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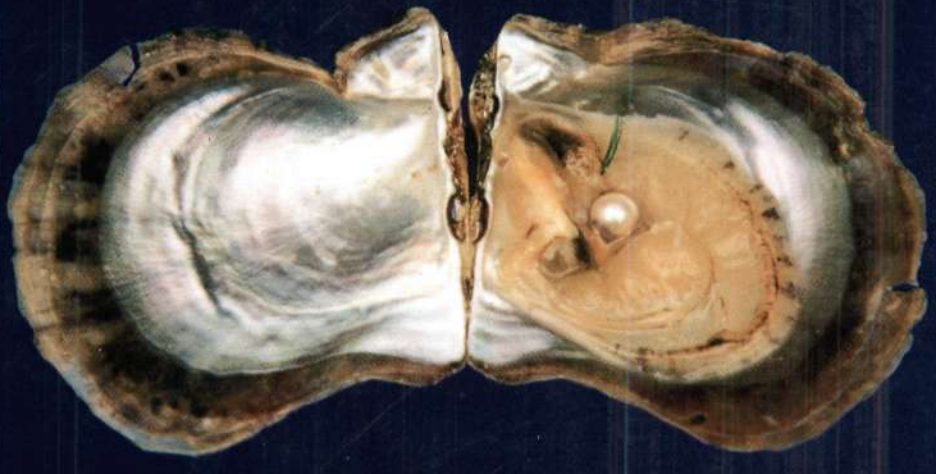
# MANUAL ON PEARL OYSTER SEED PRODUCTION, FARMING AND PEARL CULTURE



CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
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# MANUAL ON PEARL OYSTER SEED PRODUCTION, FARMING AND PEARL CULTURE

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*Front Cover* : Pearl Oyster with a cultured pearl

*Back Cover* : Pearl culture racks in shallow water

## PREFACE

The Central Marine Fisheries Research Institute has developed expertise on various marine fisheries and mariculture technologies over the past several years. Based on this expertise the Institute has been offering regular training courses to officials from State Governments, Universities, ICAR Institutes, Krishi Vigyan Kendras, training institutions, industry and progressive farmers on subjects like marine prawn hatchery, prawn farming, pearl oyster hatchery, pearl oyster culture, pearl culture, edible oyster hatchery, edible oyster farming, seaweed culture and utilisation, SCUBA diving, estimation of marine fish production and stock assessment. The Trainers' Training Centre (TTC) of the CMFRI, Cochin, established in the year 1983, has so far conducted 83 such trainings for 590 personnel from the various maritime states including Pondicherry, Lakshadweep and the Andaman & Nicobar Islands.

The Tuticorin Research Centre of CMFRI is recognised as a lead centre for imparting training in molluscan mariculture technologies, especially in respect of the edible oyster, pearl oyster, clams and sea cucumbers for technicians in the country and from abroad. Various training packages extending from one to six months are available depending on the requirements of the participants. While extensive training courses are meant for expert technicians, short-term programmes for a period of two weeks covering specific aspects of pearl culture are available for fishermen and farmers. This Centre has been recognised for training technicians from the Southeast Asian Countries on Pearl culture by the Network of Aquaculture Centre of Asia (NACA). In collaboration with the FAO-UNDP Regional Seafarming Development and Demonstration Projects, Bangkok, the Centre had conducted a training on Pearl oyster farming and Pearl culture during February 1991. 26 technicians from 10 Southeast Asian countries participated in the training. The SEAFDEC, Philippines and the Fisheries Department of Indonesia are also making use of the Tuticorin facility for training their candidates.

Considering the requirements of the trained technicans and other users, we propose to bring out a series of manuals for all the major mariculture programmes. The manual on Pearl culture technology is the first in this series. It provides a comprehensive account of the state - of the - art of pearl culture technology. I take this opportunity to congratulate the contributors: Dr. A.C.C. Victor, Sri. A. Chellam and Sri. S. Dharmaraj for compiling this useful manual on Pearl culture. I am thankful to Dr. K.A. Narasimham, Head, Molluscan Fisheries Division and Sri. R. Marichamy, the Officer-in-Charge of the Tuticorin Research Centre for their active interest and co-operation in preparing this manual and for all the arrangements for conducting the

training successfully. I record my appreciation to Dr. V.K. Pillai, Senior Scientist and Officer-in-Charge, Trainers' Training Centre for taking up the important task of bringing out this manual in time under the banner of the Trainers' Training Centre. I wish them all success in the future programmes of the Centre.

Cochin - 14 **M. DEVARAJ**

1-12-1995 Director

# MANUAL ON PEARL OYSTER SEED PRODUCTION, FARMING AND PEARL CULTURE

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# 1

## DISTRIBUTION OF PEARL OYSTERS

### World distribution

The pearl oysters belong to the genus *Pinctada (Roding)* come under the family Pteriidae. They occur in almost all the seas of the tropical and sub tropical belt. They inhabit the seabottom from low tide level to depths down to 80m. Although 28 species of pearl oysters are reported,only 3 species have been found to produce pearls of gem quality and have commercial value. They are *Pinctada maxima* (Jameson), *P. margaritifera* (Linnaeus) and *P.fucata* (Gould). The pearl oysters occur in the Persian Gulf (Bahrain,Kuwait,Dubai,Muscat and Bushira), Red sea (Farasan Islands, South of Sabia and Jidda, West of Mecca and Sudan),Philippines, Japan, China, Korea, Myanmar, Indonesia, Papua New Guinea, French Polynesia, Cook Islands, Australia, Gulf of California, Mexico, Panama and Venezuela.

### Distribution in Indian waters

In Indian waters, they occur in 6 regions namely the Gulf of Mannar, Palk Bay, off Trivandrum, the Andaman and Lakshadweep Islands, and the Gulf of Kutch. Of these, the Gulf of Mannar and Gulf of Kutch are the most productive regions where pearl oysters occur in large numbers.Six species of pearl oysters occur in Indian waters. They are *Pinctada fucata* (Gould), *P.margaritifera* (Linnaeus), *P.chemnitzii* (Philippi), *P.sugillata* (Reeve), *P.anomioides* (Reeve) and *P.atropurpurea* (Dunker). Of these, *P.fucata* occurs extensively in the beds of Gulf of Mannar and to a less extent in the Gulf of Kutch. These two regions had contributed to the pearl fisheries in the past. The black-lip pearl oyster *P.margaritifera,* occurs in stray numbers in some pockets of Andaman and Nicobar Islands. Here they are fished more for the shells than for their pearls. In the Palk Bay, *P.chemnitzii* are found on coarse sandy-mud bottom. In Lakshadweep, settlement of spat of *P.anomioides* has been observed on the ridges of the rocks and corals in some islands. In the south-west coast of India, at Vizhinjam,the spat of *P.fucata* were collected from mussel culture ropes.

# 2

## MORPHOLOGY AND ANATOMY

### Shell - external features

The shells of the pearl oyster *Pinctada fucata* are usually reddish brown in colour but in some cases exhibit different colours. Externally 6-8 radial reddish brown bands emerge from umbo towards the free margin of the shell. There is a fairly long hinge line. Elongated ridge-like teeth are present at the anterior and posterior ends of the ligament. There are two well developed ears, one on the anterior end which is bound by the byssal notch and the other at the posterior end which is relatively large. In live animals, prominant scaly growth processes can be seen at the distal border. (Fig. 1)

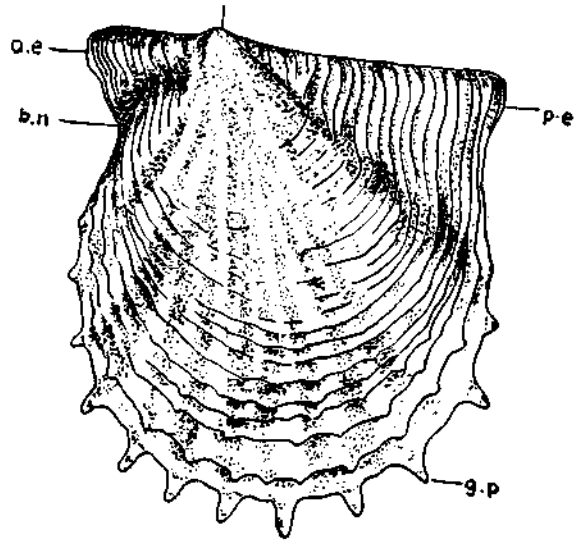
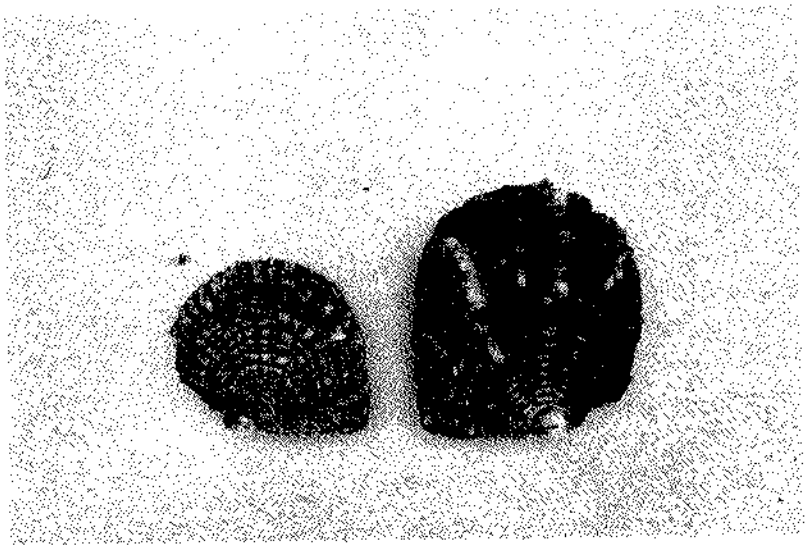



Fig. 1. External features of shell of pearl oyster *Pinctada fucata* ae-anterior ear, bn-byssal notch, pe-posterior ear, gp-growth process.

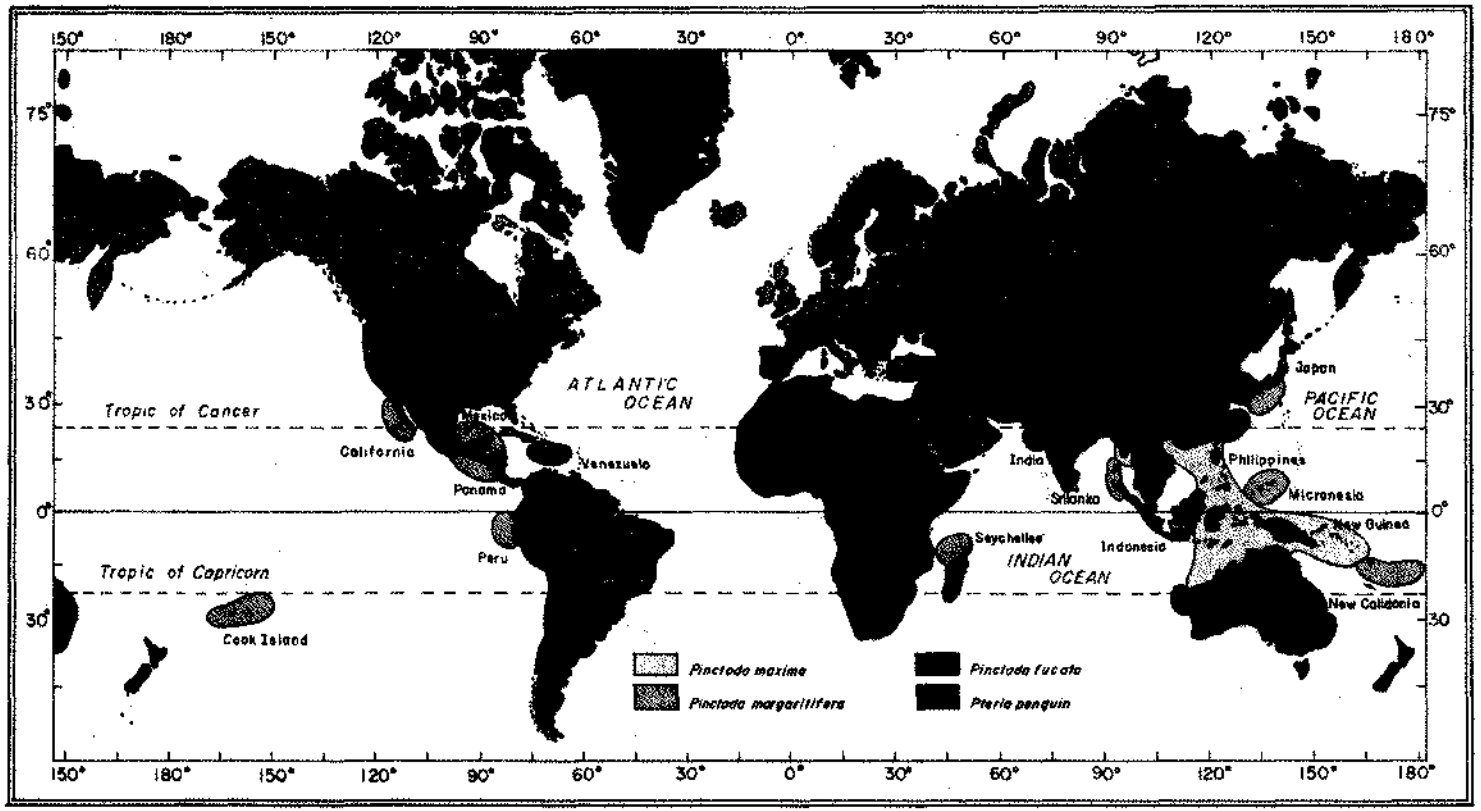
### Shell - internal features

The two valves are not identical. The left one is deeper and more convex than the right one. The nacreous portion of the shell has bright metallic lustre. The border of the shell has no nacreous layers and it has brownish reddish patches corresponding to the external radial markings. The adductor scar is elongated and sub central. There are 12-15 small

The Indian pearl oyster *Pinctada fucata.*



The black lip pearl oyster *Pinctada margaritifera*




Geographical distribution of pearl oysters

scars present between the umbo and the antero-ventral border of the shell for the attachment of pallial muscles.

**Shell structure**

The shell of pearl oyster is made up of 3 layers. The very thin outer layer is the organic conchiolin layer or periostracum. The middle prismatic layer is composed of several layers of calcite crystals of calcium carbonate arranged vertical to the surface of the shell. The calcite crystals are cemented to one another by a thin layer of conchiolin. The innermost nacreous or mother-of-pearl layer is composed of numerous fine lamellae of aragonite crystals. It is transparent under microscope having fine granular appearance in surface view.

**Anatomy**

The soft body of the pearl oyster can be divided into mantle lobes,visceral mass, gills, foot, adductor muscle and other musculature.

**Mantle**

The mantle envelopes all the other soft parts of the body. The free edge of the mantle lobe is thick, pigmented and fringed with branched tentacles. The pallial edge of the mantle is attached to the shell, a little away from the margin. Each pallial lobe may be divided into three parts, the central, distal or muscular and marginal mantle. (Fig. 2).

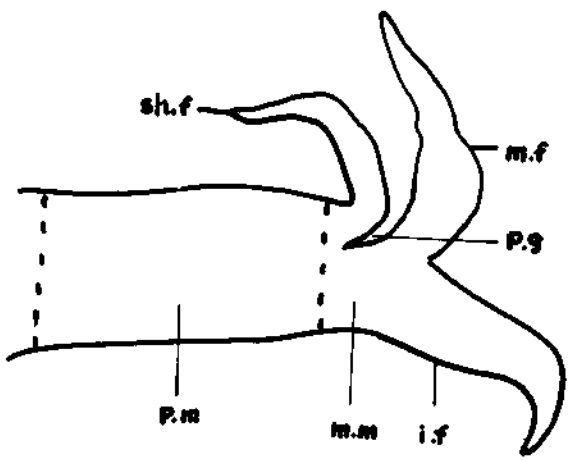



Fig. 2. Diagrammatic transverse section of mantle of pearl oyster. i. f-inner fold, m. f-middle fold, m.m-marginal mantle, p.g-periostracal groove, p.m-pallial mantle, sh.f-shell fold.

**Foot**

The pearl oyster can move with the help of the foot. It is a tongue-shaped organ capable of contraction and elongation. The major part of the foot is composed of a network of fibres running in various directions, thus ensuring a wide range of movement.

**Byssal gland**

The byssal gland organ is located ventrally at the proximal end of the foot. The byssal gland lodges the common root of a bundle of stout, laterally compressed bronze-green fibres, the byssal threads. Each fibre of the byssus anchors the pearl oysters to rocks and other objects by means of a discoid attachment at the distal extremity. The anterior edge of the mouth of the byssal gland passes into the pedal groove extending along the whole of the remaining length of the ventral surface of the foot.

**Muscular system**

The largest and the most important muscle of pearl oyster is the posterior adductor muscle. It stretches transversely across the body from valve to valve. This is made up of massive wedge-shaped muscle fibres. The fibre has two distinct regions,one a narrow tendonous strip made up of white glistening fibres forming the posterior border and a broad and massive semitranslucent fibres occupying the remainder of the mass.

**Digestive system**

The digestive system consists of the mouth, oesophagus, stomach, intestine and the rectum. The mouth is a small slit-like opening at the anterior with two labial palps on either side. The mouth leads to a short oesophagus which passes into a thin-walled stomach lined by hard cuticle. The stomach is sorrounded by a mass of sage-green hepatopancreas which acts as liver and or other digestive glands. The crystalline style extends from the stomach to the descending portion of intestine. The intestine starts from the posterior end of the stomach, passes downwards upto the ventral margin of the visceral mass and goes up to the heart region. The intestine is followed by a small rectum which runs to the posterior margin of the adductor muscle and opens out through the anal aperture.

**Respiratory system**

The gills are a paired structure on either side of the visceral mass. The gills consist of four crescent shaped plates, two half gills on either

side which hang down from the roof of the mantle cavity like book leaves. Each gill has a series of ciliated sieves which provide an efficient feeding surface. The functions of the cilia is to create a water current which enters the pallial chamber and passes over and through the branchial lamellae. They serve to purify the blood flowing in the filaments. The rhythmic lashing of cilia causes a water current. The mucus secreted by the gills help to collect the food particles. The food laden mucus sheets are wafted by cilia towards the mouth of pearl oyster.

**Circulatory system**

The circulatory system consists of a heart and a series of arteries. The heart, consisting of a single ventricle and two auricles is enclosed by a pericardium. The auricles receive blood from the body by way of the gills and mantle and pass it to the ventricle. Back flow is prevented by valves. The blood is carried away from the heart by two arteries which distribute purified blood to all parts of the body. The purificiation of blood takes place in the gills and mantle.

**Excretory system**

The excretory system consists of a pair of nephridia and numerous small pericardial glands projecting from the walls of the auricles. The other end of the nephridia open outside. The accessory pericardial glands on the wall of the auricle have excretory function.

**Nervous system**

The nervous system is laterally symmetrical and comprises three pairs of ganglia. They are a cerebral ganglia at the sides of the oesophagus, the pedals joined to form a single ganglion at the base of the foot and a pair of large visceral ganglia lying upon the anterior surface of the adductor with commissures and connectives.

**Reproductive system**

The sexes are separate. Male and female oysters cannot be differentiated through external characters. The reproductive system consists of a pair of gonads. When the oyster is mature it spreads over the intestine and hepatopancreas. The male gonad is pale yellow in colour while the female is deep yellow. The eggs and sperms are released through the paired gonoducts ending in the genital openings, located at the anterior ends of the gills.

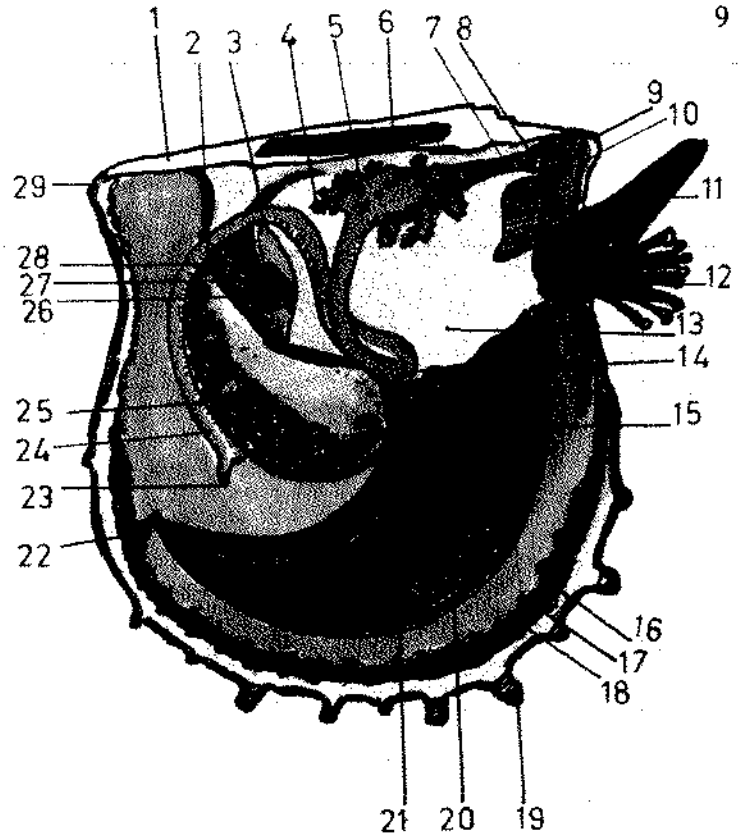
# 3

## BROODSTOCK MAINTENANCE AND CONDITIONING

*Materials* : FRP tanks - Mixed algae - Air conditioned room

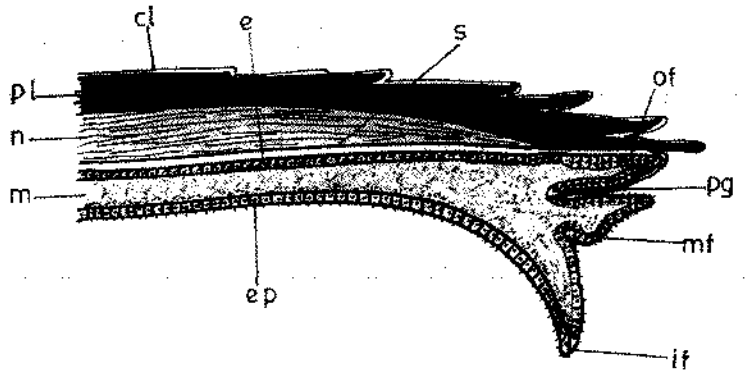
*Activity* : Keeping matured oysters for prolonged period.

Ripe oysters are kept in FRP tank (75 x 50 x 25cm) in 50 l seawater. Adequate aeration is provided. Mixed algae food consisting over 80% of *Chaetoceros* sp. is given to them at the rate of 4 l per oyster per day and maintained in air-conditioned room at 22-25°C. The broodstock is used for spawning as and when required.

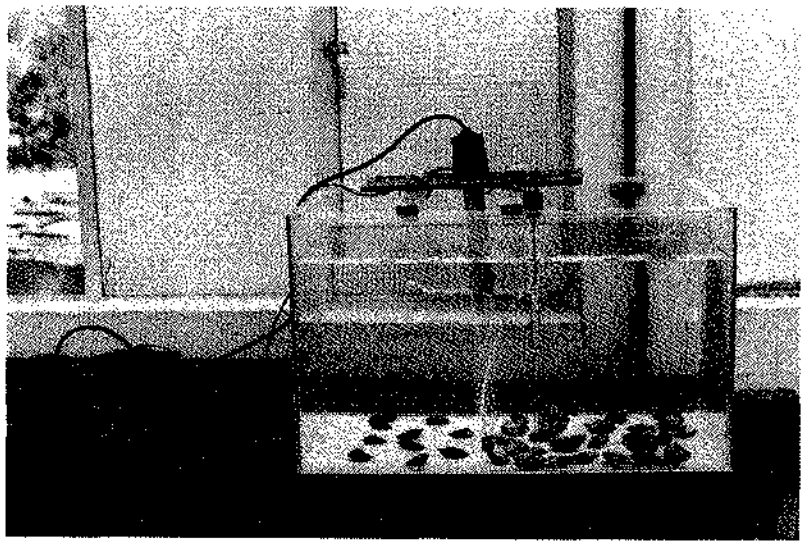



Anatomy of the pearl oyster *Pinctada fucata*

1. Hinge line
2. Posterior aorta
3. Anterior aorta
4. Liver diverticula
5. Stomach
6. Ligament
7. Oesophagus
8. Mouth
9. Anterior ear
10. Labial palps
11. Foot
12. Byssus thread
13. Gonad
14. Intestinal loop
15. Muscular ctenidial axis
16. Outer fold of left mantle
17. Middle fold of left mantle
18. Inner fold of left mantle
19. Growth process
20. Left outer ctenidium
21. Left inner ctenidium
22. Pallial fold
23. Anal process
24. Rectum
25. Adductor muscle
26. Auricle
27. Pericardial cavity
28. Ventricle
29. Posterior ear




Diagrammatic radial section of shell edge and mantle margin, Cl-Conchiolin layer, Pl-Prismatic layer, n-nacreous layer, s-site of mineralisation, Pg-Periostracum of outer fold, mf-Middle fold, if-Inner fold, oe-Outer epithelium, ie-Inner epithelium.



Spawning tank (with heating element, Jumothermometer etc.)

Inner view of pearl oyster hatchery.

# 4

## OYSTER SPAWNING

*Materials* : Perspex tanks - Jumothermometer - Silica cased immersion heater-Thermostat controller-30 µm nylobolt cloth-Ripe oysters-pH meter-TRIS buffer.

*Activity* : Spawning.

**Natural spawning**

The fully ripe oysters easily spawn when there is slight change in water temperature, water pressure, mechanical stress etc.

**Induced spawning**

**a) Thermal stimulation**

The prespex tank (76 x 46 x 46 cm) is filled with freshly filtered seawater. The silica cased immersion heater and jumothermometer are immersed in water after connecting to the thermostat controller. The required water temperature (35°C) is set in Jumothermometer. A group of ripe oysters (50-100 nos) are released into the tank. Water temperature is gradually increased by heating. When the water temperature reach 35°C,the thermostat controller unit automatically stops further heating the water.

The gradual rise in water temperature induces the ripe oysters to release the gametes into the medium. Usually the males initiate spawning, followed by the females.

**b) Chemical stimulation**

The seawater having 9.0 - 9.5 pH is prepared in a separate glass trough using TRIS buffer solution. Normal seawater with pH 8.0-8.2 is kept as control. Ripe oysters are released into the troughs. Oysters usually spawn in pH 9.0 in about 1-2h.

NaoH solution can also be used in lieu of TRIS buffer. In NaoH buffer solution higher percentage of spawning occurs in pH 9.5.

# 5

## EARLY EMBRYONIC AND LARVAL DEVELOPMENT

*Materials* : 30 µm nylobolt cloth - Siphon-Droppers-Cavity blocks

*Activity* : To monitor and rear the larvae.

When the oysters commence spawning either by natural or by other stimulations, they are allowed to spawn freely. After ensuring that enough eggs and sperms are released,the oysters are removed from the tank (Fig 3 A ).

As soon as the sperms and eggs are released into the water medium, fertilisation takes place. The fertilised eggs settle down (Fig 3 B ). The supernatent water is carefully siphoned out leaving the eggs undisturbed at the bottom. These fertilised eggs are collected in 30 µm seive and released into freshly filtered seawater in FRP tanks of 1 ton capacity containing 750 l of seawater.

The cell division begins within 45 minutes after fertilisation. At 2 celled stage, a micromere and a macromere are present Macromere does not take part in the further cell divisions whereas micromere divides repeatedly resulting into 4, 8, 16, 32 and 64 celled stages. A morula stage is reached after completion of the cell divisions. Each micromere in the morula develops a cilium. The morula swims and congregates at the surface. It exhibits phototrophism. By the reorientation of the cells, a blastocoel and a blastopore are formed. The stage is called blastula. This is reached 5hrs after fertilisation.

Gastrulation takes place. The cells convolute in and form dermal layers. Archenteron is formed. The gastrula stage is reached 7hrs after fertilisation.

Gastrula transforms into trochophore by developing a long single flagellum and preoral tuft of cilia at the apical side and post-oral tuft of cilia at the rear side (Fig. 3 C ).The larvae swim with flagellum. The ectodermal cells secrete embryonic shell material (prodissoconch I) and assume a 'D' shape or veliger or straight hinge stage (Fig. 3 D ).

At 'D' shaped stage,the flagellum and tufts of cilia disappear and new locomotory organ called velum is developed. The early embryonic development of the larva is completed by this stage. To reach this stage it takes 20 hrs.

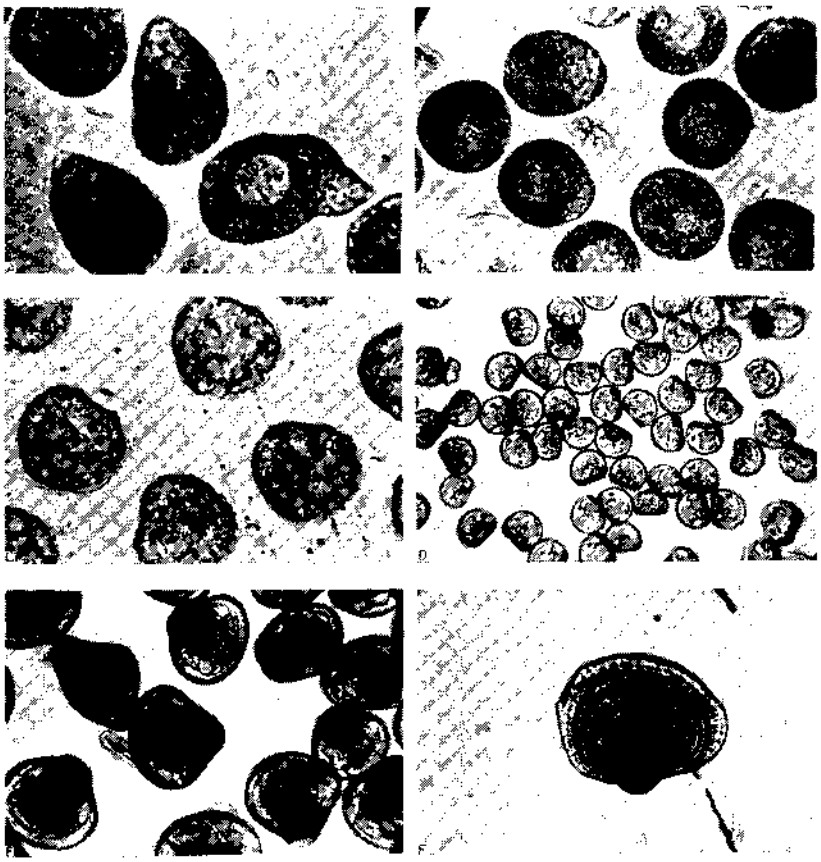
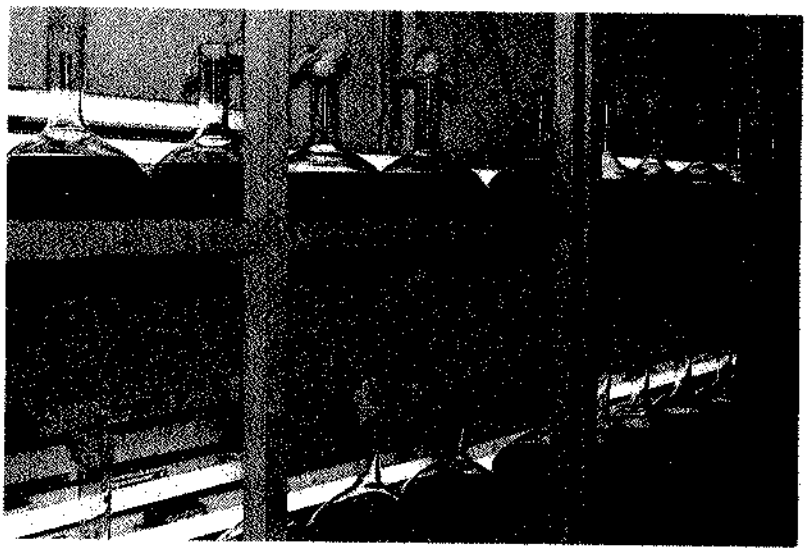


Fig. 3. Developmental stages of *Pinctada fucata* A. Just released eggs, B-Fertilized eggs, C-Trochophore larva, D-Veliger larva, E-Pediveliger larva, F-Plantigrade.



Live food culture (micro algae)

Raft for farming pearl oysters.

# 6

## LARVAL REARING

*Material :* Seives with meshes of 30 µm to 180 µm - Glass beakers - Flexible hose - Haemocytometer - Microscope - FRP tanks - Lar val counting chamber.

*Activity :* Rearing of larvae

Veliger larvae are collected in 30 µm seive and released in glass beakers (5 l cap). The concentration of larvae per ml is estimated using larval counting chamber. The veliger measures 50-55 µm in dorso-ventral measurment (DVM) and reaches in about 20 hrs after fertilisation. The larvae are stocked at a density of 2 nos per ml in FRP tanks (1 ton cap) holding 500 l of seawater. On day 1 feeding is not required.The rearing tanks are covered with thick black cloth to avoid dust fall and light. No aeration is required.

The micro alga, *Isochrysis galbana* is fed to the larvae on day 2. Water change is done once in two days. 40 µm seive is used for this. Feeding is given at 5000 cells/larva/day. The growth beyond the veliger stage is by the addition of shell material called prodissoconch II.

On day 10 - 12, the veliger reaches umbo stage (130 µm. Feeding is doubled. Shell valves are equal and mantle folds develop. 80 µm seive is used for water change.

On day 15 umbo reaches eye-spot stage (180 µm). An eye-spot is seen at the base of foot bud. Water changed using 100 µm seive.

On day 18, pediveliger stage is reached (190 µm). This is a transitional stage from swimming to crawling and the larvae have both velum and foot (Fig.3 E ). Once the foot becomes functional,the velum disappears. The byssal gland becomes active and secretes byssus threads for attachment. Gill flaments develop. *Isochrysis* is given at 15000 cells/ larva/day.

On day 20, plantigrade stage is reached (200 µm). Rapid shell growth is seen all along the margin except umbo region (Fig.3 F). Labial palps, additional gill filaments and byssus threads develop.Water change is carried by using seive of 140 µm.

On day 24 the plantigrade transforms into a spat (300 µm) with the extension of anterior and posterior ears. The left valve is slightly concave than the right one. *Isochrysis* is fed at the rate of 20,000 cells/spat/ day upto day 30. Water is changed by filtering through 180 µm seive.

# 7

## MICROALGAE PRODUCTION

*Materials* : Haufkin flasks - Fluorescent light - A/C room - chemicals - Perspex tanks.

*Activity* : Production of *Isochrysis galbana* as the larval food.

***1) Stock culture***

Conway medium is used for stock culture of the above alga. Cultures are maintained in 5 l Haufkin flasks. Nutrients are added followed by 10 ml of inoculum and is kept under illumination (1000 lux) in an air-conditioned room. When the exponential growth phase is reached in 8-10 days, the light intensity is reduced to half. The flagellates will enter into stationary phase after 15 days and it can be maintained for about 2 months with or without aeration. Before it enters into death phase, this cultures should be used as inoculum for carrying out mass production.

**Solution A - Chemicals**

| | | |
|---|---|---|
| Potassium nitrate | — | 100 g |
| Sodium orthophosphate | — | 20 g |
| Sodium EDTA | — | 45 g |
| Boric acid | — | 33.4 g |
| Ferric chloride | — | 1.3 g |
| Manganese chloride | — | 0.36 g |
| Distilled water | — | 1000 ml |

**Solution B - Trace metals**

| | | |
|---|---|---|
| Zinc chloride | — | 4.2 g |
| Cobalt chloride | — | 4.0 g |
| Copper sulphate | — | 4.0 g |
| Ammonium molybdate | — | 1.8 g |
| Distilled water | — | 1000 ml |

Acidify with HCl to obtain a clear solution

**Solution C - Vitamins**

| | | |
|---|---|---|
| Vitamin B (Thiamin) | — | 200 mg |
| Vitamin B12 | | |
| (Cynocobalamin) | — | 10 mg |

Each vitamin dissolved separately in 100 ml distilled water and stored in a refrigerator.

Soution A, B and C are prepared in different reagent 1 bottles. 1.0 ml of A, 0.5 ml of B and 0.1 ml of C each are added to 1000 ml of filtered and sterilized seawater.

***2) Mass culture***

Perspex tanks of 100 l capacity are used for mass culture. 2 l inoculum is added per 100 l of seawater. Maximum algal bloom is obtained in 5 to 6 days. Vigorous aeration is provided.

***3) Mixed Algal culture***

Mixed algae are produced in 1 t FRP tanks in the sunlight using filtered seawater drawn from sea. Algae from the indoor mass culture is used as inoculum. The mixed algae in the open may bloom in 3 - 4 days. This may contain a mixture of diatoms along with the *Isochrysis*. Chemicals used for open culture in 1000 l of sea water are given below:

| | | |
|---|---|---|
| Potassium nitrate | ..... | 13.2 g |
| EDTA | ..... | 6.6 g |
| Sod. orthophosphate | ..... | 6.6 g |
| Sod. silicate | ..... | 6.6 g |

## NURSERY REARING OF SPAT

*Materials :* Seives-Mixed algae food.

*Activity :* Rearing of Spat.

The spat are allowed to settle on the sides and bottom of the tank itself. Aeration is provided. Feeding is increased to 30000 cells/spat/day upto day 45. The spat grow faster and reach 1000 µm. Feeding dose is correspondingly increased to 50,000 cells/spat/day upto day 60.

Mixed algae cultured in the open are mixed with *Isochrysis* and given to spat at 50 : 50 ratio. The mixed algae constitute mostly of *Chaetoceros* sp and other diatoms. *Chaetoceros* sp is considered to be a very good food for the spat. The spat reaches 2 - 3 mm size and at this stage *Isochrysis* feeding is stopped and only mixed algae are given. By day 90 the spat reaches 3-5mm and are transferred to farm for further growth.

*Suggestions*

- Running water system for the nursery rearing of spat.
- Avoid light.
- Culling of spat may improve growth rate.

# 9

## PEARL OYSTER FARMING

*Materials* : Pearl oyster-rafts/racks - Onshore tanks - Culture containers.

*Activity* : Rearing of juveniles, mother oysters, nucleated oysters.

Selection of a suitable site for pearl oyster farming is very important. Due consideration should be given for the water inflow, primary productivity of the water, siltation, nature of seabottom etc., to obtain good growth and production of quality pearls. Unusual fluctuations in the salinity and temperature, appearence of red tides, presence of hydrogen sulphide and industrial and domestic pollutants can affect the oysters and pearls. Sheltered bays and calm coastal waters where sufficient depth of water is available are suitable for pearl oyster farming.

### *Rearing methods*

#### *Raft culture*

Culture of oysters from raft is one of the suitable farming methods in sheltered bays. A unit raft of the size 6 x 5m, constructed with logs of teak, lashed with coir rope and floated with 4 buoys of 200 1 capacity is considered to be suitable for Indian conditions. This raft can hold about 100 culture cages. Raft culture can be resorted to when the depth of water is 5m and more.

#### *Rack culture*

If the water depth is less than 5 m, the rack system can be followed. In this,teak poles are driven into the seabottom at intervals of 1m and horizontal poles are lashed with coir ropes above the seawater level. Culture cages are suspended into the water from the horizontal poles. The rack can be extended as per the requirement.

#### *Onshore tank culture*

Large concrete tanks constructed on the shore with the holding capacity ranging from 75 to 150 tons of seawater can also be used for rearing the oysters. The preferred depth of the water is 3 m to get the normal growth in oysters. Under this system, feeding the oysters/juveniles with cultures of phytoplankters is needed.

Different systems like long-line culture and onbottom culture can also be followed according to the condition of the sea, seabottom etc,.

***Rearing containers***

*Culture of juveniles*

Juvenile pearl oysters are reared in net cages. Net cages made of synthetic fabric of velon screen whose sides are stretched in the form of a prism are used for rearing juveniles of the size 3-20 mm. To prevent clogging by silt and other outgrowths, the velon screen net bags are replaced periodically. As the juveniles grow, number of the juveniles in the cages are reduced to obtain fast growth.

*Culture of mother oysters*

Box cages of the size 40 x 40 x 10 cm with synthetic webbing are used for rearing mother oysters. The mesh size is usually 10 mm knot to knot. The frame of the cages are made of 6 mm mild steel rod with lid and painted with coal tar.

To study the performance of individual oysters,frame net cages are used. The cage contains two frames of the size 60 x 40 cm, each having 5 compartments. They are meshed with synthetic twine and hinged at one end. They open as a book. The oysters are arranged in rows and are held in position when the frame is closed.

*Culture of the nucleated oysters*

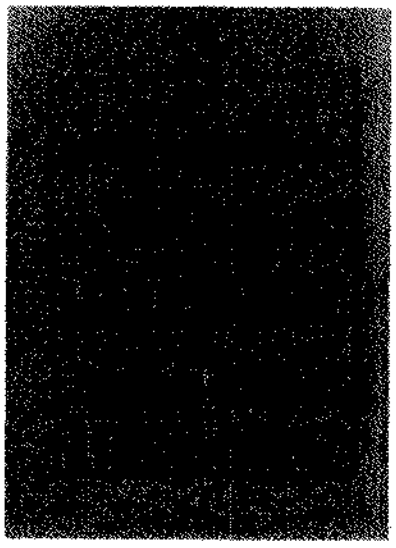
The nucleated/implanted oysters are reared in box cages as in the case of rearing of mother oysters. In the beginning, a velon netting is provided inside the net cage so that the rejected nuclei can be retrieved.

***Biofouling organisms***

In the farming of pearl oysters, biofouling organisms cause major problems. They settle and grow on the shells and cages. Most of the fouling organisms are filter feeders and hence they are the competitors for food. Removal of them is a labour intensive process. Seasonal dominance is exhibited by the fouling organisms and they have to be removed periodically.

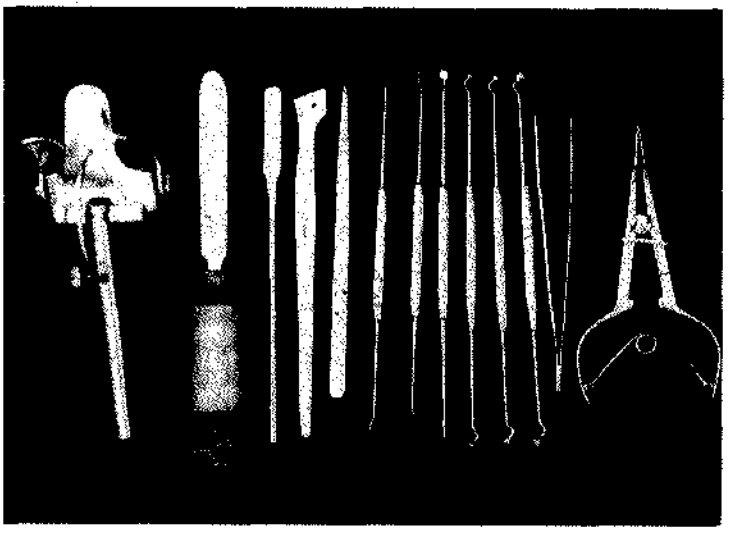
The barnacle *(Balanus amphitrite )* is one of the major fouling organisms. Heavy settlement of this causes physical obstruction to the opening and closing of the valves. They completely cover the entire surface of shell valves, if left uncleaned. The removal of these organisms sometimes, damage the shell margins and result in the recession of the shell growth.

Wooden racks with oyster cages in shallow water farm.



Frame net (book type) cage with pearl oysters.

Juveniles of *Pinctada fucata*.



Surgical instruments used for nucleus implantation.

The ascidians both simple and compound,the bryozoans, the molluscs particularly *Avicula* sp,*Crassostrea* sp and *Modiolus* sp seasonally settle in large numbers and affect the culture of juveniles and mother oysters and the production of cultured pearls. Other minor foulers are sponges, hydroids and algae. In addition anthozoans, tubiculous polychaetes, crabs, polyclad worms and *Pinna* also form the fouling community.

*Boring organisms*

The boring organisms usually riddle through the shells making them weak and friable. These include the polychaetes,sponges, molluscs and isopods. *Polydora* sp causes simple and compound blisters on the inner side of the oyster shells. The sponge borers belong to the species *Cliona* . The infestation is initially at the umbo region and spreads to the surface of the valves. By heavy attack, the shells become extremely fragile and susceptible to further infestation and damage.

*Predator organisms*

Besides the boring and fouling organisms, the predators like *Cymatium, Murex* (mollucs), crabs and the puffer fish are a menace, in damaging the juveniles and mother oysters in the oyster farm.

# 10

## JUVENILE AND MOTHER OYSTER REARING

*Materials :* Juvenile oysters - Mother oysters - Culture containers - Raft/ Rack/Onshore tanks.

*Activity :* Juvenile and mother oyster rearing - maintenance - removal of pests and foulers.

The spat after rearing in the hatchery, for 6-9 weeks will grow to 3-5 mm in dorsovental length. They are suitable for further rearing in the farm. They are put in velon net cages. An additional covering with old fish net is given over the velon screen cage. This will give additional protection against damage by the predators. In the beginning about 10000 spat can be grown in each net cage. Replacement of the velon screen net is done once in 20-25 days to prevent congestion through the settlement of silt and growth of fouling organisms on the net. These nets are sundried and used again. As the spat grow, they have to be thinned out and put in additional net cages. On attaining the thumbnail size of 15-20 mm,they are transferred and reared in box cages with a webbing of 5-10 mm. This box cage can hold about 2000 spat.

Juveniles of the size 20-30 mm are reared in box cages with velon screen netting. The rearing density is 750-1000 per box cage. Further thinning is done when they reach the size of 40-45 mm. The number is also reduced to 250-300 per net cage.

The mother oysters with the size ranging from 45-50 mm are reared in box cages of the size 40 x 40 x 10 cm with the synthetic twine webbing of 10 mm knot to knot. The number of oysters in each cage ranges from 150-200.

***Growth of juvenile oysters***

The pearl oyster is found to attain a model size of 47.0 mm at the end of the first year, 64.5 mm at the end of the second year and 75.0 mm at the end of the third year. The corresponding weights at ages 1 to 3 years are 8.3, 31.6 and 45.4 g respectively. The longevity under farming condition is about 7 years.

# 11

## SURGICAL INSTRUMENTS

These instruments are made for specific use in oyster cutting, graft cutting and trimming, opening and regulating the valves of the shell holding the oyster, cutting and making passage, graft tissue and nucleus insertions. These instruments can be made to specification by any surgical tool manufacturing company.

The instruments used for the graft preparation are:

***Knife***

The knife has a 9 cm long blade and a 11cm long wooden handle. The width of the blade is 1.2 cm at the base and 1.5 cm near the tip. The anterior portion of the blade is slightly curved corresponding to the curve of the oyster shell, so that the blade can be easily inserted between the two shells in closed condition. The blade is made by hand-forging and finished by filling and grinding. The kinfe is used to open the unconditioned oysters by sharply cutting the adductor muscle without touching the mantle lobes.

***Scissors***

A pair of straight surgical scissors of 10 cm length are used for cutting a long and narrow strip of mantle from its edge. The cutting edges are sharp and the tips are finely ground so as to enable quick cutting of a strip before the mantle withdraws under the stimulus of contact.

***Forceps***

The forceps is usually 14 cm long. The two components are filed and ground and are provided with serrations and finely ground points at the tips. The material near the joint is ground to proper size to get required mild tension after due hardness is imparted. It is used to lift the mantle strip from the shell, to hold it while cleaning and trimming and to reverse the strip on the wooden block.

***Spatula***

The spatula is 17.5 cm long, with a round handle of 13 cm length and 1 mm diameter and a blade 4.5 cm in length and 8 cm in

width. The required springiness is given to the blade by grinding and the edges are smoothened out. The spatula is used to remove dirt on the mantle strip and to smoothen the folds on it. It is also used to gently liftback the mantle, labial palps and gills of the oyster during surgery so that the foot and the main body are exposed.

**Scalpel**

The scalpel is flat and 17 cm long, the length of the blade portion being 3.5 cm. The scalpel is produced by forging from bar stock or blanked from sheet metal and the actual size and shape are obtained by filing and grinding. The instrument is then heat treated to get high hardness. The 2 cm broad cutting edge provided at the end has a delicate curve and is smooth and sharp. The scalpel is used for trimming the mantle strip on both edges, to remove unwanted tissue and to sharply cut the tissue into small bits of the required size. It is also used in place of scissors to cut strips from the mantle.

The tools used for the actual operation are :

***Oyster stand***

The stand is used to hold the oyster in a stable position, so that the operator's hands are free to perform the surgery. It consists of two parts, the base and the clamp. The base consists of a wooden board, to which is screwed a metal square plate, 4.5 cm wide. A vertical tube of 15 cm in length and 1 cm inner diameter is welded to the basal plate. The tube has a collar at the top provided with a threaded hole for fixing a bolt to hold the shaft of the clamp tightly in position.

The clamp consists of two plates, the head-plate and a movable jaw. The head-plate is mounted on an adjustable tilting head supported by a shaft. The movable jaw is held against the head-plate by a spring. The front edges of the two plates form short, slightly curved legs, which tend to follow the curve of the oyster shell and prevent lateral movement of the oyster. To the head-plate is fixed a curved rod, which passess through a hole in the shaft. A threaded hole and bolt are provided at this point to fix the rod in position. The plate assembly can be tilted from a vertical to a horizontal position according to the convenience of the operator. For fixing the oyster, the movable jaw is opened by applying finger pressure at the bottom of the plate and after the oyster is placed in position the pressure is released. The jaw holds the oyster firmly against the head-plate. The head-plate has a breadth of 5.3 cm and a height of 7.0 cm. The movable jaw is 5.5 cm

broad and 8.5 cm high.The shaft is 11.5 cm long and its diameter is slightly less. The components are individually made to size and shape and are heat treated to ensure sufficient hardness. They are then assembled to form the oyster stand.

***Shell speculum***

The shell speculum is used to keep the oyster open for the duration of the operation. The instrument is 14.5 cm long and consists of two components, which are made by forging from round bar stock to proper size and shape. Each component has a long straight portion and an arc. The two arms are fitted together by a male-female joint at about 5 cm from the tip. The top of the straight portion is flat and rectangular with rounded corners. The spring between the two arcs keeps the instrument in a closed position normally. A metal collar, which is provided around the straight arms, helps to regulate the distance between the flat ends. A maximum opening of 1.5 cm is obtained between the flat ends with the collar pushed to the bottom. This is about the distance between the two valves of the operable size oyster when the adductor muscle is in a fully relaxed condition under narcotisation. When the oyster partially opens its shells, the flat end of the speculum is inserted between the two valves. By gently closing the two arcs, the flat ends open and along with them the shell valves. When the desired gap is obtained, the collar is slipped down to maintain the gap. The maximum possible opening between the shell valves differs from oyster to oyster.

***Retrtactor/Foot puller***

It is a slender, flat rod 15 cm in length, provided with a sharp bent hook at the tapered end. The retractor is used to hold the foot of the oyster in a stretched position during the operation.

***Lancet-cum-graft lifting needles***

There are three such needles. Each needle consists of an elongated spindle-shaped aluminium handle in the middle (6.5 cm long) with a lancet and a graft lifter, each 5.5 cm long, at the two ends. The lancet is a thin (2mm) stainless steel tapered shank with its tip slightly curved and flattened to form an elliptical blade. The edge of the blade is rendered smooth and sharp. The graft lifter is similar to the lancet, but the tip is provided with a sharp, pointed spur. The lancet is used to make a sharp incision at the base of the oyster foot and to cut a channel through the tissues of the gonad upto the site chosen for nucleus implantation. The spurred tip of the needle is used to pick out the small graft tissue from the wooden block and to insert it into the site of implantation

through the channel. The sizes of the cutting blade of the lancet and the spur are a graded series according to the size of the graft tissue to be lifted. The lancets and graft lifters are made to the desired shape and size by hand forging and finsihed by filing and grinding with abrasive wheels. They are polished to the required extent and fitted to the handle.

***Nucleus-lifting needles***

These are similar in construction to the needles described above, but are provided with hemispherical cups at both ends of the shanks. There are three such needles, each with two cups at the ends. The cups are of different dimensions to enable lifting of nuclei (spherical shell beads) of 2-8 mm diameter range. The cup shoe is initially drawn by hand forging and finished to dimensions by pressing with iron balls of proper size in the cold condition. Then the hemispherical cup is cut to the required size of slightly less than the diameter of the sphere and imparted a vacuum finish. The cup is moistened by dipping in seawater and made to touch the dry surface of the nucleus which immediately adheres to it. The cup end is inserted into the channel through the incision cut on the body of the oyster and the nucleus is placed in contact with the tissue graft. While withdrawning the needle, the nucleus is made to drop from the cup by a slight turn of the needle.

# 12

## SHELL BEAD NUCLEUS

Spherical shell beads are used as nuclei for the production of round cultured pearls. These beads are prepared out of thick shells of freshwater mussels. These mussels, themselves are pearl producing and are available in the River Missisippi and the tributeries of the Tennessee River in U.S.A. The shells of the mussels, pig-toe *(Tritogonia)*, three-ridge *(Pleurobema)* and wash-board *(Megalonais)* are imported into Japan. They are cut, ground, shaped and polished using appropriate machines and tools into spherical balls.

Only molluscan shell material is preferred due to their phylogenic affinity, chemical composition, binding strength and heat resistant properties which are closely similar to the calcite crystalline substance of pearl oyster shell.

Dimensional accuracy, smooth finish and high polish are important factors to get pearls of uniform nacre coating. The preparation of nucleus using the sacred chank *Xancus pyrum* in India did not give satisfactory result. The average micro-hardness of the shells of the chank is found to be 388 kilo pressure per $mm^2$, whereas it is 258 for the imported nigher-head shells and 288 for the giant clam *Tridacna* sp. In future, the giant clam shell may form a substitute to the imported nuclei in India. For the Indian pearl oyster, *Pinctada fucata* nuclei of 2-6 mm can be used for pearl production.

# 13

## SELECTION AND CONDITIONING FOR SURGERY

*Materials* : Oysters - Glass troughs with lid - Menthol - Shell speculum -Wooden pegs.

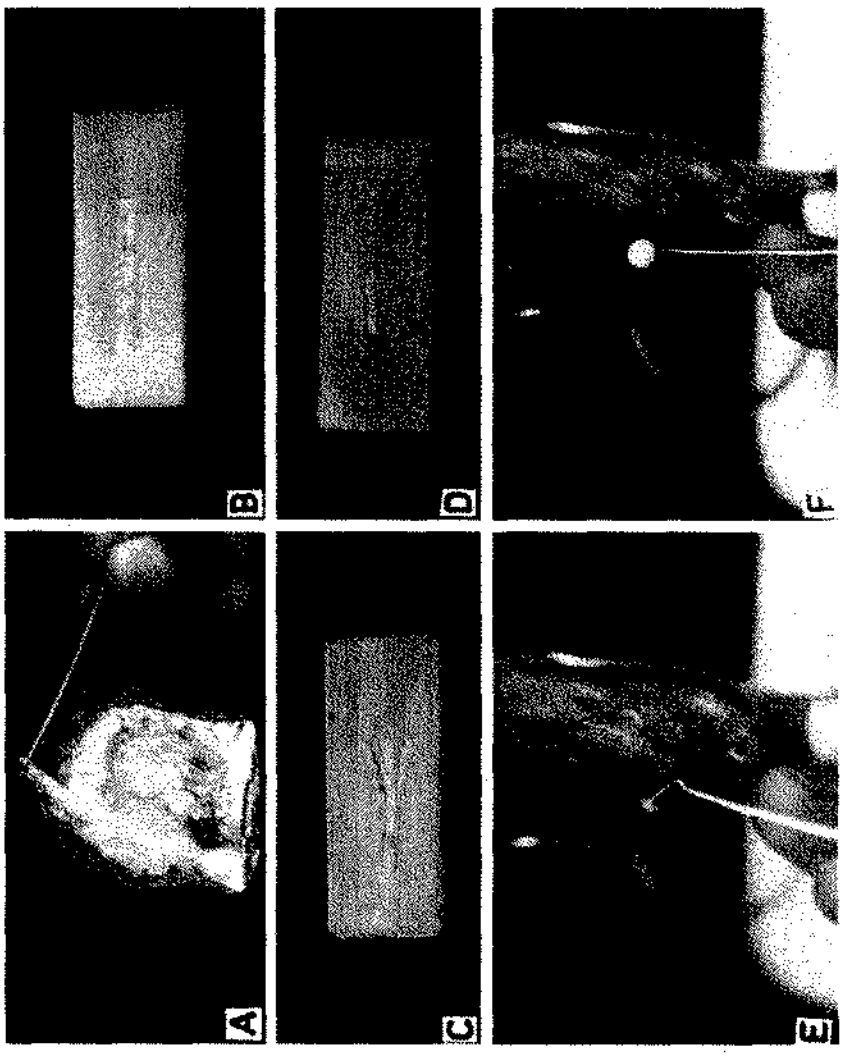
*Activity* : Selection of oysters suitable for surgery-conditioning them.

For surgery, oysters having weights of 20 g and above are used to obtain good result. They must be healthy without infection of borers. Oysters with maturing and matured gonads are not suitable because during surgery, the gametes ooze out and block the visibility of the implantation site. The orientation of the graft tissue and nucleus may not be possible due to the copious flow of the gametes through the passage. Therefore oysters in the post-spawning recovery stage or early phase of gametogenisis should only be selected. Shells should be free from polychaete blisters and sponge borers and the soft parts from trematodes infection. The oysters should be cleaned of all the fouling organisms.

Conditioning the oysters for surgery is done by chemical means. Menthol crystals are sprinkled over the sea-water in troughs where the selected oysters are tightly arranged with their hinge down. In about 45-60 minutes, the oysters get narcotized and due to the relaxation of the adductor muscles, the valves open. The oysters, one by one, are taken and a wooden peg is inserted in between the valves and washed in seawater. These narcotized oysters should be used as quickly as possible for the surgery. Within 30-45 minutes, the oysters recover if they are put in fresh seawater after the surgery.

Conditioning of pearl oysters using menthol.

Pearl oyster surgery in progress.




Pearl oyster surgery, A-Removal of mantle piece from a donor oyster, B-Mantle as removed from the oyster, C-Trimming the mantle edges, D-Pallial mantle piece cut from the strip, E-Insertion of graft tissue and F-Implantation of nucleus.

# 14

## GRAFT TISSUE PREPARATION

*Materials* : Pearl oyster - Pearl oyster surgical instruments - Wooden blocks - Eosin - Beakers - Sponge.

*Activity* : Preparation of graft tissue.

Healthy oysters, not affected by polychaete and sponge boring and free from infection are selected as donor oysters. Oysters of the same size and age group as the recipient ones are selected for the preparation of graft tissue.

***Steps in the preparation of graft tissue***

*The donor oyster is cut open as follows :*

1. Hold the oyster at hand facing the dorsal side down and the posterior side facing the technician.
2. Insert the curved end of the oyster cutting knife between the two valves from the posterior side of the oyster. Push the tip of the knife to the anterior end.
3. Press the knife straight downward to cut through the adductor muscle. Open the valves, separate them from the hinge. The mantle lobes are removed from the shells as follows:
   (i) Brush aside the gills gently with the tip of the spatula. Expose the mantle without touching the mantle lobe.
   (ii) Cut the mantle with the graft cutting knife from the posterior to the anterior margin.
   (iii) Lift the mantle gently with the forceps and place it on a clean, wet wooden block without changing the side of the mantle.

*Processing of the graft tissue is done as follows:*

1. Stretch gently the tissue, end to end.
2. Gently wipe the mucus and dirt with a wet sponge.
3. Cut away the folds of the marginal mantle with pigmentation with the graft cutting knife.
4. Cut and remove the inner muscular portion of the mantle.

5. By holding one end of the ribbon, reverse the side and place it on the block. Now the outer epithelial portion faces up.
6. Wipe the mucus and dirt gently with a clean, wet sponge.
7. Trim the margins with the graft knife. Now the width of the ribbon may be 3 mm.
8. Cut the ribbon sharply into small bits of 2-3 mm.
9. Keep the graft bits moist till they are used.

The size of the graft tissue must be in proportion to the nucleus size. The graft should cover one third of the nucleus surface. Being live, the graft tissue should be used for operation within 30 minutes of its preparation to get good result.

***Precautions***

1. Use only filtered, clean, sterilized seawater for this operation.
2. All instruments should be washed in freshwater and sundried.
3. Use only clean and wet sponges for wiping the tissue.
4. Use only clean, smooth, moist wooden blocks. Glass plates can also be used instead of wooden blocks.
5. Use only the mantle of healthy oysters. Shrunken mantles are difficult to handle.

# 15

## NUCLEUS IMPLANTATION

*Materials* : Pearl oysters - Pearl oyster surgical instruments - Shell bead nuclei -Menthol - Eosin - Beakers - Plastic basins.

*Activity* : Insertion of graft tissue and nucleus.

The number and size of the nuclei to be used in the implantation is decided for the oysters to be operated upon. Double and multiple implantations can usually be carried out if small pearls of the size 2-3 mm are required. Nuclei of 5-6 mm are gnerally used in single implantation. If nuclei of 4-6 mm are used in double implantation, a large and a small nuclei can be used.

Oysters with partially spent and spent gonad should be used for nucleus implantation. The site of implantation is the ventral portion of the gonad. One nucleus of large size can be inserted in the gonad. In double implantation, the smaller second nucleus is inserted into the dorsal region of the gonad close to the hepato-pancreas.

***Steps in pearl oyster surgery***

1. Insert the end of the speculam through the postero-ventral corner of the oyster and open it very slowly by sliding backward the gap-regulator ring. Care should be taken not to open the oyster too much as the adductor muscle may snap and kill the oyster. The shells and the mantle lobes should not be damaged due to the insertion of the speculum.

2. Mount the oyster with the speculum in between the plates on the oyster mounting clamp.

3. Hook the tip of the foot with the footpuller with the left hand and pull it gently so that the base of the foot is slightly elevated. Hold the foot in this position till the operation is completed.

4. Make a shallow but sharp opening at the base of the foot with the oval knife end of the incision-cum-grafting needle. Through this opening, pass the needle below the outer skin gently and cut a passage upto the implantation site. Gently withdraw the needle through the passage.

5. Pick a piece of the graft tissue with the tip of the needle and gently insert it through the passage and leave the graft piece at the implantation site in such a way that the outer epithelium of the graft tissue is facing the passage. Withdraw the needle.

6. Dip the nucleus cup in water and press it against the nucleus. The nucleus will stick to the cup and gently insert the nucleus through the passage and leave it at the site by a slight deflection of the needle. Now the nucleus will be in close contact with the outer epithelium of the graft tissue, already inserted. Withdraw the nucleus cup gently through the passage.

7. Smoothen the passage and incision with the cup so that the air inside the passage will come out and the two margins of the incisions come in contact.

8. Remove the oyster from the clamp, withdraw the speculum by slipping the gap-regulator forward and leave the oyster in fresh seawater undisturbed.

**Precautions**

Always remember that you are doing a surgery on a live animal. Concentratoin, skill and patience are the main requirements in a successful surgery.

1 Before and after use, wash the instruments quickly in clean seawater.

2. Adjust the pressure on the foot with the needle of the footpuller in such a way that it does not tear while pulling.

3. Make the incision to the correct size of the nucleus.

4. Do not use maturing/matured oysters for nucleus implantation.

5. Do not damage stomach, intestine or heart.

6. Remember the orientation of the graft tissue is important in pearl formation.

***Implantation through the byssal groove***

Implanting of nuclei of 3-4 mm can be done through the byssal groove. The byssal threads along with their base can be pulled out and a passage is made with the needle as is done from the base of the foot, upto the gonad. The graft and the nucleus can be inserted through this passage. Care is taken not to make the passage deep into the muscle of the oyster. By this method of implantation, ejection of the nucleus is minimum.

# 16

## POST - OPERATIVE CARE AND CULTURE

*Materials* : Operated oyster - Plastic basins - Aeration/flow - through system - Culture cages - Raft.

*Activity* : Keeping the oysters in the laboratory for convalescence - culturing them in the raft.

The operated oysters are kept in a flow-through system where a gentle flow of water replaces the water in the container. If no flow-through system is available, the water should be changed frequently. The oyster slowly overcomes the effect of narcotization and resumes its normal function of opening and closing the valves.

The oysters are kept in the laboratary for 3-4 days with the supply of clean, filtered water, under observation. Exposure of the oysters to the rough, farming condition may exert undue stress to the implanted oysters.

The operated oysters are taken to farm in suitable cages for further rearing . During the post-operative culture, the density of the oysters should be low . They should not be disturbed frequently. They must be suspended at greater depths. In Indian condition, the culture duration ranges from 3-12 months for the nuclei of 2-5 mm. Periodic monitoring is done and trial harvest is made for each batch to decide the time of harvest.

# 17

## PEARL FORMATION

### *Natural pearl formation*

The principal causative factor in pearl formation in a pearl oyster is the presence of a nucleus. It can be of organic or inorganic origin, such as parasites, adults or larvae, molluscan eggs, decaying parts of plants, sand grains, epithelium or blood cells of the same animal etc. These tiny particles or organisms enter the oyster when the shell valves are open for feeding and respiration. These foreign bodies may become embedded between the shell and mantle. In response to this stimulus, the foreign body is invaginated by the outer epithelium of the mantle and a pearl-sac is formed around it (Fig. 4 a).

Pearls are not produced without the formation of the pearl-sac. The pearl-sac is derived from the internal or external layer of the epithelium of the mantle or of the gill plates. The epithelial cells of the pearl-sac secrete the nacre which becomes deposited over the foreign body, forming a pearl in due course of time. These pearls are produced either within the mantle, in other soft tissues of the oyster, or between the mantle and the interior surface of the shell. Such pearl production is accidental and occurs very rarely. They are generally small and irregular. Large and spherical pearls are still rarer to find. When the extraneous matter becomes fixed to the shell, only the exposed portion becomes covered by the pearl-sac resulting in a blister pearl.

### *Cultured pearl formation*

Cultured pearls are formed in a pearl oyster, thanks to human interference. In any pearl formation, two things are required, the outer epithelium of the mantle lobe and the core substance or nucleus. It was found that cut pieces of the mantle epithelium would provide the pearl secreting cells and that processed shell beads would be accepted by the oyster as the foreign body. Through careful surgery the mantle piece graft tissue and the shell bead nucleus are implanted together, side by side,into the gonad of the oyster.

The oysters are then returned to sea for further growth. The outer epithelial cell of the graft tissue proliferate and rearrange themselves over the shell bead nucleus, forming a pearl-sac. The inner epithelium and connective tissue of the mantle disintegrate and become

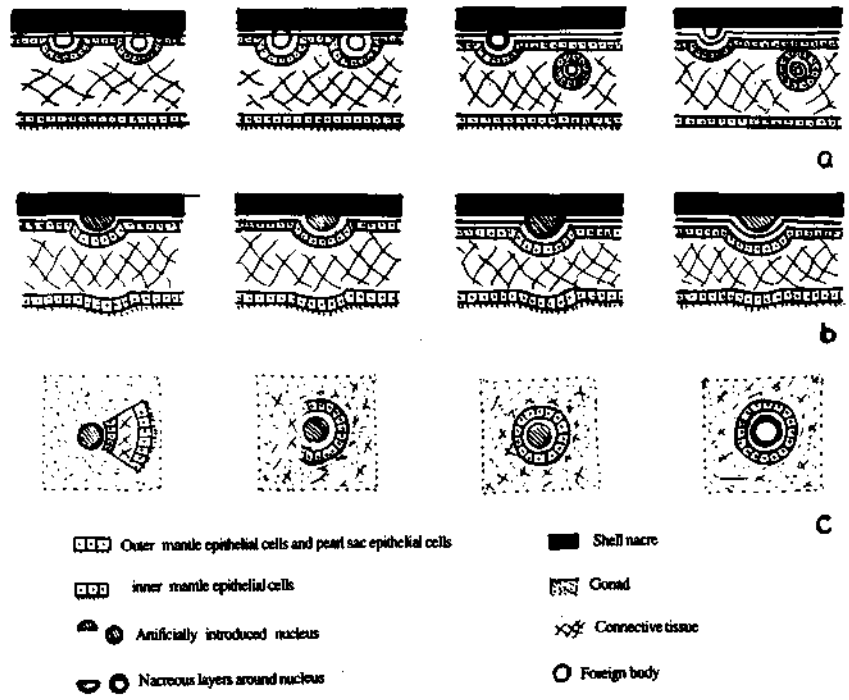
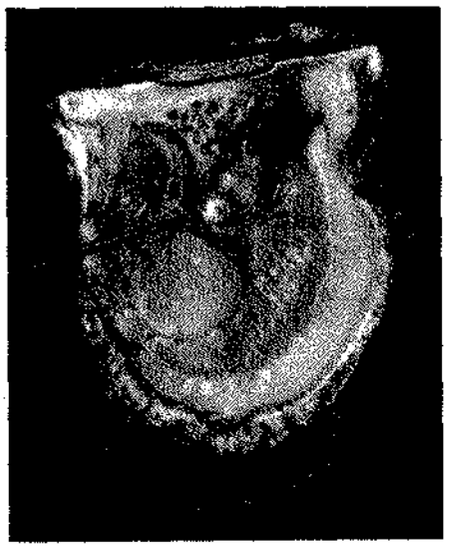
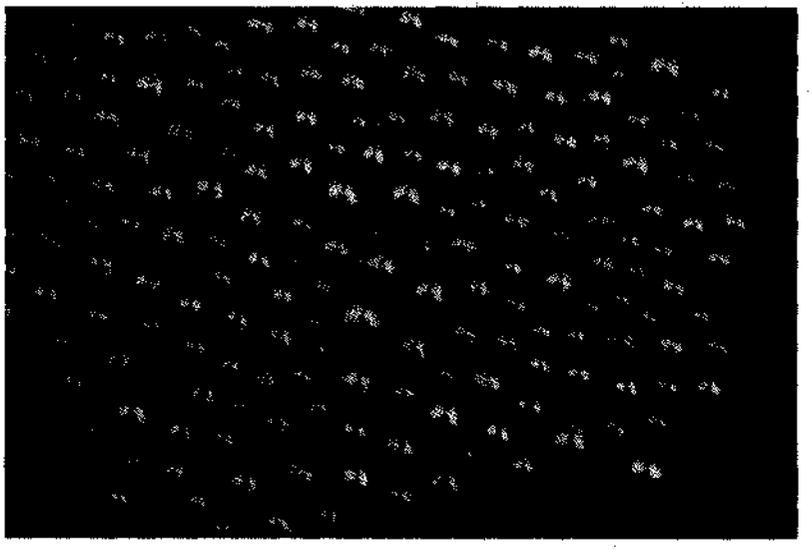



Fig. 4. Process of pearl formation a. Round and half natural pearls, b-Half cultured pearl and c-Round cultured pearl with artificially introduced nucleus.



Harvesting the cultured pearl from the oyster.



Lustrous cultured pearls.

absorbed by the surrounding tissue. The cells of the pearl-sac derive their nourishment from the surrounding tissues and soon reassume their function of nacre (mother-of-pearl) secretion which is deposited over the nucleus in the form of concentric micro-layers (Fig. 4 c). The nacreous matter consists of thin alternate layers of aragonite and conchiolin deposited around the nucleus. The conchiolin is organic in nature and consists of mucopolysaccarides. It forms the binding layer for the aragonite crystals. The aragonite layers are 0.29 - 0.60 mm thick and are made of calcium carbonate in the form of highly laminated crystals. In cultured pearls the nacre quality and the process of pearl formation are the same as in the formation of natural pearls. Cultured half-pearls (Fig.4 b) are produced by affixing many nuclei on the inner surface of the shell valves. The outer epithelium of the mantle forms the pearl-sac on the free surface of the nucleus and the half-pearl is formed.

The formation of a cultured pearl is a biological process and it is controlled by the pearl oyster itself. The quality of the pearl is influenced by several hydro-biological factors such as primary production, temperature, water current, trace metal content of the water etc. In addition, the inherited capabilities of the individual oyster constitute to the colour and quality of the pearl. A calm and clear coastal water body having a depth of more than 5 m and with good exchange of water, offers a favourable site for the formation of good quality pearls.

# 18

## PEARL HARVESTING AND GRADING

*Materials* : Oysters with pearl - Knife - Salt- Distilled water

*Activity* : Collection of pearls - cleaning and grading

Harvesting of cultured pearl is usually done manually. The pearls are extracted by cutting and separating the two valves, making an incision on the gonad and squeezing the pearl out. In case the oysters are to be reused, the pearls are carefully removed by opening the pearl-sac through the gonad taking care not to damage or give stress to the oyster. Afterwards these oysters can be used for production of pearls for a second time.

The harvested pearls are washed in distilled water, polished with refined salt and again washed in distilled water. They are sorted according to size, colour, shape, lusture, irridescence and other external characteristics.

The cultured pearls are categorised as follows:

*Class A* : Flawless, one flaw, small flaws, small stain marks, pink, silver or light cream in colour.

*Class B* : Fairly large flaws, stain marks, creamy in colour and irregularities in the shape.

*Class C* : Wild shaped, badly coated, heavily marked,clayey lumps, half good and half bad. These are "trash pearls"

To run a commercial farm economically, a combination of Class A and Class B pearls should account for 60%. The nuclei of the trash pearls can be salvaged and used after reprocessing.

# 19

## ECONOMICS

Pearl oyster farming in terms of value is one of the world's leading Aquaculture industries. In 1990 over 900 million dollars worth of pearls were produced in the world. Indian import of cultured pearl is worth 29 million dollars per annum. With the expansion and development of pearl culture activities in India, there is good scope for exporting marine pearls besides curtailing import. Pearl culture is a long-term investment proposition and huge profits can be made by successful operations.

In a recent study conducted by the Institute at Valinokkam bay, the economic evaluation of pearl culture by the raft culture method was worked out. From a raft of 6m x 6m size, a total of 100 cages were suspended in the sea and a total of 10355 oysters were cultured. Out of these, 941 oysters were sacrificed for the preparation of graft tissue. The remaining 9414 oysters were implanted with nuclei of 3-5 mm dia. Mortality during the post-operative culture period was 2108 oysters (22.39%) . On harvest, the remaining 7306 oysters have yielded 1849 pearls (25.31%). A total of 5457 oysters (74.69%) did not contain pearls due to rejection of nuclei or non deposition of nacre. The 1849 pearls were categorised into 6 grades and sold for Rs.73133/-. The local fishermen actively participated in the farming activities and a part of the harvest was given to them in lieu of their labour. The rate of return worked out to 55.7%. Pearl culture gives the highest gross income for unit area when compared to various production systems in aqua culture..

### DATA ON ECONOMICS OF PEARL CULTURE

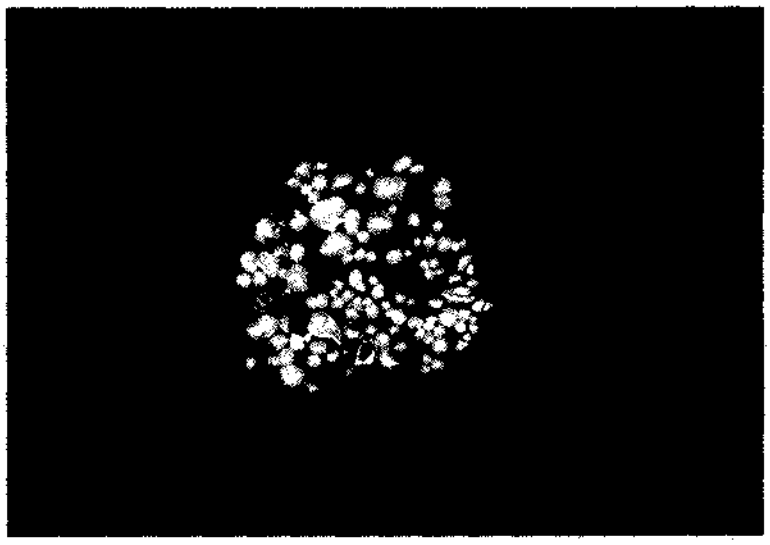
Method : Cages suspended from a 6 x 6m raft

| | Input cost (for two years) | | Rs. |
|---|---|---|---|
| 1. | Cost of teakwood poles, floats, anchor chains | : | 13,000 |
| 2. | Cages(100 nos.) for rearing 10355 oysters | : | 10,000 |
| 3. | Cost of 10355 pearl oysters at Rs. 1.40/seed | : | 14,500 |
| 4. | Cost of 9494 shell bead nuclei at Re 1/bead | : | 9,500 |

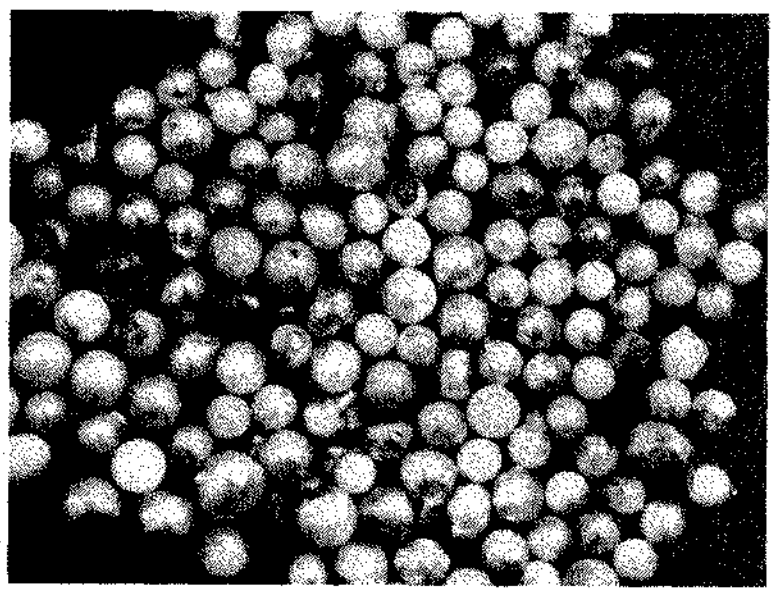
| | | | |
|---|---|---|---|
| 5. | Cost of menthol, glasswares, plastic wares,surgical instruments etc. | : | 5,000 |
| 6. | Labour charges for pearl oyster surgery | : | 3,000 |
| | Total | : | 55,000 |

**PRODUCTION AND REVENUE**

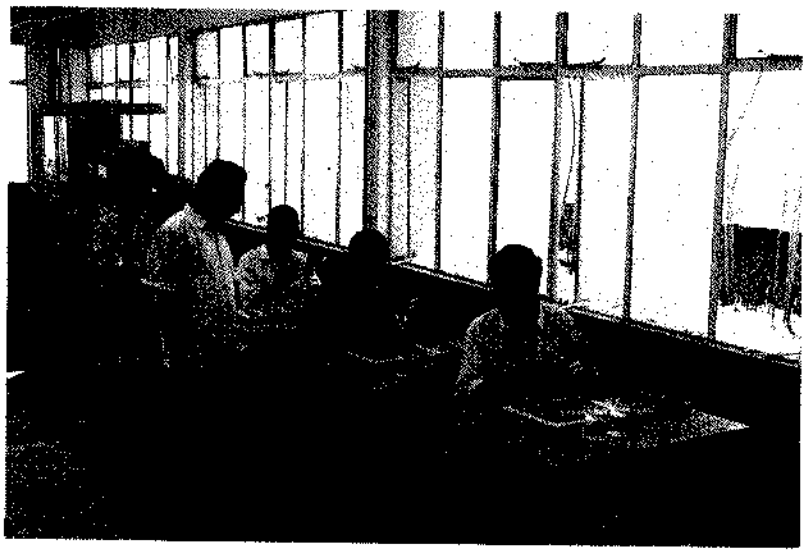
| | | | | |
|---|---|---|---|---|
| | Total pearls produced | Nos | : | 1849 |
| 1. | Sale proceeds of 1296 pearls (wt. 138.28g) | Rs. | : | 73,133 |
| 2. | Cost of 250 pearls distributed to fishermen in lieu of their labour | | : | 12,500 |
| | Total earnings | | : | 85,633 |



Natural pearls.



Baroque pearls.



Training session in progress.

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