper.

INTRODUCTION

Large scale production of seed of the Indian pearl oyster *Pinctada fucata* was done in the shellfish hatchery at the Tuticorin Research Centre of Central Marine Fisheries Research Institute using the live natural food *Isochrysis galbana* (Alagarswami et al, 1983). Acceptability of other microalgae such as *Pavlova lutheri, Dicrateria* sp and *Chromulina* sp was also tested, In all these natural diets the larvae grew and set as spat between 18 and 20 days. In order to promote faster growth of larvae and early settlement, artificial encapsulated and formulated diets were prepared. Earlier reports on artificial diet as bivalve larval feed are rather limited. However, some studies were reported on the effect of dried particles of *Ulva*, *Fucus* or *Laminaria* on clam larvae which grew to metamorphosis in 13-17 days. The larvae receiving frozen *Ulva* did not grow as rapidly as those receiving live foods but reached metamorphosis in 8-13 days (Chanley and Normandin 1967). Stickney (1964) fed clam larvae with ground and strained *Zostera* leaves but the larvae did not grow on this food mixture even with the addition of antibiotics to control the bacterial population. The effect of algal and artificial diets on the growth and fatty acid composition of *Crassostrea gigas* spat was studied by Langdon and Waldock (1981). The attempts to promote larval growth on various organic materials such as yeast cereals, baby foods etc., have remained largely unsuccessful and unreported (Ukeles 1975). However, in the present study, a preliminary attempt

has been made in feeding the pearl oyster larvae and spat with artificial diet. The results of the experiments are given in this paper.

MATERIAL AND METHODS

The larvae of *P. fucata* used are from the shellfish hatchery and are from the same brood. The larvae were transferred, on the fifth day after spawning, to one litre filtered seawater in a glass beaker at 12 larvae/ml. The size at dorsoventral aspect was taken as the parameter in growth studies. The average size of larvae in the experiment varied from 81.0 μm to 91.3 μm. Weekly sample of 30 larvae in each concentration was measured. No aeration was provided during the larval phase in any of the concentrations. Water was changed on alternative days. During the experiments, which lasted for 35 days, the water temperature varied between 23.9°c to 29.0°c (av. 25.4°c); salinity from 25 6°/$_{oo}$ to 32.55°/$_{oo}$ (av. 28.34°/$_{oo}$); oxygen 3.4 to 4.2 ml/1 (av. 3.77 ml/1) and pH 7.53 to 8.20 (av. 7.85).

I. galbana was fed to the larvae at 5000 cells/larva/day in all the concentrations as the main live natural food. The size of the alga was 8 μm. In addition to this, the three gelatin encapsulated diets prepared using oyster oil diet (OOD), fish oil diet (FOD) and lecithin diet (LD) were given as supplemental feed. The size of encapsulated diets (OOD, FOD and LD) varied from 2 to 5 μm. Two concentrations, 1000 capsules/larva/day (OOD-1) and 2000 capsules/larva/day (OOD-2) in each of the three encapsulated diets were tried. A control was kept for each set wherein only *I. galbana* was given as feed.

The spat selected for the assessment of OOD was 1.5 months old and had an average size range of 1252.5 μm to 1443 3 μm, for FOD it was between 930.8 μm to 1065.0 μm and for control 1071.8 μm to 1125.8 μm. For each study 200 spat were taken in one litre glass beaker. The spat were measured weekly while water was changed on alternative days. *I. galbana* was rationed to all at 50,000 cells/spat/day. It was supplemented with OOD at 10, 20, 30, 40 and 50 thousand capsules/ spat/ day in each beaker. A duplicate was kept for these concentrations. The control beaker received oniy / *galbana*. A similar feeding regimen was also followed for FOD. Water temperature ranged between 22.7°C and 29.8°C (av. 26.0°C) during the experimental period of 37 days.

A third set of experiment was conducted using larger (3.9 months old) spat of about 2890μm in average. OOD and FOD were given at two levels—20,000 and 40,000 capsules/spat/ day. Only for FOD, in addition, 80,000 capsules/spat day was also tried. Herein the LD was not used. All the beakers received *I. galbana* at 3.3 million cells/spat/day while the control was given algae only. 50 spat were tested in each concentration. Weekly sample of 30 spat were measured and were also weighed. The water temperature recorded during the experimental period of sixteen days varied from 22,7°c to 29.8°c (av. 26.0°c).

The microparticulate diet and floculated natural diet comprising mixed phytoplankton were also tested in the pearl oyster larvae separately each in two 1 l beakers. Two beakers were also kept as control where *I. galbana* alone was given

PREPARATION OF DIETS

Capsules

Gelatin coated microcapsules were prepared from the meat of *Crassostrea madrasensis* (OOD), Cod liver oil (FOD) and Soybean lecithin (LD) using chloroform-methanol method. The solvent soluble factions were extracted from the homogenated oyster meat and were concentrated with the help of rotary vacuum evaporator. It was further concentrated by drying over nitrogen gas. 2 g diet ingredient was weighed and mixed with 80 ml of 92% gelatin solution. A jet of nitrogen was passed till the capsules were fully formed. The mixture was then placed on a water bath at 40°C and homogenised at 14,000 rpm for two minutes. Subsequently the speed was reduced to 500 rpm. The pH of the mixture was reduced to 3.9 by adding 0.01M HCl drop by drop. It caused the gelatin to coacervate around each lipid droplet The stirring was reduced to 100 rpm at 40°C for 40 minutes. Now the pH was

raised to 9.3 by dropwise addition of 1 M NaOH. The capsule suspension was added to 600 ml of distilled water at a temperature of 5°C and stored there for 1 h to harden the capsules. The solution containing microencapsulated diet was autoclaved at 115°C for 15 minutes and stored in a freezer. Everyday, after bringing a small subsample to the room temperature the diet was given to the larvae.

Carageenan microbinding diet

Artificial micropartculate diets were prepared using Carageenan and Zein as binding substances. The composition of the particulate diet is given in the Table 1.

10 g of diet ingredients was mixed well with 40 ml of distilled water. The mixture was kept on a water bath at 80°C and Carageenan was added slowly with constant stirring. The diet was cooled in a refrigerator for 30 minutes. The solid diet was cut into small pieces and a bit was tested for the binding effect. The diet was then freeze-dried, made into powder and then sieved through 20μm mesh.

Zein microbinding diet

10 g of the diet ingredient was mixed with 25 ml of Zein solution which was prepared by dissolving 1.0 g Zein in 25 ml of 60% ethylalcohol. The whole mixture was freeze-dried. powdered and sieved through 20 μm mesh

Floculated natural diet

Mass culture of mixed phytoplankton was raised in 1 t capacity tank in the open light by adding 30 l fresh seawater as inoculum. The thick green bloom of mixed phytoplankton was precipitated using KOH solution. The bloom was then concentrated to 30 l, filtered and freeze-dried. The diet was stored in refrigerator.

RESULTS

The effect of encapsulated diets such as oyster oil diet, fish oil diet and lecithin diet as supplemental feed for the pearl oyster larvae was shown in the Table 2. In all cases control gave better results. The larvae fed with *I. galbana* and OOD in the ratio 5 : 1 (OOD-1) showed a growth rate of 1.91 μm per day: In the 5 : 2 ratio (OOD-2) it was 1.77 μm and 4.11 μm in 5 : 0 ratio (control).

TABLE 1. *Diet composition of microparticulate food*

Ingredients	Carrageenan (5 g) as binding substance		Zein as binding substance	
	Diet 1	Diet 2	Diet 1	Diet 2
	(g/100 g diet)		(g/100 g diet)	
Egg yolk	5.0	5.0	5.0	5.0
Casein	19.0	20.0	19.0	20.0
Egg albumin	5.0	5.0	5.0	5.0
Soybean lecithin	1.0	1.0	1.0	1.0
Yeast extract	5.0	5.0	5.0	5.0
Cholestrol	1.0	1.0	1.0	1.0
Lactose	20 0	25.0	20.0	25.0
Oil mix	5.0	5.0	5.0	5.0
Mineral mix	5.0	5.0	5.0	5.0
Vitamin mix	3.0	3.0	3.0	3.0
Aminoacid mix	5.0	5.0	5.0	5.0
Methionine	1.0	1.0	1.0	1.0
Skin milk	25.0	19.0	25.0	19.0
Carrageenan	—	—	—	—
Zein solution	—	—	25 ml	25 ml
Water	400 ml	400 ml	—	—

TABLE 2 *Growth of larvae of* Pinctada fucata *on encapsulated diet as supplemental feed for 35 days.*

No. of cells/larva/day			Length of larvae in DVM (μm)		Growth increase	Rate of growth	Day of settlement	Percentage settlement
			Initial	Final	(μm)	per day(μm)		
I. galbana	—	OOD						
5000	—	1000	82.7	149.5	66.8	1.91	34th	1.27
5000	—	2000	81.2	143.2	62.0	1.77	34th	21.68
5000	—	Nil	84.2	228.2	144.0	4.11	27th	27.45
I. galbana	—	FOD						
5000	—	1000	81.0	135.3	54.3	1.55	34th	13.45
5000	—	2000	81.3	126.8	45.5	1.30	34th	6.15
5000	—	Nil	83.0	206.5	123.5	3.53	27th	12.5
I. galbana	—	LD						
5000	—	1000	82.7	115.0	32.3	0.92	N.O	0.017
5000	—	2000	*	—	—	—	—	—
5000	—	Nil	91.3	141.8	50.5	1.44	34th	15.95

* Total mortality
N. O. Not observed

In similar feeding combination between *I. galbana* and FOD, the rate of growth per day was 1.55 μm in FOD-1; 1.30 μm in FOD-2 and 3.53 μm in the control. With regard to the lecithin diet the result was very poor being 0.92 μm in LD-1 and 1.44 μm in the control. The larvae fed with LD-2 did not survive.

The acceptability of encapsulated diet in the larvae was assessed on the basis of growth and percentage of spat settlement. The settlement of spat occurred on 27th day in the controls and 34th day in other concentrations. The percentage of settlement was 1.27% in OOD-1, 21.68% in OOD-2 and 27.45% in OOD-control. In FOD feeding the percentage of settlement was 13.45% in FOD-1, 6.15% in FOD-2 and 12.5% in FOD-control while in LD-1 it was 0.017%; nil in LD-2 and 15.95% in LD-control.

Few larvae were found dead during the experiment in OOD-1, OOD-2, FOD-1 and FOD-2. All the larvae fed with LD-2 died by the second day. Fresh set of larvae was replaced in LD-2 and they too met with a similar fate. Pseudofaeces were seen in LD concentrations. As a result of mortality in different concentrations the development of ciliates occurred in the respective media. Mortality has also occurred in the controls but in less numbers. Heavy mortality was recorded in OOD-1 and LD-1 after 30 days.

The spat in the range of 1252.5μm to 1443.3 μm, when supplemented with 10, 20, 30, 40 and 50 thousand capsules of OOD to the 50 thousand cells of natural diet *I. galbana* per spat per day, the growth rate was higher in the concentrations than in the control. The growth was 17.23 μm, 15.25 μm, 12.05 μm, 19.08 μm and 16.58 μm per day in the respective concentrations and 11.44 μm in the control. It worked out to 50.6%, 33.3%, 5.33%, 66.78% and 44.93% based on the control.

The spat which ranged between 730.8 μm and 1065.0 μm showed a growth rate of 9.87 μm, 7.75 μm, 7.36 μm, 9.1 μm and 12-09 μm per day when fed with FOD in the above similar concentrations and 10.2 μm per day in the control. In contrast to OOD, the growth rate in all concentrations of FOD was less than the control except the one concentration (5000 capsules of FOD and 50,000 cells of *I. galbana*). Based on the growth rate in the control the fall was to a degree of 3.2%, 24.0%, 27.8% and 1.08% in the concentrations referred to above.

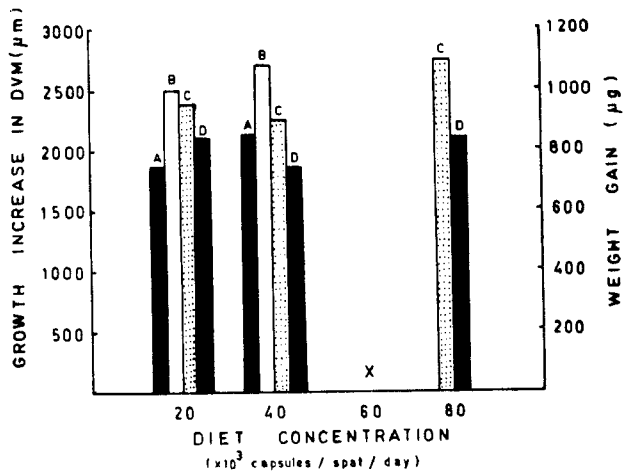

Fig. 1. Differences in the growth of pearl oyster spat fed with *I. galbana* and supplemented with oyster oil diet (OOD) and fish oil diet (FOD). A. OOD — control; B. *I. galbana* and OOD; C. *I. galbana* and FOD and D. FOD-control.

The effect of OOD and FOD on the growth of spat is shown in Fig, 1.

It is significant to note that the spat in the range 2800 μm showed a growth rate of 50μm and 57 μm per day in the concentration of 20 and 40 thousand capsules of OOD and 50 μm, 48μm and 58 μm per day in the concentrations of 20, 40 and 80 thousand capsules of FOD. In the control it was 48 μm per day. The growth was almost similar in all the concentrations. The growth and weight increase in respect of OOD and FOD at different concentrations is given in the Fig. 2.

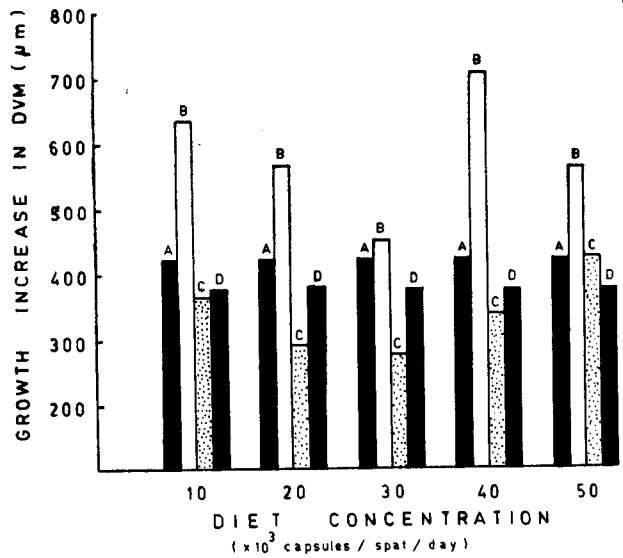

Fig. 2. Differences in growth increase and weight gain with oyster oil diet (OOD) and fish oil diet (FOD) as supplemental feed. A. Weight gain with OOD; B. Growth increase with OOD; C. Growth increase with FOD and D. Weight gain with FOD.

The pearl oyster larvae fed with artificial microparticulate diets survived only two days. The diets, on supplying to the medium, sunk to the bottom and are not available to the swimming larvae. Moreover separation of these particles from the larvae was found difficult. Accumulation of such particles in the medium resulted in the development of ciliates. Similar effect was also observed when floculated mixed phytoplankton was added to the medium. The addition of this food increased pH of the medium as it had KOH which was used as floculation agent. It is known that addition of food material other than live leads to the contamination of medium.

DISCUSSION

Early literature concerning the value of non-algal foods such as bacteria, detritus and dissolved organic compounds has been reviewed by Ukeles (1971). The results of these studies are inconclusive and there is little quantitative information to support that the filter feeding bivalve molluscs can be supported entirely with non-algal feed. Knowledge on artificial diet as supplemental feed for bivalve larvae was limited. Carriker (1956) reared clam larvae on an extract of cereal and concluded that good growth was due to the bacterial population appearing as a result of rich cereal extract. The improved growth rate of the larvae was related to an increase in a selected group of bacteria (Hidu and Tubiash 1963). Clam larvae when fed dried *particles* of *Ulva*, *Fucus* or *Laminaria* grew to metamorphosis in 13-17 days. Larvae reared with frozen *Ulva* did not grow as rapidly as those receiving live foods (Chanley and Normandin 1967). Loosanoff and Davis (1963) reported that dried, ground seaweed *Scenedesmus* sp when fed to clam larvae the growth was as effective as the one fed with best live naked flagellates. Stickney (1964) showed that the clam larvae fed with ground and strained *Zostera* leaves did not grow even with the addition of antibiotics to control the bacterial population. In the present study on the pearl oyster larval nutrition, the natural diet *I. galbana* gave good results than the encapsulated diets. The oyster oil diet has yielded better results than fish oil and lecithin.

It indicated that the diet prepared from the allied (molluscan) group promoted better growth and settlement than fish oil and lecithin diets. When compared to the natural diet the results are not encouraging. Yet it is considered to be a significant step that the larvae could grow, metamorphose and set as spat on feeding these diets.

Interest in the nutritional requirements of juveniles and adult bivalves has increased considerably in recent years. But no nutritionally adequate formulated diet for bivalves has yet been developed. However, Langdon and Waldock (1981) demonstrated that increasing the lipid content of the diet with triolein capsules did not enhance the growth of spat fed on *Tetraselmis suecica* or *Dunaliella tertiolecta* but the addition of encapsulated oyster lipid extract to the diets increased the growth. Castell and Trider (1974) have reported that the adult oyster *Crassostrea virginica* when fed with artificial diet showed lesser growth rate compared to those fed with natural diet. Trider and Castell (1980) reported that hydrogenated coconut oil fed oysters showed little weight gain after 30 weeks. The diets with higher levels of fatty acids produced significantly greater weights and the diets containing cod liver oil, ethyl esters, either sterol free or supplemental with 1% cholesterol produced significantly poorer weights than natural food. In the case of pearl oyster spat the growth was better in OOD than FOD but in respect of weight gain remarkable increase in FOD fed spat was worth noting. It can be seen that OOD has promoted length increase whereas FOD weight gain. Negligible mortality of spat on these diets proved their acceptability. Further work on these lines would perhaps help in developing suitable food in respect of fast growth and high survival rate of pearl oyster spat.

Valuable contributions have been made in the processed natural diet either as major source of food or as supplemental one. Lyophilised cultures of the flagellates, *Dunaliella euchlora* and *Isochrysis galbana* fed to clam larvae produced survival and growth comparable to that obtained when clams were fed live algae. The larvae of the American oyster *Crassostrea virginica* failed to grow on lyophilised preparations of *I. galbana* (Hidu and Ukeles, 1962). Spray-dried *Chlorella* cultures from Japan, a culture of *Monochrysis luther* vacum dried in manitol and lyophilised *I. galbana* gave similar results with larvae of European oyster *Ostrea edulis* (Walne 1974). Loosanoff and Davis (1963) showed that the clam larvae fed freeze-dried *I. galbana* grew as rapidly as larvae fed live cells of the same alga. In the present study the pearl oyster larvae fed with floculated, freeze-dried samples of mixed phytoplankton did not yield results.

Failure of microparticulate diet as artificial feed for pearl oyster larvae and spat way due to the following reasons: 1) It was found difficult to grind the microparticulate diet into particles small enough to be ingested by the larvae or spat; ii) The particles quickly settled on the bottom thus becoming unavailable to swimming larvae; iii) Separation of these particles from the larvae was found difficult and iv) Finally because of rapid decomposition of microparticulate diet, the larval cultures became fouled and the bacterial flora and ciliates developed

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72. A SEMICONTINUOUS PROCESS FOR MOLLUSCAN HATCHERY

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ABSTRACT

This paper describes a continuous running water hatchery with a semicontinuous production. The system can be used not only for molluscs such as mussels, edible oysters and pearl oysters; but also other ecologically similar marine organisms such as clams, prawns, crabs, lobsters and fishes. It is designed in such a way that all the flows could be regulated by operating appropriate valves.

The sea-water pumped into the overhead tank passes down by gravity through sand filter, micro-filter, supply tank and u. v. irradiator. From there they can be diverted to different tanks. The fluidised incubator is designed in such a way so as to purge out the excess sperms, tissue fluids and at the same time to retain the fertilized eggs. After incubation the eggs are transferred to the larval rearing tanks, where continuous flow of water is maintained and spats are collected in the spat collectors. Then they are acclimatised to ordinary sea-water. The system can produce 15,00,000 seeds once in 10 days.

INTRODUCTION

In recent years the demand for edible and commercially important molluscs have increased considerably. The mussels, oysters, clams and other shell fishes which were once considered to be cheap items of food exclusively meant for the fishermen community and other poor people dwelling in coastal areas, have in recent years attracted the attention of even the affluent population of the cities. The increased demand for edible molluscs as well as commercially

important pearl oysters have persuaded several Research Institutes in the field of fisheries to come forward to develop a technology to culture most of the commercially important species. Here comes the necessity for the establishment of a full fledged hatchery which will be able to supply adequate quantities of good quality seeds round the year, for culture purposes.

Several countries have developed techniques to rear the larvae of bivalve molluscs under the laboratory conditions. Loosanaff and Davis (1963) standardised a method to culture the oyster larvae to metamorphosis in the mid 1940s. Walne (1958) succeeded in rearing the larvae of. *Ostrea edulis*. In French Polynesia, AQUACOP produced commercial size spat of green mussel *Mytilus viridis* in 1980.

In India, considerable work has been done on the development of the larvae of bivalve molluscs by several scientists including Devanesan (1955) on *Ostrea madrasensis* (= *Crassostrea madrasensis*), Rao et al (1976) on *Mytilus, viridis*, Rao (1983) on *C. madrasensis* and Desai (1983) on *C. rivularis, C. belchen, C. gryphoides* and *Ostrea cucullata*.

Small-scale hatcheries were attempted by Samuel (1983) on *Crassostrea madrasensis* (Preston), Alagarswami et al (1983) on *Pinctada fucata* and Nayar et al (1984) on *Crassostrea madrasensis* (Preston).

The conventional molluscan hatcheries use aerated still water for larval rearing, involving extensive labour in the periodical transfer of larvae, cleaning tanks, maintenance of quality of sea-water suited for larval rearing etc. Quite often contamination sets in resulting in high mortality. This paper describes a continuous running water hatchery with a semicontinuous production. This can overcome the difficulties encountered in the conventional hatcheries. This system is designed in such a way so as to regulate all the flows by operating appropriate valves. Another advantage in this hatchery is that not only molluscs such as mussels, edible oysters and pearl oysters, but also other ecologically similar organisms such as clams, prawns, crabs, lobsters and fishes could be hatched and seed produced either simultaneously or species-wise. This invention is illustrated in the drawings (Fig. 1)—the section elevation and plan. The diagrams are self explanatory.

EQUIPMENTS

(1) Centrifugal pump of 10m³/h. capacity & 2.5 KW Motor. Foot valve is suitably anchored by a buoy to have a clearance from sea bed of about 1 m and a depth of about 5 m.

(2) Overhead tank made up of puzzolona cement concrete of 10 m³ capacity, erected over the top of a structure.

(3) Sand filter, with dished ends having provision for backwash, of 2m³ capacity filled with filter media in the order of pebble, gravel charcoal, sand if necessary kaolin.

(4) Micro filter of cartridge type, suitable for removal of particles above 5μ

(5) Supply tank, Rubber lined, Carbon steel of 10 m³ capacity.

(6) UV irradiator 2 Nos., connected in series, having a capacity of 2000 litrs/h.

(7) Fluidised incubator, test tube shaped, fitted with detachable ring sieve of BSS 300 mesh and having provisions for back wash, inlet, drain, filtrate drain, and outlet.

(8) Larval rearing tank— U-shaped having a capacity of 2000 l lined inside with removable polythene sheet. The tank is provided with detachable sieve cap of various meshes, drain and transparent cover plates. The tank can accommodate 300 suspended spat collectors made of nylon net of 1 m² area with a reusable plastic frame. The tanks are provided with longitudinal ribs with recess on both sides so as to accommodate the spat collectors.

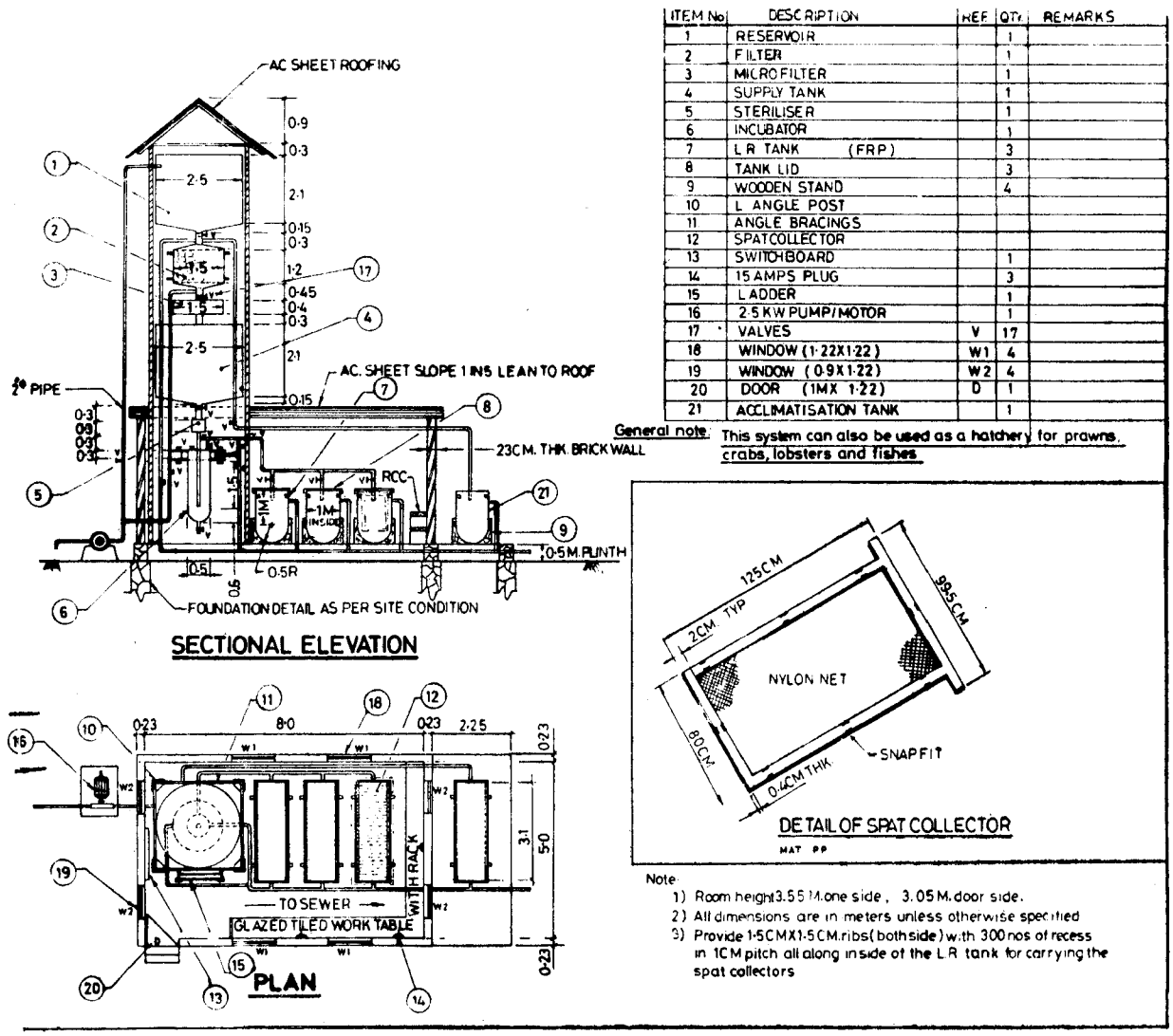
(9) Acclimatisation tank is similar to larval rearing tank but without lid.

PROCESS

The sea-water from a depth of 5 m is pumped to the over-head tank as and when required. From the overhead tank water can be diverted to flow into the filtering unit and the acclimatisation tank simultaneously (Fig. 1). The filter media used will remove

silt, sand particles and other sedimentary materials from the water. Kaolin used here has the advantage of adsorbing bacteria. The water then flows through the micro-filters where particles larger than 5μ in size are eliminated. This prevents the entry of large protozoans, algae, eggs and cysts of marine organisms and other organic materials into the culture tanks. The water emerging from the filters are collected in the supply tank which acts as a temporary reservoir. Here the water is subjected to U. V. irradiation by which organisms including bacteria which would have escaped the filteration process, are killed. This gives practically sterile water. From the steriliser, water is directed to flow into the incubator, larval rearing tanks, acclimatisation tank, breeding tanks and algal culture tanks (not shown in the figure).

Mussels or edible oysters or pearl oysters as the case may be are induced to breed in the breeding tanks. The eggs and sperms at a ratio of 1:10 are introduced into the incubator. At a time the incubator can contain a minimum of at least 80,00,000 eggs. The water from the steriliser is allowed to flow through the incubator at a very slow rate initially just sufficient to agitate the contents. This helps the eggs to remain in suspension which in turn increases the rate of fertilization. The fertilization will be over by about 45 minutes. After fertilization a water flow of 100 l per h is maintained in the incubator. Excess sperms



ITEM No	DESCRIPTION	REF	QTY	REMARKS
1	RESERVOIR		1	
2	FILTER		1	
3	MICRO FILTER		1	
4	SUPPLY TANK		1	
5	STERILISER		1	
6	INCUBATOR		1	
7	L R TANK (FRP)		3	
8	TANK LID		3	
9	WOODEN STAND		4	
10	L ANGLE POST			
11	ANGLE BRACINGS			
12	SPATCOLLECTOR			
13	SWITCHBOARD		1	
14	15 AMPS PLUG		3	
15	LADDER		1	
16	2·5 KW PUMP/MOTOR		1	
17	VALVES	V	17	
18	WINDOW (1·22X1·22)	W1	4	
19	WINDOW (0·9X1·22)	W2	4	
20	DOOR (1MX 1·22)	D	1	
21	ACCLIMATISATION TANK		1	

General note: This system can also be used as a hatchery for prawns, crabs, lobsters and fishes

Note:
1) Room height 3.55 M. one side, 3.05 M. door side.
2) All dimensions are in meters unless otherwise specified
3) Provide 1·5CMX1·5CM. ribs (both side) with 300 nos of recess in 1CM pitch all along inside of the L.R. tank for carrying the spat collectors

Fig. 1. Semi continuous Molluscan hatchery system (Scale 1:100)

and tissue fluids and tissue pieces, which form a source of contamination are purged out through the ring filter. An incubation time of 24 h is allowed so that the larvae could reach the straight-hinge stage. After the incubation, the larvae are flushed into the larval rearing tanks by operating the valves. Most of the unfertilized eggs, dead and slow developing larvae will get collected at the bottom of the incubator. This is later removed by opening the drain pipe. Once the incubator is emptied, the water is allowed to by-pass the incubator. A flow of 400 l per h is maintained in the larval rearing tank so that the residence time of water will be 5 h approximately. Unicellular algae less than 10μ in size acceptable to the larvae can be fed into the larval rearing tanks as desired by the culturist.

After 10 days a second batch of eggs are introduced into the incubator and fertilized. The larvae are flushed into the second larval rearing tank. Similarly, after 10 days third batch is also introduced into the third larval rearing tank.

Twelve days after the introduction of larvae into the larval rearing tanks, a maximum of 300 spat collectors are suspended in the larval rearing tank. The larvae get settled on the spat collectors. On the 30th day, the spat collectors with spat of the 1st larval rearing tank can be transferred to the acclimatisation tank. The used polythene sheet cover of the larval rearing tank, can be replaced by new one and the tank will be ready to receive another batch of larvae. The use of polythene sheet cover prevents the settlement of spat of the surface of the tank and thereby avoid considerable labour involved in cleaning the tanks.

Acclimatisation of spat to the ordinary sea water is done by gradually reducing the supply of sterile water and progressively increasing the supply of unfiltered sea-water coming directly from the over-head tank. This minimises the rate of mortality during acclimatisation and the spat produced will be well equipped to withstand the conditions prevalent in the natural environment.

For three larval rearing tanks, one acclimatisation tank is sufficient. When 30 days of rearing is completed in the first larval rearing tank the spat are transferred to the acclimatisation tanks. The first larval rearing tank can now be used io receive another batch of larvae. Acclimatisation is completed in 10 days and by this time the spat in the second larval rearing tank will be ready for acclimatisation. This can go on as a semi-continuous process. The proposed system will be able to produce at least 15,00,000 seeds once in 10 days i. e. 450,00,000 seeds in 300 days. If we are increasing the number of tanks 10 times we can expect a production of 15,00,-000 seeds per day i. e. 45,00,00,000 seeds in 300 days.

The period of rearing in the tanks can be either increased or decreased according to the species reared. Another advantage is that different animals such as mussels, edible oysters, pearl oysters, clams, prawns, crabs, lobsters and fishes can be hatched and seeds produced simultaneously or species-wise as and when required.

All the drain pipes of the system will be connected to a sewage which opens into the the sea. Since this is a running water system not much pollution is envisaged.

DISCUSSION

The problem of intake of sand along with the inlet water is prevented by giving a minimum of one meter clearance between the foot valve and the sea bed.

It is quite common that the filtering unit may get clogged with sediment due to continuous use. But here provision has been made to back flush the filtering unit and bring it back to use.

The U. V. irradiator used in the system will sterilize the filtered water. Loosanaff and Davis (1963) have also observed that the use of two U. V. units connected in series should give practically sterile water at a rate of 10 gallon per minute.

Several workers in this field of work have expressed difficulty in segregating fertilized eggs from excess sperms and tissue fluids which

form a source of contamination in the culture. Loosanoff and Davis (1963) have adopted sedimentation method whereas Samuel (1983) adopted centrifugation method to overcome this difficulty. But in this system the specially designed fluidised incubator has the facility to purge out the excess sperms and tissue fluids at the same time to retain the fertilized eggs.

Culture of larvae in still water is normally prone to infection and use of antibiotics becomes necessity. The works of Walne (1958), Millar and Scott (1967) Loosanoff and Davis (1967), AQUACOP (1979) and Samuel (1983) have revealed that they have used antibiotics in the culture media to prevent contamination. Since this is a running water system with a residence time of just 5 hours the chance of contamination is very remote and therefore the use of antibiotics can be avoided.

The use of conventional spat collectors such as lime coated country tiles, corrugated asbestos, bamboo, pine branches, twings, shells of oysters and other molluscs, slate, stones, pebbles, earthen pipes and ropes have been reported by several scientists including Imai (1977), Nayar and Mahadeven (1977, 1983) and Thangavelu and Sundaram (1983). These spat collectors have been found to be difficult to handle and the isolation of spat collectors laborious, often leading to the mortality of the spat. The 2000 l U-shaped rearing tank suggested here is designed to accommodate a maximum of 300 no of $1m^2$ spat collectors made up of nylon net with reusable plastic frame. The advantage here is that these spat collectors help in the better utilisation of the available space in the tank, provide greater surface area for the settlement of the spat and easy handling of the spat as well as the spat collectors. The nylon nets with the spat settled on it, as such can be transferred to the culture beds whhereas the plastic frame can be reused.

Another difficulty encountered in the conventional hatcheries is the settlement of spat on the inner wall of the rearing tanks. The removal of these spat is very difficult, laborious and the remains of the spat cause contamination to subsequent cultures. Lining the inner side of the rearing tanks with disposable polythene sheets suggested here can solve these problems.

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Session - IV

PROCESSING AND PRODUCT DEVELOPMENT OF BIVALVES AND GASTROPODS

73. PROCESSING AND PRODUCT DEVELOPMENT OF BIVALVES AND GASTROPODS

—Theme Paper

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INTRODUCTION

Food eating habit of the people is changing very fast particularly in recent times, due to improvement in socio-economic conditions of the people, availability of new resources as food, application of enriched, prepared foods etc, for the convenience of the customers. In this changing situation, processing good quality food in different parts of the country. The domestic market is vast and practically remains untapped as far as fishery products are concerned. In the export sector also, product diversification is the urgent need of the hour. Even after three and half decades of fisheries development, the sea-food export industry still depends for its export earnings on one single item namely frozen shrimp, though other items like lobsters, squids, cuttle fish and fishes like pomfret earn foreign exchange to some extent.

WORLD PRODUCTION OF PROCESSED OYSTERS, CLAMS, MUSSELS AND GASTROPODS

In recent years, a few categories of bivalves have become a popular seafood item in many countries. A considerable quantity of oysters, clams, mussels and gastropods are processed into frozen products, canned products and dried products in different countries of the world. The following table indicates the quantity of these commodities produced by important countries.

Commercially important bivalves and gastropods in India

In our country, oysters, clams, mussels and a few gastropods are local delicacies along the coastal region from where they are collected. They are good sources of food material available at reasonable prices and the local population buy them for culinary purposes. These varieties are not marketed in the interior region of the country, except in the form of canned products and as pickles to a limited extent in recent years.

Bivalves are by far the most important group compared to gastropods, for commercial exploitation and utilisation as food. Among the bivalves, edible oysters (*Crassostrea* sp), Window pane Oysters *(Placenta placenta)*, various clam species (*Meretrix meretrix, M.* Casta, *Villorita cyprinoides, Gafrarium tumidum, Tapes pingius Katelysia opima, Donx* sp, *Anadara granosa Paphia* sp, *Tridacna maxima)*, the green mussel *(Mytilus viridis)* and brown mussel *(Mytilus* sp) etc, are utilised as food and also to some extent for processing and export.

The gastropods are mainly fished for their beautiful shells which are of ornamental value and for the manufacture of lime. The meat is sometimes used as bait. Only a few species are utilised as food to a very limited extent by the coastal population. The gastropods which can be utilised as food include limpets (*Cellana radiata*), *Trochus* sp, whelks (*Thais rudolphi* and

World Production (Qty in Metric tons)

	1984	*1983*	*1982*	*Countries*
I. Frozen Products				
a) Oyster Meat	3,105	3,528	4,162	Canada & U. S. A.
b) Clam Meat	15,053	15,906	15,890	U. S. A. & Rep. Korea
c) Mussel Meat	8,726	8,016	2,559	Denmark & New zealand
d) Univalves	3,745	2,307	4,344	Chile
Total	30,629	29,757	26,955	
II. Dried products				
a) Oyster Meat	548	954	1,075	
	548	954	1,075	Rep. Korea
III. Canned products				
a) Oyster meat	8 426	12,504	8,648	Rep. Korea & Japan
b) Oyster specialities	2,455	2,666	4,504	U. S. A.
c) Clam meat	21,436	20,465	19,700	U. S. A , Italy, Spain & Chile
d) Clam Chowder	34,910	36,967	37,515	U. S. A.
e) Clam specialities	6,703	3,047	3,834	USA
f) Mussels	8,000	10,979	11,000	Netherlands
g) Mussel Meat	17,392	15,081	17,567	Denmark, Spain & Rep. Korea
h) Univalve Meat	1,581	1,885	710	Chile
Total	100,903	103,594	104,553	

(Source : FAO - Yearbook of Fishery Statistics 1984, Fishery Commodities, Vol. 59)

T. bufo), olives *(Oliva* sp), buttonshell *(Umbonium vestiarium)* and the sacred chunk *(Xancus pyrum)*. Meat from some other gastropods may also be edible, but further studies are needed to find out their suitability for human consumption. At present, the meat from *Umbonium* sp is perhaps the only gastropod ulilised for food in some places in Maharashtra coast.

The availability of the above resources in sufficient quantity for commercial processing and marketing has to be studied carefully so that the resources are not depleted due to large scale exploitation.

Chemical composition of bivalves

Oysters, clams and mussels form a reasonably good source of protein and glycogen, though the protein content is not as high as in the case of fin-fish. Following is the chemical composition of the above mentioned bivalves.

Edible oyster meat	*Farm oyster*
Moisture %	80.05
Crudle protein %	12.26
Glycogen %	2.66
Ash % (DWB)	11.69
Clam meat	
Moisture %	78.50
Protein %.	10.09
Fat %	2.52
Glycogen %	6.68
Ash %	0.86
Mussel meat	
Moisture %	85.00
Protein %	8.40
Fat %	1.20
Glycogen %	3.50
Ash %	1.40

Processing of bivalves

Oysters, clams and mussels are mainly processed into frozen, canned, smoked and canned, dried and pickled products. The different stages involved in the processing of bivalves are briefly described below:

Depuration/Purification

After harvesting the bivalves are washed well in running water to remove the mud, dirt etc. Their intestines are often loaded with mud and sand, besides bacteria depending on the bacterial quality of the environment. The gut contents impart a muddy flavour and grittiness to the meat, if retained within. Manual removal of sand from stomach is time consuming and also will result in distortion/damage. Therefore, a cleaning operation to achieve depuration as well as elimination of bacteria is a very important step that should precede processing of bivalves.

Depuration means starving of the bivalves in filtered sea/water from their natural habit at normally for a period of 12-24 hours. The bivalves do not feed, but at the same time, they will empty their intestine through excretion. During this process, mud, sand etc. are also emptied from the alimentary canal and the bacterial load is considerably reduced.

Live animals after depuration in filtered water from naturat habitat for 12–24 h are relaid in filtered natural water chlorinated to 3-5 ppm level for 2-3 h Though depuration in chlorinated watet offers no significant improvement in the bacterial quality of the meat, treatment with chlorine after depuration and holding the live animals in that system for 2 h show definite improvement in the bacterial quality of the meat.

Shucking operation

Shucking means removal of the meat from the shell of bivalves and this can be done manually, or by immersing the live animals in boiling water/sea water or by steam cooking for a few minutes until the shell of the animal gape or open. Manual shucking is a strenuous job and highly time consuming. In commercial operation, shucking is mainly done either by boiling or by steam cooking.

Average shucking yield (after cooking) from raw material

Edible oyster	: 3-4%
Clam *(Meretnix* sp & *Villorita* sp)	: 9%
Green mussel	: 19%

The shucked meat is washed well in water/ running water to remove the shell pieces, dirt etc, if any, adhering to the meat. In the case of mussel the byssus is to be removed. The shucked and cleaned meat have to be chilled if there is some delay in further processing.

Freezing of bivalve meat

Oyster meat: Prior to freezing, the oyster meat is washed again and immersed in 1-2% salt solution containing 0.2% citric acid for about 10 minutes. One problem in the freezing of oyster meat is the high amount of drip loss due to freezing and thawing, which is found to be in excess of 20%. The brine treatment will reduce the drip loss to some extent. After the brine treatment, the oyster meat is drained, and packed in suitable unit size (1 Kg/ 2 Kgs/ 5 Kgs) in duplex cartons with polythene lining. The packed material is frozen at –30°C using contact plate freezer and stored at -20°C.

Clam meat: During the Year 1981, frozen clam meat was added on to the list of seafood exports from India. Today, there are a few seafood processing plants processing the clams for the purpose of export.

After depuration and shucking, the clam meat are graded according to size and the following size grades are followed by the freezing industry.

Size grades for frozen clam meat (Count/Kg)

300-500	1000-1200
500-700	1000-1500
700-1000	Broken

After size grading, the clam meat are washed in 5 ppm chlorinated water. The washed clam meat may also be boiled in 2-3% brine for just half to 1 minute to reduce the bacterial load. Packing is done in 2 Kg units in duplex cartons with polythene lining, the blocks are frozen using contact plate freezer at -30° C

within a period of 2-2½ h and stored at below -20°C.

Very recently, clam meat is also frozen as IQF (Individually quick frozen) for the purpose of export.

Mussel meat: Freezing of mussel meat is yet to be tried on a larger scale on a commercial basis by the freezing industry either for demestic market or for export. The freezing procedure is not much different from that of clam meat.

After depuration and shucking, the meat from mussels are carefully cleaned to remove the byssus, shell pieces and washed thoroughly in 5 pp chlorinated water. If necessary, the mussel meat may be boiled again in 2-3% brine for 1-2 minutes Packing may be done in 1/2 Kg, 1 Kg or 2 Kg units and packed in duplex cartons with polythene lining, and frozen in contact plate freezers. The frozen mussel meat are stored at below -20°c.

Canning of bivalves

Canning is an important method of processing of seafood, whereby a stable finished product is obtained which can be stored at ambient temperature for a considerable length of time, usually for one year or more.

Oysters

Canning of oyster meat and smoked oyster meat are being done on a pilot plant scale/semi-industrial scale by the Integrated Fisheries Project, Cochin, for the last 5 Years utilising the cultured edible oysters (*Crassostrea madrasensis*) from the oyster farm of C.M.F.R.I. unit and a freezing plant there. The frozen oyster meat are transported in insulated trucks to Cochin, which involves a transportation time of 8-10 h. The frozen meat when received at Cochin are stored in frozen storage at below -20° C. The frozen meat are utilised for canning.

The technological process for canning of oyster meat involves thawing of frozen oyster meat in the chill room at 0° C overnight. Next day morning, the oyster meat block is immersed in chilled water to separate the meat.

Canned oyster meat in brine

The thawed oyster meat is blanched in 3% brine for 2-3 minutes. The blanched oyster meat is packed in easy open type quarter dingley aluminum cans and hot 3% brine with 0.2% citric acid is added to nett weight. The quarter dingley cans have nett weight of 112 gm. They are exhausted for 6-8 minutes seamed and sterilised at 115°C for 30 minutes in superpressure autoclaves and then the cans are cooled down to room temperature within the autoclave itself.

Smoked-canned oyster meat

The thawed oyster meat is cold blanched (brined) by immersing in 5% salt solution for 3-5 minutes and arranged inside the smoking chamber. Hard wood saw dust is burnt to generate the smoke and the smoking is done initially at 40°C for 30 minutes and then at 70°C for 75-80 minutes. During the smoking process, the flavour of the oyster meat is improved due to absorption of volatile and other substances from the smoke, colour of the meat changes from bluish green to light brown and the texture improved due to partial dehydration.

The smoked oysters are packed in easy to open type quarter dingley aluminium cans, 80-85 gm in each can. Hot, double refined ground nut oil is added to nett weight (112 gms) and the cans are exhausted, seamed and sterilised at 115°C for 25 minutes in superpressure inside the autoclave itself.

Canned clam/mussel meat in brine

There had been some attempts by the seafood canning plants in India to process and export canned clam and mussel meat during the last decade, but good progress could not be achieved in this direction. The processing method adopted for canning clam and mussel meat is basically the same as described in the previous paragraphs for the canning of oyster meat in brine. The blanched meat were packed in 8 oz. (Nett wt : 200g) round tin containers, and these cans were given a sterilisation time of 45 minutes at 115°C temperature.

But at present, there is no canning of clam/mussel meat in India on a commercial/semi-commercial scale.

Pickling of oyster/clam/mussel meat

In order to develop products from these bivalves suitable to the Indian taste, detailed studies have been conducted and methods formulated for the processing of oyster clam/mussel meat into pickles by the Scientists of the Central Institute of Fisherey Technology. Pickling of clam meat and mussel meat had been taken up by the entrepreneurs on a commercial scale, and this product is already available in the markot in some cities and towns in India.

In general, the procedure involves frying of the depurated, shucked and washed meat in edible oil (gingelly oil) until the meat becomes light brown/brown in colour The fried meat is kept apart. Required quantities of ingredients like mustard, garlic, ginger, green chilly and curry leaves are fried together in refined oil for 2-3 minutes. At this stage, pre-determined quantities of pepper powder, chilly powder, turmeric powder etc are added, followed by the fried meat. The entire mass is boiled under stirring for a few seconds and removed from the flame. When sufficiently cooled, Vinegar is added and mixed thoroughly. The pickle is packed in pasterised glass screw cap bottles and stored at room temperature. The shelf-life of pickles made from oyster/clam/mussel meat have been found to be around 6 months.

Drying of oyster/clam/mussel meat

Drying of bivalves is not a common practice in India. Nevertheless, the procedure is outlined here.

The depurated, shucked and washed meat from oyster/clam/mussel are blanched in 3-5% boiling brine for 2-5 minutes depending on the size of the meat The purpose of blanching is mainly to inactivate the enzymes, reduce the bacterial load and moisture content from the meat. Now, the meat is either sun-dried/dried in a hot-air drier. Drying should be done properly to reduce the moisture content to the level of 10-15% in order to have sufficient shelf-life.

Possibility of new products from bivalves

There are possibilities of producing some diversified products from bivalves and some of them are briefly mentioned below : In all the cases the bivalves are to be purified (depurated) shucked and washed before they are used for making the products.

Frozen products

Minced meat

The oyster/clam mussel meat may be sent thorugh a meat cutter or meat mincer having a screen of 2-5mm diameter to obtain coarse pieces of minced meat. Mincing may be done after blanching the meat in 2-3% salt solution for 3-4 minutes. The minced meat thus obtained may be packed in duplex cartons with polythene lining and frozen using a contact plate freezer and stored it below-20°C.

This frozen minced meat may be used for making cutlets meat balls etc by blending with boiled potatoes, onion, chillies etc. The frozen minced meat may also be useful for making different types of soups etc. (eg. Oyster and corn soup)

Batteerd and breaded IQF meat

Oyster meat and mussel meat may be useful for producing battered and breaded products. The shucked oyster/mussel meat is to be blanched mildly in boiling 2-3% brine for 3-4 minutes. The blanched meat is dipped in a batter mix made of wheat flour, salt, sugar, spices, Vegetable oil etc as per the taste and breaded with bread powder. Now the battered and breaded meat may be individually quick frozen to -30°C using a suitable freezing equipment. The IQF meat may be packed in polybags and stored at below -25°C.

The battered and breaded IOF meat is ready for frying in hot vegetable oil as it is taken out of frozen storage/freezer cabinet of the home refrigerator.

Canned products

For the purpose of making diversified canned products all the three commercially important bivalves namely oysters, clams and mussels may be useful.

Minced meat

The shucked meat may be used for mincing directly or after mild blanching using a meat

mincer. The minced meat is packed in suitable cans. The juice that runs out of the minced meat may be collected, boiled and added into the cans as liquid medium. The cans are to be exhausted, seamed and sterilised.

The canned minced meat may be used for making soups, cutlets, meat balls etc.

Soups/soup stock

During the mincing operation for oysters/ clams/mussels a considerable quantity of liquid flow out from the meat. Some quantity of this liquid is added into the can as the medium, but still surplus quantity of liquid may be present.

This liquid may be boiled with spices, tomatoes, onions, salt etc. and canned as soup or nectar. The hot liquid is filled into cans, seamed and sterilised.

The soup/necter may be used as a soup stock for preparing soups or as a flavouring agent for other preparations.

Chowder

The example for this product is clam chowder. The shucked clam meat are thoroughly washed and then chopped in a grinder or meat cutter. Diced potatoes and bacon are added. Other ingredients like tomatoes, onions, white pepper and salt also added in stages. Now the ground clam meat along with all ingredients are boiled for about 10 minutes filled into cans under strring. Now, the cans are exhausted, seamed and sterilised.

Extracts

The examples for this product is clam extract. When the clams are shucked by steaming and also when the clam meat is blanched, considerable amount of liquid/juice is released from the meat. This liquid is collected, filtered and concentrated by boiling. The concentrated extract is filled into cans, exhausted, seamed and sterilised. Clam extract may be useful as a food for convalescents and invalids.

Marketing of Bivalves and Gastropods

Domestic market

Bivalves in live condition or their shucked meat are marketed to some extent in India along the coastal regions of Kerala and Karnataka and mussel meat in north Kerala coast.

Edible gastropods are occasionally collected and utilised as food, by fishermen in the coastal areas. The meat from button shell, *umbonium,* is perhaps the only species that is reported to be sold in fish stalls in Malvan (Maharashtra).

Oysters are eaten in live condition in some countries and are considered to be a delicacy, with increased number of tourists from developed countries visiting India, there is a possibility of serving live oysters in large hotels and restaurants in our country. This possibility should be explored further. Oysters will remain alive for about 24 h under the shade outside sea water after harvesting. If transportation by train/air and distribution is arranged properly, it may work out economical to market them live. Similarly, mussels and clams also could be marketed live to large hotels in the country.

Marketing of frozen oyster, clam and mussel meats within the country is also a possibility. But this will require educating the people regarding the nutritional qualities of their meat, preparing of recipes to guide the customers to use them as per the local taste, distribution to various consuming centres and sales promotion through advertisement and publicity.

Among the canned products, smoked oyster meat has very good demand in large cities and towns within the country though expensive. Similarly, smoked mussels and clams also may find a good market within the country.

PRODUCTION OF CANNED OYSTER MEAT (FOR DOMESTIC MARKET)

	Quantity : in Kgs			Value : in Rupees	
	1985-86	1984-85	1983-84	1982-83	1981-82
Q:	602.2	254.5	252.5	352.5	96.0
V:	48,393	20,448	22,698	25,184	6,856

(Source: Integrated Fisheries Project, Cochin-16)

Pickles made from clam meat and mussel meat are already produced and marketed to some extent on a commerciol scale. This requires

further sales promotion with the aim of increasing production and marketing.

Similarly, boiled and dried meat of oyster, clam and mussels may be powdered and used as a protein supplement in various types of foods like soup powders, chutney powders etc. Possibility of marketing such products should be explored further.

Export market

As mentioned earler, frozen clam meat are exported from India from the year 1981 onwards to countries like Japan/Kuwait, Federal Republic of Germany, U. S. A., and U. A. E. The quantity exported and value realised are given below:

EXPORT OF FROZEN CLAM MEAT

Quantity: in m. tons Value: in Rs. Lakhs	1985-86	1984-85	1983-84	1982-83	1981-82
Q:	392	1034	654	510	16
V:	62.37	148.71	83.25	97.36	1.11

Some attempts were made to export canned clams and mussels during the last decade, but the quantity exported and value realised are negligible, as seen below:

Export of canned clam and mussels

Qty: in m. tons Value: in Rs lakhs				
Year	1981	1980	1979	1975
Clam Qty :	10.0	—	—	0.1
Value :	1.85	—	—	0.04
Mussel Qty :	—	0.07	1.5	0.1
Value :	—	0.04	0.48	0.03

Some quantity of clam meat pickle also had been exported to Japan and U. A. E. during the years 1981 and 1982

Year	1982	1981
Q :	9.1	1.6
V :	0.61	0.28

Good potential for export of frozen, pickled, canned smoked and canned oysters, clams and mussels exist. But in order to exploit these markets, we must be in a position to effect regular supply of these commodities in considerable quantities.

Conclusion

It is possible to process marketable products from various types of bivalves by freezing, canning, smoking and canning, pickling, drying etc which may find a good domestic market with effective popularisation measures. A good potential already exists for export of these products to various countries.

But exploiting the domestic and export markets call for large scale availability of raw-material regularly. For this, we may not be in a position to depend entirely on natural resources as the known resources are limited. So, large scale farming of oysters, clams and mussels on commercial basis will have to start immediately. Culture techniques for farming, processing methodology and market potential already exist within the country. The only missing link appears to be the commercial farming of the valuable bivalves.

74. POST HARVEST TECHNOLOGY OF MUSSEL PROCESSING AND PRODUCT DEVELOPMENT

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ABSTRACT

This paper deals with studies on depuration, handling, transportation and product development carried out using mussels *Perna viridis*. Best method of depuration is shown to be starvation in water from natural habitat. Fresh mussel stored in ice remained organoleptically acceptable upto eight days. However, when intended for canning the iced storage should not be more than two days. It has been shown that fresh frozen mussel meat remained acceptable for 40 weeks when stored at -23°C whereas frozen meat prepard out of material iced stored for 8 days was acceptable only upto 15 weeks at -23°C. Standard process has been worked for canning mussel meat in oil and brine. Processes have also been worked out for mussel meat pickle, dried, smoked and marinated mussel meat, mussel chutney powder and lime from mussel shell.

INTRODUCTION

Mussel meat processed in different ways is very popular in several countries. There is a fairly large world trade in such commodities as can be seen from the figures of production and export presented in Tables 1A and 1B.

Green mussel *(Perna viridis)* and brown mussel *(Perna indica)* are fairly heavily distributed in the west and east coasts respectively of India. However, the estimated annual production from these natural sources is only around 3,079 tonnes (Alagarswami et al 1980). This is too meagre a quantity to support a mussel meat based processing industry. Normally mussel is sold for fresh consumption in local areas.

TABLE 1 A. *Production of Mussel meat products (MT)*

Countries	Canned			Dried			Frozen		
	1982	1983	1984	1976	1977	1978	1982	1983	1984
Netherlands	11,000	10,979	8,000						
Chile, Denmark, Korean Republic, Newzealand and Spain	17,568	15,018	17,392						
Hongkong	—	—	—	2	3	1			
Chile, Denmark, Korean Republic, Newzealand, South Africa and U.S.A.							2,559	8,016	8,726

Source: Yearbook of Fishery Statistics, Vol. 59, 1984, FAO, Rome.

TABLE 1 B. *World trade in fresh chilled or frozen mussel meat*

Countries		Imports			Exports			Quantity: mt Value: US $ 1000
		1982	1983	1984	1982	1983	1984	
France, Belgium, Italy, Netherland, FRG, U. K., Switzerland, Denmark	Q.	1,00,508	1,18,485	1,23,367				
	V.	40,991	41,534	32,059				
Netherlands, Spain, Newzeland, France, U. K., FRG, Italy, Denmark, Chile, Korean Republic.	Q.				69,546	1,04,789	1,30,396	
	V.				26,795	39,395	47,623	

Source: Year Book of Fishery Statistics : Vol. 59, 1984, FAO, Rome.

Some attempts have been made in the past to export processed mussel meat, the quantity involved being very little. There are steady trade enquiries for processed mussel meat. The lack of assured supply of raw material is a major impediment in exploiting such potential.

A right step in increasing mussel resources in the country is the importance given to developing the farming techniques by different agencies in India. It is reported that large scale culture of mussel has been successfully demonstrated (Kuriakose, 1980). No account is available of the actual production of mussel by farming. However, with production from capture and culture techniques, its production is likely to increase several fold. In the absence of a system for effective conservation by processing into stable products and marketing, the returns from the increase in production is liable to be uneconomic. This need was anticipated by the Central Institute of Fisheries Technology well in advance and research and development activities on utilisation of mussel meat were initiated which have resulted in providing a complete spectrum on different aspects of preservation and processing of mussel meat including utilization of mussel shell. These studies were largely carried out using green mussel *(P. viridis)* from natural sources.

RESEARCH INPUTS IN PROCESSING AND PRODUCT DEVELOPMENT

COMPOSITITION OF MUSSEL MEAT

Mussel meat is a protein rich food. It also contains substantial quantities of glycogen which is primarily responsible for its characteristic sweet flavour. Chemical composition of

TABLE 2. *Composition of mussel meat*

Moisture %	78.24-80.28
Protein %	11.02-13.82
Fat (ether extractibles) %	2.38-3.02
Glycogen %	5.36-10.78
Ash %	3.6-4.20
Inorganic phosphate (mg %)	15.1-43.18
Free amino acids (mg %)	
Phenylalanine	1.234
Glycine	2.938
Cystine	0.132
Tyrosine	0.932
Histidine	1 938
Valine	0.127
Lysine	0.937
Methionine	0.998
Glutamic acid	1.107
Isoleucine	0.031
Leucine	1.767
Serine	1.087
Tryptophane	0.016
Proline	0.985
Arginine	1·372
Threonine	0.343

mussel meat including the free amino acid contents is given in Table 2 (Balachandran and Unnikrishnan Nair 1975; Balachandran and Prabhu 1980 a, b; Chinnamma et al 1970).

Depuration

Mussel is a sedentary bivalve growing attached to rocks in coastal waters by means of byssus threads. They are filter feeders and therefore, at any given time, their stomachs are likely to be loaded with mud/sand besides bacteria. Surendran et al (1984) studied the distribution of faecal indicator bacteria in clams, mussels and oysters and their aquatic environments and found them to harbour large bacterial populations including faecal coliforms, *Escherichia coli* and faecal streptococci. Based on a study on the bacterial profile of mussel and its aquatic environment, Surendran et al (1986) concluded that mussel is a good indicator of faecal pollution of aquatic environments, particularly of immediate past origin.

It is rather easy to purify mussels of bacterial pollution because they cleanse themselves of all pollution bacteria if kept in clean sea water for some hours. This treatmeet can also free mussels of most of the sand in the stomach. Balachandran and Nair (1975) experimentally proved that mussel kept alive in sea water for 24 h expelled sand almost completely. More recently Surendran and Balachandran (1986), studied in detail depuration of live mussels in different systems and concluded that best results are obtained by depuration in clean sea water from rhe natural habitat of mussel. The extent of bacterial cleansing and removal of sand by this method is shown in Table 3.

Preservation and transportation

Balachandran and Prabhu (1980 a) have studied transportation of mussel in different forms and its further iced storage with a view, particularly, to use the meat subsequently for canning. Whole mussel, meat shucked from live mussel as well as meat shucked from boiled mussel were transported in ice from Calicut to Cochin and used for canning during progressive iced storage, simultaneously following the changes in chemical characteristics. The results are presented in Table 4.

Analysis of the canned samples prepared out of material stored in ice showed that products prepared out of meat from whole mussels or meat shucked from live mussels and stored in ice upto two days can be used for cannning. Meat from boiled mussels stored in ice rated poorer compared to the other samples. The corresponding organoleptic rating of canned mussel meat processed out of iced stored material are given in Table 5.

Meat shucked from iced stored whole mussel was slightly better in organoleptic characteristicts compared to fresh shucked meat stored in ice. However, transportation of whole mussel involves the transportation of shell

TABLE 3. *Effect of depuration of live mussels in different systems for 18 hrs. (overnight) on the quality of mussel meat*

	Raw meat before depuration	Natural water (sea water)	Natural water chlorinated at 5 ppm level	Potable water	Potable water chlorinated at 5 ppm level	Sodium chloride solution (2.3%)	Sodium chloride solution (2.3%) chlorinated at 5 ppm level
Total bacterial count/g	8.3×10^{6}	4.38×10^{6}	6.1×10^{5}	$7\ 82\times10^{5}$	9.86×10^{5}	4.9×10^{6}	5.62×10^{6}
Total coliforms/g	6.71×10^{2}	105	238	218	486	118	118
E. coli/g	230	93	108	124	138	92	105
Faecal streptococci/g	486	124	118	230	238	108	114
Acid insoluble as (sand) %	0.42	0.02	0.032	0.088	0.18	0.02	0.06
Glycogen %	5.36	4.82	4.54	4.60	4.22	4.90	4.63

TABLE 4. *Changes taking place in mussel composition during iced storage*

Material used	Days of storage	Moisture %	TN %	NPN %	Glycogen %
Stores in ice	0	78.36	1.98	0.352	5.43
Whole mussel	2	81.26	1.87	0.361	5.06
	3	82.34	1.81	0.314	3.04
	4	82.40	1.82	0.272	3.01
Fresh shucked meat	0	78.36	1.98	0.352	5.43
	2	81.49	1.82	0.324	4.92
	3	82.64	1.80	0.302	3.16
	4	82.91	1.76	0.264	2.95
Boiled and shucked meat	0	74.27	2.03	0.382	3.94
	2	76.59	1.98	0.317	3.03
	3	76.43	1.96	0.310	2.76
	4	76.86	1.89	0.312	2.58

TABLE 5. *Organoleptic rating of canned mussel meat processed out of correspondingly iced stored material*

Days of storage	Material used	Overall organoleptic rating
Initial	A	Very good
	B	Very good
	C	Good
2	A	Good
	B	Good
	C	Fair
3	A	Good - Fair
	B	Good - Fair
	C	Fair
4	A	Fair
	B	Fair
	C	Fair - Poor

A - Whole mussel B - Meat shucked from fresh mussel C - Meat shucked from boiled mussel.

making the process uneconomic. Therefore, it was concluded that when used for canning, it is ideal to transport fresh shucked meat in ice. On the basis of studies on iced storage characteristics of whole mussel, Chinnamma (1970) reported that it remained in organoleptically acceptable condition upto 8 days even though the prime quality was maintained only for 2 days.

Freezing

Changes in chemical, bacteriological and organoleptic qualities of mussel during freezing and subsequent frozen storage in relation to pre-process iced storage was studied by Chinnamma George (1974). Whole mussels were stored in ice, samples withdrawn at regular intervals of 2 days upto 8 days, meat shucked and frozen with adequate glaze at 40°C and stored at 23°C. Analysis of the frozen samples at regular intervals showed that fresh frozen mussel meat remained in an organoleptically acceptable condition upto 40 weeks whereas the samples prepared from mussel iced stored for 8 days had a shelf-life of only 15 weeks.

Chinnamma George and Nair(1976) studied the effect of pre-process iced storage on the quality of cooked frozen mussel meat.

Whole mussel was cooked and stored in ice upto 5 days. Similarly uncooked whole mussel was stored in ice, samples withdrawn at periodic intervals and then cooked. Meat was shucked from both specimens and frozen at 40°C and stored at -23°C. Analysis of the frozen stored material indicated that samples prepared out of cooked whole mussel iced stored for one day had a shelf-life of 38 weeks and those stored for 3and 5 days had a shelf-life of only 28 days. Storage life was on an average of only 16 weeks for samples prepared out of raw mussel stored in ice and then cooked and frozen.

Canning

Canning mussel meat is a popular item of commerce. Mussel meat renders well for canning in oil, brine or sauces. Balachandran and Nair (1975) carried out studies on working out a standard process for canning mussel meat. The process of canning consists of the following steps Whole live mussels after depuration are either heated in open vats or steamed in autoclave until the meat becomes firm enough to render shucking easay. The shucked meat after washing well is blanched in 5% brine for 5 minutes. Blanched meat is filled in cans, the medium added, exhausted, seamed and heat

processed in steam at 115°C for 20 minutes. Suitability of iced stored mussel for canning has been discussed earlier.

Development of other products

A number of processes involving low cost technology have also been developed for utilization of mussel meat which includes processes for pickles, marinades, dry meat, smoked meat and preparation of lime from mussel shell.

Mussel meat pickle

A very successful product which has met with ready acceptance from consumers is mussel meat pickle. A recipe for preparation of pickle is give below:

Blanched mussel meat (Stomach removed)	—	1 Kg
Green chilly (Split)	—	100 g
Ginger (Skinned and cut into small pieces)	—	100 g
Garlic (Skinned)	—	100 g
Curry leaves	—	10 g
Chilly powder	—	150 g
Turmeric powder	—	5 g
Mustard, crushed	—	25 g
Oil (Gingelly or groundnut)	—	300 ml.
Vinegar (Acetic acid content 4%)	—	400 ml
Salt	—	To taste (around 100 g)

Process

Mussel meat is blanched for 5 minutes in boiling brine (50 g salt in 750 ml water). After draining and cooling, the gut content is chopped off and the remaining part cut into small pieces. Wash well and drain. Fry the meat in oil until the colour turns brown and set apart. Fry green chilly, ginger, garlic in oil followed by other spices. Mix together all the ingredients, allow to cool and add Vinegar and salt to taste. Mix thoroughly and fill in clean wide mouthed bottles. Care is to be taken to see that no solid material is exposed. A layer of oil should be present at the top in packed samples. (Muraleedharan, Joseph and Devadasan 1982).

Dried mussel meat

The simplest method of preservation of mussel meat is by drying. Process details and shelf life of dried mussel meat have been worked out by Unnikrishnan Nair et. al (1983). The method involves blanching meat shucked from fresh depurated mussel in 5% boiling brine for five minutes and then drying in sun or an artificial dryer until the moisture content is 10-15%. After equilibration of moisture, the dried meat is packed either in glass bottles or polythene bags. The product had excellent organoleptic characteristics and was found bacteriologically. Shelf-life studies revealed that dry meat remains well at room temperature in good condition upto 6 months after which rancid flavour develops as also the colour becomes slightly brownish. The product yield is approximately 20% of the meat. After rehydration for 30 minutes in water it can be used for ordinary preparations.

Smoked mussel meat

A popular processed mussel product is light smoked and dried mussel meat. Smoking improves the flavour and succulence of the product and hence its acceptability. The process worked out for the preparation of smoke cured mussel meat is as follows:

The meat shucked from depurated mussel is blanched for 5 minutes in 5% boiling brine. This is dried to a moisture level of 40-45%. The dried meat is smoked at 80-90°C for 30 minutes which imparts characteristic smoked colour and flavour to the product. The smoked meat is further dried to a final moisture level of 10%. It has been shown that at this moisture level the product has a shelf life of not less than six months (Muraleedharan, Nair and Joseph, 1979).

Mussel meat 'Chutney' powder

Another product which has been developed out of mussel meat is a dry 'Chutney' powder (Anon 1980). This can be used with the breakfast snacks like *Iddli* or *Dosai*. This is easy to prepare, handle and store. Recipe and preparation method are as follows:

Dried mussel meat	500 g
Skinned black gram	500 g
Red chilly	75 g
Coriander	50 g
Asafochera	5 g
Salt	To taste

Mussel meat is fried in a pan until the colour is brown. The other ingredients except salt are fried together and all are powdered and mixed together with sufficient salt. For consumption the chutney powder should be mixed with a little warm edible oil.

Marinated mussel meat

The best process for preserving mussel meat for a short period of 2-3 months is by marinating. A process worked out suitable for the species available locally (Unpublished data) consists in blanching meat from live depurated mussel in 3% brine for 5 minutes, followed by cooking and packing the meat in glass jars and covering the meat with a solution containing 3% salt and 3% acetic acid. The product remains in prime condition upto 2 months and in acceptable condition upto 3 months after which the meat tends to become very soft. The product has the advantage over dried/smoked meat in that no rehydration is required before further processing for the table and the texture does not become hard.

Utilization of shell waste

No serious attempts had been made on utilization of the mussel shell. Except using a small quantity as liming agent in coconut plantations no other use for it was known. The possibility of converting the shell into lime was experimented and it was found out that good quality lime can be prepared out of this shell waste. The process is similar to making lime from clam shells. The process has been reported to be quite profitable (Kalaimani, et al 1984).

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75. LOSS OF NUTRIENTS DURING CANNING OF CLAMS AND MUSSELS

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ABSTRACT

Shellfish play a vital role in India's economy and the industry based on processing of the meat of mussels and clams has immense possibility to develop in future because of the abundant availability of this highly nutritious raw material. The influence of pre-process ice storage on the quality of the canned product prepared from the clams, *Villorita cyprinoides* has been studied and chemical and organoleptic aspects of the canned material prepared out of clams stored upto nine days under ice was reported. The results showed that the product prepared from material iced upto three days was acceptable with respect to colour, odour and flavour.

Quantities of nutrients lost during different stages of canning such as initial boiling, blanching and sterilisation have been worked out. Loss of soluble nitrogenous constituents was maximum at the blanching stage.

INTRODUCTION

Mussels and clams have attracted the attention of man from pre-historic times because of their sedentary habits and easy accessibility. The main objective of canning is to get a product that may be stored for a considerable length of time at ambient temperature at the end of which it will be tasty and safe to eat. Gangal and Magar (1967) studied the product quality and loss of nutrients in canned crab meat treated with anti-oxidants. Balachandran and Nair (1975) reported the methods that could be employed for canning clams and mussels in oil.

Hardy (1953) gave an account of the processing of minced razor clam meat and utilisation of clam juice as a filling medium or separately canned as clam juice, nectar or clam broth. Korobkina et al (1970) studied the loss of weight, nitrogenous compounds, vitamins and minerals occurring during canning of black sea mussels pre-processed as boiled frozen blocks.

The present paper deals with studies on suitability of ice stored clams for canning, nutritional loss at different stages of processing of clams, standardisation of the processing conditions to get good quality canned clams and mussels and examination of the canned products.

MATERIAL AND METHODS

The clams *Villorita cyprinoides* collected from Cochin backwaters were allowed to starve in clean water for a day and then kept in chlorinated water (5 ppm) for further two hours.

For the studies on suitability of ice stored clams for canning the selfpurified clams were stored in an insulated ice box in direct contact with ice (1:1 ratio). At regular intervals material was released for canning. Shellon clams were boiled in water for two minutes, drained and the meat was shucked out. The meat was blanched in 7% brine for 3 minutes, drained and cooled. The material was packed in cans and filled with hot brine (2% sodium chloride plus 0 1% citric acid) leaving some head space (10 cms). The cans were exhausted for 10 minutes in steam and seamed immediately. They were heat processed under 0.703 kg/cm² for 20 minutes, cooled, washed and the surface wiped dry.

In order to evaluate the loss of nutrients at different stages of processing samples of meat and cooking medium were withdrawn at each stage and analysed.

The method followed for canning of mussels was similar to that of clams with slight modification (1) blanched in 5% brine for 5 minutes and (2) heat processed for 30 minutes at 0.703 kg/cm².

The cans were examined for external defects if any and vacuum and cut open. Brine was drained out as completely as possible by inverting the can over a funnel for 10 minutes. The meat was examined for organoleptic characteristics and the minced meat and brine were analysed for chemical parameters.

Moisture, protein lipid and sodium chloride were estimated according to the procedures o A. O. A. C. (1975). The estimation of water soluble nitrogen was made by digesting an aliquot of the water extract with concentrated sulphuric acid followed by kjeldhal distillation method. Non-protein nitrogen determinations were made on the trichloracetic acid extracts of the muscle by the kjeldhal method. Free alpha amino nitrogen was estimated by the method of Pope and Stevens (1939). Glycogen was estimated by the method of Van de Kleiy (1951), ribose by the method of Mejbaum (1939) and phosphorus (Pi) by the procedure of Fiske and Subbarow (1925).

The organoleptic quality of the canned products was judged by the taste panel of the Institute according to the Official Methods of A. S. T· M. (1968).

RESULTS AND DISCUSSION

The analytical data of the canned products prepared from clams ice stored upto 9 days are presented in Table 1. The moisture content of the finished product ranged from 72.44 to 69 69%. Free alpha amino nitrogen content in the muscle and the filling brine (2% salt) showed a gradual increasing trend as the days of icing advanced i. e., 24.3 to 80.0 mg% in meat and 26.5 to 72.6 mg% in brine. The organoleptic qualities showed that the products prepared from material iced upto three days were graded as fair with respect to colour, odour and flavour,

TABLE 1. *Chemical and organoleptic characteristics of canned products prepared from fresh and ice stored clams*

Pre-process ice storage days	Moisture %	F & NH_2N		Organoleptic qualities				Score
		Muscle mg%	Brine mg%	Colour	Texture	Odour	Flavour	
0	72.44	24.3	26.5	Good	Soft and firm	Good	Good	8
2	72.40	26.0	19.3	,,	,,	,,	,,	7
3	70.37	69.8	47.1	Fair	Slightly tough	Fair	Fair	6
5	69.29	73.9	65.4	,,	,,	F-P	F-P	5
7	70.03	82.1	65.3	,,	,,	,,	Poor	3
9	69.69	80.0	72.6	F-P	,,	Poor	Bittor	2

TABLE 2a. *Analytical values of clam muscle of different stages of processing*

	Moisture g%	Protein g%	W.S.N. mg%	N.P.N. mg%	F.α-NH_2N mg%	Fat DWB g%	Salt content g%	Yield I g%	Yield II g%
1. Raw muscle	84.03	8.4	308	140	86.8	9.8	—	16.2	—
2. Boiled muscle	74.93	13.3	140	126	46.2	11.3	—	7.29	45.0
3. Blanched muscle	73.92	16.08	112	119	30.8	10.1	4.47	5.84	36.04
4. Heat processed muscle	74.56	15 05	154	142	30.8	9.75	1.74	5.94	36.66

TABLE 2b. *Analytical values of liquid medium at different stages of processing of clam muscle*

	T. N. mg%	N. P. N. mg%	F.oC NH_2N mg%	Salt content g%
1. Boiling solution	319.1	265.2	136.96	—
2. Blanching solution	175.4	100.5	35.20	3.08
3. Filling solution	222.3	140.5	19.0	2.92

Note: TN — Total nitrogen; WSN — Water soluble nitrogen; NPN — Non-protein nitrogen F.α-NH_2N — Free alpha amino nitrogen; Yield I — On the basis of whole weight Yield II — On the basis of raw muscle weight

after which the colour changed to dull white to brown and texture to tough with bitter taste.

The loss of nutrients at different stages of processing such as initial boiling, blanching and sterilisation is indicated in Table 2. Moisture content was reduced from 84.03 to 74.92% on boiling the shellon clams and the protein and fat contents showed corresponding increase in boiled meat. Water soluble nitrogen, non-protein nitrogen and free alpha amino nitrogen decreased in boiled meat. Nitrogenous constituents leached out in appreciable quantities into the boiling water, blanching brine and filling brine. Maximum loss was during the initial boiling stage as the shell liquor constituents also contribute to this loss (Chinnamma 1984). Loss of nitrogen at different stages of processing are 319, 175 and 222 mg%; non-protein nitrogen 265, 100 and 140 mg% and free amino nitrogen 137, 35 and 19 mg%. Water soluble nitrogen and non-protein nitrogen in the muscle at the last stage indicated some increase probably due to the peculiar nature of the clam muscle proteins (Anon 1976; Chinnama George 1984) which might have degraded to simpler compounds.

The results indicated that a greater proportion of water soluble constituents are lost during the canning operation of clam muscle.

Table 3 gives an account of the analytical data of the canned mussel. The loss in weight during sterilization was only 1.2% and the soluble constituents lost in brine (filling

TABLE 3. *Examination of canned mussel* Perna viridis *in brine*

Can Exterior and interior	Good
Sensory evaluation	
a) Colour	Good
b) Smell	Good
c) Texture	Soft and firm
d) Flavour	Good
e) Nature of brine	Slightly cloudy
f) Score	8
Biochemical parameters	
a) Reduction in weight during sterilisation	1.3 %
b) Moisture	74.66%
c) Protein in meat	19.94%
d) Protein in brine	2.90%
e) Free alpha amino nitrogen in brine	40.5 mg%
f) Phosphorus (Pi) in brine	22.1 mg%
g) Glycogen in brine	129.7 mg%
h) Ribose in meat	116.4 mg%
i) Ribose in brine	176.3 mg%

um) were protein 2.9%, free alpha amino nitrogen 40.5 mg%, phosphorus (Pi) 22.1mg%, glycogen 129.7 mg% and ribose 176 3 mg%. This is in agreement with the results obtained for canned crab meat (Chinnamma George 1984).

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76. UTILISATION OF THE EDIBLE OYSTER, *CRASSOSTREA MADRASENSIS* — PREPARATION OF CERTAIN VALUE ADDED PRODUCTS

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ABSTRACT

A variety of new products have been developed with the edible oyster, *Crassostrea madrasensis* and comparative study of their storage characteristics is reported. Of the different types of products developed oyster soup, oyster nectar, oyster curry and oyster pickle will have export potential, as these items are popular in western countries. In addition to the above mentioned products, oysters canned in brine, oil etc. have been prepared and it is hoped that there will be a good market for these products among people especially in urban areas. The products can either be canned or frozen and preserved for reasonable storage period.

INTRODUCTION

Attempts have been made at the beginning of this century to develop methods for the culture of the edible oyster, *Crassostrea madrasensis* in Pulicat Lake due to the food value of the oyster. Only recently, after intensive research in this subject at the Central Marine Fisheries Research Institute, methods have been evolved for the culture of *C. madrasensis*. It is now possible to produce large quantities of oysters through farming. Except for a few places there is no demand for oyster meat in our country. Therefore there is need for popularizing oysters as an item of food.

Unless suitable methods are evolved for the preservation and processing of oysters and for the preparation of various products it will not be possible to cater to the needs of a large segment of the population. Preparation of diversified and value added products from oysters will provide a steady outlet for the edible oysters and bring remunerative prices to the fishermen who are engaged in oyster culture. No attempts have so far been made for the preparation of such products using edible oysters eventhough various fish and shellfish have been used for such preparations (clam pickles, Vijayan et al 1982), (green mussel pickles, Muraleedharan et al 1982) (Blood clam pickle, Gupta and Basu 1985) (pickle from low cost freshwater fish, Chattopadhyay et al 1986), (canned fish curry, Vijayan and Balachandran 1986). An attempt has also been made on the canning edible oyster meat by Balachandran et al 1984. The method of preparation and shelf life study about different oyster products are given in the present study.

MATERIAL AND METHODS

Shucked oysters were obtained from the oyster farm of the Tuticorin Research Centre of the Central Marine Fisheries Research Institute. The oysters were collected and depurated in settling tanks in the CMFRI laboratory Complex in Karapad. The shucked oysters were brought to the shore laboratory of the Fisheries College in the Fishing Harbour premises and were immediately processed for the preparation of different diversified products such as oyster pickles (hot), oyster pickles (sweet and sour), oyster soup powder and canned preparations which included oyster curry, oyster nectar, oyster in brine, oyster in oil, oyster in masala, oyster in tomato sauce and smoked oyster in oil. The method of preparation of different products and shelf life studies on them is detailed below.

Oyster pickles (hot)

The shucked oysters were washed well in running water and blanched in 5% boiling salt solution for 8 minutes. The blanched meat

was drained and fried in refind oil to a brown colour and the fried meat kept aside. Then the different ingredients for preparation of masala (spices) as given (Table 1) were fried in minimum quantity of refined oil. Half of the remaining quantity of hot oil was then added and the masala made into a paste. The fried oyster was added to the past, and gently stirred. Vinegar and the remaining oil were then added and set aside. The next day the pickles were packed in bottles and closed air tight

TABLE 1 *Standard recipe for oyster pickle (Hot)*

Ingredients	Amount
Gyster (shucked meat)	1 kg
Salt	130 g
Chilly powder	100 g
Turmeric powder	2.5 g
Mustard	19.0 g
Garlic	88.0 g
Ginger	25.0 g
Green chillies	40.0 g
Curry leaves	5 0 g
Dill	5.0 g
Asafoetida	1.0 g
Masala powder	5.0 g
Citric acid	5 0 g
Refined vegetable oil	500 ml
Vinegar	240 ml
Sodium benzoate	2.0 g

TABLE 2. *Standard recipe for oyster pickle (sweet and sour)*

Ingredients	Amount
Oyster (shucked meat)	1 kg
Salt	110 g
Chilly powder	35 g
Turmeric powder	1.0 g
Mustard	10 g
Asafoetida	1.0 g
Dill	5.0 g
Garlic	80.0 g
Ginger	100 g
Green chillies	20 g
Curry leaves	5.0 g
Sugar	250 g
Refined vegetable oil	500 ml
Vinegar	100 ml
Sodium benzoate	2.0 g

Oyster Pickles (Sweet and Sour)

This variety of pickles was prepared in a manner similar to the hot variety except that the ingredient composition of the masala was slightly changed as given in Table 2. In addition to refined oil and vinegar, sugar syrup and ginger extract were added.

Oyster currry

The shucked oysters were washed well in running water and steam cooked for 5 minutes and kept aside. Chopped onion was fried to a brownish tint in vanaspathi and then it was boiled in prawn broth. Maida suspended in water was also added to the mixture of fried onion and prawn broth, which was boiled again. Then the different ingredients for the preparation of curry as given in Table 4 were added to the above mixture followed by the cooked oyster meat. The entire contents were again mixed thoroughly for a few seconds and finally packed in 301 x 203 SR lacquered cans with a pack weight of 175 g and all the cans were retorted at 121°C for 45 min.

TABLE 3. *Sensory evaluation oyster pickle*

Characteristic	Hot pickle	Sweet & sour pickle
Appearance	Good	Good
Colour	Excellent	Good
Texture	Fair	Good
Flavour	Good	Good
Tests	Good	Good
Overall quality	Good	Good
Remarks	Hard and fibrous	—

TABLE 4 *Standard recipe for oyster curry*

Ingredients	Amount
Oyster (Shucked meat)	1 g
Chopped Onion	500 g
Vanaspathi	35 g
Maida	5 g
Chopped tomato	200 g
Minced fresh prawn	50 g
Prawn broth	150 ml
Salt	10 g
Pepper Powder	5 g
Chilly Powder	5 g
Masala powder	10 g

Oyster nectar

The shucked oyster meat was ground well to extract the liquor. which was collected by filtration. The liquid was boiled in 1% salt solution. Finally it was packed in 301 x 203 SR lacquered cans with a pack weight of 175 g and the cans were heat processed at 15 the lb pressure for 20 min.

Smoked oyster

The shucked oyster meat was washed well in running water and blanched in 5 % brine for 5 min. Then the meat was smoked in AFOS smoking kiln at 45°C for 30 min initially and then at 60°C for 30 min. Finally the smoked oyster meat was packed in 301 x 203 SR lacquered cans with the hot refined groundnut oil as a filling medium and the cans were heat processed at 121°C for 20 min. The pack weight was 140 g.

Canned oyster in brine, oil, masala and Tomato sauce

The shucked oyster meat was washed thoroughly in running potable water and blanched in 3% boiling brine containing 0.2% citric acid for 8 min. The blanched meat was drained well and then packed in 301 x 203 SR lacquered cans with the pack weight of 140 g for the brine and oil packs, 125 g for tomato sauce and 175 for masala pack. For the preparation of masala pack, the blanched oyster meat was fried in hot refined oil till it turned brown and then the different ingredients for the preparation of masala as given in Table 5 were mixed and fried for a short time with the meat and finally this mixture was packed in cans.

TABLE 5 *Standard recipe for the preparation of masala (spices) used in canning oyster*

Ingredients (for 1 kg of meat)	Quantity
Masala powder	20 g
Chilly powder	35 g
Salt	20 g
Refined oil	175 ml
Chopped Onion	300 g

2% table salt solution and hot refined groundnut oil were used as filling media for brine and oil pack respectively, whereas for the tomato sauce pack, commercially available tomato sauce was diluted with potable water in 1 : 1 ratio and then used as filling medium.

After filling with the media, the cans were, exhausted and seamed and finally the cans were heat processed at 115°C for 45 min for brine and oil packs and for 60 min for masala and tomato sauce packs respectively.

Oyster soup

The shucked oyster meat was washed well and steam cooked for 20 min. Then the different ingredients as given in Table 6 were mixed well and ground throughly to give a homogenous dough. It was then dried at 50°C in vacuam oven. The dough was placed in a mould and the soup was obtained in the form of cubes. The cubes were over-wrapped in aluminium foil and kept in bottles air tight. The cubes can be dissolved in boiling water and soup prepared whenever required. Sensory evaluation was conducted by a taste panel and the product acceptability tested. Can opening test was conducted for the canned products and presented in Table 8.

TABLE 6 *Standard recipe for the preparation of oyster soup*

Ingredients	Quantity
Oyster (shucked meat)	1 kg
Chopped Onion	600 g
Vanaspathi	100 g
Refined salt	60 g
Maida	300 g
Pepper powder	15 g
Garlic	50 g
Cumin seeds	50 g
Curry masala powder	5 g
Turmeric powder	2 g
MSG	2.5 g

DISCUSSION

The results of the sensory evaluation of oyster pickles and canned oyster products have been given in Tables 3 and 7 respectively. The overall quality of the pickles (hot as well as sweet and sour) was found to be good, but the texture was hard and fibrous in the case of hot pickles. The overall quality of the soup powder

TABLE 7. *Sensory Evaluation of Canned Oysters*

Characteristics	Oyster nectar	Oyster in Brine	Oyster in Oil	Oyster in masala	Oyster in Tomato sauce	Smoked oyster in oil	Oyster curry
Appearance	Good	Good	Good	Good	Fair	Good	Fair
Colour	Good	Fair	Good	Good	Fair	Good	Fair
Texture	—	Fair	Good	Good	Fair	Good	Good
Flavour	Poor	Fair	Good	Good	Fair	Good	Good
Taste	Poor	Fair	Good	Good	Fair	Excellent	Good
Overall quality	Fair	Fair	Good	Good	Fair	Good	Good
Remarks	—	Greenish-tinge doserved in the meat Slightly bitter in taste	Greenish tinge observed in the meat	Slightly bitter in taste	Bitter taste	— —	Slightly bitter in taste

TABLE 8. *Can Opening Test for Canned Oyster*

Particulars	Oyster in Brine	Oyster in oil	Oyster in masala	Oyster in Tomato sauce	Smoked oyster in oil	Oyster Curry
Can Exterior & Interior	Good	Good	Good	Good	Good	Good
Vacuam (cms of Hg)	22	22	22	9	17	13
Head space (mm)	9	8	8	7	6	9
Gross weight (g)	250	245	240	255	245	245
Net weight (g)	200	195	190	205	195	195
Drained weight (g)	135 (67.5%)	150 (77 %)	167 (88 %)	135 (66 %)	120 (61.5%)	185 (95 %)
Volume of Liquid Drained (ml)	60	55	26	74	85	10
Exudate per centage of total liquid drained	—	25	—	—	35	—

prepared from the oyster meat was good and flavour was found to be excellent. These products kept well for more than 3 months during the study period and are expected to have a shelf life of 6 months.

The can opening test showed sufficient vacum and head space in all the cans. The drained weight was above 65%. The exudate percentage of the drained liquid of smoked oyster in oil pack was 35 which was a little more than in the ordinary oilpack, wherein the exudate percentage was 25. Based on sensory evaluation of the canned products, oil pack was rated high than all the other packs. The canned products also kept well during the study period and are expected to have a shelf life of 2 years and more. It is hoped that the recipes and processing methods will be useful in making oyster a favoured food and also lead to the development of exports to western countries.

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Session - V

QUALITY CONTROL OF MOLLUSCAN PRODUCTS

77. QUALITY CONTROL OF MOLLUSCAN PRODUCTS
—Theme Paper

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INTRODUCTION

The molluscan shell fishes, like clams, mussels, oysters and scallops are important animals in the ecology of coastal waters particularly with respect to the productivity of coastal waters and their role in aquaculture. They also represent an important food source in many parts of the world, particulary in Far East, South America and Europe. The scientific exploitation of this food resource and its proper processing is very important in the national economy of these countries. Besides effecting substantial improvement in the economy of the fisherman it can also meet the acute protein defficiency of a country like India.

Mussels are widely used by scientists as a monitor in pollution studies. Most studies on molluscan fish carried out in India have a physiological orientation, in the sense being carried out by biologists who are basically concerned with metabolic regulation of the whole animal. Hence, many data, particularly on biochemical composition, accumulated over the years have of little applied value to the processing technologists whose principal aim is to process and sell. In this article the author summarises the various reports which are of applied value and aids in drafting possible quality standards for the molluscan products.

Nutritive value of molluscan fishes

Several workers (Lakshmanan and Nambisan 1980, Chinnamma George, 1984,) have reported varying values. It is likely that seasonal variations, feeding habits, availability of food, temperature of the habitat and stages of sexual growth would have largely contributed to the vast differences in the bio chemical composition reported by the several investigators. However, the data shows, from the nutritional points of view, that these molluscan forms one of the best source of protein, fat and minerals. It is said that mussels are best to be consumed in late autumn and winter, probably due to high nutritive value in these months. No such views are seen for clams or oysters.

Problems of processing molluscan resources

Heavy metal contents

Being filter feeders and also bottom feeders they eat all the dirt and detritus. Hence, their meat is likely to contain large quantity of mud, chlorophyl, sand and microorganisms. Apart from this, these fishes have no system in their body by which they can metabolise/destroy the absorbed heavy metals and pesticide residues. When living on polluted coastal water they accumulate large quantity of heavy metals. The relative amount of these heavy metal that can be contained as an integral part of the muscle constituent has no fixed limits. It only reflects the amount that is contained in the ecosystem. Clams and mussels caught from water bodies where there is a discharge of industrial effluents will invariably contain a heavy load of such metallic residues. Hence, they can be used as animals to monitor the rate of environmental pollution. This is also applicable to the bacterial flora of the molluscan fisheries.

Nambisan and Lekshmanan (1977, 1979 1980 and 1983) have done extensive investigations in the heavy metal content of molluscan fish and toxicity. Processing of contaminated

molluscan fish and eating them poses enormous problems of health hazards to man. This necessitates proposing of limits for all contaminants in molluscan products. Our experiences in CIFT have revealed that often the processed products fail to meet the prescribed standards. This is one major reason why our fish processing establishments did not show much interests in processing and exporting substantial quantity of our molluscan resources.

Microflora of clam, mussel and oysters

Since molluscan bivalves like clams, mussels and oysters are filter feeders, they accumulate in their body a large number of bacteria from their environmental water. The major group of bacteria found usually are coliforms, *E. coli*, Faecal *streptococci* and occasionally pathogens like *Salmonella*, *Shigella*, *Vibrio parahaemoliticus* and *Vibrio cholerae*. Generally the profile of the bio-accumulated bacteria will be a true reflection of the bacterial profile of their environmental water. Since clams are harvested from the brackish water, which are usually more polluted than sea water they are to harbour more bacteria of public health significance. As sea water has some bactericidal properties, mussel and oysters harvested from sea have less number of faecal bacteria. Surendran *et al* (1985 a, b) and Balachandran *et. al.* (1984, 1985) have done an extensive study of this aspect of the nature of molluscan microflora. Their study unmistakably proved one fact that molluscan fish, particularly clam, mussel and oyster, can create health hazards if not properly processed. The study also showed that both *Faecal streptococci* and *Coliforms* are invariably present in clams while they are insignificant/seen in lesser limits in mussels and oysters. This shows that for molluscan products we have to recommend higher limits for the total number of organisms per g. of sample compared to fish and prawn.

Pesticide residues

Indescriminate use of large quantities of pesticide residues result in pollution of water bodies associated with farm lands. Both clams and mussels are found to accumulate substantial amounts of pesticide residues. In recent times international standards have been suggested for maximum limits for pesticide residues in processed foods. However, this has not become a major problem to the seafood quality and hence not discussed in detail here.

Opening of bivalves

This is a moajor problem while consuming the bivalves. The following methods are widely used:

1. Opening by hand
2. Opening by steam. Cooking at 240°F plus and at and at pressures 12 psig plus.
3. Opening by heat and water jet.
4. Opening by infrared light.

Processed products

Generally clams, mussels and oysters are processed to get the following products:

Drying

Dried clams and mussels are usually prepared with a view to keeping for long periods of time. Meat is shucked, blanched in boiling brine (5%), drained and dried to a moisture level 10% Shelf-life 6-8 months.

Smoking

Shucked meat is blanched in 5% boiling brine, drained, semidried and then smoked in conventional smoke kiln for 30-45 min. It is further dried to 10% moisture content. Shelf-life 6-8 months.

Quality problems

The product is usually attacked by moulds, fungus and halophilic bacteria.

Standards

There are no standards postulated in India or elsewhere so far for either smoked or dried clams and mussels. There is also practically little or no export of these commodities.

Canning

After heat treating both clams and mussels, the shuckled meat is blanched in 5% brine. The materials are canned in the usual way. A relatively higher heat processing time

is usually recommended for both clams and mussels owing to the occurrence of high amounts of Coliforms and *F. streptococci* in the native meat. Clams and mussels are processed mainly as 'oil pack'. Brine is also used as a filling material.

Standards

There are no Indian Standards for canned mussels and clams.

Freezing

Clams and mussels:

Prior to freezing the materials are often kept under ice in insulated containers. Meat is separated by one of the earlier referred processes and then frozen either individually or as blocks at -40°F and kept stored at -40°F and kept stored at -10°F. Usually water is used as a glaze to the frozen material.

Shelf - life

Mussel : Fresh frozen : upto 40 weeks iced (upto 8 days) and frozen, 15 weeks

Clams : Fresh frozen : 35 weeks Iced (8 days) and frozen : 4 weeks.

Processing of oysters

Processing of oysters encounters another technical problem which is not seen for both clams and mussels. When oyster is removed from its shell it immediately begins to bleed losing much of its juices and liquid with consequent loss of weight and flavour. Therefore, it is recommended that oysters should be immediately eaten once its shell is opened. The oysters must be transported (preferably alive) under refrigeration, the shell must be forcibly opened and immediately consumed. This poses the economical marketing of oysters at a distance from sea difficult.

Oysters can be best processed in the following ways:

1. As frozen material (IQF)
2. Transported fresh as live and served (cooked) immediately.
3. As canned in oil medium.
4. As a processed oyster powder.

Quality criteria for processed molluscan products

As there are no international standards recommended for molluscan products it is difficult to stipulate standards However, based on the work carried out at CIFT and elsewhere the following approximate standards can be adopted for various products. Only boiled clam meats are sold locally. Over the years about 200 samples were analysed by CIFT for their microbial quality.

Code of practice for handling and processing

Depuration

Since all molluscans invariably contain mud and high levels a of bacteria and studies conducted conclusively proved, depuraion must be recommended as an accepted code of practice for handling and further processing of these material. By depuration in clean natural habitat water, preferably over night for 18-24 hrs., in live condition usually 90% reduction in bacterial Population can be achieved. Also substantial improvement in the flavour of the meat is also obtained. A subsequent washing of the meat in 5 ppm chlorinated water is also recommended.

Metallic impurities

All molluscan processed products must contain a certificate enclosing the levels of metallic residues as per the proposed standards.

ACKNOWLEDGEMENT

The author records his deep sense of gratitude to Scientists of CIFT for making available a large number of data, unpublished, for this paper. He is also grateful to Mr. M. R. Nair, Director, for his suggestion to present this theme paper.

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78. POST HARVEST TECHNIQUES AND SANITATION FOR OYSTERS

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ABSTRACT

Oysters are often transported alive and consumed raw. They are likely to harbour pathogenic microorganisms due to their filter feeding habit. Therefore depuration of the shellfish using appropriate method is essential. The need for monitoring the bacterial quality and levels of the oyster growing areas and the bacterial load of oyster meat is emphasized. Results of bacteriological studies on the water quality in the oyster farm at Tuticorin and meat of cultured oysters are discussed.

INTRODUCTION

Oysters, mussels and clams are filter feeders and are likely to accumulate pathogenic bacteria such as *Samonella* spp, *Straphylococus* spp and *Clostridium spp* (FAO and WHO 1974). The viral disease transmitted appears to be infectious 'viral hepatitis' (Mason and Mclean 1962). Hence shellfish have to be rendered free of bacteria before marketing.

The awareness that the shellfish could be purified and thus rendered harmless goes back in history much farther than the medieval times. The Romans during the first century B. C. consumed cockles and oysters after keeping them in unpolluted seawater in tanks which are the earliest known examples of 'cockle washery' (Yonge 1962).

Purification of bacteria contaminated oysters have been effected by utilising their own physiological filtration mechanism at the Fisheries Experimenfal Station, Conway, U. K. (Dodgson) 1928). Wells (1923) described the purification of oysters using chlorinated seawater. The method of chlorine sterilisation is still in vogue in many developed countries. Recently the

process of purification has been to a large extent superseded by ultraviolet sterilisation and ozonisation. Using sophisticated ultraviolet sterilisers, reduction of coliform as high as 99% could be attained (Wood 1961; Kelly 1961). In this paper the purification and processing methods of oysters suited to Indian conditions have been presented.

The salient features of the pilot purification plant designed by the Tuticorin Research Centre of CMFRI have been explained in this paper. Further the continuous monitoring of the bacterial levels of the oyster growing areas and the tolerable bacterial level of the oyster meat is also discussed. The accumulation of toxic materials in the oyster meat (Organic and inorganic) have to be monitored.

Purification of oysters

Most of the oysters produced in developed countries such as U. S. A., U. K and European countries are distributed alive and frequently eaten raw. Therefore in many countries, strict sanitary control in farming the oysters, as well as elaborate purification methods have been followed. Oysters are held for 36 h in filtered and UV sterilised seawater or by relaying them in filtered running seawater for 48 h and later treating them for 1 h in chlorinated seawater.

Nayar et al (1983) have designed and operated a simple method to purify the oysters cultured in the farm at Tuticorin. In this method the oysters are purified to a satisfactory level at the rate of 14,400 oysters (1,300 kg) per day. The harvested oysters are cleaned externally to remove silt and other debris by a strong jet of seawater and culled for removing the damaged or moribund oysters. Then the oysters are placed in trays one or two layers deep and placed in concrete tanks on wooden grids. The floor of the tank slopes with a gradiant of 2 cm per metre towards the drain valve to facilitate the flushing of silt, faeces, pseudofaeces and debris out of the tanks. The drain valve in the tanks is provided with a PVC 'T'. The vertical limb of 'T' is raised at a height of 50 cm, so that the same height of water column is maintained in the tank. The horizontal limb is plugged when the tank is engaged in cleaning operations. The plug is removed while draining the tank. A slow and steady flow of filtered seawater is maintained in the tank for 12 h. At the end of this the drain valve is released and the oysters are flushed with strong jet of seawater and once again this operation is repeated for another 12h At the end of this, the flushing is again repeated and the oysters are relayed in chlorinated (3 ppm) seawater for 1 h and again flushed with a strong jet of filtered seawater.

QUALITY OF THE SEAWATER

The oysters' metabolic activity especially the pumping rate will vary in response to changes in water quality. In order to achieve purification to an optimum level it is necessary to know the effect of environmental factors during the depuration process. In general, the variables which control the depuration process are temperature, dissolved oxygen content, salinity and turbidity.

Temperature

The average temperature of the seawater is 30° C. However a slight increase in the temperature do not affect the rate of pumping of the oysters and thereby will not affect the affect the purification proces. The depuration process is not recommended when the temperature is below 20° C the area..

Dissolved oxygen

The oxygen requirement of the oysters during the depuration process is to be maintained at a satisfactory level. The normal oxygen level of the seawater is 4 to 7 ml/l. During the hosing and jetting of seawater the level is slightly increased by 0 2 to 0.5 ml/l. But under static condition, the oxygen level is much reduced and tha pumping rate eventually ceases. Hence the depuration process is always accomplished by slow flow of running seawater. While oxygen concentrations below certain limits are detrimental, there is also an upper limit determined by the solubility of oxygen in water which also could be harmful. The solubility of oxygen decreases with rise in temperature and with increase in salinity. When supersaturated water warms, it releases the excess oxygen (and other gases) in the form of bubbles and this in turn can cause

death of oyster by embolism. Therefore supersaturation of the water is avoided.

Salinity

Oysters in nature grow and reproduce in regions where mean salinity range form about 5 ppt. Although oysters may be depurated over a wide salinity range (15 ppt to 35 ppt) depuration could be properly effected in salinity ranges in which the oysters have been originally thriving. If oysters are moved form a high to low salinity or from a low to high, a period of acclimation may be needed for resumption of normal pumping activity of the oyster. This will prolong the purification time.

Turbidity

Depuration process will not be effective with turbid waters. The filtration process becomes expensive when turbidity is high. Filters get clogged very often. Further sterilization can not be properly effected with turbid waters, Hence while selection of site for depuration plant, areas with excessive growth of seaweed, high waves, and currents should be avoided.

BACTERIOLOGICAL INVESTIGATIONS

Since the early 1900's bacterial indices (as exemplified by the coliform counts) have been used to demonstrate the degree of faecal pollution of water including marine waters. As pollution levels have increased the number of approved shellfish reefs in U.S.A. have declined. The shellfish industry has lost ground steadily and today is becoming more dependent on relaying and depuration practices for survival.

MATERIAL AND METHODS

For each sample a minimum of 10 oysters were taken. The shucked oyster meat and shell liquor were blended in sterile containers. 10 g of the sample was taken for dilutions on sterile phosphate buffer solution. Bacterial counts were determined with four plate method by placing 1 ml of of appropriate dilutions on ZoBell Marine Agar medium 2216. Plates were incubated at 28°C ±2°C. Colonies were counted after 48 h and on the 5th day of incubation. To determine microbial types, colonies were picked at random from countable plates. The colonies were identified by the scheme followed by Usiosimudo and Kayayoshi Aiso. Total plate counts at 28°C ± 2°C of freshly harvested oysters ranged from 10^3 to 10^4 colonies per g of oyster meat. After 24 h purification in filtered seawater the total plate counts ranged from 10^2 to 10^3 colonies per g of oyster meat. Samples were assayed in MacConkey Broth medium for faecal coliform counts. Faecal coliform counts in oyster meat by MPN method was 7.8 to 37 per 100 g of meat. *Achromobacter, Pseudomonas, Vibrio* Sp. predominated in the fresh oysters. Pathogenic bacteria such as *Salmonella* and *Staphylococcus* were absent both in the oyster meat and the water samples collected from the oyster growing area.

The total bacterial count of water samples taken from the Karapad farm area ranged from 10^1 to 10^2 colonies per ml and the faecal coliforms count (MPN) was 0 to 47 per 100 ml of water.

TOXICOLOGICAL INVESTIGATIONS

Bacteriological and toxicological analysis carried out at the inspection laboratory of the Marine Products Export Development Authority, Cochin indicated that the meat of oysters from the oyster farm of CMFR Institute at Tuticorin, heavy metals such as Copper, Mercury and Cadmium were found to be below permissible limit (Silas et al 1982).

However monitoring studies of this aspect of work has to be continued to watch the changes in the level of heavy metals.

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79. COMBINED TOXICITY STUDIES ON *PERNA* SPP.

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ABSTRACT

Knowledge of the interaction of various pollutants in the environment is necessary to set water quality standards. The water body receiving the effluents can have pollutants of varied nature resulting in a conglomeration of toxic components. Measurements of toxic effects of pollutants on sessile marine bivalves provide a valuable indication of environmental impact since the resident time of such animals in any locality follows a specific pattern In this connection a multiple factor approach to study toxic effects is warranted. With this view in mind combined toxicity studies employing heavy metals, crude and pesticides were undertaken with mussels as target organisms. In the present document one of such investigations is reported. The joint action of silver (unvarying) + copper (varying) and copper (unvarying) + silver (varying) mixtures were delineated, In the case of *Perna viridis* these combinations produced less than additive reaction whereas in *Perna indica* the reaction was more than additive, species specific dependence in toxicity. Silver was proved to be highly toxic when present alone in the test medium The results clearly show that the interaction between two or more pollutants should be considered while estimating environmentally 'safe' levels of pollutants.

INTRODUCTION

It is konwn that marine animals in the field are exposed to many different combinations of environmental conditions and toxicants, Most data on acute toxicity experiments deal only with the effects of individual variables. Since metals usually occur as mixtures rather than singly in estuarine and coastal regions, information on their interactions might help a more realistic assessment of their toxicity to estuarine organisms. Bliss (1939) suggested that toxicant mixtures may have the following pattern of actions on a biological system (a) independent joint action (where each toxicant acts on a different site), (b) similar joint action (where each toxicant acts on the same site), or (c) synergistic action. Our previous studies (Pra-

bhudeva 1983; Prabhudeva and Menon 1986) have shown that silver and copper, when tested individually have deleterious effects on the life of *Perna viridis* and *P. indica*. Recent studies have shown that metals, depending on their effective concentration level maintained may interact synergistically or antagonistically with reference to a biological reaction (Mac Innes 1981; Negilski et al 1981; Mathew and Menon 1983; Prabhudeva and Menon 1986; Mohan et al 1986).

In the present study an attempt was made to study the toxic effects of copper (unvarying) + silver (varying), and silver, unvarying) + copper (varying) mixtures on survival of *Perna viridis* and *P. indica*.

MATERIAL AND METHODS

The green mussel, *P. viridis* from Someshwara beach (12°47'N; 74°51'E) and the brown mussel *P. indica* from Shakthikulangara beach (8°56'N; 76°35'E) were transported to the laboratory in polythene containers. The animals were maintained under laboratory conditions (water temperature 30 ± 1°C, salinity 32 ± 0.5 ppt, pH 8.2 - 8.4) for a period of 48 h before the commencement of the experiment. Mussels of 15 - 20 mm shell length were used for the experiments.

Copper sulphate ($CuSO_4.5H_2O$) and silver sulphate ($AgSO_4$) were the source of copper and silver respectively. The experimental vessels were cylindrical glass troughs of 5t capacity containing 4 t test media prepared in aged seawater, which was aerated to saturation before use. Mortality test was performed for 96 h. The inability to close the valves upon mechanical stimulation and/or valve gaping of 5 mm were the criteria used to define the death of the test organisms. The media were replenished with fresh ones at every 24 h and the dead animals were removed from the experimental media at 12 h intervals. Ten mussels were exposed to each metal mixtures, along with a control group.

All concentrations reported in this paper are the calculated levels of metal ions added at the start of the test and do not include background levels. Actual concentrations of each metal in the test cultures were not determined. The test containers were not aerated but dissolved oxygen level in the water was monitored. The lines of best fit were drawn after linear regression analysis. Additive toxicity index developed by Marking and Dawson (1975) was used to determine the toxicity of metal mixtures.

RESULTS

Perna viridis

The progressive rate of mortality of *P. viridis* exposed to a mixture of copper and silver (ie. 50 ppb Cu + 30 to 65 ppb Ag) is shown in Fig 1. The 96 h LC 50 value calculated was 51.7 ppb silver with 50 ppb copper (95% confidence limits : 50.8 to 52.5 ppb Ag + 50 ppb Cu). The additive index computed for joint action of copper + silver mixtures on mortality of *P. virids*, was -0.124.

The progressive rate of mortality of *P. viridis* exposed to a mixture of silver and copper (ie. 40 ppb Ag + 40 to 80 ppb Cu) is shown in Fig 2. The 96 h LC 50 estimated was 64.0 ppb (95% confidence limits: 63 to 65 ppb) of copper with 40.0 ppb silver. The additive index of silver + copper mixtures was -0.111.

Perna indica

Fig 3 shows the progress of mortality of *P. indica* exposed to a mixture of copper and silver (9.0 ppb Cu + 3 to 12 ppb Ag). The 96 h LC50 worked out was 6.35 pph (95% confidence limits : 9.81 to 5.36 ppb) of silver + 9 ppb copper. The additive index was +1.02.

Fig 4 indicates the progress of mortality of *P. indica* exposed to a mixture of silver and copper (9 ppb Ag + 3 to 12 ppb Cu). The 96 h LC 50 was 7.3 ppb (95% confidence limits: 12.28 to 4.33 ppb); of copper with 9 ppb silver. The additive index was +0.76.

DISCUSSION

Assessment of the toxicity of chemical combinations is done by adding the concerned chemicals in a definite ratio decided by the chemicals individual toxicity. In practice, one of the chemicals will be retained at a fixed

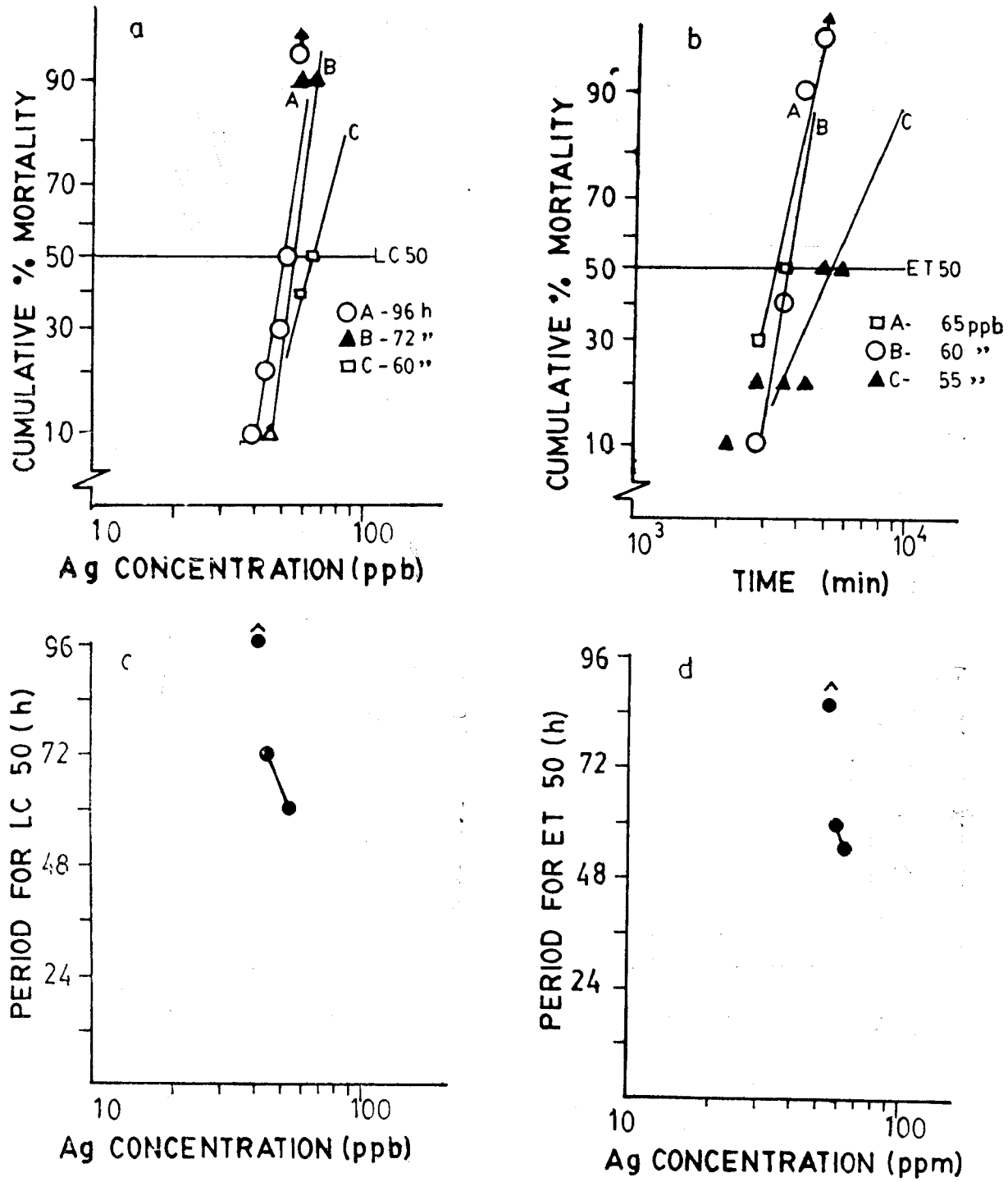

Fig. 1. Lethal effects of 50 ppb copper along with varying concentrations of silver on *Perna viridis* a. Progress of mortality against concentration. b. Progress of mortality against time. c & d. Toxicity curves.

concentration and the other treated as a variable. Although, such a procedure is possible under controlled laboratory conditions, it is quite unlikely that such a situation exists in nature. Similarly, in the present work four sets of experiments were performed where copper and/or silver was in combination, either as a constant or as a variable.

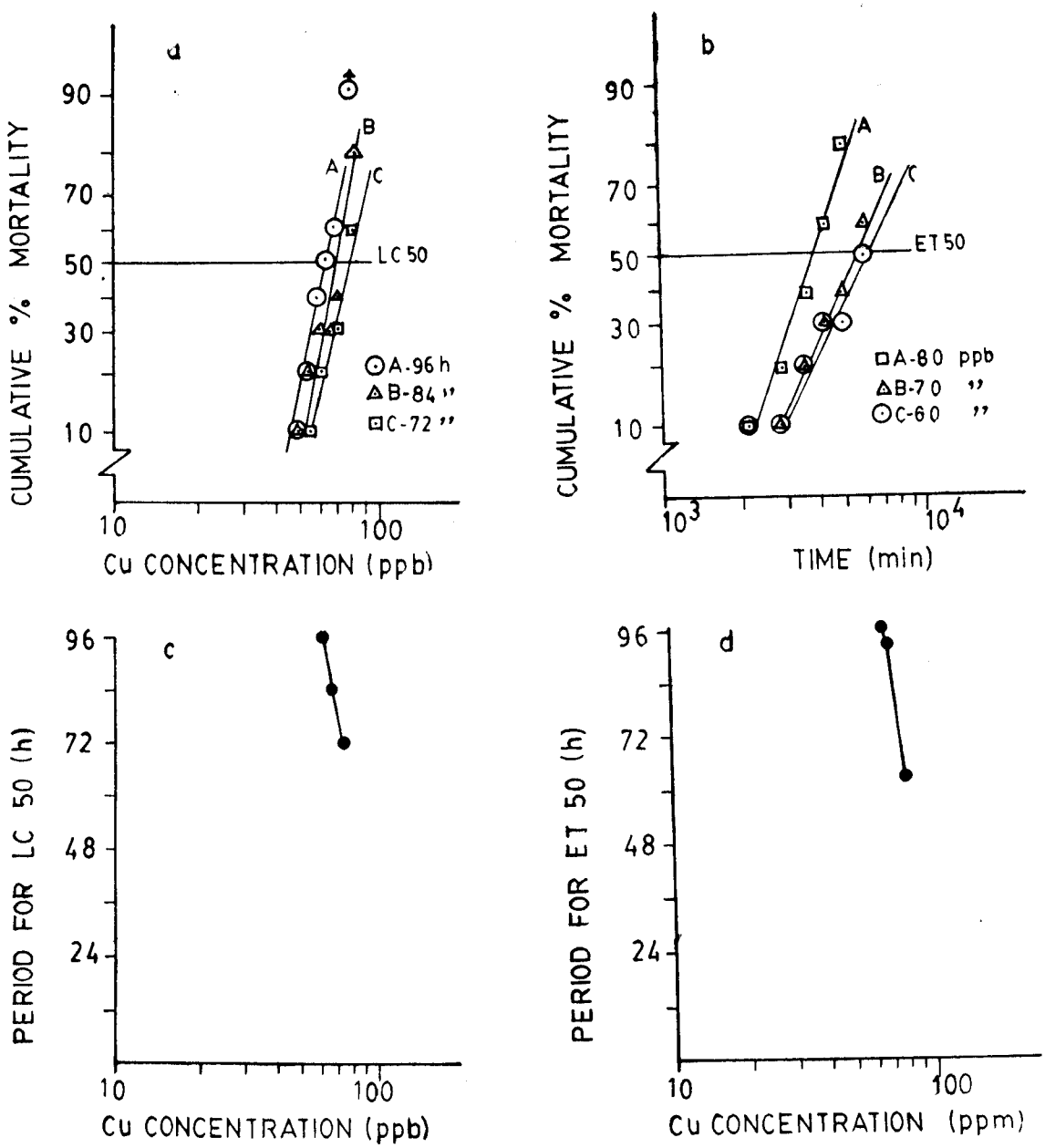

Fig. 2. Lethal effects of 40 ppb silver along with varying concentrations of copper on *Perna viridis* a. Progress of mortality against concentration b. Progress of mortality against time, c & d. Toxicity curves.

Working on combined toxicity, Mathew and Menon (1983) found that a mixture of 31.0 ppb copper and 31.0 ppb silver caused 50% mortality of *P. viridis* in 96 h. They further found that silver in combination with copper becomes more toxic. Similarly, Mac Innes and Calabrese (1978) reported less than additive interaction of mercury + silver and zinc + copper on the embroys of *Crassostrea virginica*. Discussing on the combined toxicity of copper and zinc on *P. viridis*, Prabhudeva and Menon (1986) reported less than additivity at lower concentrations and more than additivity at higher concentrations of these two metal mixtures. They also found that zinc in combination with copper becomes more toxic. Pavicic (1977) concluded that a combination of cadmium and zinc increased the toxic resistance of the embroys of *Mytilus galloprovincialis*.

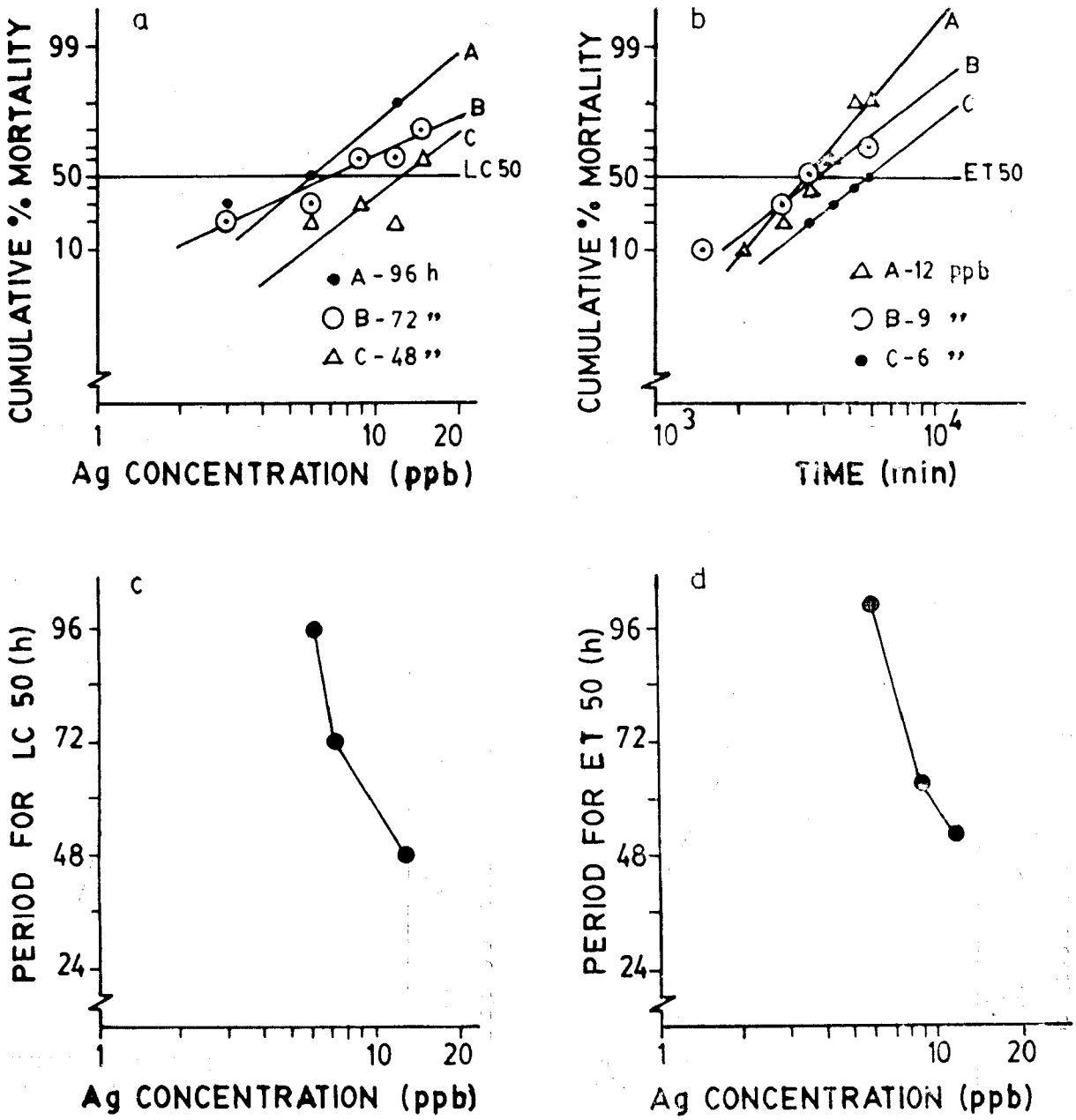

Fig. 3. Lethal effects of 9.0 ppb copper along with varying concentrations of silver on *Perna indica* a. Progress of mortality against concentration, b. Progaess of mortality against time. c & d. Toxicity curves.

In the present study the 96 h LC 50 with reference to copper + silver and silver + copper on *P. viridis* was 51.7 ppb Ag + 50.0 ppb Cu and 64.0 ppb Cu + 40 0 ppb Ag respectively. The additive indices of -0.124 and -0.111 respectively indicate less than additivity in both the cases. However, the individual 96 h LC50 for *P. viridis* was 79.8 ppb silver and 105.0 ppb copper. In the case of *P. indica* the 96 h LC50 was 6.35 ppb Ag + 9 ppb Cu + 9 ppb Ag respectively for copper + silver and silver + copper mixtures. The additive indices + 1.02 and + 0.76 indicate that these two mixtures interact more than additivity in causing lethal toxicity to *P. indica*. She 96 h LC50 was 24.0 ppb in the case of silver and 38.0 ppb in the case of copper. Here also the individual toxicity of the two metals was relatively high. Mac

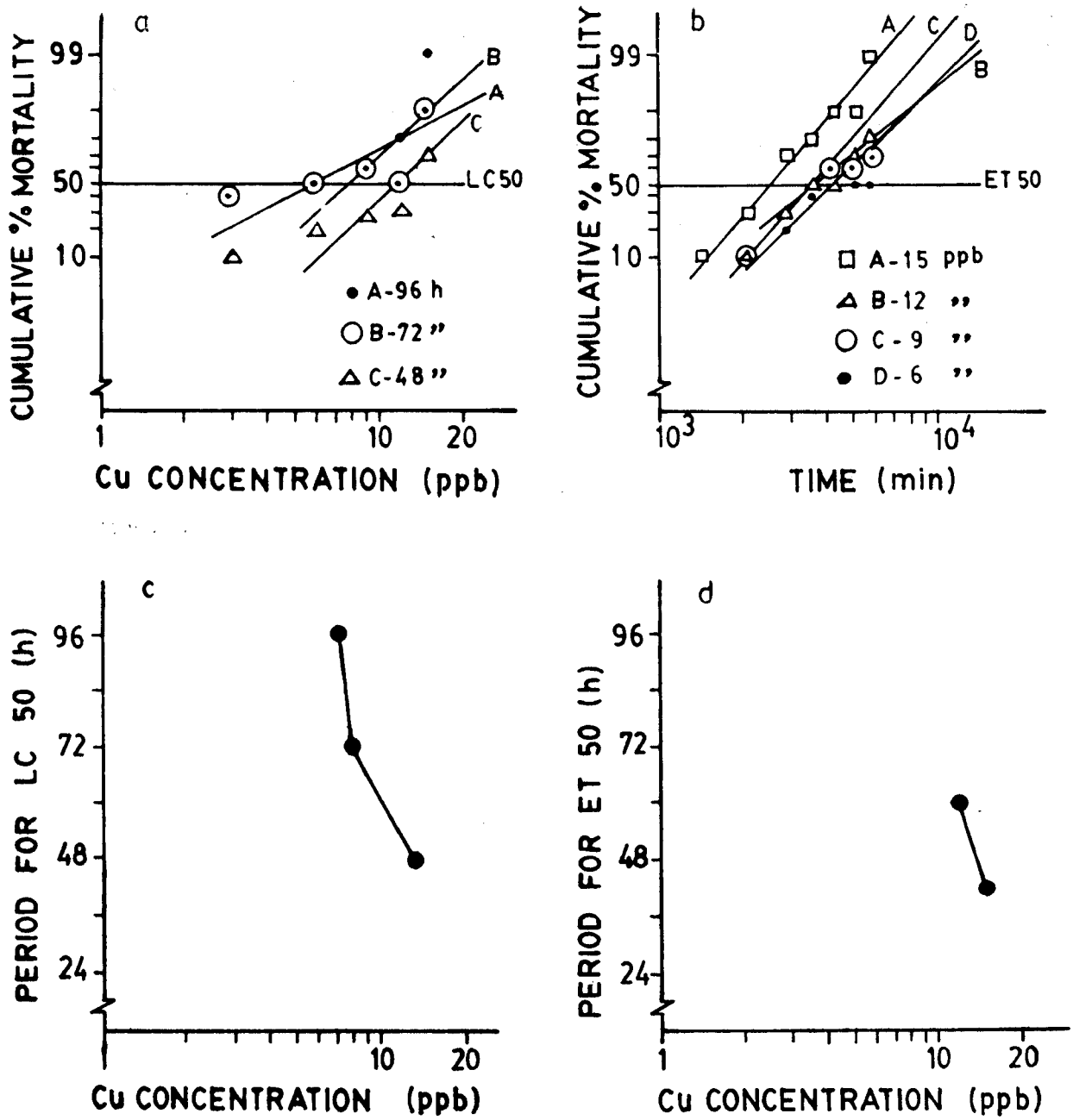

Fig. 4. Lethal effects of 9.0 ppb silver along with varying concentrations of copper on *Perna indica* a. Progress of mortality against concentration. b. Progress of mortality against time. c & d Toxicity curves.

Innes (1981) noticed either antagonistic effect or simple additivity in lowest metal concentration of copper + mercury, copper + zinc and synergistic activity at high concentrations. Contrary to this, Prabhudeva and Menon (1986) reported more than additivity at lower concentrations and less than additivity at higher concentrations for copper and silver mixtures on *P. viridis*. Similarly, the present results showed more than additivity at lower concentrations on *P. indica* and less than additivity at higher concentrations on *P. viridis* Mohan and Menon (1986) found a more than additive interaction between mercury and cadmium on *P. viridis*. The alterations in toxicity recorded here could be due to the capacity of *P. viridis* and *P. indica* to selectively block the binding site of such metals to which they have high resistance.

The ecological implications of this study becomes significant only if the metal concentrations existing in the estuaries and coastal waters approach such high levels as used in the laboratory. However, with the ever-growing evidence of increasing pollution in certain estuaries and coastal waters the probability of attaining toxic concentration of these metals in certain areas increases with time. Evidences gathered on the sub-lethal effects of these two commercially important bivalves show that even at considerably low concentrations of these metals, the basic physiological activities are negatively affected. Therefore continued existence in the nature where the present metal levels are low, could lead to serious impairment of the 'scope for growth' of these bivalves although direct deleterious effect as indicated by mortality is not evident at majority of such localities. A realistic assessment of the effects of pollutants in marine animals, therefore, should be based on the study of the collective effects (antagonism, addition or synergism), as well as the mode of action of mixtures of pollutants, on these animals in future studies. Especially, the possibility of interaction between two or more compounds should always be considered or it could lead to the over-estimation of 'safe levels' for the environment.

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80. REMOVAL OF PATHOGENIC BACTERIA AND GRITTINESS FROM CLAM *(VILLORITA CYPRINOIDES)* AND MUSSEL *(PERNA VIRIDIS)* MEANT FOR PROCESSING BY A BIOLOGICAL MEHOD

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ABSTRACT

Live clams (*Villorita cyprinoides*) from Vembanad Lake (Kerala) and live mussels *(Perna viridis)* from Calicut (Kerala) were examined for their bacteria and sand content. It was observed that the flesh of these bivalves harboured large bacterial populations including faecal coliforms, *Escherichia coli* and faecal streptococci. Also their intestines contained mud and sand (acid insoluble ash) sufficient to impart muddy flavour and gritiness to the meat. A cleansing operation to achieve the elimination of pathogenic/indicator bacteria, mud and sand from the clam and mussel meat has been worked out. process involves depuration of the bivalves in their clean natural water for 18-24 h, followed by chlorination of the system to 5 ppm level and maintaining in that condition for an additional 2 h. By this process, there was complete removel of pathogenic/indicator bacteria from their muscle. Also, the acid insolucle ash decreasep to negligible levels.

INTRODUCTION

Molluscan shell fish such as clams, mussels, and oysters are filter feeders. They filter large volume of water during their feeding activities and while doing so, they may concentrate within their bodies bacteria such as coliforms, faecal streptococci, and salmonella or enteroviruses present in the water. Human infections caused by bacterial, viral and protozoan pathogens have been traced to the ingestion of shellfish, harbouring such pathogens.

Kaysner (1981) reported the incidence of faecal coliforms, mainly comprised of *Escherichia coli* in the clams from Bering sea. *Klebsiella pneumoniae* were recovered in increased numbers from summer harvested Louisiana oyster (Boutin et al 1986). Thison and Fleet (1980) found that edible oysters (*Crassostrea commercialis)* harvested from the major cultivation areas in New South Wales, Australia were contaminated with food poisoning organisms like *Bacillus cerius, Clostridium perfringens, Vibrio parahaemolyticus* and *Salmonella*. Metcalf et al (1979) found that clams bioaccumulated faeces-associated natural viruses mainly in their hepatopancreas and siphon tissues. Pillai (1980) reported that the suspended cultured mussels (*Perna indica*) from Vizhinjam harboured large populations of coliforms, *E. coli*, faecal streptococci and coagulase positive staphylococci. Most of these microorganisms are of faecal origin and cause great health hazards.

In addition to bacteria, the intestines of clams and mussels are often loaded with mud and sand, which impart a muddy flavour and grittiness to the meat if retained within. Therefore a cleansing operation to achieve depuration and elimination of bacteria is a very important step that should precede processing of these molluscan meat.

Nowak (1970) described the mechnism of purification of bivalves in water. Stroud (Torry Advisory Note No. 84) advised cleansing of oysters in recirculating sea water treated with U. V. light or in static water. Prabhu and Balachandran (1980) reported about the practice of holding clams in cages in clean areas in the sea in Canada. Balachandran and Surendran (1984) studied the depuration of live clams (*Vilotita* sp). In this paper, a simple method of purifying clams and mussels, so as to remove bioaccumulated bacteria and grittiness from their muscle, by the process of depuration is described.

MATERIAL AND METHODS

Live clams (*Villorita cyprinoides*) from their natural beds in Vembanad lake near Vaikom

(Keraia) and live mussels *(Perna viridis)* from the shallow sea of Calicut (Kerala) were collected and brought immediately to the laboratory, keeping in water from the same area of collection Water and bottom mud samples from the same area of harvesting of clams and mussels. were separately collected in sterile bottles, Depuration of clams and mussels was carried out in the respective water from the habitat of clams and mussels, potable water, sodium chloride solution made up to the strength of water from their respective natural habitat, as also all these chlorinated to 5 ppm level. Effect of all these on mortality, bacterial quality, removal of sand and contents of glycogen in the meat of both clam and mussels were studied.

Moisture, crude protein, fat and acid insoluble ash of the clam and mussel meat were determined according to AOAC (1975) methods and glycogen by the method of Umbriet et al (1959). Total bacterial count (TPC) was determined using trypton-glucose-beaf extract agar (TGA). The plates were incubated at 28 ± 2°C (room temperature, RT) for 48 h. and counts taken.

Total coliforms and faecal coliforms were determined using a three dilution-three tube replication of lactose broth (LB) in a standard most probable number series (MPN) with an incubation temperature of 37°C. Confirmation of total coliforms was done by MPN method using brilliant green lactose bile broth 2% (BGLB) incubated at 37°C. Loopfuls of culture from positive BGLB tubes were transferred to EC broth tubes and incubated for 48 h. at 45 ± 0.5°C. Tubes with positive growth and gas production showed the presence of faecal coliforms. Tests for *E. coli* were done for cultures from positive EC tubes by first transferring to eosine methylene blue agar (EMB), followed by IMVIC tests. Faecal streptococci were determined using KF streptococci agar. The plates were incubated at 37°C for 48 h. and dark red colonies and colonies with red and pink centre were counted as faccal streptococci colonies (APHA 1970). *Staphylococcus aureus* was determined by the direct direct plating method using Baird Parker agar.

RESULTS AND DISCUSSION

Proximate composition and bacterial quality of raw clam meat and mussel meat, as well as the bacterial profile of the water and bottom mud samples from the natural habitat of clams and mussles are presented in Tables 1 and 2 respectively.

Both clams and mussels harboured a large population of bacteria of the order of a million per gram of raw muscle. The clams carried a total coliform load of 10^3-10^4/g muscle, of which *E. coli* formed the major constituent. Also a heavy load of faecal streptococci was found in its flesh. But, total coliforms in the shucked raw meat of mussel were comparatively less, being only in the order of hundreds. Both *E. coli* and faecal streptococci in the mussel meat were less than those in the clam meat. It can be seen from the Tables (1 and 2) that the environmental water and mud of both clams and mussel carried these bacteria, but to a lesser extent. Due to their filter feeding activities, both clams and mussels have concentrated these bacteria in their body. Coliforms including *E. coli* and faecal streptococci are faecal indicator bacteria. Their presence in the muscle show that there are chances of other pathogens like *Salmonella*, from faecal material, to be present in these bivalves.

Both clam and mussel meat contained acid insoluble ash (sand), 0.38% in clam meat and 0.33% in mussel meat. This acid insoluable ash imparts grittiness to the meat, making it unsuitable for human consumption.

Ability of the contaminated shellfish to rid themselves of the baecteria when placed in clean water is well known and has been extensively exploited in artiificial depuration system (Hartland and Timoney 1979). The same principle is made use of in cleansing clams and mussels, in our studies too.

Live clams were depurated in clean water from the natural habitat, filtered through a cloth 100 kg of clams were kept in 60 l of water, keeping a water column of 7.5 cm above clams. After intervals of 18 h 24 h and 48 h samples were drawn for estimation of acid insoluble ash (sand) and bacteriological examination of raw shucked meat. Results are presented in Table 3.

TABLE 1. *Proximate composition and bacterial quality of clam meat and bacterial profile of water and mud from the clam habitat*

	Raw meat	Water	Mud
Moisture %	78.50	—	—
Fat % (DWB)	2.52	—	—
Protein	10.09	—	—
Ash %	0.86	—	—
Acid insoluble ash (sand) %	0.38	—	—
Glycogen %	6.68	—	—
Total bacterial count	1.2×10^6/g	5.5×10^4/ml	9.06×10^3/g
Total coliforms	6.3×10^3/g	100 ml	25/g
E. coli	3×10^3/g	52 ml	16/g
Faecal streptococci	8.5×10^3/g	2.1×10^2/ml	82/g
Coagulase + ve staphylococci	Nil	Nil	Nil

TABLE 2. *Proximate composition and bacterial quality of mussel meat and bacterial profile of water and bottom mud from the mussel habitat*

	Raw meat	Water	Mud
Moisture %	78.24	—	—
Protein %	12.61	—	—
Fat % (DWB)	3.02	—	—
Glycogen %	7.90	—	—
Ash %	0.82	—	—
Acid insoluble ash (sand) %	0.33	—	—
Total bacterial count	5.3×10^6/g	6.2×10^4/ml	3.12×10^3/g
Total coliforms	2.3×10^2/g	93/ml	210/g
E. coli	1.15×10^2/g	75/ml	63/g
Faecal streptococci	180/g	42/ml	93/g
Coagulase + ve staphylococci	Nil	Nil	Nil

TABLE 3 *Effect of depuration of live clams in natural water for various periods on the bacterial quality and and acid insoluble ash (sand) content of raw clam meat*

	Before depuration	After depuration for 18 h	After depuration for 24 h	After depuration for 48 h
Total bacterial count/g	4.22×10^6	6.52×10^5	4.68×10^5	3.12×10^3
Total coliforms/g	8.31×10^3	8.50×10^2	3.50×10^2	1.16×10^2
E. coli/g	2.74×10^3	1.06×10^2/g	98	Nil
Acid insoluble ash (sand) %	0.38	0.06	0.01	0.01

TABLE 4. *Effect of depuration of live mussels in natural water for various periods on the bacterial quality and acid insoluble ash (sand) content of raw mussel meat*

	Before depuration	After depuration for 18 h	After depuration for 24 h	After depuration for 48 h
Total bacterial count/g	5.3×10^6	6.81×10^5	4.72×10^5	3.03×10^3
Total coliforms/g	2.3×10^2	118	93	24
E. coli/g	115	24	9	Nil
Faecal streptococci/g	280	118	115	28
Acid insolube ash %	0.33	0.026	0.012	0.01

TABLE 5 *Effect of depuration of live clams in different systems for 18 h (over night) on the quality clam meat*

	Raw meat before depuration	Natural water (lake water)	Natural water chlorinated at 5 ppm level	Potable water	Potable water chlorinated at 5 ppm level	Sodium chloride solutions (1.03%)	Sodium chloride solution (1.03% chlorinated at 5ppm level
Total bacterial count/g	5.8×10^6	3.82×10^5	8.91×10^5	5.62×10^5	5.81×10^5	4.14×10^5	4.31×10^5
Total coliforms/g	3.8×10^4	2.19×10^3	7.06×10^3	4.74×10^3	5.03×10^3	3.89×10^5	3.48×10^3
E. coli/g	2.2×10^2	Nil	Nil	12	Nil	Nil	Nil
Faecal streptococci/g	5.14×10^4	4.82×10^3	9.10×10^3	9.20×10^3	1.01×10^4	8.84×10^3	6.62×10^3
Acid insaluble ash (sand) %	0.34	0.012	0.024	0.056	0.094	0.015	0.026
Glycogen %	6.68	5.9	5.6	5.6	5.2	5.6	5.0

TABLE 6 *Effect of depuration of live mussels in different system for 18 h (over night) on the quality of mussel meat*

	Raw meat before depuration	Natural water (sea water)	Natural water chlorinated at 5 ppm level	Potable water	Potable water chlorinated at 5 ppm level	Sodium chloride solution (2.3%)	Sodium chloride solution (2.3%) chlorinated at 5ppm level
Total bacterial count/g	8.3×10^6	4.38×10^5	6.1×10^5	7.82×10^5	9.86×10^5	4.9×10^5	5.62×10^5
Total coliforms/g	6.71×10^2	105	238	218	486	118	118
E. coli/g	230	93	108	124	138	92	105
Faecal streptococci/g	486	124	118	230	238	108	114
Acid insoluble ash (sand) %	0.42	0.02	0.032	0.088	0.18	0.02	0.06
Glycogen %	5.36	3.82	4.54	4.60	4.22	4.90	4.63

TABLE 7 *Bacterial quality of clam meat after depuration for 24 h in natural water and subsequent chlorination of the system and keeping for 2 h*

Bacterial counts	Raw meat before depuration	After depuration	After depuration and chlorination
Total bacterial count/g	5.8×10^6	3.82×10^5	2.92×10^5
Total coliforms/g	3.8×10^4	2.90×10^3	1.02×10^3
E. coli/g	2.2×10^2	Nil	Nil
Faecal streptococci/g	5.1×10^4	4.82×10^3	2.96×10^3

TABLE 8. *Bacterial quality of mussel meat after depuration for 24 h in natural sea water and subsequent chlorination of the system and keeping for 2 h.*

Bacterial counts	Raw meat before depuration	After depuration	After depuration and chlorination
Total bacterial count/g	7.46×10^6	3.29×10^5	1.06×10^5
Total coliforms/g	1.13×10^3	2.04×10^2	118
E. coli/g	230	Nil	Nil
Faecal streptococci/g	2.81×10^3	1.18×10^2	93

Similarly mussels were depurated in clean filtered sea water from the natural habitat and after intervals, samples were analysed for sand and bacterial quality. Results are presented in Table 4.

The primary aim of depuration of live clams and mussels was removal of sand and gritty matter. Not only that this is achieved by this starvation method, but there is very good improvemen tin the bacterial quality of their meat as evidenced by the data presented in Tables 3 and 4.

Studies were also carried out on alternate depuration systems, to find out their ralative efficiency. In addition to the water from the natural habitat of clams and mussels, potable water from municipal water supply, sodium chloride solutions made up to the strength of natural water (1% in the case of clams and 2.3% in the case of mussels) and the above systems chlorinated to 5 ppm level were used for depuration of both clams and mussels. The results are summarised in Tables 5 and 6.

Live clams when kept in water remained with shell slightly agape so that they can filter enough water.

However, it was noticed that when the water is chlorinated, the shells remained tightly closed until such time that the available chlorine disappeared from the system. Until this time no activity leading to depuration took place. This should be the reason why the extent of depuration leading to the decrease in sand and bacteria, was comparatively less in the chlorinated systems than the corresponding untreated systems. The data definitely showed that the best results in depuration is obtained when both clams and mussels are allowed to starve in clean water from their respective natural habitats.

Upto a period of 24 h no mortality was observed in the natural water, in the case of both clams and mussels. But in other media, some mortality though negligible was observed. in other systems, the minimum mortality was observed in sodium chloride solutions of the same strength as the respective natural water.

Acid insoluble ash (sand) content in the muscle could be brought down to an insignificant level by depuration in the water. The retention of glycogen which is the source of stored energy also was the highest in this

system. The total bacterial number in the muscle was brought down considerably. There was 90% decrease in the total bacterial count in total faecal indicator bacteria. The *E. coli* was completely eliminated with 24h of depuration in natural water.

In another series of experiments live clams and mussels were depurated in their respective natural water for 24h and then the system was chlorinated to 5 ppm and maintained like that for another 2h. The bacterial qualities of their meats at different stages in this experiment are presented in Tables 7 and 8. Though depuration in chlorinated water was found to provide no significant improvement (Tables 5 and 6) the bacterial qualities of the meats of clams and mussels were considerably improved in the case of treatment with chlorine for 2h after depuration in natural water for 24h.

It follows from these experiments that for achieving best results in removing the grittiness and eliminating pathogenic bacteria from the clam and mussel meat meant for further processing or consumption, they should be depurated for 24h in clean water from their respective habitat followed by chlorination of the system to 5 ppm level and maintaining like that for 2 more h.

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81. EFFECT OF MERCURY EFFLUENTS ON MARINE BIVALVES

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ABSTRACT

High concentration of mercury and acidity have been noticed in the effluents of Dharangadara Chemical Works and Plastic Resins and Chemical Centre near Kayalpatnam, south of Tuticorin. The bar mouth of the polluted lagoon is opened during November-January and the discharges of heavy metal toxicants in the open sea is of great concern in the management of marine and nearby ecosystems. Sea water in the industrial coastal area contains mercury in the range 18-70 µg/ml. Marine organisms such as bivalves have a particularly high capability for concentrating heavy metals. Investigations have been carried out on the survival of two important bivalves of the region *Crassostrea madrasensis* and *Mesodesma glabratum* of different size groups by abruptly exposing to different concentrations from sharp lethal to non-lethal concentrations of the industrial effluents, Samples of these two species have also been exposed to different sublethal conentrations for varying durations to study the uptake and rate of accumulation of mercury in the tissues of the bivalves. The results of the observations are discussed. The study provides information as to when exactly the bivalves are brought under stress and for planning preventive measures to protect the valuable resources.

INTRODUCTION

The marine environment, which offers one of man's great hopes for future food supplies is not excempt from the adverse effects of pollution. Among different abuses of this environment, the discharging of the industrial effluents is considered to bring about deleterious effects on the ecosystem especially when the effluents contain heavy metals like mercury, lead, nickel and cadmium. In India, the pollution problems of Tamil Nadu coast have been reported by several workers (Natarajan et al 1982; Nammalwar 1983, 1984; Nammalwar et al 1985). Ganapathi (1975) has stressed that in the face of industrialization, discharges of heavy-metallic toxicants are of great concern in the management of marine and estuarine ecosystem. The majority of the metal toxicants are absorbed by marine animals and stored in them. The concept of the use of sentinel organisms as indicators of the state of pollution in the coastal waters is receiving wide approval as it not only helps to assess the bioavailability of pollutants, but for better management of the environment as well. Establishment of chemical industries like Dharangadara Chemical Works (DCW) and Plastic Resins and Chemical Centre near Kayalpattinam has led to the discharge of effluents of these industries into the coastal water of Tuticorin. Consequently it is felt that studies on the effects of these effluents on the ecosystem is highly essential to keep a constant watch on the extent of damages caused to the marine environment as these effluents have been reported to contain mercury and are highly acidic also (Marichamy and Rajapackiyam, M.S). Keeping these points in view, present study was undertaken on the effect of these effluents on the survival of two bivalves, *Crossostrea madrasensis* and *Mesodesma glabratum* and also the rate of accumulation of mercury in tissues of these species. Information on these aspects is expected to be very useful for suggesting regulatory measures for conservation of the environment.

MATERIALS AND METHODS

Two hundred specimens of *C. madrasensis*, measuring 68 to 132 mm DVM, obtained from the oyster culture farm of CMFRI., Tuticorin and 200 specimens of *M. glabratum*, measuring 18 to 32 mm DVM, collected from the sandy intertidal beach of Hare island at Tuticorin were used for this study and the test animals were maintained in the laboratory in sea water (35 ppt) for a minimum period of 7 days before experimentation. No mortality occurred in the holding stock and this served as control.

Effluent water was collected from the lagoon adjacent to DCW near Kayalpatinam and used

as test medium. The required percentage of effluent mix was obtained by appropriate dilution with sea water. Different hydrological factors such as temperature, salinity, oxygen content, pH and mercury content were estimated in each test medium. A set of 10 samples, each containing 10 animals were drawn from the stock and abruptly exposed to different concentrations from 10% to 1% of effluent water. All through the experiments, a close observation was maintained and the time to death of each animal was recorded. The exposure time was fixed as 10.000 minutes (approximately 7 days). Cessation of response to external stimuli is taken as the index of death. The dead animals were removed immediately and the length and weight were noted down. The data on time to death were initially treated on probability charts to obtain the median lethal time (TLM 50). Median lethal time is the time at which 50% of the sample suffer mortality at a particular dose. The median lethal concentration (LC 50) is the dose in which 50% of the population suffer mortality and this divides the lethal and non-lethal concentrations. The data on median lethal time which bring about 100 to 0% mortality were used to estimate the LC50 by regression analysis (Snedecor and Cochran, 1967).

Another set of 10 experiments were conducted in each species by exposing different size groups in 2.5 ng/ml, a non-lethal mercury concentration for a period of one week to study the rate of accumulation of mercury in the tissues of these species. Mercury Analyser MA-5800 A, manufactured by the Electronic Corporation of India Ltd, was used for the estimation of mercury content in water and tissues.

RESULTS AND DISCUSSION

Different hydrological parameters of the test media, the data on the percentage mortality, median lethal time (TLM 50) and mercury accumulation in tissue of *C. madrasensis* and *M. glabratum* are given in Table 1 and 2 respectively. The hydrological parameters indicate that salinity and oxygen content of the test media were within normal range of tolerance. However, pH was observed to be on the lower side varying from 6.75 to 2.68 (Table 1) and 6.36 to 2.72 (Table 2) in the test media for *C. madrasensis* and *M. glabratum* respectively. This acidic nature of the test media might have also increased the lethal nature of the effluent in addition to mercury. *C. madrasensis* suffered mortality in mercury concentration of 3 ng/ml and above and *M. glabratum* died even in 2.2 ng/ml of mercury concentration. Median lethal time increased with the increase in pH and decrease in mercury concentration in both the species. TLM 50 of *C. madrasensis* increased from 5258 minutes in 7.4 ng/ml of mercury to 9282 minutes in 5.2 ng/ml whereas TLM 50 of *M. glabratum* was 3034 minutes in 7.4 ng/ml which increased to 5220 minutes in 3.0 ng/ml. As seen from the median lethal time, *C madrasensis* could resist mercury for a longer duration

TABLE 1 *Percentage survival and median lethal time (TLM 50) of* C. madrasensis *in different concentration of mercury and other hydrological factors*

Experiment No.	1	2	3	4	5	6	7	8	9	10
Mercury ng/ml	7.4	6.7	5.9	5.2	4.4	3.7	3.0	2.2	1.5	0.7
Oxygen ng/ml	4.1	5.2	4.5	4.3	4.2	4.4	3.7	3.6	3.8	3.8
Salinity %	37.58	39.30	38.79	38.10	38.62	38.10	36.89	36.20	36.72	36.72
pH	2.68	2.76	2.82	2.89	2.95	3.06	3.58	6.35	6.58	6.75
Percentage mortality	100	100	50	50	30	10	10	0	0	0
TLM 50	5258	8144	9210	9282	—	—	—	—	—	—
Mercury in tissue ng/g	17.40	14.29	15.11	15.64	9.78	10.85	10.75	18.83	12.83	15.17

TABLE 2 *Percentage survival and median lethal time (TLM 50) of* M. glabratum *in different concentration of mercury and other hydrological factors*

Experiment No.	1	2	3	4	5	6	7	8	9	10
Mercury ng/ml	7.4	6.7	5.9	5.2	4.4	3.7	3.0	2.2	1.5	0.7
Salinity %	38.10	38.10	37.93	37.84	37.76	37.41	37.24	36.89	36.55	36.20
Oxygen ml/l	5.26	5.65	3.67	4.86	3.90	5.37	4.35	4.63	4.18	4.63
pH	2.72	2.78	2.87	2.92	3.00	3.09	3.24	3.50	5.44	6.36
Percentage mortality	100	100	100	100	100	80	60	30	0	0
TLM 50	3034	3684	2936	3091	4076	4325	5220	—	—	—
Mercury in tissue Ng/g	21.8	46.5	32 4	36.2	32.7	59.3	23.1	29.6	29.9	24.8

TABLE 3 *Accumulation of mercury in tissues of* C. madrasensis *and* M. glabratum *expossed to 2.5 ng/ml of mercury for one week*

Expt. No.	*C. madrasensis*		*M. glabratum*	
	Size (DVM) in mm ± 1 SD	H_g ng/g tissue ± 1 SD	Size (DVM) in mm ± 1SD	H_g ng/g tissue ± 1 SD
1.	128.3 ± 4.4	10.1 ± 0.6	29.2 ± 1.2	21.3 ± 1.2
2.	116.1 ± 7.2	11.4 ± 0 9	29.9 ± 1.1	23.3 ± 0.9
3.	100.2 ± 8.1	13.2 ± 1.0	27.1 ± 0.7	24.7 ± 1.1
4.	88.1 ± 5.2	14.9 ± 0.5	26.3 ± 0.9	29.0 ± 0.7
5.	79.7 ± 2.7	15.3 ± 0.2	25.9 ± 0.9	29.9 ± 1.4
6.	76.3 ± 1.3	16.4 ± 0.7	25.4 ± 1.0	32.0 ± 1.8
7.	74.0 ± 1.1	18.3 ± 0.8	25.0 ± 1.5	32.5 ± 1.3
8.	72.1 ± 1.0	20.9 ± 2.1	23.6 ± 1.9	36.2 ± 0.8
9.	70.2 ± 1.1	22.4 ± 1.5	20.8 ± 1.4	41.0 ± 1.2
10.	70.8 ± 1.2	25.7 ± 1.8	20.1 ± 1.3	51.2 ± 2.9

of time than *M. glabratum*. The median lethal concentration is estimated to be 5.1 ng/ml for *C. madrasensis* and 2.8 ng/ml for *M. glabratum* and this indicates that the later species is more susceptible for mercury as it dies in lesser time and lower concentration of mercury. The data on the mercury accumulation in tissue in the lethal study did not show any definite correlation with any of the hydrological factors as shown in Tables 1 and 2 and this may be due to multi-factorial variation such as time to death and size of the test animals.

The data on the rate of accumulation of mercury in tissues of *C. madrasensis* and *M. glabratum* exposed to non-lethal concentration of mercury are shown in Table 3. Size of the animal is found to exhibit a direct relationship on the rate of mercury accumulation in tissues in both the species as smaller animals have been recorded to accumulate more mercury and the rate of accumulation decreases as the size increases. The rate of mercury accumulation in *C. madrasensis* increased from 10.1 ng/g tissue among animals measuring 128.3 mm DVM to

25.7 ng/g tissue in oysters among 70.8 mm DVM size. Similarly in *M. glabratum* it increased from 21.3 ng/g in animals measuring 29.2 mm DVM to 51.2 ng/g in specimens of 20.1 mm DVM size. *M. glabratum* is observed to accumulate more mercury than C. *madrasensis* and this may be again owing to the use of smaller sized specimens in the experiments or perhaps due to species specificity. This may be one of the reasons for the higher intolerance of this species to mercury as pointed out already. Low tolerance of mercury compounds by molluscs, which in short-term experiments had toxic effects at 0.1 ppm was reported by several investigators (clarke 1943; wisely and Blick 1967). The reasons for higher accumulation of mercury in smaller animals may be due to varied nature of biological activities. Further study on the physiology including the metabolism of mercury by these animals may provide more information on the causative factors for the mortality of these species. Marine organisms having developed under relatively stable and uniform environment in their chemical composition are very sensitive to sudden changes (Prosser and Brown, 1962). The high toxicity of metallic mercury and mercury compounds was described in antiquity (Goldwater 1936; Bidsrrup 1964) but not until the mass poisioning known as Minamata disease did mercury investigations become concerned with the hamful effect of heavy metals released by man into the marine environment.

The biological effects of mercury is strongly dependent on its concentration, chemical form and the organism. Mercury enters organisms by absorption through free surfaces such as skin (Schamberg 1918) or gills (Harnnarz 1968), by intake of water or food containing mercury compounds.

Present study reveals that these species come under the heavy metal stress even at lower concentrations. The median lethal concentration indicates that the population of these species will suffer heavy mortality when the surrounding water happens to get effluents of mercury concentrations higher than LC 50 values as determined. Thus, the periodical monitoring of marine pollution in the coastal waters is the existing of marine pollution in the coastal waters in the existing situation becomes an obvious necessity.

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82. MERCURY LEVEL IN THE EDIBLE OYSTER, *CRASSOSTREA MADRASENSIS*

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ABSTRACT

Chemical analysis of the meat of *C. madrasensis* of size range 75-151 mm and meat weight of 2-2.6 g showed that the level of mercury was less than the accepted standard limit of 0.5 ppm in the edible meat.

INTRODUCTION

Like fish, adult bivalves are also known for their ability to accumulate mercury even from low levels in water (Vernberg et al 1979; Love 1980). Chichester and Graham (1973) stated that mercury is a cumulative poison which causes injury through progressive and irreversible accumulation in the human body as a result of ingestion of repeated small amounts, which causes sublethal or even lethal effects in the human population. The best known incidence of casuality due to ingestion of mercury contaminated sea food is the minamata disease which occurred in Japan in 1953 and 1964 (Kurland et al 1969; D'ITRI 1977). An understanding of the level of total mercury in the flesh of edible sea food will help us to recommend it for safer human consumption (Bligh 1972; Kamps et al 1972; Jayachandran and Raj 1975; Arima and Umemoto 1976; Neelakantan 1976; Sankaranarayanan et al 1978; Kumagai & saeki 1978; Eisler 1981; Geyer 1981; Philips et al 1982; Ekanath and Menon 1983; Itano and Sasaki 1983: Ndiokwere 1983; Rickard and Dulley 1983; Harakheh and Aftim 1985; Kakulu Dsibanjo, 1986). The present study has been designed for the determination of the level of total mercury in the flesh of edible oyster *C. madrasensis* in Tuticorin waters.

MATERIAL AND METHODS

The specimens of edible oyster, *C. madrasensis* were collected from the coastal waters of Tuticorin Bay (N=29). The length, breadth and weight of the whole oysters were recorded. The edible flesh weight was also recorded. The size range of the oyster varied from 75 mm to 151 mm in length and 52 mm to 82 mm in breadth. The flesh weight of the oyster examined varied from 2 to 9.6 g. The level of total mercury content in oyster flesh was determined following the method suggested by Louie(1983). A mercury analyser (Electronic Corporation of India Limited MA 5880A model) was used in the above estimation. The results were expressed as ppm on dry weight basis.

RESULTS

The present study reveals that the level of total mercury content in the edible oyster *C. madrasensis* varies from 0.0024 ppm to 0.17 ppmwith a mean vaiue of 0.045 + 0.0813 ppm. Hussain and Bleiler (1973) are in accordance with the results of present study that the contamination of mercury in oyster *Crassostrea commercialis* varied widely from very low level to high concentrations.

The relationship between the total mercury content and length, breadth and flesh weight of *C. madrasensis* is peresented in Figure 1 and were peculiar to note that the mercury level in the edible oyster was decreasing with increase in size groups of breadth and flesh weight. This is in agreement with result reported by Cunningham and Tripp (1975) that only small oysters (less than 7.85 g) contained significantly higher mercury content than larger individuals (7.86-20.98 g). This may be due to the more rapid turn over of cellular material and subsequent increase in body weight which will dilute the metal concentration and smaller bivalves have a larger surface to volume ratio than larger individuals, therefore proportionately more surface area will

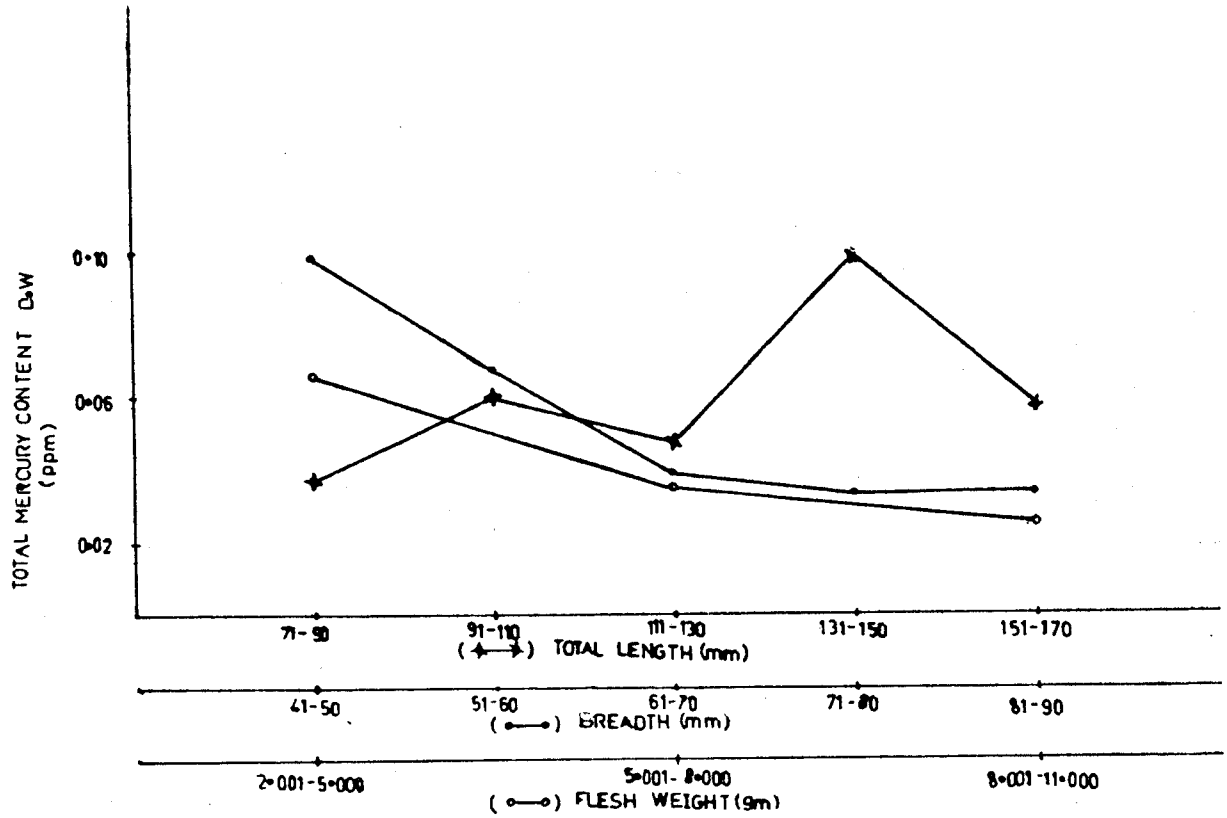

Fig. 1. Relationships of mercury with length, breadth and flesh weight of oyster.

be available for both the accumulation and removal of metals to occur (Dame 1972). From the present study, it is clear that the level of mercury contamination in edible oyster *Crassostrea madrasensis* from Tuticorin water was well below than the standard limit of 0.5 ppm dry weight basis (FAO 1933) and can be recommended for the the safe human consumption.

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83. HEAVY METALS IN COMMERCIALLY PROCESSED MOLLUSCAN PRODUCTS IN RELATION TO QUALITY

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ABSTRACT

Heavy metals (Hg, Cu, Zn, Cd, Fa, Mn, Pb and Sn) were determined in several brands of three commercially processed canned and frozen molluscan products - mussels, clams and oysters Concentrations of Hg, Cu, Zn, Cd, Pb and Sn were well below the recommended maximum concentrations in clams and mussel products. However, copper and zinc were higher in oyster products: Overall mean concentrations being 56.88 and 178.6 ppm respectively. Products in Aluminium cans were better in quality compared to the products in traditional tin cans. Impact of heavy metals on the safety and evaluation of colour and flavour for product for acceptability are discussed Depuration studies have been suggested to remove heavy metals from molluscs.

INTRODUCTION

Study of the levels of heavy metal residues (e. g. mercury, cadmium, lead, copper, zinc, arsenic etc) in seafoods has assumed importance in recent years, in view of their possible toxic effects on humans through the food chain. Among the various aquatic organisms benthic filter feeding molluscs are noted for their ability to concentrate these metals from water and sediments to a very high level. As a result of industrialisation there is an increasing build up of these metals in the coastal waters. There is, therefore, growing concern throughout the world with the impact of pollutants on the quality and safety of the consumer from the aquatic resources. Heavy metals can also cause problems in certain fishery products from offensive colour and flavour. Nitta (1972) attributes green discolouration of oysters to copper and zinc pollution either in solution or from sediments. Levels of heavy metals in molluscs had been studied by various workers (Brookers and Rumsby 1965; Bertin and Goldberg 1972; Bryan 1973; Bryan et al; 1977; Topping 1973; Eustace 1974; Ratkowsky et al 1974; Eisenbery and Topping 1984; Khristoforova, et. al 1984). Heavy metal levels in canned seafoods also been determined by a few workers (Hall 1974: Sanchez etc al; 1980; Yamomoto et al 1980: Suddendorf et al 1981; Mauro et al 1981). However, in India work on the occurrence of heavy metals in seafoods is rather scanty. Bhat et al (1965) have determined certain metals in oysters from the Bombay region. Somayajulu and Rama (1971) have determined mercury in sea foods collected from coastal waters off Bombay. Zingde et al; (1976) and Sankaranarayanan et al (1978) have also studied the levels of certain heavy metals in molluscs from the Goa and Cochin region respectively. Lakshmanan and Nambisan (1983) have studied the distribution and seasonal variation of certain trace metals in three bivalve molluscs from Cochin waters.

The objective of the present studies was to monitor the levels of toxic heavy metals (viz. Hg, Cu, Zn, Fe, Mn, Pb Cd and Sn) in canned and frozen molluscan products on a commercial scale and to evaluate their quality with respect to heavy metal levels and sensory criteria and to suggest measures to remove heavy metals from them. With canned foods in particular, shelflife assessment is often made by monitoring the building up of metals especially tin and iron during storage.

MATERIAL AND METHODS

Canned molluscan products were procured from retail outlets in Cochin and a few canned mussel samples processed in the Central Institute of Fisheries Technology, Cochin. The species comprised oyster, *Crassostrea madrasensis* and green mussel, *Perna viridis* (Linnaeus). Frozen clams (*Meretris casta* and *Villorita*

cyprinoides) and mussel (*Perna viridis)* were obtained from fish processing factories located near Quilon. About 20% of the samples were purchased from retail cold storages. A total of seventyfive samples comprising thirty canned products and fortyfive frozen samples were examined for toxic heavy metals and qualities of taste and smell. The soft tissues of various fishery products were homogenised in a glass mortar and subjected to wet digestion using concentrated HNO_3 and concentrated H_2SO_4 mixture (AOAC 1975). The metals were then determined by Flame Atomic Absorption Spectrophotometer. Mercury was estimated by cold vapour technique in a Mercury Analyser (ECIL Model MA 5800) after digesting the sample in in Bethge's apparatus using Con, HNO_3 and Con. H_2SO_4 (4: 1 v/v). Glass distilled water and Analar Reagent Grade chemicals were used in the study.

Three experiments of 48 h duration were performed for depuration with the clam, *Meretrix casta* and oyster, *Crassostrea madrasensis*. Clams for the study were collected from Quilon and oyster from Cochin region. The live animals were immediately transferred into a perspex tank containing filtered seawater (25%). in static condition. In one experiment with the oyster, chelating agent (EDTA) was introduced in the depuration tank at 100 ppm level. The metal levels in the soft parts of the animals were determined immediately after catch and after 48 h depuration.

Sensory evaluation of the canned products and frozen products after cooking were performed by a taste panel team. Emphasis was given to the colour and flavour of the products.

RESULTS AND DISCUSSION

a) Canned Products:. The levels of various heavy metals, viz. Hg, Cu, Zn, Fe, Mn, Ca, Pb and Sn in different brands of canned oyster, *C. madrasensis* and the mussel, *P. viridis* are presented in Table 1. The data showed that the toxic metals like Hg, Pb and Cd were below the permitted limits Indian Standards for heavy metals in canned fishery products are : Hg =0.5 pmm, As=1 ppm, Cu=10ppm, Pb=5ppm, Zn=50 ppm. anb Sn=250 ppm US-FDA permits a maximum of 1.0 ppm Hg in seafood and Australian Authority 2 ppm Cd in shellfish in 90% of the canned products. About 10% of the canned oysters had cadmium content above the permitted

TABLE 1. *Heavy metals in canned Oyster,* Crassostrea madrasensis *and mussel,* Perna viridis *(Linnaeus). Mean and range of values in *ppm (Original weight basis)*

Name of species and type of pack	*Metals*							
	*Hg	Cu	Zn	Fe	Pb	Cd	Mn	Sn
Oyster								
(C. madrasensis)								
Tin cans								
1. Canned in oil	70.7	62.64	195.83	245.22	4.465	3 375	4.983	42
	65-78	58.64-68 0	164.56-227.6	221.7-264.47				
2. Canned in tomato sauce	102.5	68.64	201 98	386.50	4.563	3.155	8.075	50
	90-120	66.20-71.34	178.84-235.86	325.44-342.36				
Aluminium cans								
3. Canned in brine	101.6	46.59	163.60	77.89	0 5125	1.580	5.035	Nil
	98-112	43.41-53.50	142.6-183.73	57.72-109.4				
4. Smoke oyster in oil	89	54.81	154.86	69.40	Nil	1.165	4.123	Nil
	86.4-98	52.51-59.15	141.30-183.7	51.11-98.40				
Mussel								
(P. viridis)								
Canned in oil (Tin can)	45.9	4.12	34.48	320.965	1.99	0.308	8.823	62
	27-57.6	2.46-5.35	17.47-42.06	196.70-488.79				

* Mercury content is expressed in ppb; since the variations were not wide, only mean vaiues are given for Pb, Cd, Mn & Sn.

TABLE 2. *Heavy metals in three commercially frozen molluscan products; viz.' two species of clams and a mussel (Mean and range of values in *ppm wet weight).*

Species & Grade (Count/lb)	Metals *Hg	Cu	Zn	Fe	Cd	Pb	Mn
Clams							
1. *meretrix sp.*							
200-300	24.58	8.54	16.88	97.59			
	19-35	6.86-9.89	13.77-19.82	77.20-121.62	0.188	1.301	4.358
	21.65	5 25	12.17	92.75			
300-500	16.6-28	4.32-6.50	10.16-14.25	81.76-106.85	0.179	1.580	5.044
	15.75	4.43	11.55	84.60			
500-700	11-22	4.12-5.30	10.44-13.84	59.5 -108.44	0.239	2.539	3.99
	6.0	4.28	12.86	87.4			
700-1000	Traces-14	3.91-4.58	11.47-14.03	63.9 -102.5	0.473	1.750	4.566
	5.0	3.58	10.09	61.32			
1000-1500	Traces-11.3	3.04-4.59	8.59-12.04	54.10- 79.2	0.577	2.494	2.828
2. *Villorita sp*							
200-300	29.63	4.31	44.50	544.37			
	22-38	4.09-5.11	41.86-47.18	403.95-768.38	0.395	1.560	10.33
300-600	22.48	4.80	40.9	515.50			
	18-29	4.32-506	39.50-46.26	384.89-768.80	0.301	0.878	10.56
	20.30	4.51	31.91	435.4			
700-1000	15.2-26	4.20-4.84	25.85-36.50	291.6-688.32	0.737	2.225	9.35
3. *Mussel*							
Perna viridis	27.46	1.59	10.81	17.05			
Smaller size	23.0-36.5	1.47-1.68	8.90-12.14	14.40-19.70	1.192	0.686	2.41 6
	48.90	2.36	14.04	59.86			
Larger size	40.6-65	1.37-3.86	9.35-16.85	24.43-158.30	0.437	1.132	3.051

* Mercury is expressed in ppb: since the variations were not wide, only mean values are given for Cd, Pb & Mn.

TABLE 3. *Heavy metal levels in canned molluscan products showing discolouration and metallic flavour*

Product	Metal content in ppm Cu	Zn	Fe	Mn	Sensory Evaluation Colour	Flavour
1. *Oyster* (Tin can)	> 60	> 190	> 250	> 5	Normal	Metallic taste
2. *Oyster* (Aluminium can)	> 40	> 150	> 65	> 5	Green	Metallic taste
3. *Mussel*	> 5	> 35	> 300	> 10	Normal	Metallic taste

limit of 2 ppm. The mean mercury content of canned oysters and mussels were 92 and 46 ppb respectively. Lead was below the limit (5 ppm) in all the products and was nil or in traces in aluminium canned products. All the canned mussel products were safe with respect to their heavy metal content. However, copper and zinc were higher in all the oyster products, overall mean concentrations being 56.88 and 178.6 ppm respectively. Oyster products in aluminium cans contained lesser quantity of Cu, Zn and Fe compared to tin cans and Pb, Cd and Sn were either nil or traces. There was a high build up of iron and tin content in the products canned in the traditional tin containers. Thus, there was an average increase of around 324% iron content in these products compared to aluminium cans.

The sensory evaluation of the products showed that 15% of the mussel products had a metallic flavour. However, 33.3% of oyster products developed metallic flavour and 10% of the sample had green discolouration. The metal levels in the discoloured/off flavoured products are given in Table 3. From the result it seems that Cu and Mn do play a major role in the development of metallic flavour.

The high levels of Cu and Zn observed in the present study in all the oyster products are not abnormal. Higher values have been reported by other workers. Sankaranarayanan et al (1978) have reported copper and zinc concentration in oyster, *C. madrasensis* ranging from 70 to 205 µg/g and 2450 to 12500 µg/g respectively. Zingd et al (1978) have reported values for zinc in *Crassostrea* sp. varying between 323 to 2800 µg/g compared to the above:

Compared to the above results, the present findings indicate lower concentration for these metals. The raw materials for the canned oyster products were collected mainly from Tuticorin where Pillai et al (1986) have reported levels of copper and zinc in fresh oyster from the same area which are comparable with the present observation.

b) Frozen products, A total of 45 frozen mussels/clams have been examined during the present study. The distribution of heavy metals in various size grades of the molluscs are given in Table 2. The important observation is that none of tne products had toxic heavy metals above the permissible limits. The highest concentrations of mercury observed in the various species were 35 ppb in *M. casta* 38 ppb in *Villoritta* sp. and 65 ppb in *P. viridis*. The other two highly toxic metals, Cd and Pb were also very low in these samples; the mean values can be seen from Table 2. Few samples of frozen *Villorita* contained 10 ppm Mn in their meat. Based on heavy metal levels in these products, it can be presumed that 100% of the products are safe and acceptable to the consumer.

The distribution of the metals in various size grades of the clams indicated that the

TABLE 4. *Depuration of heavy metals by the clam,* M. casta *and oyster,* C. madrasensis *in filtered seawater (Salinity = 25% and FS containing EDTA (100mg / litre).*

Mean metal content in ppm.

		M. casta		
Clams from bed		After 48h depuration in seawater		
		I	II	
Cu	7.65	3.56	4.66	
Zn	13.40	8.59	8.89	
		C. madrasensis		
Oyster from bed		After 48h depuration in seawater		After 48h depuration in FS-EDTA medinm
Cu	43.80	43.23		28.60
Zn	892.00	743.00		497.00

concentration of various metals increased with size. In the mussel also larger size showed higher values than smaller size groups (Table 2). The higher levels of metals in larger size groups may be attributed to bioaccumulation of these metals. However, this trend was not conspicuous in the case of Cd, Pb and Mn.

Depuration of metals by clams and Oysters:- The results of the depuration studies are given in Table 4. Only, the values for copper and zinc are presented in the table; iron could not be estimated. The concentrations of Cu and Zn in the tissue declined in both clams and oysters. Mean Cu and Zn concentrations in the clam, *M. casta* declined from 7.65 to 4.106 ppm & 13.40 to 8.73 ppm respectively. In the oyster, the mean Zn concentration (ppm) in filtered seawater was 743 Vs. 497 in seawater containing EDTA in the 48 h depuration period compared to the background level of 892 ppm. Copper did not leach out from the oyster in the filtered seawater media; however, significant amount of copper was depurated in seawater containing EDTA. Copper content of oysters in the EDTA-Seawater mediums was 28.60 ppm Vs. 43.80 ppm before depuration.

Results of the depuration studies seemed to be encouraging. However, detailed investigations are required before any conclusion is drawn from the limited information.

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84. HEAVY METAL RESISTANT BACTERIA ASSOCIATED WITH THE BLACK CLAM *VILLORITA CYPRINOIDES* VAR *COCHINENSIS* (HANLEY) AND WATER COLLECTED FROM COCHIN BACKWATER

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ABSTRACT

A total of 147 strains of heterotrophic bacteria, isolated from water and the black clam *Villorlia cyprinoides* var *conchinensis* from Cochin backwater were subjected to heavy metal sensitivity tests for five heavy metals viz. mercury, zinc, cadmium, copper and lead. In general, the isolates from water showed higher resistance towards the heavy metals. Members of all the genera except Coryneform group showed similar trend of resistance. The strains of Coryneform group isolated from animals were more resistant than their counterparts isolated from water. Minimum inhibitory concentration (MIC) of the metals varied. It may be concluded from the results that the habitat of the organisms plays a unique role in the ecology of heavy metal resistant bacteria.

INTRODUCTION

The Cochin backwater, a part of the Vembanad lake which is attached with several rivers and a network of canal, receives effluents from a number of Industries. Large quantities of heavy metals are present in these effluents. It is true that most of these metals are essential in trace amounts for the normal metabolism of aquatic organisms. But excessive amounts of these metals have been proved lethal.

Considerable interest has been shown to know the effect of heavy metals on micro-organisms present in aquatic environment. Tolerance to elevated levels of heavy metal is evident in microorganisms isolated from metal contaminated environments (Gracia Toledo et al 1985). In Cochin backwater the effect of heavy metals on macroorganism such as fish, molluscs etc. have been studied (National Seminar on Mussel watch, Cochin 1986). However, similar attempt to understand the influence of heavy metals on the microbial load is not made. In the present study, the distribution of heavy metal resistant baeteria in water and in association with black clam of Cochin backwater was made.

MATERIAL AND METHODS

The black clam (*Villorita cyprinoides* var *cochinensis)* and the water samples were collected from Vembanad lake near the Kumbalam island and transported to the laboratory in an insulated ice box. Standard methods were followed for enumeration, isolation and identification of bacteria (Sreekumari and Lakshmanaperumalsamy 1986)

Metal sensitivity of selected bacterial isolates was tested on nutrient agar medium (Peptone 0.5%; Beef extract 0.5%; NaC1 1.5%; agar 2%). Filter sterilized salts of five metals (mercury, zinc, copper, cadmium and lead) were incorporated in the sterile molten basal medium at different concentrations. before dispensing into petriplates. Isolates enriched in nutrient broth (6 h) were spot inoculated on the metal incorporated medium. Plates were incubated at 37°C for 18-24 h. If no growth was seen after 24h, plates were reincubated for an additional 24 h. If growth was observed within 48 h, the isolate was treated as resistant to that concentration of the metal. The criteria used by Austin et al (1977) were further extended to other metals, for differentiation of the strains into sensitive and resistant forms (critical concentration was fixed as 10 ppm for mercury and 100 ppm for other metals). Minimum inhibitory concentrations (MIC) of the resistant strains were found out.

RESULTS AND DISCUSSION

All the isolates tested were found resistant to zinc and lead. Resiatance to mercury, copper and cadmium varied among isolates. 90.5% of the isolates were resistant to mercury; 97.3% to cadmium and 76.9% to copper (Table 1).

TABLE 1. *Percentage of frequency of heavy metal resistant heterotropic bacteria*

Metals	Total	Water	Animal
Mercury	133	37	96
	(90.5)	(94.9)	(88.9)
Zinc	147	39	108
	(100.0)	(100.0)	(100.0)
Cadmium	143	39	104
	(97.3)	(100.0)	(96.3)
Copper	113	31	82
	(76.9)	(79.5)	(75.9)
Lead	147	39	108
	(100.0)	(100.0)	(100.0)

The percentage frequency of resistance of heterotrophic bacterial isolates to various metals on a samplewise analysis showed that isolates from water exhibited higher resistance to mercury, cadmium and copper than those from animal samples. Since Cochin backwater receives heavy metals from effluents of various factories, higher percentage of metal resistant bacteria might have occurred. Also, the periodical input of heavy metals might have affected the bacterial strains to get them trained for higher level of tolerance. Similar findings were reported from various geographical locations (Cook and Goldman, 1976; Austin et al. 1977; Mills and Colwell 1977). The presence of more heavy metal resistant bacteria in water than animal is not in agreement with the findings of Pradeep (1986) who reported higher percentages of metal resistant *Vibrio parahaemolyticus* strains associated with plankton, prawns and fishes. The bivalves are well known for the accumulation of heavy metals at higher proportions in the various organs of the body. The incidence of lesser percentage of metal

TABLE 2. *Generawise analysis of percentage frequency of heavy metal resistant heterotrophic bacteria*

Genera	Sample	Hg	Zn	Cd	Cu	Pb	Total
Pseudomona	W	100.0	100.0	100.0	100.0	100.0	9
	A	86.4	100.0	95.5	77.3	100.0	22
Vibrio	W	100.0	100.0	100.0	75.0	100.0	4
	A	84.0	100.0	96.0	72.0	100.0	25
Aeromonas	W	100.0	100.0	100.0	100.0	100.0	2
	A	100.0	100.0	100.0	95.2	100.0	21
Enterobacteriaceae	W	100.0	100.0	100.0	90.9	100.0	11
	A	92.9	100.0	92.9	57.1	100.0	14
Alcaligenes	W	100.0	100.0	100.0	0.0	100.0	1
	A	75.0	100.0	100.0	87.5	100.0	8
Acinetobacter	W	100.0	100.0	100.0	100.0	100.0	1
	A	50.0	100.0	100.0	50.0	100.0	2
Elavobacterium	W	—	—	—	—	—	—
Cytophaga group	A	100.0	100.0	100.0	100.0	100.0	1
Moraxella	W	100.0	100.0	100.0	100.0	100.0	1
	A	100.0	100.0	80.0	80.0	100.0	5
Bacillus	W	80.0	100.0	100:0	80.0	100.0	5
	A	66.7	100.0	100.0	33.3	100.0	3
Coryneforum group	W	66.7	100.0	100.0	33.3	100.0	3
	A	100.0	100.0	100.0	66.7	100 0	3
Micrococcus	W	100.0	100.0	100.0	100.0	100.0	2
	A	100.0	100.0	100.0	100.0	100.0	4

resistant bacteria shows that there may be some synergistic antagonistic activity which may be playing an imporant role between the host microenvironment and the bacteria and this requires extensive study.

Generawise analysis of percentage frequency of heavy metal resistance showed that except Coryneform group of bacteria, all the genera encountered in the study, showed similar pattern i. e., water samples contained more heavy metal resistant bacteria than those from animal samples (Table 2). This may be attributed to the fact that the bacteria sharing a common environment may share a common mode of development of hevy metal resistance.

Out of 147 strains subjected to sensitivity studies on heavy metals, none of them were found to be resistant to a single metal species alone. All the strains showed multiple resistance. Maximum resistance was found towards all the five metals tested followed by four and three metals respectively. The percentage of multiple resistivity was in the order of 72.8%, 21.1% and 6.1% respectively (Table 3). The minimum inhibitory concentration (MIC) for all the strains tested were also worked out, The maximum percentage showed MIC to the tune of 25 ppm, 300 ppm, 200 ppm, 150 ppm, and 1000 ppm for mercury, Zinc. Cadmium, copper and lead respectively.

TABLE 3. *Multiple resistance of heterotrophic bacteria*

Resistant to heavy metals	Resistance to number of heavy metals					
	5	4	3	2	1	Total
Number of isolates	107	31	9	0	0	147
Percentage	72.8	21.1	6.1	0.0	0.0	

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85. STUDY ON THE BACTERIAL QUALITY OF EDIBLE OYSTER, *CRASSOSTREA MADRASENSIS* AND ITS PURIFICATION

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ABSTRACT

Edible oysters (*Crassostrea madrasensis*) collected periodically during the years 1984-1986 from Central Marine Fisheries Research Institute farm at Tuticorin and from the natural beds were studied for their bacterial quality. Seawater samples from the surrounding environs were also simultaneously collected and analysed for physical, chemical and bacteriological parameters. The oyster samples were subjected to purification by employing different methods. The total bacterial count of cultured oysters and natural bed edible oysters ranged between 10^3 to 10^4 organisms per ml of oyster fluid. The T.B.C. of the sea water around cultured oysters and natural bed oysters ranged between 10^2 to 10^3 organisms per ml of seawater. Faecal coliforms were found to be very low and within permissible limits. The pathogenic bacteria *Salmonella*, *Streptococci* and *Staphylococci* were absent. The variations in pH, temperature, salinity and dissolved oxygen of the seawater samples were insignificant. The edible oysters were subjected for purification by employing different purification methods among which chlorination was found to be better.

INTRODUCTION

It is known that protected bays and estuaries offer suitable grounds for culture of oysters. The increase in pollution in these waters pose a threat to oyster farming. The discharge of industrial effluents and sewage in these water bodies necessitates purification of oysters before marketing. Because the oysters are filter feeders they can concentrate pathogenic bacteria that may be present in the surrounding waters. The authors in this paper have dealt the bacterial flora and purification of oysters collected at Tuticorin during the years 1984 to 1986. Also the bacterial flora of natural bed oysters collected from Tuticorin, Ennore and Pulicat were studied and reported in this paper.

MATERIAL AND METHODS

The oyster samples were collected from Central Marine Fisheries Research Institute Farm at Tuticorin at regular intervals alongwith the farm water samples. On few occassions oysters were also collected from natural beds from Tuticorin, Pulicat and Ennore backwater and examined for bacterial flora. A sample of 3 to 5 oysters were used for collecting the oyster liquid which was blended with equal amount by the weight of the Normal Saline solution so that 2 ml of oyster liquid contained 1 g of oyster meat. Plate count of the oyster liquid and farm water were determined by preparing duplicate plates of Tryptone glucose yeast extract agar. The plates were incubated at 37°C for 48 h (Presnell and Kelly 1961 & APAA 1976). E. C. broth with incubation at 44.5°C and Eosine Methylene Blue Agar were used for the enumeration of faecal califorms (APHA 1976) and for *E. coli*, Tergitol -7 Agar were used. For the enumeration of *Salmonella*, Brilliant Green Agar, Bismuth Sulphite Agar and Triple Sugar Iron Agar were used. For enumeration of coagulase +ve staphylococci, Baird parket Agar and for faecal streptococci, K F Agar were employed. Various authors have described different purification methods for oysters. Eyles et al(1984) described purification methods for commercial depuration of oysters. The purification plant was of the recirculating type employing UV light for sterilisation. Mahadevan (1980) has described the depuration of oyster for 24 h in running seawater and also use of Chlorination at 3 ppm for 1 h. Subsequently they were dechlorinated before disposal for marketing. The purification of oysters by the authors were carried out by the methods described as under. (i) By keeping the oysters in filtered sea water for 24 h with the change of water once in 12 h. (2) The oyster samples were purified by keeping them in aerated seawater

for 24 h and for 48 h with the change of sea water once in 12 h. (3) The depurated oysters in filtered sea water were subjected for chlorination at 2, 2. 5, 3, 4 and 5 ppm for 3 h and after that these samples were washed thoroughly in filtered sea water. The purified oysters were then examined for bacterial quality.

RESULTS AND DISCUSSION

Bacterial flora of farm oysters

Oysters (*C. madrasensis*) and oyster farm water collected from Central Marine Fisheries Research Institute Farm. Tuticorin were examined for total bacterial count and pathogens *F. coliforms, E. coli, F. streptococci* and *Salmonella*. The data are given in Table 1. The total viable count of the oysters ranged from 3.43×10^2 to 1.9×10^4/g and the TBC of the farm water ranged from 1.6×10^2 to 2.9×10^3 ml. The TBC of the surrounding seawater was conststently lower than the corresponding counts of oysters. This is in agreement with the findings of Durairaj et al (1983). The pathogenic bacteria were found to be absent except faecal coliforms in all the oysters and seawater samples. The faecal coliforms were noticed on few occasions and the count was very less and with in the permissible limits. This also is in agreemnt with the findings of Durairaj et at (1983). The values of faecal coliforms were found to be between 3 to 38/100/gm in oyster and in farm seawater it ranged from 3 to 23/ml. According to A PHA (1976) the permissible limits of coliforms is 230/100 g, in depurated oysters. Coliform counts of water were reported to be maximum under low salinity conditions (Pressnell & Kelly 1981). Though low salinity conditions were not observed in Tuticorin waters, higher counts of *E. coli* were observed during the periods of lower salinity. During the period July to September 1986 the minimum salinity recorded was 32 ppt and during this period a maximum of 39 counts of *E. coli* were recorded in the oyster and 23 in the seawater sample.

David Hussong et al (1981) have indicated that coliform MIN counts of oysters were found to increase significantly during October and early November of each year when the temperature was maximum. Similar findings were recorded at Tuticorin when maximum coliform count of 39 in oysters and 23 in seawater were

TABLE 1. *Data on bacterial flora of edible oysters and farm water collected from Central Marine Fisheries Research Institue farm, Tuticorin*

Period	Oyster				Farm Seawater			
	TBC/g		F. coliforms/100g		TBC/ml		F. coliforms/100g	
	Min	Max	Min	Max	Min	Max	Min	Max
1. 1984 Apr - Jun	26.95×10^2	9×10^3	Nil	Nil	7.8×10^2	16.5×10^2	Nil	Nil
2. 1984 Jul - Sep	4.9×10^2	8.5×10^2	Nil	Nil	3.6×10^2	6.2×10^2	Nil	Nil
3. 1984 Oct - Dec	3.43×10^2	7.5×10^2	Nil	Nil	3.8×10^2	4.2×10^2	Nil	Nil
4. 1985 Jan - Mar	23.2×10^2	1.9×10^4	Nil	Nil	5.4×10^2	20.5×10^2	Nil	<3
5. 1985 Apr - Jun	5.8×10^2	50.8×10^2	Nil	Nil	3.2×10^2	19×10^2	Nil	Nil
6. 1985 Jul - Sep	16×10^2	5.6×10^3	Nil	15	2.9×10^2	2.9×10^3	Nil	8
7. 1985 Oct - Dec	5.2×10^2	18.4×10^2	3	14	6.2×10^2	8×10^2	Nil	4
8. 1986 Jan - Mar	6.8×10^2	34.8×10^2	11	36	1.6×10^2	20.8×10^2	7	12
9. 1986 Apr - Jun	12.2×10^2	24.2×10^2	9	39	2.8×10^2	12.5×10^2	3	21
10. 1986 Jul - Sep	18.2×10^2	32.3×10^2	11	39	1.8×10^2	16.5×10^2	3	23
11. 1986 Oct - Dec	11.510^2	43.5×10^2	9	11	4.0×10^2	20×10^2	3	11

regarded when the temperature was maximum at 34.5°C during July 1986. The low TBC load of the oysters (10^2 to 10^4/g) and surrounding seawater (10^2 to 10^3/ml) and the complete absence of pathogens except faecal coliforms on few occasions, showed that the oysters were free from pollution in Tuticorin waters.

Bacterial flora of natural bed oysters

The samples of oysters from natural beds and also the surrounding seawater samples were collected on few occasions from Tuticorin, Pulicat and Ennore back waters and examined for bacterial flora and the data are given in Table 2. The TBC of the natural bed oysters near Tuticorin is ranged from 3.43×10^2 to 5.5×10^3 g and the TBC of the surrounding seawater ranged from 1.6×10^2 to 2.5×10^3 ml. The faecal coliforms of the natural bed oysters from Tuticorin ranged from nil to 39/100g and that of the seawater nil to 28/100 ml The total bacterial load of Pulicat oysters and backwaters were 6.2×10^3/g and 2.8×10^3/ml and in case of Ennore oysters and backwaters the total bacterial load were 11.6×10^3/g and 9.8×10^3/1 ml.

From the data given in the table 2 it is noted that the TBC content of Ennore oyster and backwaters was on higher side than the other two places viz Tuticorin and Pulicat. This is because of the discharge of seawage and industrial effluents in the Ennore backwater from the factories situated near Ennore. Coliform 9/100 ml were recorded in oysters collected from Ennore. The other pathogenic bacteria were however nil in Tuticorin, Ennore and Pulicat natural bed collections.

Hydrological parameters of the seawater samples

During the period under report, farm water samples and natural bed seawater samples were collected along with the oyster samples. Dissolved oxygen, salinity, pH of the water samples were determined and the temperature were noted. The Hydrological parameters are given in Tables 3&4. There was however no marked fluctuation in pH and other hydrological parametersr The analysis of water was carried out as per the methods of AOAC (1970)

Purification of oysters

From the data given in Table 5 it was noted that there was reduction in bacterial counts as a result of purification by the methods already described. Depending on the feasibility any one of these methods can be successfully

TABLE 2. *Data on bacterial flora of natural bed oysters and seawater samples collected near Tuticorin, Pulicat and Ennore seawater*

Date	Place	Oyster		Sea water	
		TBC/gm	F. coliforms/100gm	TBC/gm	F. Coliforms/100ml
1. 12-5-84	Tuticorin	$6x10^2$	Nil	$1.6x10^2$	Nil
2. 29-6-64	,,	$5.5x10^3$	Nil	$20.25x10^2$	Nil
3. 17-9-84	,,	$5.41x10^2$	Nil	$6.2x10^2$	Nil
4. 11-10-84	,,	$5.0x10^2$	Nil	$4.6x10^2$	Nil
5. 4-12-84	,,	$3.43x10^2$	Nil	$4.4x10^2$	Nil
6. 7-1-85	,,	$1.9x10^3$	Nil	$5.4x10^2$	Nil
7. 17-6-85	,,	$3.9x10^3$	Nil	$2.5x10^3$	Nil
8. 12-5-86	,,	$24.2x10^2$	39	$4.5x10^2$	28
9. 25-9-86	Ennore	$11-6x10^3$	9	$9.8x10^3$	Nil
10. 25-8-86	Pulicat	$6.2x10^3$	Nil	$2.8x10^3$	Nil

TABLE 3. *Hydrological parameters of the oyster farm sea water at Tuticorin*

Period	Temperature °C		Dissolved Oxygen ppt		pH		Salinity ppt	
	Min	Max	Min	Max	Min	Max	Min	Max
1984 Jan-Mar	27.0	27.6	4.5	5.4	7.2	8.5	35.0	46.0
1984 Jul-Sep	29.4	30.8	4.0	5.6	8.1	8.5	33.5	33.5
1984 Oct-Dec	26 0	27.0	4.6	5.0	7.9	8.3	34.0	36.5
1985 Jan-Mar	26.0	28.1	5.8	6.0	8.4	6.4	35:7	36.0
1985 Apr-Jun	28.0	31.0	Nil	5.2	7.5	8.4	36.4	40.0
1985 Jul-Sep	29.5	33.0	2.6	5.2	8.1	8.3	36.0	36.1
1986 Jan-Mar	29.0	32.0	0.8	3.2	8.0	8.0	36.0	36.2
1986 Apr-Jdn	32.0	34.5	2.2	3.0	8.0	8.8	38.0	38.5
1986 Jul-Sep	31.0	34.5	2.0	4.6	8.0	9.5	32.0	33.0
1986 Oct-Dec	28.6	30.2	3.2	4.4	8.4	8.5	32.3	33.0

TABLE 4. *Hydrological parameters of the natural bed seawater samples collected near Tuticorin, Pulicat and Ennore backwater*

Date	Place	Temperature °C	Dissolved Oxygen	pH	Salinity ppt
1. 12-1-84	Tuticorin	24.2	4.0	7.2	35.2
2. 29-6-84	,,	30.0	6.6	8.1	33.5
3. 17-9-84	,,	26.6	4.8	8.7	33.4
4. 11-10-84	,,	29.4	5.2	8.3	35.2
5. 4-12-84	,,	27.6	4.7	8.3	32.0
6. 7-1-85	,,	23.8	6.3	8.4	35.5
7. 17-6-85	,,	26.4	2.5	8.5	39.0
8. 12-5-86	,,	34.2	2.2	8.0	38.5
9. 25-8-86	Ennore	32.2	4.4	8.4	33.2
10. 25-8-86	Pulicat	30.0	1.6	8.6	35.5

utilised for purification of oysters before marketing. Mahadevan (1980) has suggested depuration of oysters for 24 hours in seawater followed by chlorination with 3 ppm for one hour and it was subsequently washed in seawater before marketing. Balachandran et al (1981) have suggested the method of chlorination upto 5 ppm at the end of depuration in seawater for a period of 16-18 h. Ray (1984) has suggested a depuration period of 36-48 h for purification of oysters. He is of the view that chlorination is effective at 2 to 3 ppm levels and the expensive method of chlorine depuration makes it less attractive when compared with other forms of purification. The observations recorded by the present authors (Table 5) indicate that the bacterial count of the oysters could be brought down effectively either by washing

TABLE 5. *Data on purification studies of oysters*

	Date	Raw Oyster	Seawater sample	Filtered seawarer sample	Oyster after washing in filtered sea water for 24 h	OYster after 24 h aeration in filtered sea water	Cyster after 48 h aeration in filtered sea water	Particulars: Depurated oysaer after chlorinated for 3 h and then throughly washed 2 ppm (a)	2.5 ppm (b)	3.0 ppm (c)	4 ppm (d)	5 ppm
1.	9-4-85	$9.2x10^2$	$5.2x10^2$	90/ml	$4.2x10^2$	$3.5x10_2$	$2.4x10^2$	$3.4x10^2$	$2.8x10^2$	$1.2x10^2$	ND	ND
2.	18-4-86	$25.8x10^2$	$19.8x10^2$	80/ml	$9.8x10^2$	$8.7x10^2$	$4.6x10^2$	$9.6x10^2$	$8.8x10^2$	$1.6x10^2$	ND	ND
3.	23-5-85	$4.4x10^2$	$3x10^2$	75/ml	$3.8x10^2$	$3.5x10^2$	$3.1x10^2$	$3.6x10^2$	$2.8x10^2$	$1.4x10^2$	ND	ND
4.	15-6-85	$126x10^2$	$33x10^2$	85/ml	$112x10^2$	$86x10^2$	$62x10^2$	$42x10^2$	$26x10^2$	$16x10^2$	ND	ND
5.	16-7-85	$13.8x10^2$	$8.2x10^2$	90/ml	$8.8x10^2$	$6.8x10^2$	$5x10^2$	$6.8x10^2$	$4.2x10^2$	$4x10^2$	ND	ND
6.	17-6-85	$78x10^2$	$25x10^2$	90/ml	$62x10^2$	$24x10^2$	$22x10^2$	ND	ND	ND	$18x10^2$	$11xv0_2$
7.	26-6-85	$88x10^2$	$32x10^2$	90/ml	$68x10^2$	$48x10^2$	$36x20^2$	ND	ND	ND	$28x10^2$	$24x10^2$
8.	16-7-85	$9.6x10^2$	$4.2x10^2$	85/ml	$6.4x10^2$	$9.4x10^2$	$8.2x10^2$	$6.8x10^2$	$5.8x10^2$	$4.2x10^2$	ND	ND
9.	8-1-86	$12.5x10^2$	$3.4x10^2$	75/ml	$9.75x10^2$	$8.75x10^2$	ND	$6.8x10^2$	$4.4x10^2$	$2.2x10^2$	ND	ND
10.	18-2 86	$8.75x10^2$	$4.1x10^2$	90/ml	—	$6.2x10^2$	ND	$5.4x10^2$	$4.5x10^2$	$3.2x10^2$	ND	ND

them in filtered seawater for 24 h or keeping them in aerated seawater for 48 h. The bacterial quality could be further improved by chlorination at the end of depuration, The average reduction of the total bacterial count was 46.14% in the oysters, kept in filtered seawater for 24 h. 61.51% by aerating the oysters in filtered sea water for 48 h and the average reduction was 76.90% by chlorinating at 3 ppm level. As the initial TBC load in the oysters is well below the permissibe levels, the purification of oyster could be done either by keeping the oysters in filtered aerated seawater upto 48 h with change of water once in 12 h or by chlorination at 3 ppm level at the ene of depuration in filtered seawater. The chlorinated oysters were thoroughly washed before marketing.

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86. A STUDY ON THE BACTERIAL QUALITY OF BROWN MUSSEL *PERNA INDICA* AND ITS PURIFICATION

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ABSTRACT

Brown mussel *(Perna indica)* samples were collected periodically during 1983-1985 from Vizhinjam Central Marine Fisheries Research Institute farm and also from the natural beds and were studied for their bacterial quality. The seawater samples surrounding the mussels were also collected along with the mussel samples and analysed for physical, chemical and bacteriological qualities. The mussel samples were subjected to purification by employing different purification methods The total bacterial count of cultured brown mussels and natural bed brown mussels ranged between 10^2 to 10^3 organisms per ml of mussel fluid. The T. B. C. of the sea water around cultured brown mussels and natural bed brown mussels ranged between 10^2 to 10^3 organisms per ml of seawater. The faecal coliforms were found to be very low and they were in permissible limits. The pathogenic bacteria *Salmonella*, *Streptococci* and *Staphylococci* were absent. The variations in pH, temperature, salinity and dissolved oxygen of the seawater samples were insignificant. The mussels were subjected for purification by employing different purification methods and chlorination was found to be better.

INTRODUCTION

The increasing pollution in seawater poses threat to mussel farming and the discharge of industrial effluents and sewage in these waters necessitates purification of mussels before marketing because the shell fish are filter feeders and can concentrate pathogenic bacteria that may be present in the surrounding waters. Fraiser et al (1984) have reported the incidence of *Salmonella* in clams and oysters in Florida. Deapola et al (1983) have reported the occurrence of various strains of *Vibrio cholerae* in shell fish, sediments and water along the US Gulf coast. Though information on the qualitative and quantitative aspects of bacterial flora is available on fish and also offshore waters, data in respect of shell fish in the tropical seas are scanty. Durairaj et al (1983) have studied the bacteria flora of edible oysters of Tuticorin waters during the year 1982-83. The present paper deals with the bacterial flora of the mussel samples collected from Vizhinjam. Attempts were also made to purify the mussels employing different purification methods.

MATERIAL AND METHODS

Fresh brown mussels *(P. indica)* were collected at regular intervals from Central Marine Fisheries Research Institute from the natural bed which exist in the vicinity of Vizhinjam Bay. Seawater samples were also collected on few occasions. The samples were collected in sterile containers and brought to Tuticorin in live condition.

A sample of 2 to 5 mussels were used for preparing mussel fluid which was prepared by blending with equal amount by weight of mussel with equal volume of sterile 0.85% saline solution and used as dilution for plating purpose. Plate count of the mussel liquid and seawater samples were determined by preparing duplicate plates, tryptone Glucose Yeast extract agar. The plates were incubated at 37°C for 48 h (Presnell and Kelly 1961) and APHA (1976). Ec broth with incubation at 44.5°C and Eosin Methulene Blue Agar were used for the enumeration of faecal coliforms (APHA 1976) and for *E. coli* Tergital 7 Agar were used. For enumeration of coagulase + Ve staphylococci Baird parker agar and for faecal streptococci KF Agar were employed. For the enumeration of *Salmonella*, Brilliant Green agar, Bismuth sulphite agar and Triple sugar Iron Agar were used. During the period under report farmwater samples, and natural bed seawater were collected along with the mussel samples. The hydrological parameters of the seawater samples such as dissolved oxygen, salinity, pH were estimated on the spot according to the standard methods of water analysis (AOAC 1970).

The mussel samples were subjected to purification by employing different purification techniques. Various authors have described diffferent purification methods for shell fishes. Eyles and Davy (1984) have described purification methods for commercial depuration of shell fish. The purification plant was of the recirculating type employing UV light for sterilisation. Balachandran et al (1984) suggested the method of chlorination upto 5 ppm at the end of depuration to improve the bacterial quality of shellfishes. They have suggested the depuration of mussels in seawater for a period of 16-18 h. Ray (1984) has suggested a depuration period of 36 to 48 h for purification of oysters. Three methods were followed during the recent study. The mussel samples were thoroughly washed and allowed to remain in filtered seawater for 24 hours with change of water once in 12 h. The mussel samples were kept for 24 h and 48 h in filtered and aerated seawater with the change of water once in 12 h. (3) In the 3rd method the depurated samples were kept in filtered seawater and chlorinated at 2, 2.5 and 3ppm for 3 h and then taken out and thoroughly washed and examined for bacterial quality.

TABLE 1. *Bacteriological studies of mussels and farm water collected from Central Marine Fisheries Research Institute farm at Vizhinjam*

Date	*Farm Mussels*		*Farm Seawater*		
	TBC/g	*Faecal coli/100g*	*TBC/ml*	*Faecal coliform/100ml*	
1. 23.6.83	23X 10_3	12	14.8X 10_3	6	
2. 26.7.83	32.25 X 10_3	14	14.0X 10^2	8	
3. 25.8.83	12.25 X 10^2	Nil	6.5X 10^2	Nil	
4. 27.9.83	9.55 X 10^3	16	9.4X 10^2	12	
5. 25.10.83	11.56 X 10^2	12	3.75 X 10^2	6	
6. 15.11.83	11.56 X 10^2	12	4.4 X 10^2	8	
7. 21.5.84	16 X 10^2	Nil	3 X 10^2	Nil	
8. 20.7.84	12.4 X 10^2	Nil	4.2 X 10^2	Nil	
9. 17.8.84	14.5 X 10^2	Nil	3.4 X 10^2	Nil	
10. 26.10.84	0.5 X 10^3	Nil	11.8 X 10_2	Nil	
11. 29.11.84	2.7 X 10^3	Nil	2.9 X 10^2	Nil	
12. 23.1.85	1.6 X 10^3	Nil	3.7 X 10^2	Nil	
13. 27.3.85	8.7 X 10^2	Nil	4.8 X 10^2	Nil	
14. 25.4.85	9.4 X 10^2	7	4.4 X 10^2	6	[Natural bed Mussel & seawater)
15. 26.6.85	8.0 X 10^2	14	3.2 X 10^2	8	,,

RESULTS AND DISCUSSION

Bacterial flora of mussels and seawater samples

Table 1 indicates that the total viable count of the mussels ranged from 8.51 X 10^2 to 32.25 X 10^3/ and the TBC of the farm water ranged from 2.9 X 10^2 to 14.8 X 10^3/ml. The TBC of the natural bed mussels ranged from 8.0 X 10^2 to 9.4 X 10^2/ g and the TBC of the natural bed mussels ranged from 8.0 X 10^2 to 9.4 X 10^2/ g and the TBC of the farm water ranged from 3.2 X 10^2 to 4.4 X 10^2 /ml. The TBC of the surrounding seawater was consistently lower than the corresponding counts of the mussels. This is in agreement with the findings of Durairaj et al (1983). The TBC of the seawater and natural bed mussels was found to be lower than that of the farm mussels. This may be due to the obvious reason that the Vizhinjam bay is sujected to sewage and domestic pollution This is in agreement with the findings of Thangappan Pillai (1980).

The faecal coliforms in the farm mussel samples and farm seawater sample ranged from nil to 16/100/g and nil to 12/100/cc respectively. The faecal coliforms in the natural bed mussel and seawater ranged from 7 to 14/100/g and 6 to 8/100 ml respectively. According to APHA (1970) the permissible limits of coliforms is 230/100 g in depurated oysters. Coliform counts were reported to be maximum under low salinity conditions (Presnell and Kelly 1961) From the observations given in Table 1 it is observed that highest counts of coliform (16 Nos/100 gm) was noticed in mussels during September '83 when lower salinity of 30.9 ppt was recorded. David Hussong et al (1981) has indicated that coliform counts of oysters were found to increase during higher temperature. But no such correlation was observed at Vizhinjam by the authors. The other pathogens like *Salmonella, Streptococci Staphylococci* and *E. coli* were absent in these waters.

Hydrological parameters of seawater samples

The data of the hydrological parameters is given in Table 2. There was no marked fluctuations in pH and other hydrological parameters.

TABLE 2. *Hydrological parameters of seawater samples collected at Vizhinjam*

	Period of study	Temperature °C	Dissolved Oxygen ppl	pH	Salinity ppt
1.	23.6.83	25.2	6.2	8.4	36.9
2.	26.7.83	25.0	5.6	8.3	32.5
3.	25.8.83	23.5	5.2	8.2	33.0
4.	27.9.83	25.0	5.4	8.5	30.9
5.	25.10.83	20.0	5.0	8.3	35.9
6.	15.11.83	28.6	5.2	8.5	35.9
7.	21.5.84	27.6	5.4	8.5	35.9
8.	20.7.84	25.0	4.8	8.1	33.5
9.	17.8.84	25.0	4.6	8.7	33.4
10.	26.10.84	26.0	5.0	8.3	36.5
11.	29.11.84	28.4	5.8	8.5	34.7
12.	23.1.85	28.1	6.0	8.4	35.9
13.	27.3.85	27.0	6.0	8.4	37.0
14.	24.4.85	30.5	4.2	8.4	38.8*
15.	26.6.85	28.0	3.2	8.5	31.0*

* Natural bed seawater samples.

TABLE 3. *Purification studies of mussels collected from Vizhinjam*

Particulars	29.11.84	27.3 85
1. Raw mussel	2.7 X 10^3	8.7 X 10^2
2. Seawater sample	2.9 X 10^2	4.8 A 10^2
3. Filtered sea water	90/ml	85/ml
4. Mussel samples after washing throughly in seawater for 24 h	2.2 X 10^3	7.5 X 10^2
5. Mussel sample after 24 h aeration in filtered seawater	2.4 X 10_2	6.0 X 10^2
6. Mussel sample after 48 h aeration with change of filtered seawater	2.2 X 10^2	6.0 X 10^2
7. The depurated mussel samples after chlorination for 3 h and then thoroughly washed.		
1. 2 ppm	2.4 X 10^2	2.9 X 10^2
2. 2.5 ppm	1.3 X 10^2	2.4 X 10^2
3. 3 ppm	2.0 X 10^2	2.0 X 10^2

Purification of mussels

From the data given in Table 3 it was noted that there was reduction in bacterial load as a result of purification by the methods already described. Mahadevan (1980) has suggested depuration of oysters for 24 h in seawater, and then chlorination with 3 ppm for 1 h for better quality. Balachandran et al (1684) have suggested chlorination upto 5 ppm after the depuration to improve the bacterial quality. Ray (1984) is of the view that chlorination is less attractive when compared with the other forms of purification. The observations recorded by the authors (Table 3) indicate that the bacterial load of the mussels could be brought down effectively, either by washing in the filtered seawater for 24 h (average reduction 14.4%) or by keeping them in aerated seawater for 48 h (average reduction 58.2%). The bacterial quality could be further improved by chlorination at 3 ppm at the end of depuration average reduction 84.5%). As the initial TBC load of the mussels in Vizhinjam is well below the permissible limit, the purification of mussels could be done either by keeping the mussels in filtered aerated seawater upto 48 h with the change of water once in 13 h or by chlorination at 3 ppm level at the end of depuration in filtered, seawater. However the chlorination gives better results. The Chlorinated mussels were thoroughly washed for marketing purpose.

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Session - VI

MARKETING OF MOLLUSCS

87. MARKETING OF MOLLUSCS : INDIGENOUS MARKETING

— Theme Paper

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Marketing is a most important aspect of the exploitation of shellfish resources as it involves selling of the harvested shellfish which determines the income which they can fetch Marketing of molluscs has received the attention of the Government of India and Central Marine Fisheries Research Institute since forties of this century. One of the early publications of the Government of India on fisheries is on the marketing of fish in India which also deals with marketing of molluscan shellfish in the country.

Marketing of molluscs is carried out in India using time old methods. The fishermen who exploit the molluscs sell them to shellfish merchants, who sell them either directly to the consumer or to a retail merchant who finally sell them to the public. Although molluscs are utilized as food only in some places mostly in coastal areas, a large number of others are exploited for a variety of other purposes and therefore these are gathered, processed and marketed.

Marketing of molluscs used for various purposes differ in the spread and pattern of organisation and can be distinguished into those used as food, those used as a source of lime which has manifold uses, those which yield gems, those which are of decorative value or have traditional use and those which are purchased by shell collectors.

MOLLUSCS USED AS FOOD

Clams, mussels and oysters fished from different coastal villages and towns along the east and west coasts are marketed in the same places and as well as neighbouring villages and towns including nearly interior places There is large scale consumption of clams and mussels along the west coast as there is awareness of the value of the shellfish and they are very much relished. The clams marketed are *Meretrix casta M. meretrix, Katelysia opima* and *Villorita* sp. The price of the clams varies in different states. The price of *Meretrix* spp. varies from Rs. 2/- to Rs. 3/- per 10 kg in Kerala, Rs. 5/- to Rs. 7/- in Karnataka and Rs. 6/- at Muthkad, near Madras, Large quantities amounting to 5,000 - 6,000 tonnes of the clam *Katelysia opima* are exploited from Ashtamudi lake and the fishermen extract and boil the clam meat and sell at Rs. 12/- to 15/-per kg to the exporters or their agents. *Villorita cyprinoides* are collected in huge quantities from Vembanad lake and Ashtamudi lake in Kerala and Nethravathi, Gurpur, Udyavara. Swarna and Sita estuaries in Karnataka and marketed. In Kerala the clams are sold shell on at Rs. 2/- per 2 3 kg. In Karnataka the prices Re 1/- to Rs. 1.50 per kg.

In southern Kerala the brown mussel is sold at a number of places like Kovalam, Vizhinjam, Mulloor, Pulinkudi and Chowarah and the price ranges from Rs. 3 - to Rs. 7/- per 100 mussels. During the lean season the price goes up to Rs. 10/- per 100. In Colachel - Muttom area the price varies rrom Rs. 2/- to Rs. 5/- per 100. While the above are the retail prices of clams and mussels the fishermen who exploit the shellfish get much lower price selling them per basket.

Oysters are collected by fishermen and sold at Rs. 5/= to Rs. 6/= per kg in a few places in

Kerala. The Tamil Nadu State Fisheries Department sells oysters from Ennore at Rs 20/= per 100 oysters.

The Integrated Fisheries Project, Cochin has processed meat of oysters cultured by CMFRI at Tuticorin and meat of mussels and clams also, canned them in lime or in smoked form in oil and sold them in several cities of the country. The canned shellfish meat has been very well received and a market could be built up of steady suppliers could be assured by adopting culture practices.

MOLLUSCS USED AS SOURCE OF LIME

Molluscan shells mostly those of clams and to some extent oysters which are subfossil deposits are collected from several areas on the east and west coasts in huge quantities and supplied to calcium carbide, cement or lime companies. The cost of the shells varies in different place places from Rs. 160/= to Rs. 300/= per tonne. Live clams present in the vicinity are also harvested and sold for lime preparation.

MOLLUSCS WHICH YIELD GEMS

The pearl oysters are valuable resources yielding pearls. The pearl oyster resources in the Gulf of Mannar which are under the control of Tamil Nadu Government exploited until 1961 by conducting pearl fisheries. At present, pearls are imported in large quantities annually and marketed. Pearls of golden yellow colour are held in great esteem in India. The pearls are imported via Bombay and sold in the several cities in our country. The price of the pearls depends on the perfection of form, lustre and absence of blemishes.

MOLLUSCS WHICH ARE OF DECORATIVE VALUE OR HAVE TRADITIONAL USES

The shells of a variety of molluscs with beautiful shape and colours like *Turbo marmoratus, Trochus niloticus*, sacred chank *Xancus pyrum*, the five fingered chank *Lambis lambis*, cowries, cone shells, *Hemifusus cochlidium*, *Cassis rufa* and button shells which are collected diving or in fishing nets are cleaned and marketed in pilgrim centres like Rameswaram, Kanyakumari, Dwarka, Banaras and cities like Madras, Bombay and Goa. There is increasing demand for shells as well as shell products like lamp shades, ash trays figures of plants of birds. Some large scale firms and a few hundred small dealers market the shells and shell products offering livelihood to a large number of persons.

MOLLUSCS PURCHASED BY SHELL COLLECTORS

The shell dealers mentioned above deal with shells of a large number of species which amount to a few hundreds for which there is demand from shell collectors mostly in the other countries.

Only very small portion of the 20,000 tonnes of cephalopod production, viz., squids and cuttlefishes are marketed in the coastal parts of our country. The squids and cuttlefish are marketed mostly in fresh condition and small quantities in cured form after drying in sunlight.

AREAS REQUIRING INVESTIGATION

The studies made so far on marketing of molluscs in our country are those which have been carried out along with those on exploitation or fisheries. Marketing surveys have to be given priority to determine the turn-over of shellfishes marketed and study the trends in marketing of molluscan shellfishes in successive years. There is good scope for expanding marketing of the different groups of molluscs and molluscan products if adequate efforts are made. The fishermen who exploit the molluscan shellfish generally are not satisfied with the price which they get. This is partly due to the fact that they have to accept whatever price the shellfish merchants pay. This problem has to be solved and efforts are required to see that the fisherman gets satisfactory price for the shellfish fished.

88. INDIAN BIVALVES AND GASTROPODS: STRATEGIES FOR PRODUCTION AND MARKET DEVELOPMENT

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ABSTRACT

Techno-economically viable bivalve culture systems have been evolved and are under use in several countries. The tremendous potential of cultured shellfish resources to food supply and rural employment is widely claimed. In India, rapid strides have been made on culturing clams, mussels, edible oysters, windowpane oysters and pearl oysters. However, these aquaculture technologies have not been undertaken on commercial lines due to constraints like shortage of seed, lack of demand, lack of awareness about the potential of these resources in alleviating poverty and malnutrition, and in providing employment and increasing income. More importantly, the role and efficiency of various fish marketing systems in India need to be studied before encouraging production on a massive scale. Therefore, identification of constraints to marketing of these cultured shellfish, and evolving and implementing suitable strategies to market them successfully merit the attention of policy makers.

The potential of the cultured shellfish resources in providing cheap animal protein and additional employment, in improving the socio-economic status of the users, in exploiting the fisheries optimally and, in increasing the foreign exchange earnings are discussed in the backdrop of the fish marketing systems in India. The constraints to production and to domestic and export marketing of the cultured shellfish resources are identified and needed strategies are presented. The need to improve the efficiency of the fish marketing systems is emphasised.

INTRODUCTION

Harvesting of unexploited and underexploited fishery resources largely depends on the scope for marketing fish species and fishery products. The potential for domestic as well as export marketing of them has to be explored. Some of the strategies that may be relevant to bivalves and gastropods are presented below.

SCOPE FOR DOMESTIC MARKET DEVELOPMENT

The development of domestic market should be preceded by an assessment of the regularity of or the certainty in the supply of bivalves and gastropods. If the supply cannot be assured marketing development efforts will be a waste of funds and time. Stock assessment surveys to be carried out by fishery biologists, are a must. Publicity and propaganda can be used to prepare the consumers psychologically to buy and consume bivalves and gastropods.

SCOPE FOR EXPORT MARKET DEVELOPMENT

Aquaculture of shell fishes like mussels, clams and pearl oysters offer vast scope for entering into international trade arena. Techno-economically viable mariculture methods have been developed in India. It is interesting to note that efforts have already been taken to culture pearl oysters in Tamil Nadu jointly by the Tamil Nadu Fisheries Development Corporation and the Southern Petro-Chemicals Industries Corporation (SPIC).

a) *Export trade in clams*

Among the molluscan resources of India clams top the list. They are distributed along both the coasts of the country. *Meretrix casta*, *Katelysia opima* and *Villorita cyprinoides* are the three species that mainly support the clam fishery. The clams are fished by hand picking or with slop nets. Clams are exported in three forms : frozen clam meat, canned clam meat and clam meat pickles.

i) *Frozen clam*

The export of frozen clams started during 1981 and since then the export trade has been showing an increasing trend. Japan is the major importing country. The quantity and value of frozen clam meats exported to the foreign markets from the year 1981 to 1984 are given in Table 1.

The export of frozen clam meat, which was 15.6 t rose to 1085.8 t and from a Rs. 0.11 million to 15.3 million in terms of value in just four years. It is expected that the trade will flourish in the coming year also.

ii) *Canned clams*

During the decade, 1975 to 1984, canned clams were exported only to two countries. Oman imported 154 kg worth Rs. 4423 in 1975 aed then, the UAE imported about 10,070 kg worth Rs. 1,85,794 in 1981. Since then this item has not been exported.

iii) *Clam meat pickles*

Clam meat pickles were exported to UAE in 1981 and to Japan in 1982. The UAE imported 1600 kg worth Rs 28,212 and Japan imported 9192 kg worth Rs 61,416. This item has not been exported after 1982.

b) *Export trade in mussels*

The export of canned mussels started in 1975. The exports of canned mussels are given in Table 2.

TABLE 1.

Importing country	1981	1982	1983	1984
		(in kg)		
Japan	15,600 (1,11,340)	3,95,696 (84,42,325)	5,93,754 (73,60,026)	1,07,2383 (1,50,99,902)
Kuwait	—	—	—	13,372 (1,50,930)
Federal Republic of Germany	—	—	12,422 (1,30,228)	—
U. S. A.	—	91 (3,500)	2,446 (117,517)	—
U. A. E.	—	1,643 (32,743)	—	—
Total	15,600 (1,11,340)	3,97,430 (84,78,568)	6,08,622 (76,07,771)	10,85,755 (1,52,50,832)

(Source : MPEDA, Cochin, 1984)
(Figures in parantheses indicate value in Rupees)

TABLE 2

Importing country	1981	1982	1983	1984
Saudi Arabia	—	407 (12,944)	1,526 (48,928)	—
U. A. E.	—	—	—	77 (4,287)
Oman	123 (3165)	—	—	—
Total	123 (3,165)	407 (12,944)	1526 (48,928)	77 (4,287)

(Source : MPEDA, Cochin, Year 1984)
(Figures in parantheses indicate value in rupees)

TABLE 3

Importing country	1981	1982	1983	1984
		(in kg)		
Kuwait	—	10,000 (81,000)	2,00,000 (1,28,376)	3,00,000 (2,30,179)
S. Arabia	200 (12,000)	—	—	3,24,200 (2,09,361)
S. Yeman	—	—	15000 (1,25,949)	—
U. A E.	—	—	2,00,000 (1,13,691)	30,000 21,587
Total	200 (12,000)	10,000 (81,000)	5,50,000 (3,68,016)	6,54,200 (4,61,134)

(Source : MPEDA, Cochin, year 1984)
(Figures in parantheses indicate value in rupees)

c) (i) *Export of oyster*

There has been no effort to culture edible oyster commercially, and/or to export edible oyster. The MPEDA has received enquiries from foreign buyers for importing frozen oyster meat. Concerted efforts to culture edible oysters and to export them would help india earn more foreign exchange.

c) (ii) *Export trade in oyster shell powder*

Oyster shells from oysters fished from wild waters are exported in powder form. The export of this product started in 1981 and since then, the trade has been growing encouragingly. The exports of this item are given in Table 3.

d) *Export trade in ocean pearl*

Pearls from pearl oysters fished from wild habitats were exported for the first time in 1975 About 2080 kg of ocean pearls valued at Rs 5086 were exported to Taiwan in 1975. This item has not been exported after 1975. It is expected that this trade will revive soon since efforts to produce artificial pearls through culture methods are being done in Tamil Nadu and Gujarat.

e) *Export trade in chank meat*

The chank fishery has been well documented and has been in existence in Tamil Nadu, Kerala and Gujarat coasts. The chank shells are used to make bangles which are quite popular in West Bengal, and the chank meat is consumed domestically. The traditional chank divers of Tuticorin, the "parawas", started consuming chank meat since the famine of 1877. The production of full size chank shells was about 14,29,940 shells during 1982-83r Each chank is estimated to yield 20-100 g flesh depending upon the size. Assuming an average yield of 60 g per chank the total chank meat production can be estimated to be 85,796 kg. The meat is sold in measures, each measure weighing 2 kg. One measure of meat is sold from Rs 15/- to 20/- depending upon demand and supply. However, the export price for chank meat is 2-3 US $ per kg (FOB). This means that the export of the estimated 85796.4 kg could earn a foreign exchange between Rs 23,16,520 and 34,74,780. The foreign exchange earning could well increase since the reported production may be inaccurate owing to the fact that the fishery being a monopoly of the State Government in Tamil Nadu, the divers do not bring all the shells collected to the shore. The MPEDA has received enquiries for import of frozen chank meat upto 300 t per annum by Japanese buyers. The chank meat meant for export should be boiled for 4 mts, the shells and guts be removed and and sorted into 20/30 and 30/60 pieces per kg and frozen and packed as 1 kg units in polythene bags. Twelve such bags are packed in one master carton.

The major constraint in developing export trade in chank meat is the monopoly nature of the fishery, as is the case in Tamil Nadu.

Because of this, the divers sell chanks illegally to private parties since they offer higher price than the State Department of Fisheries. Hence, the production figure for chanks are believed to be under estimated.

f) *Export of molluscan shells*

Molluscan shells and corals possess fascinating ornamentation and eye catching designs and colours unparallelled in the living world. The molluscs are popular among the common man as ornaments, currency and as panacea to ward of evil spirits and had tremendous impact on Indian tradition and economy. Besides being used as raw material for many calcium carbonate based industries as well as domestic appliances, they are used in exquisite handicrafts like rings, bangles VIP garlands, eve chains, necklaces, ear rings and studs. They are also used to make household articles like table lamps, bathi stands, and ash-trays. The shells are used as a base for mounting flower pendent for key chains, lockets of jewellery, milk feeder for babies etc and fair sized shells are carried with sceneries and greetings which serve as valuable presents. Further more, the various items of curios made out of these shells include models of antelope, deer, dancing peacocks packing and sea gulls, wading ducks, dancing beauties, replica of big mansions and other dolls and models.

The demand for polished shells and handicrafts thereof, at home and abroad encouraged an entrepreneur to start cottage industry producing beautiful curios and serveral utilitarian objects in Tamil Nadu, chiefly in the Ramanathapuram district. There were about 25 small establishments dealing with these objects in that district in 1976. The export demand for these items are reported to be high, especially from the E.E.C. (Federal Republic of Germany). Efforts should be made to develop this small scale business into an export trade and the MPEDA can take steps in this regard as this would increase our exports and foreign exchange earnings.

CONCLUSION

The constraints to the production and marketing of shell fishes like mussels, oysters, clams etc need to be looked into immediately to provide cheap animal protein and additional employment, to increase production and improve the socio-economic status of the producers, to exploit the fishery optimally and, last but not the least, to increase the foreign exchange earnings.

89. ON THE EXPLOITATION AND MARKETING OF EDIBLE OYSTERS IN GUJARAT

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ABSTRACT

Ediba oyster survey was carried out between Sikka to Veraval, Gujarat, from April-August 1986. Stray population was observed at Sikka. Gagawa creek, Singach creek, Salaya (Beat kada), Salaya (Khanara creek,), Beh Laku point (Peshetra), Arambhada, Gomati creek (Dwarka) etc. and dense population was observed at Harsad (Medha creek) and Navibundar.

Edible oysters are being exploited from Harsad on small scale and are being marketed at Porbundar.

INTRODUCTION

Systematics of edible oysters have been discussed (Awati and Rai 1931). Mention is also made that some species of edible oysters are available at Cutch, Okha, Gulf of Kutch, Dwarka and Peshetra along Gujarat coast (Rao (1974). Correct identity of edible oyster is discussed north of Bombay (Durve 1973).

Few workers from the area have worked on edible oysters on different aspects such as biological, neuresecretory and biochemical (Nimavat, 1978), bionomical (Patel 1979), culture and pollution studies (Dave 1979) and edible oyster resources (Jetani et al 1981), but survey of edible oyster has not been given sufficient importance from the area between Sikka to Veraval except Gagawa, Dwarka (Gomati) and Arambhada. So, as a part of research programme on edible oyster, survey of these are included and discussed below. Gagwa, Arambhad and Dwarka (Gomati Ghat) were resurveyed.

MATERIAL AND METHODS

During low tides of spring tides, surveys were undertaken between Sikka to Veraval by covering the places Sikka, Gagwa, Singach creek, Salaya (Beat kada) Salaya (Khanara creek), Beh, Pindhara, Vasti point - Peshetra, Beyt Dwarka, Arambhada creek, Dwarka (Gomati Ghat), Harshad creek, Navi-bundar Time-Mangrol bara and Meghal.

Length and breadth of edible oyster grounds were measured through 50 m long monofilament thread of 5 mm size. Random samplings were carried out in each area where edible oysters occur by plotting 1 x 1 m wooden quadrate. Then, from the data, probable population of the whole area was estimated.

Besides, eye estimation was made in each site to get approximate population of oysters. Fishermen of the areas were also contacted to get information about availabilit of edible oysters from each area wherever possible.

Samples of oysters from each areas were taken out through hammer and chisel and were brought to laboratory for systematics.

RESULTS AND DISCUSSIONS

Species recorded during survey

(1) *Crassestrea gryphoides* (Schotheim)

Shell oblong, narrow in the anterier margin and borader in the posterior margin. Lower valve laminated, very thick particularly in anterior region below the ligament area. Shell generally curves to the left and in some to the right; upper shell is thin, Inner side of shell is white and glossy. He dentiles on inner shell margin; muscle scar more or less bean-shaped and yellowish white in colour.

(2). *Crassestrea discoidea* (Gould)

Shell large, rounded, ligament area small, upper valve of the same size and shape as to lower valve. Inner surface of valves clear,

white and glossy, no denticles, muscle sear bean-shaped and similar to *gryphoides* in colour.

(3). *Saccostrea cucullata* (Born)

Shell more or less trigonal, generally small, lower valve thick, overlapping at margin, greater portion of the margins of both upper and lower valves denticulated; muscle scar oblong and purple in colour.

Description of grounds and survey details

1. *Sikka*: At Sikka there is no creek and river meeting to the sea. Stray specimens were noticed in G. E. B. pools in which *Crassostrea gryphoides* and *Saccostrea cucullata* were met with. The later species was also found on scattered boulders near G. E. B. pools on intertidal reef flat.

2. *Gagva:* Seasonal river Padanio opens to the sea near Gagva village which results into a creek, known as Gagva creek. On one of the banks, there are salt pans. Also on both the banks there is lush growth of dwarf mangrove s It is a zig-zag creak in which at the turning points or at the junctions of creeklets there are formations of hard rocks on which growth of *Crassostrea gryphoides* was observed. *Crassostrea discoidea* and *Saccostrea cucullata* were also noted in few numbers, the creek was subjected to heavy siltation. Altogether, there were three grounds of edible oysters of small sizes. Population decreased from 2149 to 100.

3. *Singach*: Site of Singach edible oyster ground is located near Pump House No. 1 of Singach Salt Works where river Phulser 2 and Zakhar meet. The edible oyster ground was small with large boulders and burrows under them. It was also subjected to silting. Edible oysters of species *gryphoides* and *cucullata* were spotted here. Down side of creek from the ground is provided with mangroves on both banks. 140 numbers of *glyphoides* were noticed during survey line.

4, *Salaya (Beat Kada)*: It is located in between Goinjvel and Sunosada village on the shore. Edible oyster ground was 150 m in length and 100 m in breadth. *Saccostrea cucullata* was dominant on rockey grounds, made up of large boulders. Mud and sand accumulated on ground bottom. *Crassostrea gryphoides* was also available there, but in fewer numbers.

5. *Salaya (Khanara creek* : It is situated nearby Salaya. The length and breadth of edible oyster ground was 210 m and 60 m respctively. Bottom was rocky as well as sandy. *C. gryphoides* of numbers was observed during survey.

6. *Beh*: Located near Beh village where ground length was 200 m and breadth was 125 m. It was rocky and sandy in nature. 250 numbers of *C. gryphoides* was noticed during survey time. Dead molluscan shells of other species were also noticed.

7. *Pindhara*: In the horse-shoe-shaped area where dwarf mangroves protect the shore line of the area where thick growth of *Saccostrea cucullata* was observed on the dead stumps of mangroves as well on the vital stems of plants. At first instant it was felt that it was *Crassostrea rizophorae*, but after close inspection it was found that they were *Saccostrea cucullata*. Such instance was recorded in East African waters where species has invaded the mangroves habitat and it has been reported to occur in two distinct forms which Stenzel (1971) considers as ecomorphs (Ahmed 1975).

8. *Vasti Point, Poshetra*: Only *Saccostrea cucullata* was dominant. A few specimens of *Crassostrea gryphiodes* were also noted.

9. *Laku Point Poshetra*: In a small area of 400 m x 100 m, 80 numbers of disc oysters, *Crassostrea disceidea* were observed. It was dominant, Point remains submerged and exposed during minus tide.

10. *Beyt Dwarka*: In Beyt Balapur, there is a breakewall near Hanuman dandi. In the vicinity of it, *Saccostrea cucullata* was noticed in live conditions on rocky boulders which were exposed during low tide.

11. *Arambhada creek*: Arambhada creek is located between Arambhada village and Pump House of M/s. Tata Chemicals Ltd., Mithapur. It is transected by an over bridge. In the seaward side or downstream, few specimens of *Crassostrea gryphoides*were seen in 100 m x 50 m. Hornell (1905-1909) visited this place. Population of *gryphoides* depleted from 384 to 100 numbers.

12. *Dwarka (Gomati Ghat)*: In Gomati estuary there is water logging area where on single rocky line substratum, *Crassostrea gryphiodes* were available in 65 m x 60 m. *Crassostrea crystagalli*, cocks comb oyster was also noticed by earlier workers from there. Jetari et al (1981) observed 860 numbers of *gryphoides*, but now it dwindled to 110.

13. *Harshad*: Medha creek is crossed by a bridge-Harshad overbridge, On one side of bridge, Harshad Village is located and on the other side Miyani Village is situated. *C. griphoides* were seen in good numbers on scattered large boulders under bridge side. Area was 831 m x 500 m. From the area, small scale exploitation of edible oysters is being done. The estimated population was 41550.

14. *Navibundar*: Near Navibundar village River Ozat and Bhadar meet together and open to the Arabian sea. Oyster ground is at the meeting of both rivers and measured 1500 m x 200 m. It was rocky and shallow at places. *Crassostrea gryphoides*, as at Harshad was dominant. During winter, fishermen used to exploit about 40,000 oysters from the ground and dispese off their meat at Porbundar market. No exact details of exploitation were available. During survey, good numbers of shells were spotted there.

15. *Time Mangrol bara*: Creek started from Langan bridge and ended at Mangrol Bara. Area was 1200 m x 100 m. Ground was rocky and muddy. *Crassostrea gryphoides* was met with estimated population was 3600

16. *Meghal:* Meghal river meets the Arabian Sea between Chorvad to Holiday Camp. Ground was rocky and sandy covering 500 m x 100 m *Crassostrea gryphoides* was seen and the estimated population was 2000.

A NOTE ON THE EXPLOITATION AND MARKETING

20-25 persons including women belonging to 7-8 Kharva families of Miyani Village go for fishing under Harshad bridge during low tides of high spring tides. Some get few oysters whereas others get more oysters. They remove oysters by hammers and chisels from 5'-6' deep water and bring them to the hard rocks where they shuck meat by breaking shells through hammers and chisels. They put meat in aluminium utensils with sea water (locally known as "Dabari" and through away shells.

Next day early morning 4-5 fishermen with 5-6 "Dabaries" in each 5-6 kg meat, go to Porbunder market by bus for disposal. Local Kharvas and Mohmedans and Harijans are their regular customers. Selling rate of meat is 10 pieces/5 Rs. (10 Rs/kg of meat.

Collection lasts for 3-4 months in winter. During summer small scale exploitation is closed down. However, 38-40 Kharva families when they wish to eat edible oysters exploit 500-700 g meat/family for their consumption.

It was learnt from the fishermen that two years earlier daily 70-80 kgs meat was sent to Porbundar market.

No details on exploitation were available from Navi bundar.

Occasional exploitation of edible oyster was noted from Gagva and Singach. The rate of meat was Rs 15/kg there.

Moreover, at Somnath, M/s. Akbarali Hadakawala of Bhavnagar exploits fossil shells of edible systers for poultry grit. He employes 10-15 labours for this. Every year nearly 2000-3000 t of shell grit are disposed off to Bombay market, interior parts of Gujarat, Madya Pradesh and Maharashtra. Selling rate is Rs. 300/t. No lime industrie is established in Gujarat, as in Andhra Pradesh and Tamil nadu.

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90. EXPLOITATION AND MARKETING OF CHANKS FROM THE GULF OF KUTCH

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ABSTRACT

Chank is an important resource being exploited in the Gulf of Kutch. Chank resources of the area are described with a note on their exploitation and marketing in this paper. Measures to propagate, conserve and utilisation of chank, are suggested.

INTRODUCTION

Gulf of Kutch, an assemblage of different flora and fauna is a biological paradise.

Chank as one faunistic constituent supports important fishery of the area. It stands next to window pane oyster fishery of Gujarat.

Hornell (1916) has dealt with chank in his prestigious report. Thereafter, during 1960, Gokhale has written on shell fisheries of Saurashtra region. Then, Sarvaiya and Chhaya (1983) have included chank fisheries briefly in Saurashtra Molluscs. Nayar and Mahadevan (1973, 1974) and Mahadevan and Nayar (1974) have discussed chank fisheries in general from the area.

In Gulf of Kutch, not much information is available about the ecological conditions of the

chank beds (Mahadevan and Nayar 1974). Besides, no detailed information is available on chank of the area at a stretch from the literature. Moreover, there is change from time to time in mode of payment to fishermen and sizes. It is, therefore, necessary to record these changes to keep records by chank up-to-date of the area.

With this view an attempt is made here to bring all information in a consolidated form.

DISTRIBUTION OF CHANK : AREA OF OCCURRENCE AND DEPTH

Chanks are fished out from southern bank of Gulf of Kutch approximately a distance of 200 Km, stretching between Sachhana to Okha (Fig 1). This is intertidal area of patchy coral reefs, having vast exposure during low tide and high tidal amplitude during high tide. The collection centres and other details are given below:

Collection Centres		Surrender Centres	Controlling Centre	Administrative controlling centre
Sachhana	(C)	Bedi		
Bedi	(C)			
Pirotan	(I)	Sikka		
Movada	(I)			
Sikka	(C)			
Narara	(I)			
Goose	(I)			
Vadinar	(C)	Salaya	Jamnagar———→	Gandhinagar
Bharana	(C)			
Salaya	(C)			
Chusna	(I)			
Baida	(I)			
Nora	(I)			
Ajad	(I)			
Dhabdhaba	(I)	Okha		
Poshetra	(C)			
Gujar	(C)			
Laku	(C)			
Dona	(I)			
Beria	(I)			
Mangunda	(I)			
Savaj	(I)			
Paga	(I)			
Arambhada	(C)			
Beyt Balapur	(I)			
Okha	(C)			

It may not be out of place to record that chanks are found only in the vicinity of seaward rims of patchy coral reefs. Rest of the portion of vast intertidal areas are devoid of chanks. The depth of water at which the chanks occur is 4 - 6 m.

VARIETY OF CHANK FISHED OUT COMMERCIALLY

Xancus pyrum var. *acuta* is fished out commercially in Gulf of Kutch. No other species of chank is available.

This is comparatively narrow, moderately elongate elegant form with well-balanced spire. Breadth in length comes to 1.75 to 2. Shoulder rounded and low, profile of whorls in spine convex.

Male is having raising crest alongwith shell at the opening in the case of dextral form whereas in the case of female it is not.

COMMUNITIES INVOLVED

Local communities such as Sindhis, Varghers, Meghwars and Koli are involved in chank collection.

Fishing season

Chank collection season lasts from September to May with a peak period during December-January (Sarvaiya and Chhya, 1983). At and around Sikka, chank season is March-June. Thus, they are fished out throughout the year. The fishermen prefer to fish in low tide of spring tide.

Fishing craft

To approach islands for chank collection, fishermen ply their fishing crafts locally known as "Machhavas". They are plankbuilt, non-mechanised sailing boats, The overall length ranges from 6 m to 8.5 m and breadth from 1.70 m to 2.40 m. The draft of these boats are 0.6-1.2 m

Fishing gear

As a matter of fact there is no special gear to catch chanks. However, fishermen dump their catch in a bag type structure locally known as "Gumbha" for easy transport from fishing grounds to crafts and from crafts to fisheries offices etc. The size of *Gumbha* is approximately 0.6-0.75 m in length and 0.75-1.00 m in width with a mesh size of 7.5-10.00 cm.

FISHING METHODS

There are two methods for chank collection.

(1) *Hand picking*

During maximum exposure of spring tide fishermen go to chank beds by wading through. They collect chank by their hands by bending themselves anteriorly from the seawards side, They dump their catches in "Gumbha". Along with chank, they collect other food items, locally known as *Selvi* such as *Serranas* sp, *'Sarvan'*, *Octopus* sp, *'Kurchal'*, Crob etc.

(2) *Skin-diving*

During *'Gopping'*, fishermen wade in 1.2-1.5 m deep water of seaward side of patchy fringe reefs. They feel the chanks by the touch of toes and if it is there, then, they dive and pick them by their hands. Then, they dump in a bag. After collection of chanks, fishermen have to surrender them to concerned Fisheries Offices.

FISHERY VALUE

Chank fishery is a state monopoly, hence chanks are purchased by Supdt. of Fisheries, Dept. of Fisheries, Govt. of Gujarat, Jamnagar. The rate is fixed by Govt. of Gujarat. The price paid, in past and present, to fishermen are given in the following tables.

Category	Size		Price / chank (Rs.)	
	Up to 1978-79	From 1979-80 onwards	Up to	From 1979-80 onwards
Big	9 cm dia and above	10 cm dia and above	4.00	6.00
Medium	Between 6-9 cm dia	Between 8-10 cm dia	3.50	5.00
Small	Less than 6 cm dia	Between 6-8 cm dia	2.50	4.00
Worm eaten	Worm eaten	Not less than 6 cm dia	0.80	1.50

Period	No. of chank supplied	Name of party to whom supplied	Revenue realised (Rs.)
May 74-May 75	11363	Gujarat Agro Machine products Ltd , Ahmedabad	40722.11
Jun 75 to Jul 76	8203	Madhusudan Creasent Enterprises, Calcutta on behalf of Gujarat Agro Marine Products Ltd., Ahmedabad	31607.84
Aug 76 to Jul 79	13476	Gujarat Agro Marine Products Ltd., Ahmedabad	74024.50
Sep 81 to Nov 83	21358	Gujarat Fisheries Development Corporation, Ahmedabad	143718 37

TABLE-1. *Showing gross exploitation of chanks, expenditure, income etc.*

Year	Quality of chank					Expenditure		Income
	Big	Medium	Small	Worm eaten	Total	Purchase price	Bonus + Misc.	realised (Rs)
1952-53	—	—	—	—	14058	—	—	—
1953-54	—	—	—	—	16752	—	—	—
1954-55	—	—	—	—	14419	—	—	13200.00
1955-56	—	—	—	—	11628	—	—	9324.00
1956-57	—	—	—	—	10002	—	—	11132.80
1957-58	—	—	—	—	10601	—	—	—
1958-59	—	—	—	—	15580	—	—	34837.40
1959-60	—	—	—	—	23037	—	—	48492.08
1960-61	—	—	—	—	16079	—	—	—
1961-62	—	—	—	—	19373	—	—	57773.92
1962-63	—	—	—	—	18123	—	—	60536.00
1963-64	—	—	—	—	25655	—	—	60536.00
1964-65	—	—	—	—	24752	—	—	73177.31
1965-66	—	—	—	—	13688	—	—	45426.08
1966-67	—	—	—	—	12161	—	—	44927.75
1967-68	—	—	—	—	17198	—	—	68739.15
1968-69	—	—	—	—	12589	—	—	21945.99
1969-70	—	—	—	—	14247	—	—	71566.75
1970-71	—	—	—	—	13529	—	—	78791.77
1971-72	—	—	—	—	16165	—	—	—
1972-73	—	—	—	—	17462	—	—	—
1973-74	—	—	—	—	13491	—	—	15000.00
1974-75	—	—	—	—	6765	—	—	—
1975-76	1188	6654	192	2382	10416	11884.50	755.50	40722.11
1976-77	1022	6024	638	1633	9317	10390.50	765.00	31607.84
1977-78	318	1999	22	1357	3696	3813.25	15.25	—
1978-79	1002	4702	194	1372	7270	8567.50	437.00	—
1679-80	465	2126	157	1761	4509	4468.00	841.25	74024.50
1980-81	340	2555	1258	1948	6101	12167.00	—	127544.24
1981-82	261	1372	5545	3150	10328	21000.00	—	—
1982-83	385	6289	239	3994	10907	30000.00	—	—
1983-84	534	9272	303	4251	14360	50000.00	—	143718.37
1984-85	271	10730	191	9707	20899	62000.00	720.50	—
1985-86	64	3910	141	3478	7593	22000.00	120.00	—

— Not available

? Figures differing

In addition to these, Rs. 10 bonus is given to these fishermen who bring 100 chanks in a single tide.

No price for chank flesh is given to fishermen. Normally fishermen take out flesh by boiling chank in hot water and use as food For operculum also, no price is given to fishermen.

To decide sizes of various chanks, sub-offices of Supdt. of Fisheries at Bedi, Sikka, Salaya and Okha are provided with iron structures, made up of iron plates (locally known as *"Furmo"*)

EXPLOITATION OF CHANKS

Exploitation and other details are in Table 1. The actual production varied in numbers between 6101 to 25655; this is a miner fishery with fluctuations.

MARKETING OF CHANK

Marketing of chanks is done by Fisheries Dept., Govt. of Gujarat. They are marketed to different parties through Gujarat Fisheries Development Corporation, Ahmedabad.

MEASURES PROPOSED TO CONSERVE, MANAGE AND UTILISATION OF CHANK

The following measures are proposed to conserve, manage and utilisation of chank fishery:

1. Egg capsules of chanks may not be disturbed by the collecters. This may be taught to fishermen through Supdt. of Fisheries, Jamnagar.

2. It may be forbidden to pick up small/under sized chanks.

3. Illegal fishing of chank may be stopped by patrolling fish landing centre, ports as well as other coastal areas. Strict inspection may be executed at centres near Dwarka and Beyt Dwarka to stop illegal activities.

4. Fisheries Act may be put into action.

5. To propagate chanks, chank hatchery may be organised in the field area where basic facilities are available.

6 Better utilisation of chank flesh and operculum may be taught to fishermen.

7. Exploitation of chank may be taken into state fish landing account.

8. Money may be kept ready in time to different sub-offices to purchase chanks as much as possible.

9. Fishermen may be given higher prices in term of price like in market.

10. Survey to be conducted in adjoining deep waters to locate chank resources.

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