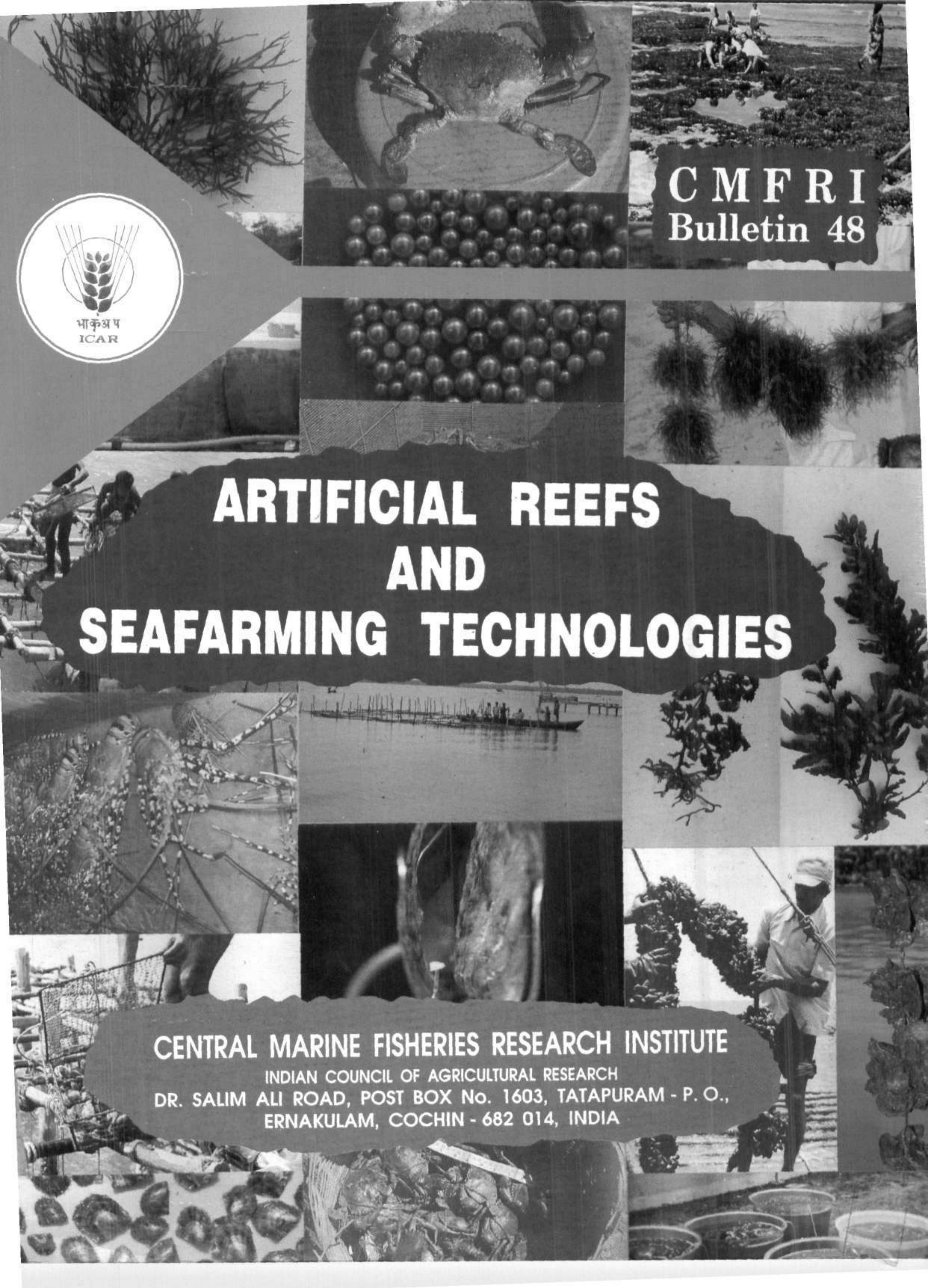

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CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
DR. SALIM ALI ROAD, POST BOX No. 1603, TATAPURAM - P. O.,
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DR. K. RENGARAJAN
Editor

January 1996

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PEARL OYSTER FARMING AND PEARL PRODUCTION

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Introduction

Natural pearls were the oldest gems known to mankind. Long before man discovered the diamond and other precious stones, pearls were considered to be the first precious gem. The Vedas of India, the Bible and the Quran make several reference of pearls as objects of adoration and worship. The natural pearls of the Gulf of Mannar and the Persian Gulf enjoyed very good reputation in the world trade from the time immemorial. The Gulf of Mannar pearls are famous throughout the world as 'Orient Pearls'.

Man has wondered how the oyster produces the pearl and many imaginative minds propounded many interesting theories. Some believed that pearl was formed when a rain drop or a droop of dew fell into the shell when it came to the surface. Some others felt that it was the tears of angels that crystalised into pearls. The truth behind this mystery was unraveled in 1907 when a Japanese scientist Tokichi Nishikawa gave a plausiable explanation "the pearl-sac theory" for pearl production. According to him, the pearl-secreting cells of the mantle migrate into the body of the oyster under the stimulus of a foreign body and by a series of cell division form a pearl-sac around the foreign body. The pearl-sac in turn secretes the nacre which becomes deposited over the body, forming a 'natural pearl' in course of time. Natural pearls are rare in occurrence, small in size and generally irregular in shape. The 'cultured pearl' is produced by human interference by inserting a shell bead "nucleus" and a mantle piece into the gonad of the oyster and growing the oyster in the sea. 'Artificial pearls' are those made of plastics, glass, etc. They are painted with pearl essence which is a mixture of enamel and silvary extract of fish scales.

Pearl oysters and their distribution

The pearl oysters occur in almost all the seas of the tropical and subtropical regions of the world. Although 28 species of pearl oysters have been identified, only 3 species have been found to produce pearls of gem quality having commercial value. They are *Pinctada maxima* (Jameson), *P. margaritifera* (Linnaeus) and *P. fucata* (Gould) (Pl. I A). *P. maxima* commonly known as the "white-lip" or "silver-lip" or "gold-lip" pearl oyster, is the largest of all the pearl oysters. It is prized for both its shell and the gold coloured and white pearls it produces. It occurs in the South Seas, Australia, Burma, Thailand, Indonesia, Philippines and Papua New Guinea at depths raning from low tide level to 80 m. It grows to 28.3 cm in shell height and weighs upto 5.5 kg (Bolman, 1941; Hynd, 1955). *P. margaritifera* the "black-lip" pearl oyster is famous for its production of fine grey to black pearls. It is distributed in the Persian Gulf, Red Sea, Sudan, Papua New Guinea, Australia, French Polynesia, Indonesia, Andaman and Nicobar Islands, southwestern part of the Indian Ocean, Japan and the Pacific Ocean. It grows to about 17 cm in shell heights. It thrives well in 2 to 40 m depth. The pearl oyster *P. fucata* is distributed in the Red Sea, the Persian Gulf, India, China, Korea, Japan, Venezuela and Western Pacific Ocean.

In the Indian waters, six species of pearl oysters namely *Pinctada fucata* (Gould), *P. margaritifera* (Linnaeus), *P. chemnitzii* (Philippi), *P. sugillata* (Reeve) and *P. atropurpurea* (Dunker) have been recorded. Among these, *P. fucata* is the most dominant species. It occurs in large numbers in pearl banks known as 'paars' in the Gulf of Mannar and in the intertidal reefs known as 'Khaddas' in the Gulf of Kutch. *P. fucata* is the only species which has contributed to the pearl fisheries in these two gulf regions. In the southwest coast in India at Vizhinjam, large numbers of spat of *P. fucata* have been collected from mussel culture ropes. *P. margaritifera* is confined mostly to the Andaman Islands where it is common in some places. From Lakshadweep, spat of *P. anomoides* has been recorded on the ridges of rocks and corals.

Pearl oyster farming

Farming of pearl oysters can be done either in a bay or in a lagoon or in coastal waters or in onshore tanks, where the environmental conditions are conducive for the growth of oysters. In a pearl culture establishment, farming activities go round the year. Therefore, the establishment must have good laboratory for oyster surgery, pearl collection centre, pearl grading and processing unit, farm stores, cage cleaning yard, mechanical workshop and boat for transport of workers, oysters and farm materials.

Pearl oyster farming can be divided into two phases, *viz.* mother oyster culture and post-operative culture. Mother oyster culture refers to farming of oysters from the time they are brought to the farm till they are used for nucleus implanation. The post-operative culture refers to rearing of oysters from the day of implantation upto the day of harvest.

Source of oysters

There are three ways to raise pearl oysters for mother oyster culture in the pearl culture farm. They are (1) collection of oysters from the natural beds, (2) hatchery production of seed and (3) collection of spat through spat collectors. In the Gulf of Mannar, the pearl oysters occur in large numbers on the submerged rocky substrates known as 'paars'. The paars lie at depths of 12 to 25 m off the Tuticorin Coast along a stretch of 70 km. The extent of these paars varies from a few hectares to several km^2. Pearl oysters from these beds are collected by skin and SCUBA divers. In the Gulf of Kutch, the pearl oysters are found sporadically on the intertidal reefs known as 'Khaddas'. Collection of oysters is done by hand-picking. The source from hatchery is more dependable than the sources from natural beds and spat collectors, as the hatchery alone can ensure a sustained supply of pearl oysters for pearl culture throughout the year. The pearl oyster hatchery of CMFRI has produced several million seeds of oysters over the last 13 years. Large scale collection of pearl oyster spats from the sea is possible if only the right type of spat collector is provided at the most propitious time. The oysters obtained from these three sources are cleaned and placed in cages and hung vertically in the sea from the raft/rack at desired depth.

Rearing methods

Raft culture, rack culture on bottom culture and onshore culture are the 4 methods of rearing pearl oysters.

Raft culture

Raft culture method is one of the most suitable method of farming oysters in sheltered bay and in open areas. The size of the rafts can be altered according to the sea and weather condition of the locality. A raft of the size 6 m x 5 m is found to be suitable. Rafts are usually constructed with teak, casuarina or eucalyptus poles of chosen length with the base of the pole having 10 cm dia, tapering to 6 cm dia at the tip. These poles are lashed with coir ropes. Four floats are attached to the four corners of the raft to give buoyancy. Floats can be empty diesel drums of 200 lt capacity with fibre glass coating, mild steel barrels painted with anticorrosive paints or FRP styrofoam floats. Rafts are moored with two anchors at opposite sides with tested quality chains and their position is decided according to the prevalent wind direction at the site. The oyster carrying cages (Pl. I B) are suspended from the raft at 5 m depth in the sea (Alagarswami, 1991).

Rack culture

Rack culture is possible only in shallow and calm seas of 2 to 4 m depth. In rack system which is a fixed structure, 121 teak or eucalyptus poles of chosen length are driven vertically into the sea bottom in 11 rows, 1 m apart. Cross and horizontal poles are arranged as per requirement on the top of the poles and lashed with coir rope at a convenient height of 0.5 m above the water level so that the rack thus erected remains always above the water. The overall size of the rack is 10 m x 10 m. A total of 400 box-type cages holding oysters can be suspended from the wooden frames (Pl. II A).

On bottom culture

On bottom culture of pearl oysters can be done in areas where the sea bottom is hard or rocky in nature. Oysters are placed in box-type cages and arranged on the sea bottom in rows.

Onshore tank culture

Pearl oysters can be successfully reared in a 50 t capacity concrete tank filled with clean seawater. Mother oysters/seeded oysters numbering 1250 can be successfully stocked and grown in the tank. The microalga *Chaetoceros calcitrans* cultured in the outdoor tanks is given as food for the oysters. This technology has greater advantages over the open sea culture system, as the growth of the oysters in the tanks is much faster, survival rate is high, predation and fouling are practically absent and ensures greater control over the environment.

Besides the above four methods, long lines and underwater platforms are used in some parts of the world. In the long line culture method, a series of spherical or cylindrical floats are attached to strong ropes at uniform intervals. The ropes are moored with anchors. The oyster cages are suspended from the strong rope of the line. Long lines are ideal for turbulent sea condition. In another method of hanging, a hole is drilled near the hinge of the pearl oyster. A small thread is put through the hole, which is then tied to a straw rope coated with tar. The straw ropes are hung from a raft. Underwater platforms are used in French Polynesia for farming black-lip pearl oysters in deeper lagoons. Oysters in strings are suspended from these platforms (Alagarswami, 1991).

Rearing containers

Culture of mother oysters

Box cages, measuring 40 x 40 x 15 cm with a lid and covered by synthetic webbings are used to rear mother pearl oysters and nucleated oysters. The size of the mesh varies with the size of the oysters to be reared. The frames of the cages are made up of 6 mm mild steel rods, coated with anticorrosive paints or coal tar. Box cages are useful in general mother oyster culture. A box cage can hold 125 oysters of 35-45 mm size, 100 of 45-55 mm, 75 of 55-60 mm and about 50 in the case of larger oysters (Pl. II B).

To trace the history and performance of individual oysters, frame nets are used. The frames, measuring 60 x 40 cm each with five compartments, meshed and hinged at one end, open as a book. The oysters are arranged in rows and held in the compartments when closed. The space available inbetween the two frames is about 10 mm which is sufficient for the oysters to open their valves for feeding and respiration.

Juvenile rearing

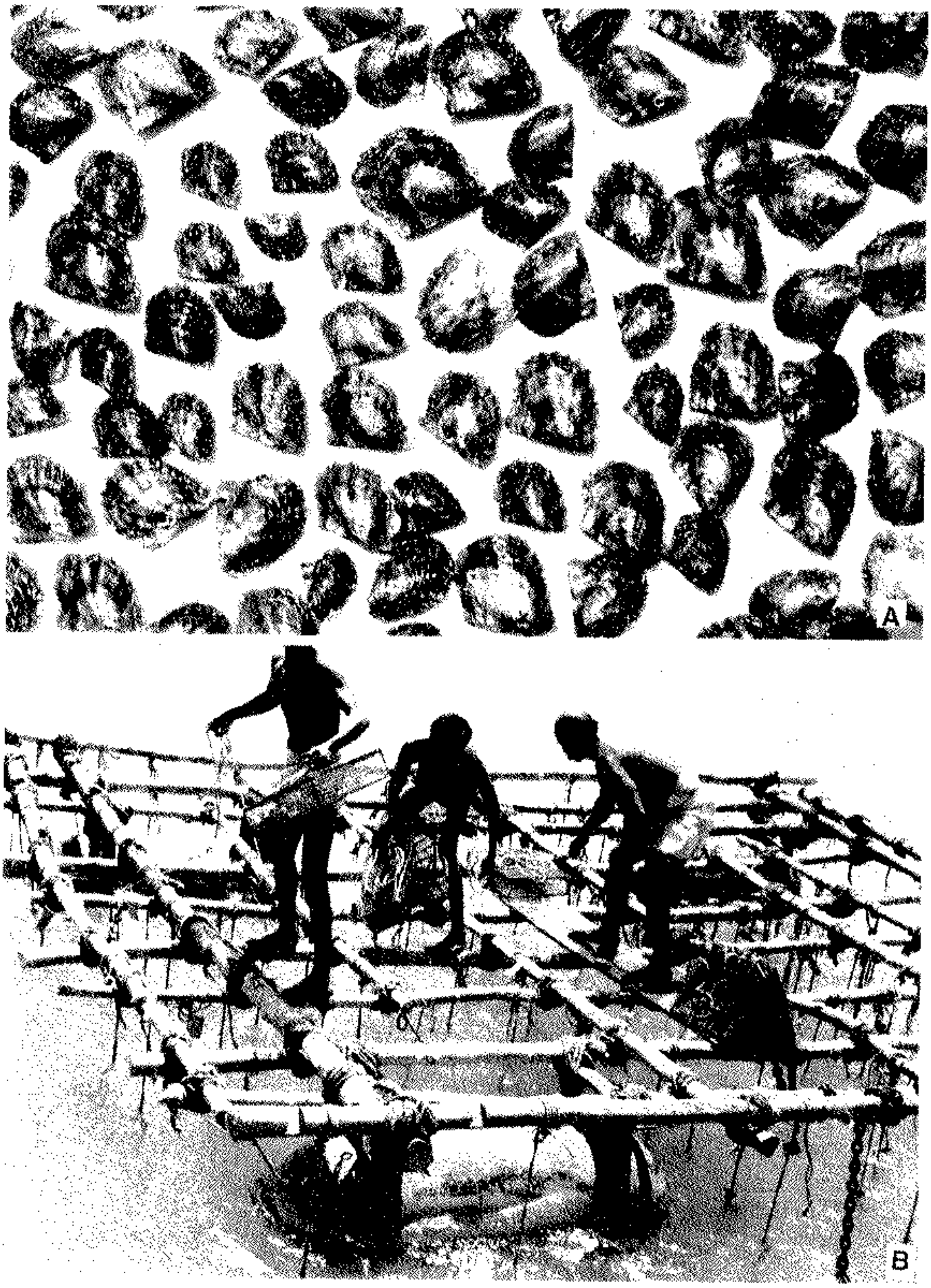
Juvenile pearl oysters are reared in net cages. Synthetic fabric of velon screen bags whose sides are stretched with a steel rod in the form of a prism are used for rearing juveniles (Pl. II C). The mesh size of the screen depends on the size of juveniles to be reared. The mouth of the bag is tied with synthetic twine which facilitates opening or closing when required. To provide further protection from predators the bags are placed in old nylon fish net bags. Clogging by silt and by the growth of fouling organisms can be prevented by periodical replacement of the velon screen bag which can be cleaned, sundried and reused. Spat of upto 2 cm in size are reared in these small net cages. Box-cages which are used for rearing mother oysters can also be used for juvenile rearing by providing an additional velon screen cover inside the cages.

Environmental conditions

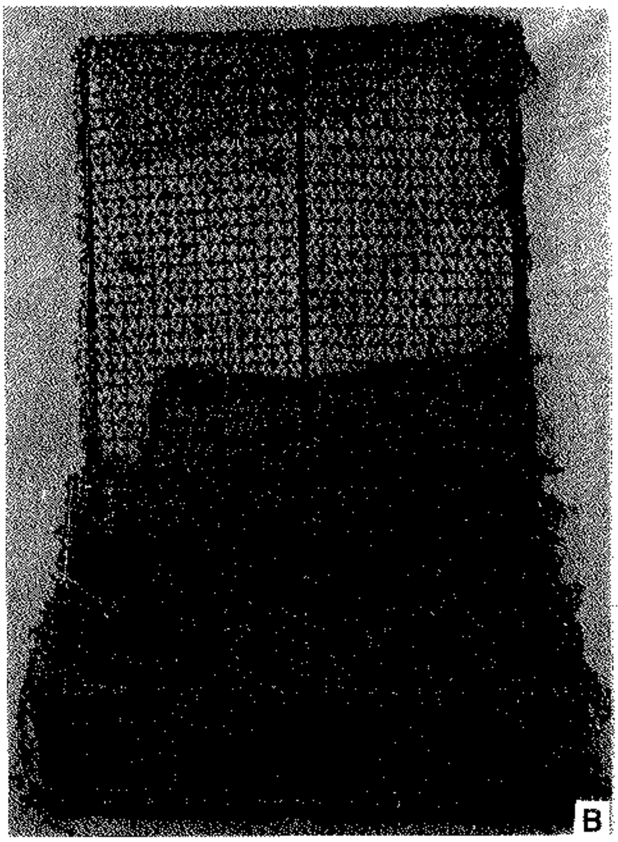
The success of pearl oyster farming and pearl production depends largely on the environment in which the oysters are reared. The oyster being a filter feeder wholly depends on the environment for all its life functions such as osmoregulation, respiration, nutrition and reproduction. Many industries let out agro-chemical and industrial effluents into the sea which adversely affect the well being of the oyster population. Therefore, the set of environmental conditions has to be ideal and this should be ensured while selecting the site for the farm (Alagarswami, 1991).

Topography

Sheltered bays are ideal locations for establishing pearl culture farms. They offer good protection to the culture structures such as rafts and cages from strong winds and waves. Shallow coastal waters where the sea is calm during most part of the year can also be considered as a suitable site. The Gulf of Mannar in India where pearl farming is practiced has been found to be moderately acceptable in the absence of better



[illegible] The Indian pearl oyster *Pinctada fucata* and B. Raft for culturing oyster



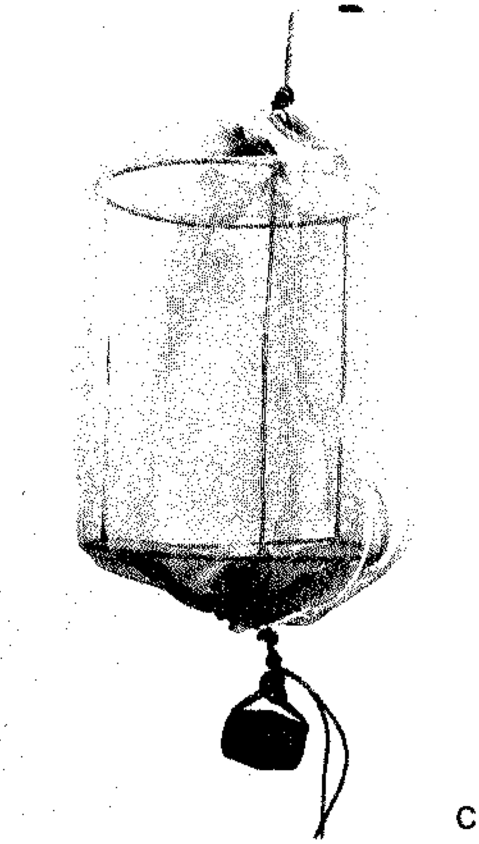


PLATE II A. Wooden racks with oyster cages in shallow water farm, B. A box cage for rearing mother oyster and C. Juvenile pearl oyster rearing cage.

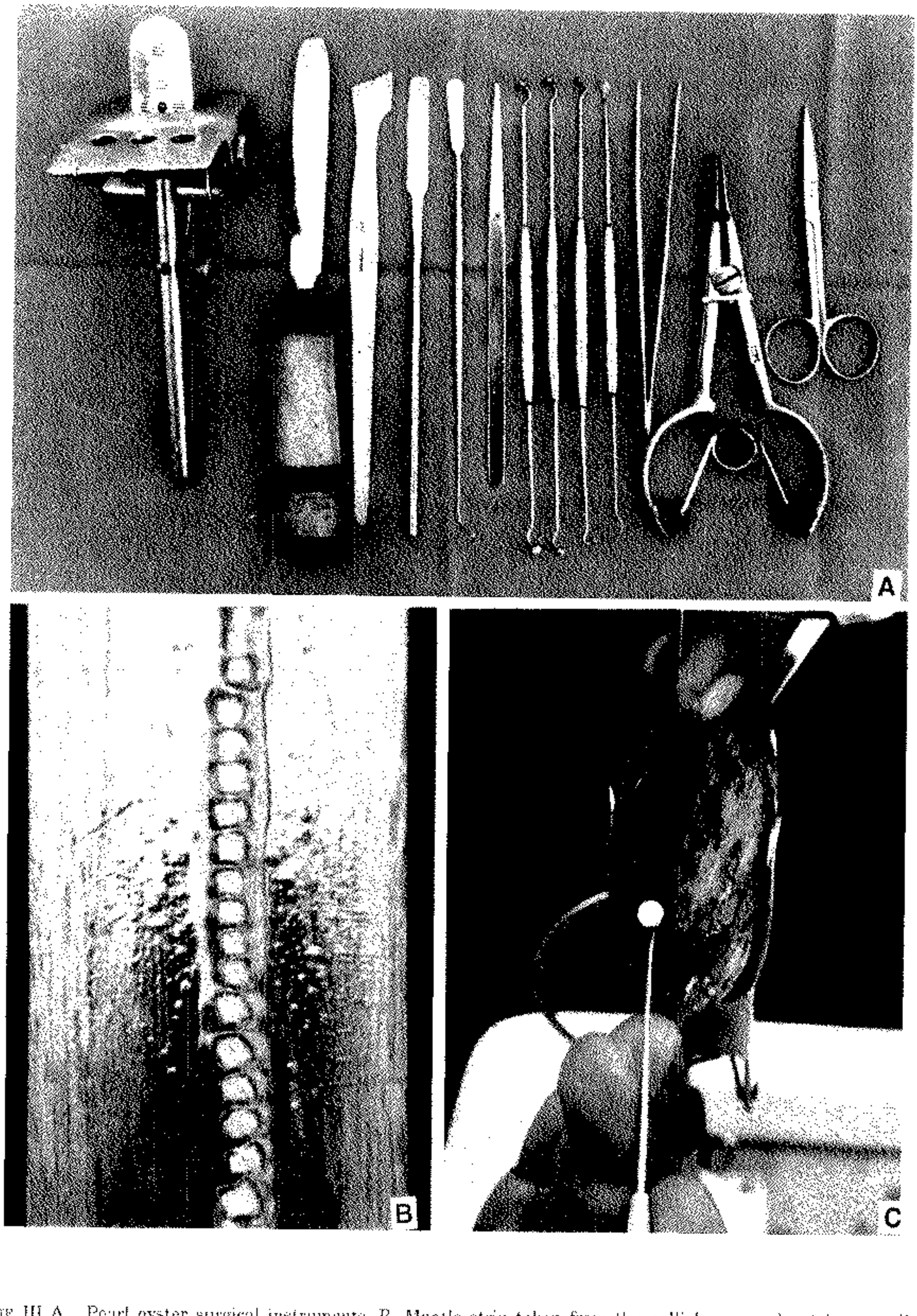


Plate III A. Pearl oyster surgical instruments, B. Mantle strip taken from the pallial zone and cut into small pieces and C. Implantation of shell bead into the oyster.

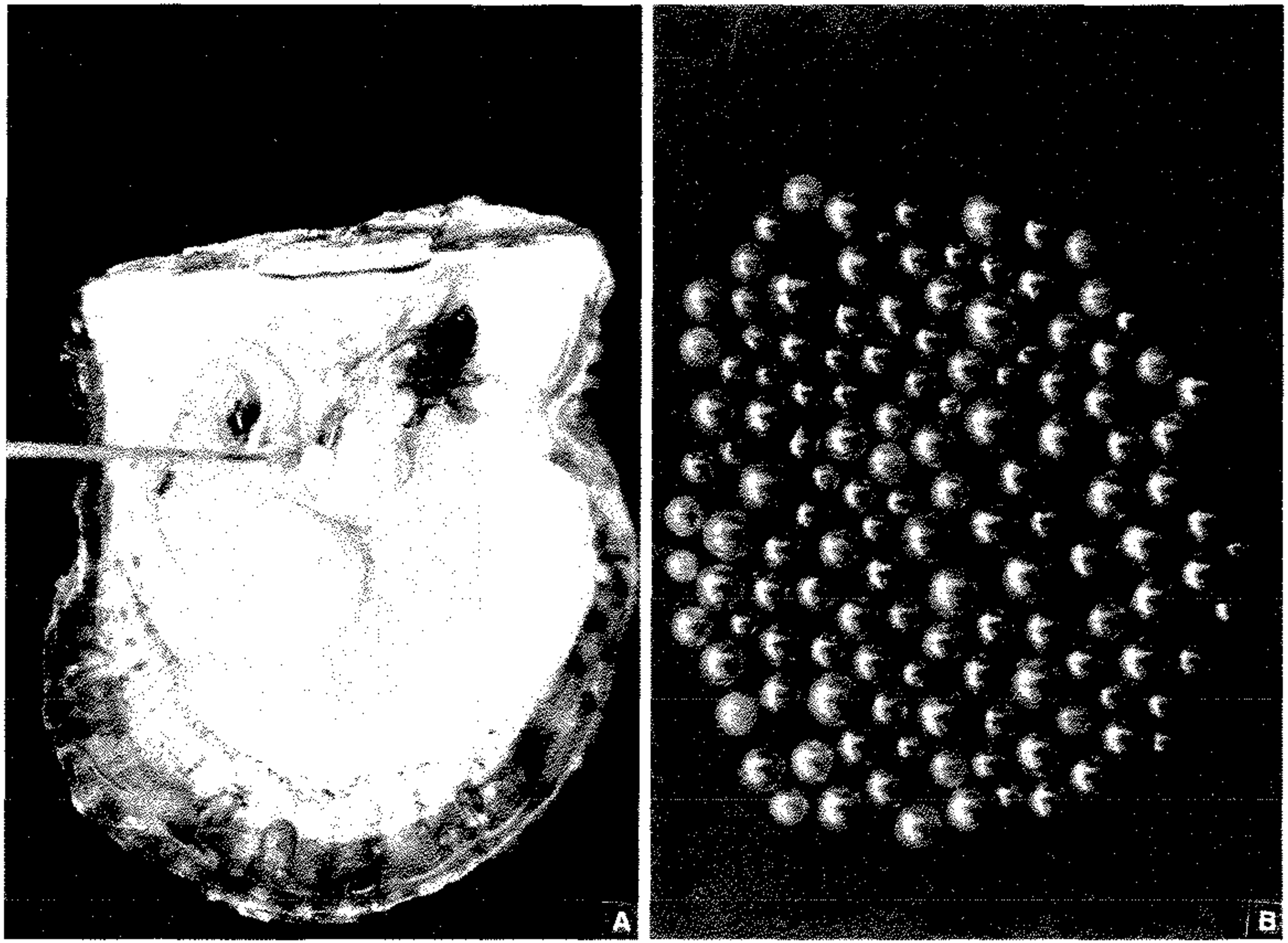


Plate IV A. Pearl *in situ* in *Pinctada fucata* and B. Lustrous cultured pearls.

locations on the coast of mainland. The small islands such as Krusadai, Pullivasal, Manoli, Hare, Nallatanni, Karaichalli, Vilanuguchalli and Vanthivu give some protection. The Andaman and Nicobar Islands have many areas which provide ideal conditions for pearl oyster farming (Alagarswami, 1983). The lagoons of some islands of Lakshadweep especially Bangaram, would seem to be favourable (Alagarswami *et al.*, 1989).

Hydrography

Depth is an important factor in rearing pearl oysters, the preferred depth is about 10 m in the open sea and 2 - 4 m in the sheltered bay. Sea bottom should be either gravelly or rocky. Muddy or sandy bottom should be avoided. A high amount of silt in the farm water may choak the gills and affect the filteration efficiency of pearl oysters. A mild water current of less than one knot/hr is essential not only as a source of oxygenrich water, but also to bring in fresh plankton on which the oysters feed as well as for the removal of metabolic products and faecal matters from the farm. Repeated culture in the same ground often deteriorate the quality of the pearls. Accumulation of biological waste of the oysters and fouling organisms on the sea bottom often affects its physical and chemical state.

The environmental factors such as temperature, salinity, hydrogen ion concentration and nutrient salts play a crucial role in the settlement, growth and reproductive pattern of oysters both in the farms and natural beds. Unlike in Japan, the variation in temperature and salinity is not much pronounced in the Gulf of Mannar. The lowest sea surface temperature is about 23.8°C and the highest 33.5°C, the monthly averages ranging from 25.9°C to 31.5°C (Victor and Velayudhan, 1987). In the Gulf of Mannar and the Gulf of Kutch, oysters show a higher growth rate in winter months in the lowest range of temperature. Higher temperature within the ambient range helps in faster growth of pearls. The salinity of the Gulf of Mannar normally varies from 30 to 35 ppt. If salinity falls below 15 ppt, and if such condition is prolonged, it may lead to mortality. This may happen during unusual heavy rain and heavy discharge of freshwater by rivers in the farm. The pH should be around 7-8. The rich nutrients discharged by rivers into the sea increase the productivity of the water. The oysters probabily derive their chief source of conchiolin from the nitrogen substance of the plankton. The organic matter and calcium dissolved in the sea water are directly absorbed by the food consumption cells. In Tuticorin bay, it ranges from 316 to 485 mg/litre. The calcium passes through the mantle to be deposited on the surface of the shell or pearl in the process of their formation. The normal level of calcium in the sea water is about 400 mg/litre. In Tuticorin Bay, it ranges from 316 to 485 mg/lt. The presence of trace elements in small quantities influences the colour of nacre. Gold and cream coloured pearl contain more copper and silver, whereas skin and pink coloured pearls contain more sodium and zinc (Matsui, 1958).

Biology of pearl - pearl formation

The pearl oyster's mantle is a thin fold of skin covering the soft body below the shell. It is formed of two lobes on either side. The two lobes are fused together dorsally below the hing line, from this point they hang down on both sides of its body. The nacre or mother-of-pearl found on the inner surface of the shell is formed by the secretion of the outer epithelial layer of the mantle. When some minute extraneous matter such as sand grain, silt particle, parasite, larva, etc., accidentally enters within the tissue of the oyster, it causes irritation to the oyster. As a means of defence against the irritant, the oyster encloses the foreign particle in a sac of epithelial tissue. If the sac happens to be formed by the outer epithelial cells of the mantle, it secretes nacre which gets deposited around the particle. The sac is the *pearl sac* and the foreign particle the *core material*. The pearl sac keeps growing with the growth of the pearl inside. The secretion continues throughout the active life of the oyster leading to the formation of natural pearl. The natural pearl generally takes the shape of the core material and is small in size and irregular in shape. The natural pearls are formed either within the mantle or in other soft tissues of the oyster or between the mantle and the interior surface of the shell. Therefore it is evident that the two pre-requisites for the formation of a pearl are the outer epithelium of the mantle lobe and a core substance or nucleus. Formation of a natural pearl is a matter of chance and therefore only a very small percentage of pearl oysters produce pearls in nature.

In the cultured pearl technique, the same process is manipulated in the oyster. A small piece of mantle from a donor oyster and a spherical shell bead, the nucleus are implanted into the gonad of a recipient oyster in proper orientation by skillful surgery. The surgery operation is called 'implanting' or 'grafting'. The inner epithelium and connective tissue of the mantle disintegrate and become absorbed by the surrounding tissue. The outer epithelium of the mantle piece undergoes cell division and rearrange themselves over the shell bead nucleus, forming the pearl sac. The epithelial cells of the pearl sac secrete and deposit the nacre or mother of pearl over the nucleus in the form of concentric micro-layers. When a large number of these layers have been deposited over a period of time, the pearl grows in size and attains its 'gem' quality. Since the pearl is produced in the oyster by manipulation through surgery and by further cultivation of the seeded oyster, it is called the cultured pearl. In cross section, a natural pearl will reveal a minute nucleus of extraneous origin surrounded by nacre. In a cultured pearl, the nucleus is large and the nacre forms only one fifth to one third of the pearl in thickness.

Production of cultured pearls

After the oysters have grown in the farm and attained the size suitable for nucleus implantation, they are brought to the laboratory. Their shells are cleaned of all fouling organisms and other encrustations and kept in seawater. Pearl production can be divided into two phases (i) the laboratory phase and (ii) farm phase. The laboratory phase is very short, which includes selection of oysters, conditioning, graft tissue preparation, nucleus, surgery and convalescence. The farm phase includes post-operative culture and pearl harvest.

Laboratory phase

Selection of oysters

The factors to be considered in the selection of oysters are their age, weight, stage of sexual maturity and overall health. Oysters of 25 g weight and above (1.5 to 2.0 years) are ideal and even smaller sizes are also considered for implanting smaller nuclei of 2-3 mm diameter. The gonad of the oyster should be in the spent resting stage. Nucleus implantation in these oysters yields good results since correct orientation of mantle piece with the nucleus is always ensured. Ripe gonads are not suitable, since during surgery the gametes tend to flow out and block the visibility of the implantation site so that proper orientation of the mantle piece and nucleus cannot be ensured. In addition, the oysters infected with polychaetes, sponges and trematodes are to be avoided.

Conditioning

The selected oysters are conditioned for nucleus implantation. Preconditioning of oysters for surgery is an essential process. Healthy oysters, when taken outside seawater close their valves tightly by contracting the adductor muscles. For surgery, a gap of 1.0-1.5 cm between the valves is required. When the valves of the oysters are opened forcefully their adductor mussels get cut and the oysters die immediately. Hence the oysters are allowed to open their valves gently by themselves. This is done by using a chemical 'menthol'. The oysters are arranged in a plastic basin with their hinges pointing downwards. Seawater is slowly poured into the basin till the oysters get immersed in the water. Sprinkle a little amount of menthol powder over the water and cover it with a lid. In about 60-90 minutes the oysters get narcotized. The adductor muscle relaxes and the shell valves open. Immediately a small wooden peg is inserted in between the valves to keep them open and thus the oysters are conditioned. The conditioned oysters should be operated as early as possible, as the delay causes swelling of tissues, increased mucus secretion and mortality. For this reason conditioning is done in batches. The conditioned oysters are washed individually in seawater and arranged in an empty plastic basin.

Surgical instruments

A set of specially made surgical instruments is needed during graft tissue preparation and nucleus implantation. The instruments can be made to specification by any surgical instrument manufacturing company. The following are the necessary instruments (1) oyster stand, (2) shell speculum, (3) incising-cum-grafting needles, (4) nucleus insertion needles, (5) graft cutting knife,

(6) spatula, (7) needle hook, (8) forceps, (9) knife and (10) scissors (Pl. III A). The other instruments needed are graft cutting wooden blocks, wooden pegs, camel hair brush, trays, rubber sponges, towels, glass beakers, etc.

Preparation of graft tissue

As soon as the oysters are narcotized, the preparation of graft tissue should commence. Preparation of graft tissue is an important step in surgery. Many graft tissues can be prepared from the mantle of a single oyster. A healthy oyster is taken from the stock of oysters. The oyster should not have been subjected to any narcotizing process. A sharp knife is inserted in between the two valves of the oyster upto the adductor muscle and the latter is cut vertically. The knife is pushed further down so as to cut the soft body into two. Care is taken not to injure the mantle tissue in any way. With a pair of scissors, a strip of 5 cm long and 0.5 cm wide mantle is cut and transferred on to a rectangular soft wooden block. The mucus of the mantle is removed gently with the blunt end of the scalpel. With the graft cutting knife, the thickened outer edge of the mantle is cut and removed. In the same manner, the inner muscular portion of the mantle on the opposite side is also cut and removed. Now a long ribbon of 5 cm length is obtained from the pallial zone of the mantle. The ribbon is then cut into pieces of 2 to 3 mm squares. Mantles from both side are used in the preparation of graft tissues. About 20-25 pieces can be cut from each ribbon. The graft tissues should be kept wet with sterilized filtered seawater all the time during preparation. Smearing a weak solution of Azumin will help to keep the cells alive for a longer duration. The graft tissues should be used within 15 minutes of preparation (Pl. II B).

Nucleus

A piece of graft, when inserted into the gonad of an oyster results in the production of an irregular pearl. In order to get a larger and spherical pearl in a short period, a spherical shell bead known as 'nucleus' is inserted along with the graft tissue. The beads are manufactured in Japan from the thick shells of fresh water mussel, pig-toe, washboard, dove, three-ridge and butterfly - which occur in the Tennesse and Mississippi Rivers in USA. The hardness and specific gravity of these nuclei are nearly identical with that of the deposited nacre. These shells are collected and exported to Japan, where they are cut, ground and processed into precisely spherical shell beads of different diameter, generally 2-7 mm. In India, chank shells have been cut and processed into beads and used in experimental pearl production.

Surgery

The conditioned oyster is mounted on the oyster stand with the right valve upwards. The shell speculum is inserted inbetween the valves to regulate the gap. The mantle, gills and labial palps are smoothly pushed aside to get a clear view of the gonad region. A sharp incision is made with incision-cum-grafting needle at the base of the foot of the oyster and a passage is cut subcutaneously through the gonad upto the predetermined site of implantation. In the case of single implantation, the site is close to the turn of the intestinal loop. In double implantation, a second site is chosen close to the hepatopancreas. In multiple implantation several other sites between the above two are selected. A piece of mantle is inserted through the passage with the incision-cum-grafting needle and left at the site. Then the shell bead nucleus is inserted through the same passage and placed in such a way that it is in contact with the outer epithelium of the mantle piece. The incision is smoothened with the cup end and the two margins of the incision come in content. With this step, the nucleus implantation operation is completed (Pl. III C).

Convalescence

The operated oyster is then removed from the stand and the peg or shell speculum is removed from between the valves. The oysters are then placed in a plastic trough or FRP tank, where seawater is allowed to flow gently. If no flow-through system is available seawater is to be changed frequently until the oyster fully recovers from the effect of narcotization. Within 30 minutes, the oysters slowly reopen their valves and commence their pumping and filtering activity. Then the oysters are placed in netlon baskets and hung in the one tonne FRP tank containing fresh seawater. A mild flow of seawater is always good and this is ensured by aerating the seawater. The faecal matters are either washed away by the mild current or kept away from the oyster. The operated oysters are kept in the laboratory for 2-3 days under observation. The dying oysters and the oystrs which reject nuclei are removed from the netlon basket. Within 2-3 days, the incision wound heals completely.

Farm phase

Post-operative culture

After convalscence, the oysters are placed in box cages, transferred to the farm and suspended from the raft/rack at 5 m/3 m depth in the sea. During the post-operation rearing period, the oyster density in culture cages at culture grounds should be kept at a minimum. Over-crowding may cause adverse effects such as production of low quality pearls, slow formation of nacreous layer, etc. In a box cage, 50-75 oysters with size 40-45 mm (25 g wt) can be accommodated. The cages are numbered with plastic number plates. The oysters are reared in the farm without much disturbance. It is ideal if oysters are reared in areas of high phytoplankton production. Once in a month, the cages are lifted to remove the predators from the cages and to scrap off the epifuna from the outer shells and cages. In Indian waters, the deposition of nacre on nuclei is much faster than in sub-tropical and temperate waters. The duration of post-operative culture varies from four to eighteen months depending on the size of the nuclei inserted and the desired size of the pearls to be obtained. When a 3 mm nucleus is inserted in an oyster, it takes a minimum of 4 months for the pearl to attain maturity and it is 15-18 months for a 7 mm diameter nucleus.

Pearl harvest

Harvesting of cultured pearls is usually carried out manually. The oysters are brought to the laboratory from the farm. With a sharp knife, the oyster's adductor muscle is cut and the pearl is squeezed out of the gonad region. In case the oysters need to be re-used for a second time, the oyster's valves are gently opened without damaging the adductor muscle and the pearl is carefully removed with instruments. The oysters are then returned to the farm for recovery and after a certain length of time they can be operated for a second time to produce additional pearls. Pearl harvest is done usually during the cooler season of the year during which time the pearl coating is thin and fine (Pl. IV A).

Cleaning and grading of pearls

After harvest, the pearls are cleaned with distilled water and given a salt wash. The pearls are mixed with powdered salt in equal volume and placed in a tub with small amount of water. Then the pearls are taken out and cleaned with distilled water. The residual mucus on the surface of the pearl is removed by rubbing with salt to obtain good lustre. The cleaned pearls are seived to size (mm) using gauging seives. Then they are sorted by size, shape, colour, lustre surface quality and flaws. They are graded into three categories (Pl. IV B).

A - grade : Flawles, one flaw, small flaws, small stain, pink, silver or light cream.

B - grade : Fairly large flaws, stains, cream colour and irregular shape.

C - grade : Trash pearls, wild shaped, badly coated, heavily pock-marked, clayey lumps, half good and half bad.

In Valinokkam farm, A - grade formed 36.2%, B - grade 54% and C - grade 9.8%.

Colour of pearls

The colour of cultured pearls largely follows the colour of the nacre of the shell of the pearl oyster which produces the pearl and is genetically determined. Besides this, the physiological condition of the oyster, the nature of the culture ground, depth, light penetration, feed, water quality, minerals and trace elements in the seawater also determine the pearl colour to some extent.

The Indian pearls show diversity in colours. In the Gulf of Mannar, the pearls produced are largely yellow in colour followed by white, ivory white, cream, grey, silver and light pink. Indian preference is mainly for yellow, golden yellow and white colours. Europeans prefer pink coloured pearls followed by white and cream coloured ones. In U.S.A, the preference is for rose, pink and cream coloured pearls. In general, the demand for white and cream coloured pearls is always good.

Drilling and processing

It is rather a common practice of the trade to improve the quality of culture pearls through processing. The pearls that need processing are drilled for holes using specialised drilling machines. The drilled pearls are treated with dilute hydrogen peroxide which not only removes the organic impurities, but also bleaches the pearls.

Marketing

The 'A' grade pearls are sold at the rate of Rs. 150-200 per carat, 'B' grade Rs. 100-150 per carat and 'C' grade Rs. 50-100 per carat. Pearls being a biological product, it is rather difficult to find homogeneity or uniformity in size and quality among them.

Quality improvement of pearls

For obtaining good quality pearls, the oysters should be grown at depths 5-10 m. Strong sunlight on oysters must be avoided since sunlight can induce nacre secreting cells to produce calcite crystals to form prismatic layer over the nucleus resulting in poor quality of the pearl.

Basically the colour, lustre and quality of pearls depend largely on the genetic character of the oyster that produces the pearl. The culture ground, the water quality, the feed and the physiological condition of the oyster also determine the quality to some extent. Graft tissue preparation is also an important factor. The tissues must be taken from the central portion of the mantle of a healthy oyster. Now-a-days in Japan, various chemicals and medicines are used to condition the oysters and make them grow healthy. Food dyes are also used in seeding operation to colour the graft tissue; activisers are used to activise the growth of pearl sac and growth promoters are used to get accelerated growth (Daniel and Durairaj, 1993).

Besides the factors mentioned above, much attention should be paid on the application of modern tools such as genetic improvement and tissue culture. The future of pearl quality improvement lies only in these two areas.

General remarks

The world production of marine pearls accounted for 78 tonnes valued at US $ 1042 million. Japan still holds the monopoly in the production of sea pearls. Even though India had the distinction of producing culture pearls in 1973 itself, it could not produce cultured pearls for world trade. India has ample scope to develop and expand the cultured pearl industry in different locations, mainly in the Gulf of Mannar and Andaman & Nicobar Islands. There is good scope for privitisation in the field, if firms which have technical and marketing collaboration with foreign countries are willing to come forward. Pearl culture is a long term investment and huge profits can be made in a successful culture operation as there is still a great demand for pearls. According to Wada (1973), in Japan, the returns from the cultured pearls are the highest among all marine product exports. The pearl industry is a biology based industry and is risk-prone as any other marine industry. India can also join with other leading pearl producing countries, if intensive and sincere efforts are put in the right direction.

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