PROSPECTS FOR HATCHERY AND CULTURE OF SEA CUCUMBERS IN INDIA

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INTRODUCTION

ACCORDING to FAO Annual statistics for 1984, the world echinoderm harvest in 1983 amounted to approximately 80,000 tonnes. The roe of echinoids roughly accounted to two thirds and the rest is contributed by processed sea cucumber. In 1989 India exported 51.5 tonnes of processed sea cucumber valued at 1.25 crores. The processed sea cucumber is known as *Bache-de-mer*. The *Bache-de-mer* industry is age old one introduced by the Chinese more than one thousand years back in India (Hornell, 1917). It is a cottage industry based in the rural areas and needs very little investment. Since sea cucumbers do not offer any resistance at the time of capture and also do not make any attempt to escape, the resources are quickly exploited from any place. A new resource of sea cucumber *Actinopyga echinites* is exploited from 1989 and by 1992 this resource has become very scarce (James and Badrudeen, 1995). Another sea cucumber *Actinopyga miliaris* is collected from Tuticorin since January, 1992 and in two months time more than six lakhs specimens were fished out. This type of over exploitation leads to depletion of natural population. In order to replenish the natural population hatchery technology for seed production of sea cucumber is developed.

The Chinese and the Japanese are the pioneers in the seed production of sea cucumbers since they consume the sea cucumbers. The Chinese consume proccessed sea cucumber and the Japanese consume the sea cucumbers in the fresh condition. It is significant to note that China and Japan do not at present import *Beche-de-mer* since they are able to meet their own needs through seed production and enriching their natural populations through sea ranching. Apart from these two countries some work is done on the seed production of sea cucumbers by the Koreans and the Russians.

PRESENT STATUS OF KNOWLEDGE

The Central Marine Fisheries Research Institute took up a Project in 1987 to produce seed of *Holothuria scabra* which is very valuable species for processing. Early success was met in 1988 when *H. scabra* was induced to spawn for the first time in the hatchery by thermal stimulation and seed produced. (James *et al.* 1989). Since then seed of *Holothuria scabra* was produced in the hatchery on number occasions. James and James (1993) wrote a paper on the prospects for sea cucumber farming. James (1994a, 1994b) reviewed the culture practices in Japan and China and also wrote on the seed production of sea cucumbers in India. James *et al.* (1994 a, 1994b) brought out a handbook on the hatchery techniques and culture of sea cucumbers and also on the breeding and rearing of the larvae and juveniles of sea cucumbers *Holothuria scabra*. These are the only publications on the hatchery and culture of sea cucumbers from India. James *et al.* (1994) wrote a paper on the experiments on the rearing of the juveniles of *Holothuria scabra*. Finally James (1995) described the prospects for the culture of sea cucumbers in India.

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WORK DONE INCLUDING THE METHODS

Collection of brood stock: The brood stock collection is an important aspect in any culture system. The brood stock is collected from the wild and from the commercial catches meant for processinng. Only large and healthy specimens alone were selected for this purpose. They were stocked in one tonne tank with sand brought from the natural bed. The sand is arranged in six inches thickness to enable the sea cucumbers to bury.

Maintenance of brood stock: The success of the hatchery depends on the brood stock and the animals have to be maintained in a healthy condition. The water in the tank is changed every day and the sand in the tanks is changed every fortnight. If the water is not regularly changed the sea cucumbers eviscerate throwing out all the internal parts including the gonads rendering the animals unsuitable for breeding purpose. Fresh algae from the sea is brought and this is ground to a fine paste in a mixie and put in water at least twice in a week. The sea cucumbers live on the organic matter present in the mud. The algal paste settles down at the bottom and this is consumed by the animals. If proper food is not provided the animals become shrunken and the gonad is reabsorbed. It is desirable to maintain the brood stock at 20-30 individuals per m^3.

Collection timing: Collection timing is very important for the success of hatchery management. Although *Holothuria scabra* spawns round the year two spawning peaks were observed one in March-April and the other in November-December. In case of *Holothuria atra* the spawning period was found to be during August-September. It is desirable to collect the brood stock material during the spawning peaks so that the chances of inducing spawning are more since most of the specimens have ripe gonads ready for release. A small rise of 5°C in temperature is enough to stimulate them to spawn. Another aspect is at present there is no known method so far to hasten the maturation process. Therefore it is desirable to conduct thermal stimulation during the breeding season of the animals.

Brood stock management: It is desirable to keep the water in the brood stock in fresh condition. The whole water is daily changed. Aeration has to be provided for the tanks to keep the animals in healthy condition. Excreta and dirt in the tank should be removed immediately. The behaviour of the individual breeders should be constantly watched.

Spawning: The main aim of artificial breeding is to successfully obtain high quality seed. Natural spawning and thermal stimulation for inducing spawning are given below.

Nattural spawning: When the gonads are fully mature, the male and female breeders release their gametes naturally without any inducement. At first the male releases the sperms, which induces the female to release the eggs after about two hours. The eggs are generallly released around 1400 hours.

Thermal stimulation: Thermal stimulation only gave results in case of *H. scabra. Holothuria atra* spawned during the breeding season when brought from the collection centre due to overcrowding and also due to agitation during transit. Earlier some specimens were subjected to chemical stimulation by injecting mild doses of Potassium Chloride. When this chemical is injected the specimen starts rolling and lengthening but no spawning was observed. When the concentration of the chemical was increased the specimens finally evicerated and became useless for further spawning experiments. For thermal stimulation first the

temperature of the water in the brood stock tanks was noted. This water is raised to 5°C by adding hot sea water. The ripe specimens are so sensitive to temperature changes that a rise of even 3°C is enough to trigger them to spawn. When the water in the brood stock tanks is changed by sea water from the sump or when specimens collected from the wild are introduced to sea water from the sump, if ripe specimens are available they spawn. In such instance the difference in tempeture is found to be only 3°C.

Spawning behaviour: In sea cucumbers the sexes are separate and it is not possible to distinguish the sexes externally. Only microscopical examination of the gonads will reveal the males and females. At the time of spawning also it is possible to differentiate the sexes since the behaviour of the males and females is different. In all cases the males only first spawn and this is followed by the females. In case of *Holothuria scabra* the males first lift the anterior end (Pl. I,A) and exhibit swaying movements. After exhibiting such movements for sometime the males start releasing the sperms, from the gonopores situated at the enaterior end in the mid-dorasl position. The male when once it starts releasing the sperms itt keeps on going in this way for about two hours. In the meanwhile if there is a ripe female in the sample it starts reacting to the sperms released in the water. The female starts ascending at the corner of the tank and the anterior end becomes bulged due to pressure created inside the body. The anterior end every time comes out of the water a little and gets into water. After a few attempts like this the female releases the eggs (Pl. I, B) in a single spurt and lies at the bottom of the tank. The eggs are ejected out in a powerful jet reaching a height of about three feet. Often the eggs fall outside the tank. The egg mass released is light yellow mucus like substance. The powerful jet helps in the dispersal of the eggs over a wide area.

.The spawning behaviour in case of *H. atra* is somewhat different especially in case of females. When *Holothuria atra* specimens are brought from the collection centre the males immediately start spawning by releasing the sperms in thick white threads which soon mix with the sea water. The females if ripe, almost immediately spawn. They release the eggs in a continuous jet like the males. The eggs are light pink in colour in case of *Holothuria atra.*

Fertilization: It is important to ensure a high survival rate in the artificial breeding by obtaining high quality eggs. Therefore it is necessary to handle the eggs carefully as soon as they are released. The fertilization is external and takes place in the water. After the eggs and sperms are released the breeders are removed from the tank. The eggs are washed several times in order to remove the excess sperms which might pollute the water in the tank resulting in reduced fertilization, and a large number of deformed embryos.

Early development of Holothuria scabra: The female usually releases about one million eggs. About 7.5 lakhs of eggs can be stocked in 750 litres of water. After fertilization the eggs undergo cleavage and develop into dipleurula stage which ranged in length from 190 to 250 μ. The eggs (Pl. I, C and D) were spherical, white and visible to the naked eye and were found to be floating. The diametter of the eggs varied from 180-200 μ. Soon two celled stage (Pl. II, A) is reached and then finally the

blastula (Pl. II, B). The dipleurula transforms into auricularia (Pl. II, C) larvae after 24 hours. They measured 430 μ in length and 280 μ in breadth. The auricularia were fed on the microalga *Isochrysis galbana* and mixed culture dominated by species of diatoms *Chaetoceros* spp. and *Skeletonema* spp. The auricularia actively fed on *Isochrysis galbana*. The mouth region exhibited constant pulsating movements and the yellowish-green concentration of *Isochrysis* spp. in the stomach was seen in circular movement. As days passed on, the auricularia larvae became more transparent and the lateral projections also became more prominent (Pl. II, D). On each side of the larvae there were four lateral projections and at the tip of each projection there is round structure. The bands also showed a number of pigment spots. The length of the auricularia larvae at this stage varied from 660-1050μ (average 860 μ) and breadth 240-690 μ (average 500 μ). Some of the auricularia were smaller in size. A few auricularia transformed into doliolaria stage on the tenth day. The doliolaria (Pl. III, 3 and 4) were barrel-shaped with five bands and with two tentacles projecting out. The posterior portion was slightly tapering. On each side there were five round structures with ossicle distinct at the posterior end. There were five groups of cilia-like structures on each side. The doliolaria moved fast in the forward direction. Their length varied from 420-570 μ (average 485 μ) and 240-390 μ in breadth (average 295 μ).

On the thirteenth day some of the doliolaria transformed into pentactula stage (Pl. III, C and D). The body of the pentactula was tubular with five tentacles at the anterior end and with one short stumpy tubefoot at the posterior end. The cloacal opening was distinct. Colour was greenish-brown. The length varied from 330-750 μ (average 307 μ). By 18th day the tube feet and tentacles became more distinct and the number of tables were seen projecting from the skin. The tentacles had a web in between them. At the posterior end two long tube feet were seen. The spires of the tables were projecting out of the skin. The tentacles and tubefeet also had tables sparcely distributed. The length of the specimens varied from 550-720 μ (average 656 μ) and the breadth varied from 210-320 μ (average 262 μ). The pentactula have the habit of moving to the edge of the tank and remain just below the surface of water. Soon they settle down to the bottom of the tank.

Develeopment of Holothuria atra

During the months of August and September specimens of *Holothuria atra* from the harbour area spawned immediately when brought to the hatchery and put in the tanks having sea water drawn from the sump due to a difference of 3°C temperature. The temperature of the sea water at the site of collection was 27°C and the temperature of sea water in the sump was 30°C. Some of the specimens spawned in the transit itself, in the plastic bucket due to overcrowding and also due to the rise of temperature of the sea water in the bucket.

Spawning behaviour of Holothuria atra: The males started spawning immediately when put in the sea water from the sump. The males (Pl. IV, A) started releasing the sperms as thick

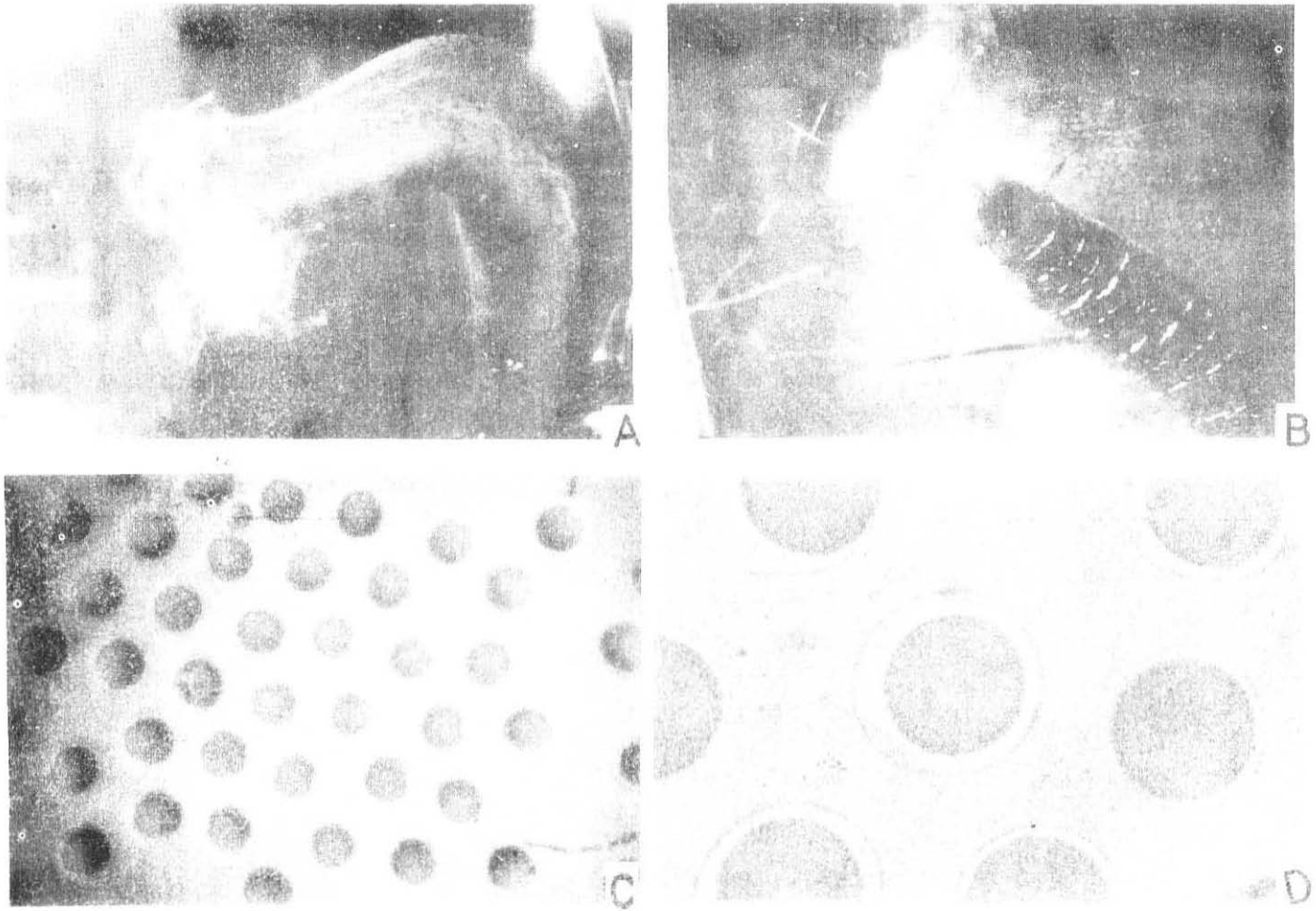

PLATE I. (A) Male spawning (B) Female spawning (C) Group of eggs (D) Single fertilized egg.

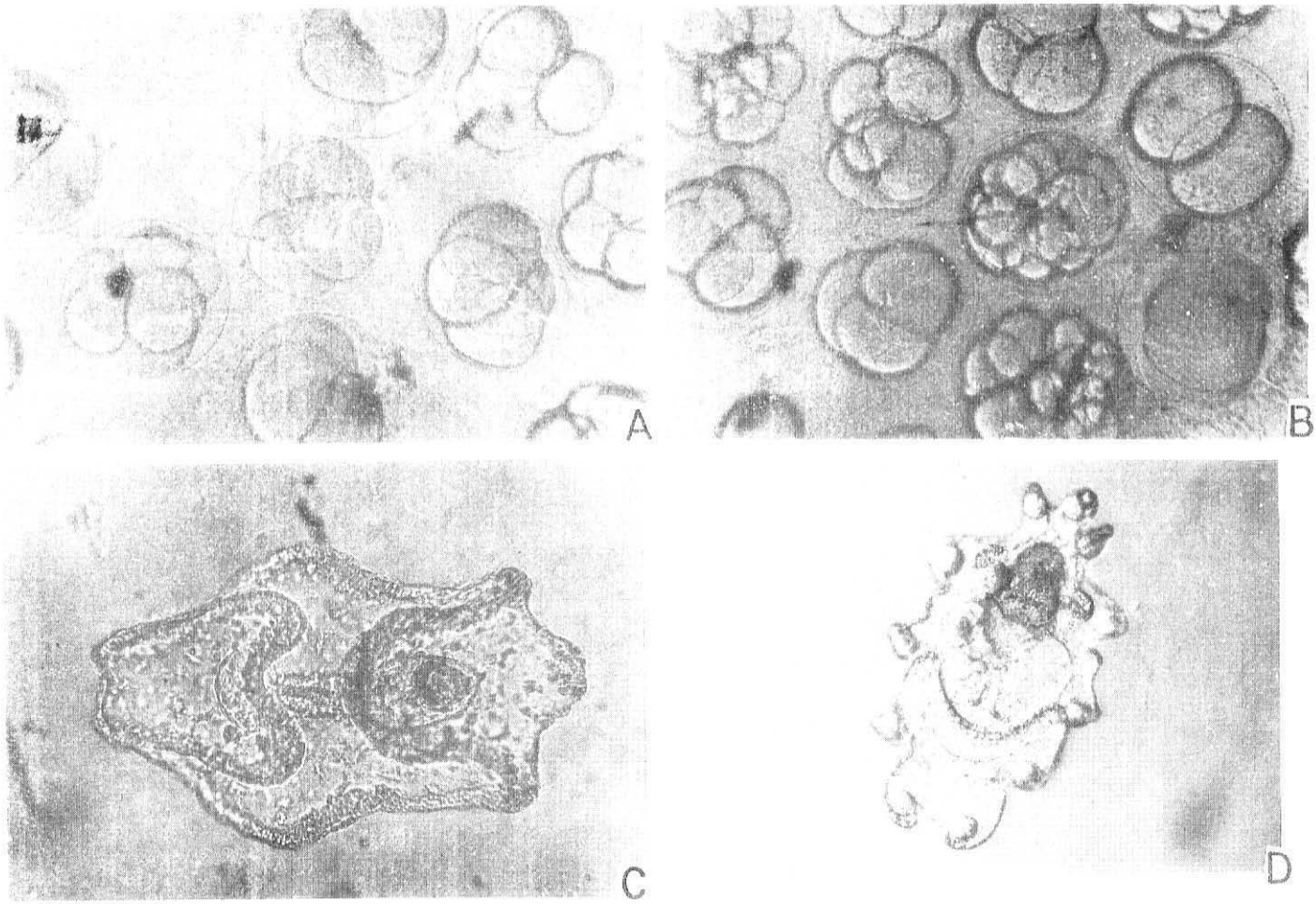

PLATE II. (A) Four celled stage (B) Blastula (C) Early auricularia (D) Late auricularia

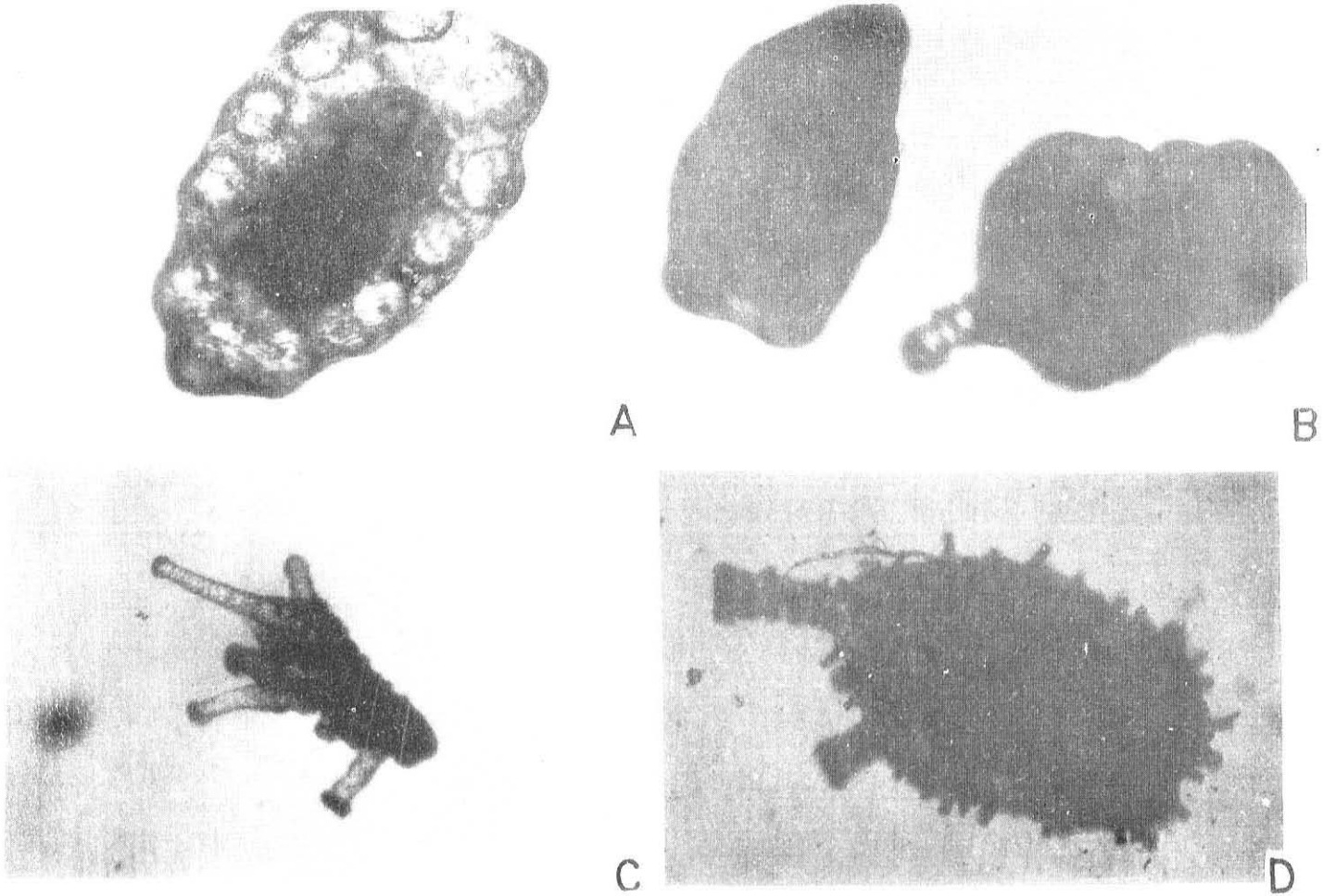

PLATE III. (A) Early doliolaria (B) Late doliolaria (C) Pentactula (D) Early juvenile

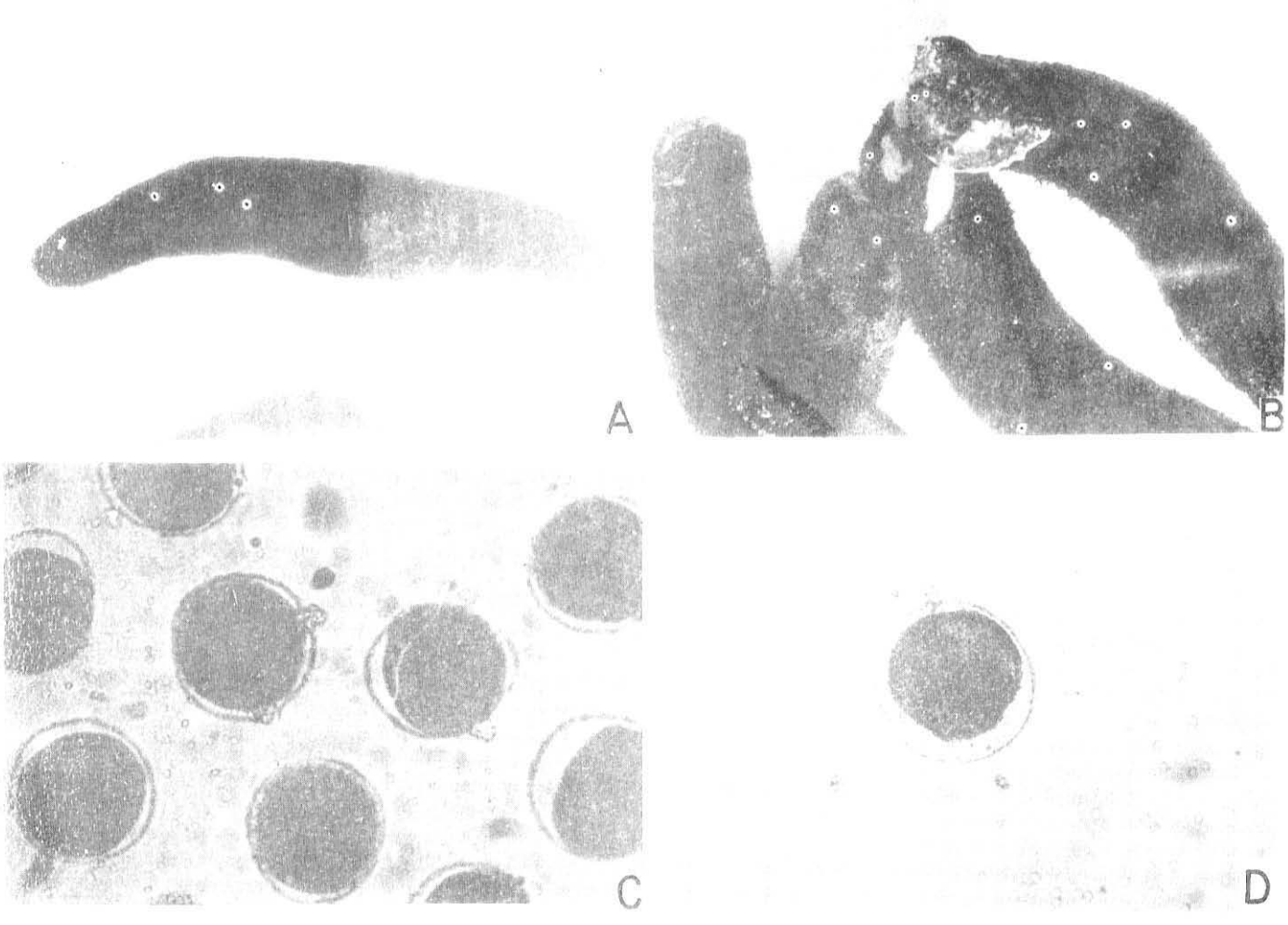

PLATE IV. (A) Male spawning (B) Female spawning (C) Group of eggs (D) Egg with polar body

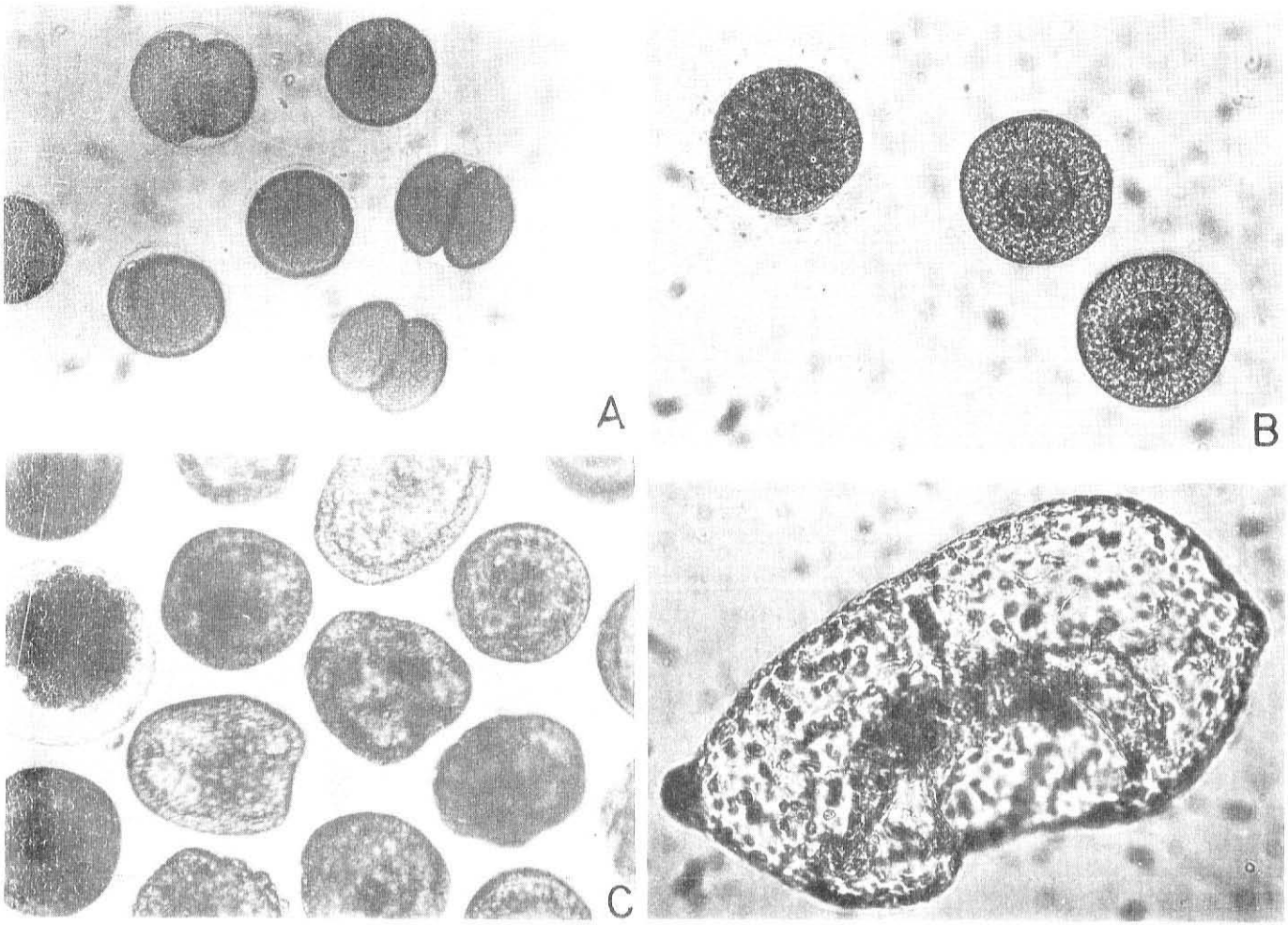

PLATE V. (A) Two celled stage (B) Blastula (C) Gastrula (D) Dipleurula

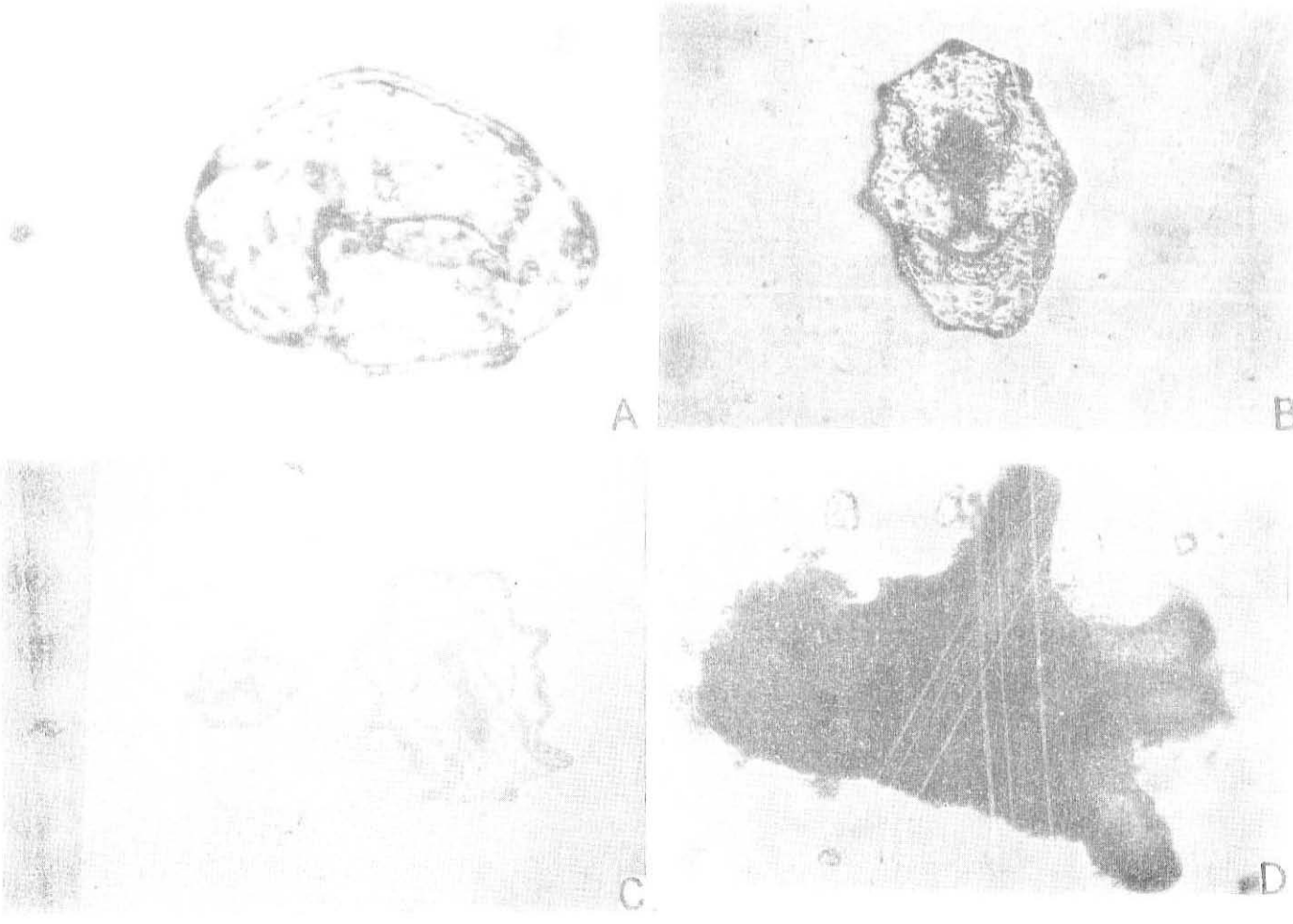

PLATE VI. (A) Very early auricularia (B) Early auricularia (C) Late auricularia (D) Pentactula

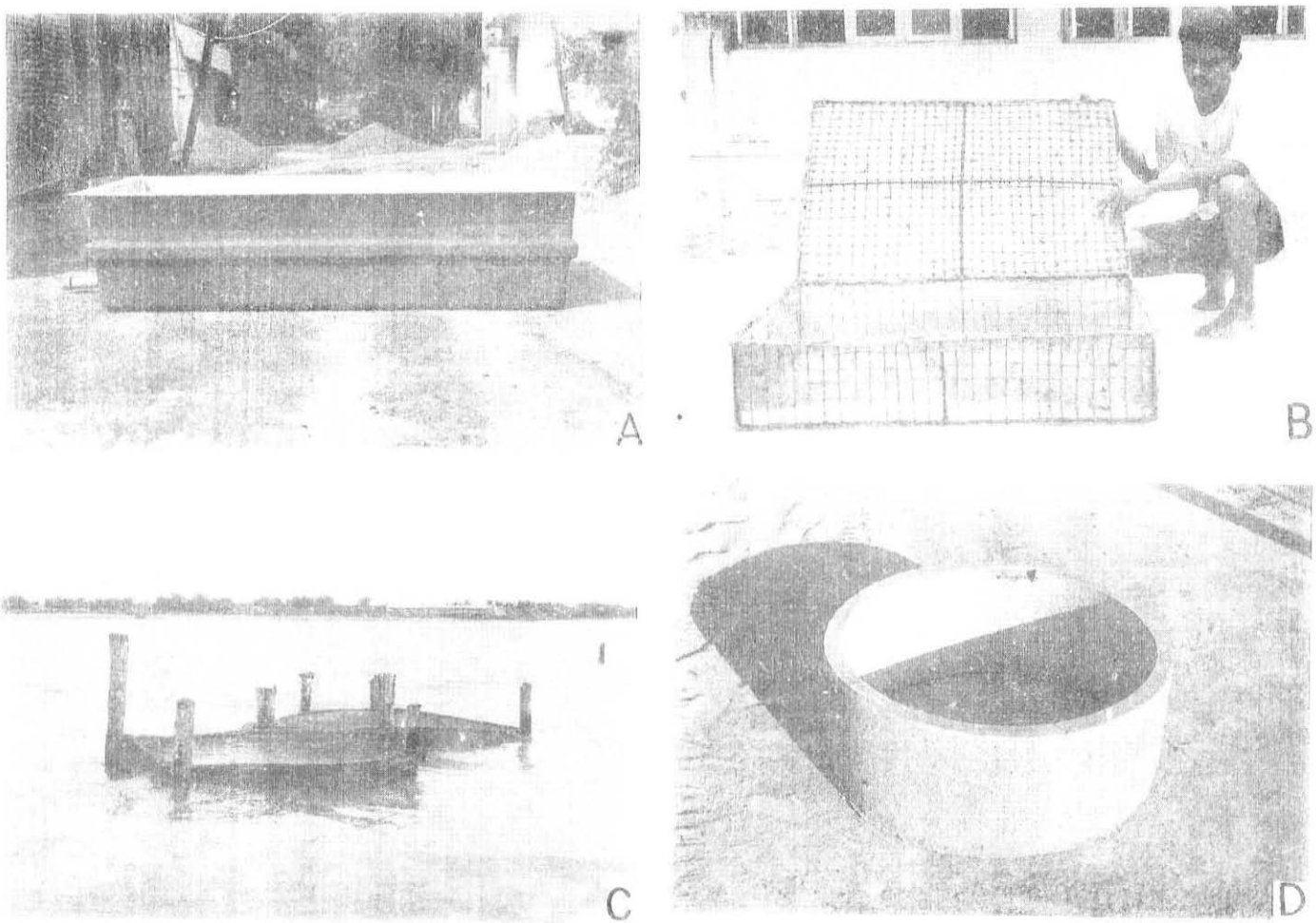

PLATE VII. (A) One tonne (B) Rectangular cage (C) Netlon cages set in the Karapad Bay (D) Cement ring.

white substance in fine jets. The body does not show any bending movements like *H. scabra* and the sperms are liberated when the specimens like straight. The females (Pl. IV,B) almost immediately release the eggs after the males spawn. The eggs are released in a continuous jet from the gonopore. The jet of eggs can be identified by the light pink colour due to the colour of the eggs. The female also does not show any bending or twisting movements during spawning.

Early development of Holothuria atra: Each female releases more than one million eggs at a time. The eggs (Pl. IV, C) are spherical, pink in colour and 130-140 μ in diameter. The first polar body (Pl. IV, D) is formed after 30 minutes. Two celled (Pl. V, A) and four celled stage are reached after 60 and 90 minutes, respectively. Blastula (Pl. V, B) is formed in the next 12 hours. Gastrula (Pl. V,C) is formed next day. Dipleurula (Pl. V, D) is seen after 24 hours. Early auricularia (Pl. VI, A and B) is formed after 30 hours. Late auricularia (Pl. VI, C) after eight days is distinct with the lateral projections well marked. The early auricularia is 275 μ in length and late auricularia is 550 μ in length. Only one occasion pentactula (Pl. VI, D) was found after 15 days. Pentactula is rather short and stumpy with five short tentacles at the anterior end. There is no distinct tubefoot at the posterior end like the pentactula of *H. scabra*. The auricularia larvae are broader than long. The preoral and post oral bands are well developed. The digestive tract is clearly demarcated. The stomach shows pulsating movements. At the posterior end a distinct osiculam is seen. During the last five year it was not possible to induce the auricularia to settle down despite various methods used. The auricularia were fed on various microalgae. They lived up to 28 days when fed on *Chromulina* spp. and *Chaetoceros* spp. but failed to transform into doliolaria and pentactula. At Solomon Islands doliolaria was obtained on the 20th day and by the 30th day all the larvae died (Ramafafia *et al.* 1995).

The early development of fertilized egg took place on surface and coloum of water. From the dipleurula stage the larvae started feeding on microalgal cultures. The auricularia and doliolaria are planktonic but the pentactula settles down to the bottom of the tank. The larvae were reared in one tonne tank in filtered and aerated sea water of salinity 32-34‰ and temperature 27-29°C. Water was changed every day. The temperature, pH and salinity were regularly monitored.

Rearing of the Postlarvae

Preparation of the rearing tanks : Rearing tanks and other tanks used in breeding especially the new tanks, must be scrubbed clean and filled with sea water for 20 days, during which period the water is changed repeatedly in order to lower the pH to less than 8.5. Before the tanks are used, they are scrubbed and filled with sea water containing 40 ppm bleaching powder and then washed clean with filtered sea water before the larvae are introduced.

Rearing density : Strict control of rearing density of larvae, i.e. the number of larvae per ml of water is first calculated. At present there are two methods to rear the larvae, still water rearing and flowing water rearing. Auricularia during their early and middle stages, concentrate at the surface of water. If the density of the larvae is more they will form as a ball and

sink resulting in death. Therefore rearing density should be controlled to ensure better survial rate. The desirable density of post larvae is 300-700 per litre. In one tonne tank having 750 litres of water 3,75,000 auricularia can be reared.

Selection and counting of the larvae : After fertilized eggs are transfered to rearing tanks, they develop into early auricularia stage in about 30 hours. The bottom of rearing tanks should be cleaned thoroughly. Healthy larvae occupy the surface layer of water, while deformed larvae and dead embryos generally stay in the lower layer of the water column or at the bottom of the tank. All the dead larvae, deformed larvae and sediment should be siphoned out in order to clean the tanks. After the tanks are cleaned, the water in the tank should be gently stirred so that the larvae can be uniformly distributed. A sample can be taken for counting the larvae. Samples,are taken separately from the two ends and middle of the tank, in a 250 ml beaker. This sample is unifromly stirred and one ml sample is taken in pipette and put in a plankton counting chamber. The number of larvae are counted in each ml. Like this two more samples have to be taken and average of three counts is taken as an indication of the density of the larvae. The result of the count would show whether the density is desirable or not. When auricularia are in their early stage, they are reared at the density level of about 500 per litre. The period of auriculaira development can be divided into three stages, *viz.*, early, middle and late stages. As they develop from one stage to the next, the bottom of the tanks must be claned completely once, or the larvae transfered to another tank. Normally the larvae are taken out after every alternate day so that the tanks can be cleaned thoroughly to avoid infestation of ciliates and copepods. On other days the water level is reduced to more than half by keeping the sieve inside the tank. The sediment must be removed to keep the water fresh. An uptodate information on the survival rate at each developing stage is necessary.

Water management : In the course of rearing, the larvae eject faces and consume dissolved oxygen constantly. Some of the larvae die in course of time. These and left over food produce harmful substances such as H_2 S and NH_3. In addition becteria reproduce rapidly with rise of temperature. Poor water quality directly affects the normal development of larvae. Therefore proper water management and sanitation is essential. Regular cleaning of tanks and changing of water are essential. The dirt and deformed larvae at the bottom of the tank are siphoned out every day. While water is changed by keeping the sieve inside the tank. The mesh size of the sieve must be smaller than the larvae. Normally 80 μ sieve is uesed since the auricularia larvae and even the eggs are more in size than the mesh of sieve. While the water is being changed with the help of a sieve some one should constantly stir the water lightly all round the tank. This will prevent the loss of larvae during water change, since siphoning would normally force the larvae to stick to the sieve causing the mechanical injury to the larvae. The sediments at the bottom of the tanks should be siphoned out completely every three or four days.

Larval feeding and feeding rates : Suitable and high quality microalgae and correct feeding schedule are the key for successful rearing. As the larvae of *Holothuria scabra* and *H. atra* develop into early auricularia larvae, its alimentary canal is well formed and the larvae must be given diet immediately. The feeding mechanism of the larvae consists of conveying the suspended bits of organisms and unicellular algae into the alimentary canal through the

mouth parts by the swaying of the peristomial cilia. The effectiveness of *Isochrysis galbana, Duniella salina, Dicrateria* spp. and mixed feed consisting of all the above mentioned microalgae was tried. The results show growh rate is better when fed with *Isochrysis galbna* and the mortality rate is also less. After four or five days the auricularia were fed with mixed culture. This chiefly consisted of the phytoplankton *Chaetoceros* sp.

The larvae require different quantities of diet during different developmental stages. Unicellular algae are fed twice a day, but the quantity given each time depends on the particular stage of the larvae. In general 20,000 to 30,000 numbers per ml in the rearing tank water is maintained. The microalga *Isochrysis galbana* cultured usually has a concentration of 80,000 cells per ml. When the bloom is good it reaches one million mark. The quantity of diet given should be increased or decreased depending on the quantity of food in the stomach of the larvae. This can be visually checked everyday before feeding them. Unicellular alagae during the period of the reproduction are the most preferred diet for the larvae.

ENVIRONMENTAL FACTORS

Monitoring of the environmental factors is important since the larvae and the juveniles of sea cucumbers are sensitive to environmental changes.

Temperature : At Tuticorin the temperature of the sea water ranges from 26-30° C. The optimum temperature for rearing the larvae was found to be 27-29° C. The water temperature should be noted twice in a day, both in the morning and also during the afternoon.

Dissolved oxygen : Dissolved oxygen level varies with water temperature. The higher the temperature, the lower the DO level. At Tuticorin the normal range for dissolved oxygen is 5-6 ml per litre. Always aeration is given to the larval tanks throughout the day to see that the oxygen level does not go down much. For one tonne tank generally two aerators are provided one at either end.

pH : Under normal conditions, the rearing sea water is generally alkaline with pH of 7.5 — 8.5. Tests have shown that the larvae of *Holothuria scabra* and *H. atra* and juveniles of both adopt to a fairly wide range of pH. However when pH rises over 9.0 or drops below 6.0 the moving ability of the larvae weakens and growth stops. Therefore the pH value of the water must be between 6.0 and 9.0.

Salinity : Salinity of normal sea water at Tuticorin ranges from 31-34‰. If the salinity is low all the larvae will die. The lethal critical salinity is 12.9‰. The optimum salinity for larval development ranges from 26.2 - 32.7%. In this range the higher the salinity, quicker is the development. Too high and too low salinity advessely affect the noramal development of the embryo and the larvae, resulting in large number of deformed larvae causing death. Salinity estimation is, therefore an important routine work throughout the entire rearing period. The salinity refractometer is now commonly used for salinity measurment. If specific gravity meter is used, the measured value can be converted into salinity value.

Amonical Nitrogen : The ammonical nitorgen content of sea water is very low, the sources in the breeding tanks are mainly the metabolites of larvae, the unconsumed diet and decomposing organisms. Too much accumulation of ammonia

can be harmful to the larvae. The larvae can develop normally with ammonical nitorgen content of 70 - 430 mg per m^3 water. When its content is over 500 mg per m^3 it will have a harmful effect on the development and growth of larvae.

REARING OF JUVENILES

The doliolaria larva settles on a hard surface when food is sufficient and also when hard substratum is available for it to settle. If these two conditions are not satisfied they continue to swim in the tank for a long time. Therefore the correct feed is given for the larvae and often settlers are provided for them to settle.

Types of settling bases : Two types of settling bases were tried for the larvae. In the first one polythene sheets are taken and kept in a tank outside the hatchery where there is good sunlight. Filtered sea water is circulated in the tank continuously for four of five days. Benthic diatoms and other algae settle on the plates. These plates are taken inside the hatchery and suspended in the tanks having doliolaria larvae. The hard surface and food induces them to settle on the plates. One disadvantage with settlers of this type is that the benthic algae which settles on the plates comes off completely after four or five days. In the other type of settlers the polythene sheets are kept in a tank having sea water. To this some algal extract filtered through 40 μ is added. Usually *Sargassum* spp. is used to make the extract and this is put in tanks with small quantity of sea water. The algal extract will stick to the plates. The water is changed daily and fesh extract is put in small quantities. After four or five days the polythene sheets are covered with a fine coat of algal extract and this serves as a good settling base for the larvae. If food is not provided on the settlers the larvae after settling will die. The settling bases should not have any toxicity and should be easily available and inexpensive.

Diet of the juveniles : Just after the completing the metamorphosis, the juveniles have only weak moving ability and their tentacles are short. Seaweeds like *Sargassum* spp. and *Halmida* spp. were tried as algal food for juveniles. *Sargassum* spp. and sea grass *Syngodium isoetifolium* which have more protein content have been found to be good for the growth of the juveniles. These seaweeds and seagrass are first cut into small bits and then put in a mixie and ground into fine paste. This is filtered by using 40 μ sieve initially. After one month 80 μ sieve is used. This filtered extract is daily given to the juveniles both in the morning and in the evening. The juveniles were found to feed actively on the algal extract and grow well.

Density of settled juveniles : When the larvae develop to the juvenile stage, they begin to crawl. Most of them stay on the settling bases. After 15 days, they have settled on the bases, they can be seen with the naked eye. The juveniles should be estimated. A remdom sampling is made with a frame of 400 sq.cm. The sampling area of each tank must be over 5% of its total area.

In order to achieve increased survival rate, it is necessary to control appropriately the settling density on settling bases at the optimum level. Too thick density of settling and insufficient diet will be adverse to the growth and survival. Hence, after they are counted, their density should be adjusted to the optimum which is 200-500 individuals per m^2.

PREDATORS AND THEIR CONTROL

Predation : Harpacticoids and other copepods and ciliates are the main predators on the auricularia larvae since their movements are sluggish. They attack, the auricularia at the sides and injure the body and kill them. They also harm the juveniles by reproducing fast in the rearing tanks and competing for food with the juveniles. Algal extracts of *Sargassum* spp. is found in the alimentary canal of the copepods. They also injure the body surface of the juveniles with their mouth parts and tear the epidermis of the juveniles. They slowly eat away the juveniles. The infested juveniles assume a ball shape and die gradually.

Predator control : Control trials on Harpacticoids and other copepods with different chemicals at different concetrations have been conducted. Harpacticoids are sensitive to organic phophorus. Thus Dipterix, Kogor and other chemicals containing orgono-phosphorus can be tried. Harpacticoidea can be killed with 2 ppm Dipterix in two hours with no harmful effects on the juveniles. However it is necessary to give careful attention to the preparation of Dipterix solution of appropriate concentration. The solution should be evenly sprinkled into the tank and the water in the tank must be changed completely after two hours. This is very important otherwise it will affect the juveniles.

RESULTS AND THEIR APPLICATION

The results so far obtained on seed production are very encouraging. For the first time *Holothuria scabra* and *H. atra* have been induced to spawn in the laboratory and seed has been produced in the case of former species. As stated in the introduction the sea cucumber resource quickly gets over exploited since the animals do not make any attempts to escape from the captors, and also they do not have defensive mechanisms against man. This has made these animals very vulnerable and due to overfishing the natural populations have dwindled alarmingly. The seed produced can be used for sea ranching in the natural beds of the sea cucumbers so that the natural populations can be enriched. Proper protection should be given to the seed that is sea ranched in a particular area. For this the co-operation of the fishermen is essential. The area where the seed has been sea ranched should be declared as out of bounds for fishermen for sometime. Now trials are conducted to test the effect of sea ranching in particular areas.

CULTURE ATTEMPTS

The seed produced in the hatchery are first grown for a period of two months in the hatchery itself. After they settle down to the bottom of the tanks they are daily fed on the extract of the alga *Sargassum* spp. First the alga is cut into small bits and made into a fine paste in a mixie. The paste is diluted in sea water and filtered through 40 micron sieve. The suspended matter settles down to the bottom of the tank as a fine film. The juveniles are found to feed well on the fine algal paste which settles at the bottom of the tank. Daily water in one tonne tank is completely changed and fresh algal extract is given to the juveniles. In two months time some of the juveniles reach a length of 20 mm. It was observed that all the juveniles of the same brood do not grow at the same rate. Some of them grow much faster than others and they are know as shooters. The shooters are removed and grown in a separate tank. After removing the shooters some of the juveniles again grow faster. In this way all the fast growing juveniles are removed and reared separately.

The juveniles produced in the hatchery are transfered to the sea after a period of two months. They are grown in old one tonne tanks, rectangular cages, velon screen cages, netlon cages, cement rings and also in prawn farms. Different growth rates were obtained during the experiments which are presented below.

The one tonne tanks (Pl. VII A) are two metres in length, one metre in breadth and half a metre in height. Usually old and condemned tanks are used for this purpose. These tanks are submerged at a depth of one metre and fixed with the help of four casurine poles at the four corners. Mud is provided in the tank to a thickness of 100 mm. No supplementary feed is given. The tank is covered by velon screen and secured by a rope to prevent undesirable organisms entering the tank. One tank was instaled in Karapad Bay at a depth of one metre and stocked with 147 juveniles. At the end of 97 days the mortality was found to be 40%. The average weight of the juveniles increased from 0.54 g to 5.9 g. The weight increase per day worked out to 55 mg. Juveniles were also maintained in one tonne tank in the hatchery. The initial average weight increased from 2.8 g to 9.8 g in / 23 days. The weight increase per day works out to 38 mg.

The rectangular cage (Pl. VII, B) are made of iron rods of 7 mm djameter. They are three feet long and two feet wide and are in the form of rectangular boxes with lid. On the outer side of the cage nylon rope of 2 mm thickness is knotted to the frame. The distance between two knots is 30 mm. The cage is lined with fine velon screen inside to prevent the sand or mud going out. The cage is fixed to the bottom of the sea at a depth of two metres with the help of four casurina poles. Rectangular cages were instaled in the Karapad Bay and Valinokkam Bay to study the growth of the juveniles. In Valinokkam Bay the cage was kept for 233 days. Initially it was stocked with 53 juveniles and at the end of the experiment the mortality rate was found to be 47%. The average weight increased from 2.8 g to 11.6 g. The weight increase per day works out to 38 mg. In the Karapad Bay the rectangular cage was maintained for 159 days with 154 juveniles. At the end of the period the mortality was found to be 60%. The initial average weight increased from 0.54 g to 11.9 g with 72 mg/day growth.

The velon screen cage was 2 sq.m. in area. It was made of velon screen of 4 mm mesh to allow free flow of water. The length and breadth of the cage was 2 m and 1 m respectively. The height of the cage was 2 m. The cage was fixed at a depth of 2 m on an algal bed. The bottom of the cage also has velon screen for easy and complete retrival of the juveniles. The cage is fixed to the ground by four poles one at each corner of the cage. The cages are further strengthened by four more poles at the middle of four sides to keep the cage in position during high gales. To keep the bottom of the cage stable four big stones were kept at four corners. After the juveniles were stocked the top is covered by velon screen and stiched so that fish and crabs may not enter the cage. Velon screen cages were instaled both at Karapad Bay and also at Valinokkam Bay. At Valinokkam Bay 100 juveniles were stocked and maintained for 214 days. At the end of the period the mortality was found to be 80%. The average weight of the juveniles increased from 0.4 g to 13.5 g giving a weight increase of 61 mg per day. At Karapad Bay only ten juveniles were stocked and maintained for 29 days. There was no mortality during the period. The average weight increased from 1.5 g to 3.0 g giving a weight increase of 52 mg per day.

Netlon cage (Pl. VII, C) is cylindrical in shape with an area of 1.65 sq. m. Diameter of the cage is 1.5 m and the height is 1.3 m. The mesh size is 5 mm. The netlon cage is erected in the sea at a depth of one metre. The cage is fixed to the bottom with the help of four stout casurina poles. The top of the cage is covered by velon screen by stiching to prevent the entry of other organisms. Every week during low tide two buckets of mud is put into the cage and this serves as food for the juveniles. The juveniles are examined every month to find out the mortality and also the increase in average weight of the juveniles. One hundered and sixty five juveniles were stocked in a netlon cage and maintained for 60 days. At the end of two months there was a mortality of 64%. The average weight increased from 6.48 g to 6.84 g. The weight increase per day works out to 36 mg.

Cement rings (Pl. VII, D) of 4 feet and 2 feet diameter were used in the harbour area. The Leight of the cement rings was one foot. Cement rings remain in sea water for a long time without any damage. At the bottom of the cement ring velon screen is placed and the top of the ring is also covered by velon screen to prevent entry of undesirable organisms. Thirty juveniles were stocked in the cement ring and at the end of 55 days 3% mortality was observed. The average weight increased from 7 g to 8.2 g. The weight increase per day works out to 21 mg. One cement ring was maintained in the prawn farm. Five medium sized and 10 small juveniles were stocked and at the end of one month no morality was seen in medium sized juveniles. The average weight increased from 20 g to 26 g. The weight increase works out to 200 mg. In case of small juveniles there was 10% mortality. The average weight increased from 8.7 g to 10.8 g. The weight increase per day worked out to 70 mg.

In the rectangular cage the area is limited and therefore only limited number of juveniles can be stocked and reared. The durability of the netlon cage in the sea is limitted. It lasts

TABLE 1. Weight increase per day in the juveniles of *Holothuria scabra* produced in the hatchery during farming experiments

S.No.	Expt. site	Farming method	No. of days	No. Juv.	Mortality %	Weight (g) Initial	Final	Wt. increase (mg) per day
1.	Karapad Bay	One tonne tank	97	147	40	054	5.9	55
2.	CMFRI Hatchery	One tonne tank	123	175	Nil	2.8	19.8	138
3.	Valinokkam Bay	Rectangular cage	233	53	47	2.8	11.6	38
4.	Karapad Bay	Rectangular cage	159	154	60	0.54	11.9	72
5.	Valinokkam Bay	Velon screen cage	214	100	80	0.4	13.5	61
6.	Karapad Bay	Velon screen cage	29	10	Nil	1.5	3.0	52
7.	Karapad	Netlon cage	60	165	64	6.4	6.8	36
8.	Harbour area	Cement ring	32	15	40	3.2	6.9	115
9.	ITC prawn farm	Cement ring (Medium juveniles)	30	5	Nil	20.0	26.0	200
10.	ITC Prawn farm	Cement ring (Small juveniles)	30	10	10	8.7	10.8	70

only for three months in the sea. After three months it becomes brittle and breaks. The velon screen cages get blocked due to the smaller mesh size and therefore they have to be periodically cleaned with a brush. The cement rings last for a very long time but the area is limited and therefore only small number of seed can be stocked. The best way to farm the juveniles of sea cucumbers is to grow them in prawn farms. They grow very well on the unused feed at the bottom of the farm and also keep the farm clean. The results of all these experiments are summerised in Table 1.

Future Scope for Research and Development

Although it is now possible to induce sea cucumbers to spawn in the hatchery and produce seed there is vast scope for further research and development. Since the breeders cannot be collected round the year due to the roughness of the sea resulting in poor visibility for the divers, it is essential to maintain the breeders collected during the fair weather season in healthy condition. The water in the brood stock tanks should be daily changed and good aeration should be given. In one tonne tank 5-20 specimens can be stocked. Algae like *Sargassum* spp. and sea grass should be made as a paste and put in the tank in small quantities twice a week. The sea cucumbers live on the organic matter present in the sand or mud. The algal extract settles down to the bottom and becomes one with the substratum. Too much of the extract should not be put since it will contaminate the water. Another area for research is to hasten the maturation process so that at any required time the sea cucumbers can be induced to spawn and produce seed. At present the larvae are fed on microalgal cultures like *Isochrysis galbana* which is produced in an airconditioned room with lot of chemicals. Substitute feed available in nature should be tried to feed the larvae. Then only it is possible to transfer this technology to the villages. Otherwise only seed has to be supplied to them. There is scope to reduce the mortality rates in case of larvae if we rear them in dechlorinated sea water. Similarly the mortality rates of the juveniles can be reduced by rearing them in flowing sea water. Lot of research has to be conducted on the feed for the juveniles. Majority of the juveniles produced have stunted growth. Only 10% of the juveniles produced show normal growth. Growth promoting substances and high energy feeds have to be used to accelerate the growth of stunted forms. It is desirable to grow them in the sea after two months since to maintain them for a long time in the hatchery is expensive and labour intensive. Initially the juveniles can be grown in velon screen cages and later they can be transfered to prawn forms where they are found to grow well. They also do not interfere with the growth of the prawns.

Acknowledgements

I thank Dr. M. Devaraj, Director, Central Marine Fisheries Research Institute, Kochi-14 for his kind intrest and encouragement. I thank the Senior Research Fellows working in the Sea Cucumber Project for assistantnce in the field and in the analysis of the data presented here.

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