Hatchery and Culture Technology for the Sea Cucumber, *Holothuria scabra* Jaeger, in India

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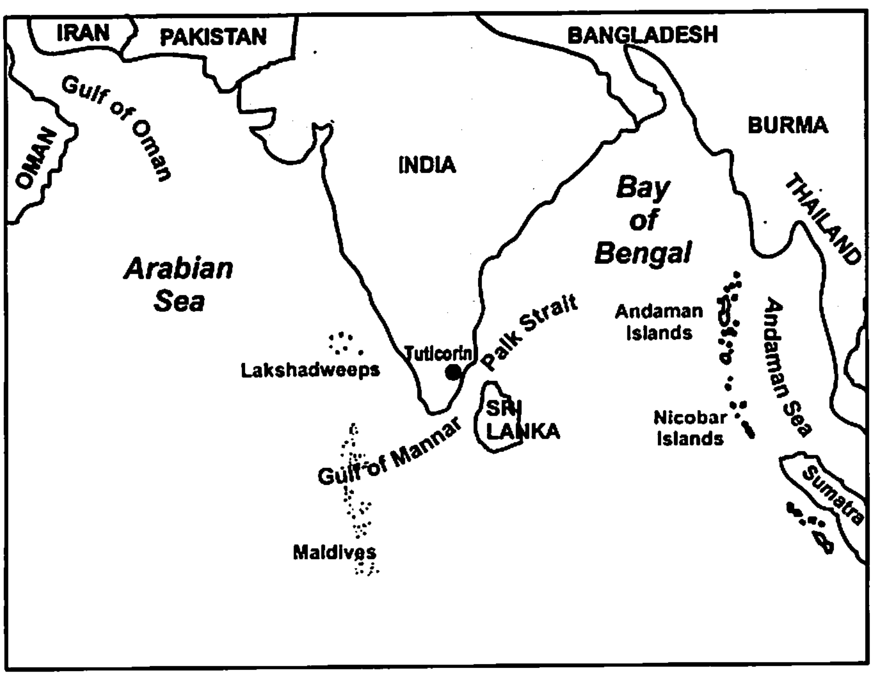
Abstract

The seed of the sea cucumber *Holothuria scabra* Jaeger is being produced at the Central Marine Fisheries Research Institute in India. This article describes the techniques being used in the production of the seed and the experiments being carried out for the rearing of juveniles. Trials to grow juveniles in hatcheries on prawn farms have shown spectacular results that are both cost efficient and environmentally friendly.

Introduction

The fresh sea cucumber *Apostichopus japonicus* is consumed by the Japanese and the Koreans. Processed sea cucumber is known as *bêche-de-mer* and is considered a delicacy in China. The Chinese introduced the processing of sea cucumbers to India more than a thousand years ago. The sea cucumber resources, fishery and industry in India are summarized by James (1989). Singapore imported S$2.84 million worth of processed sea cucumbers in 1995 from India (Ferdouse 1999). About 15 species of sea cucumbers are processed along the Gulf of Mannar and Palk Bay. Processing of sea cucumbers is banned in the Andaman and Nicobar Islands and the Lakshadweeps. Continuous exploitation along the Gulf of Mannar and Palk Bay has resulted in a depletion of the natural population. The Central Marine Fisheries Research Institute (CMFRI) at Tuticorin has started a project on the production of sea cucumber seed.



Sea cucumbers are found in several locations in the oceans around India.

The Japanese were the first to produce the seed of *A. japonicus* (Inaba 1937). The Chinese also produce the seed of this species for sea ranching and for enriching the natural population. Seed of *Actinopyga echinites* was produced for the first time in Taiwan in 1990. *Holothuria scabra* is the most expensive sea cucumber used for processing. It is considered the best candidate for stock enhancement because it is of high value, widely distributed, relatively easy to culture and grows rapidly in high densities on simple, low cost diets. In the seas around India, it occurs in the Gulf of Mannar, Palk Bay and the Andaman and Nicobar Islands. *H. scabra versicolor* occurs in the Lakshadweeps in deeper waters.

The seed of *H. scabra* was produced for the first time in India in 1988 at the hatchery of the Tuticorin Research Centre of CMFRI (James et al. 1994b). The seed of this species was produced in the Solomon Islands in 1996 by ICLARM. A private company is producing the seed of *H. scabra* in the Maldives. Broodstock material has been taken from India to the Maldives for use in hatcheries.

Hatchery and Culture Technology

The basic facilities required for a sea cucumber hatchery are: a building of 30 m x 10 m area; a seawater supply system with draw well, sedimentation tanks, filter beds, sump, overhead tank and delivery lines; drainage facilities; aeration system with storage compressors, filters, air grids and diffuser stones; perspex tanks (100 l) for spawning; one ton FRP tanks for larval and juvenile rearing and algal culture; and other items such as immersion water heaters, sieves with different mesh sizes and glassware.

Broodstock

The broodstock is collected from commercial catches. It is essential that the collection is made during the spawning season as most of the specimens are ripe and ready for immediate use. *H. scabra* has two spawning peaks at Tuticorin, one in March-May and a minor one in October-December. Only large and healthy specimens are selected and those which are injured or eviscerated are discarded. Very large and very small specimens are not useful for breeding purposes. About 30 specimens are stocked in a one-ton tank with sand (6" depth) brought from natural grounds to enable the sea cucumbers to burrow.

The water in the tank is changed every day and the sand every fortnight. If the water quality deteriorates, the animals will eviscerate and be useless for spawning purposes. Fresh algae brought from the sea is ground to a fine paste and fed to the sea cucumbers once a week. Care is taken not to add too much of the paste as it changes the water quality. The sea cucumbers feed on the organic matter that settles on the bottom of the tank. If proper nourishment is not given, the animals shrink and the gonad is reabsorbed. Maintenance of a healthy broodstock is essential for the successful operation of the hatchery.

Spawning

Spawning is induced by thermal stimulation which is the best method to induce the sea cucumbers to spawn. The animals to be subjected to thermal stimulation are put in a separate tank. It is better to start with 70-80 specimens for thermal stimulation. The water temperature in the tank is raised by 3-5°C by the slow addition of heated sea water.

It is not possible to distinguish the sex of sea cucumbers externally. The sex can be determined only by an examination of the gonads under a microscope. The ripe ovary is translucent and the ripe testis is milky white. It is possible to distinguish the males from the females by their spawning behavior. The males always liberate the milt first and the females follow. The male first lifts its anterior end like the hood of a snake and exhibits swaying movements followed by release of sperm in the form of white threads that soon mix with the sea water. The males release the sperm for one to two hours. The presence of the sperm in the sea water induces the females to liberate eggs if they are in ripe condition. The anterior portion of the female bulges due to the pressure inside the body and the eggs are released in one or two spurts. Generally the sexes are equally distributed. Only one or two males are allowed to release the sperm in the tank. The other males are removed as soon as they start releasing the sperm since the water will turn milky white and this will result in poor fertilization. Once a male starts releasing the sperm, it will continue to do so even if it is disturbed.

Fertilization

Fertilization is external. As soon as the eggs are released they are fertilized by the sperm. The eggs are washed several times to remove excess sperm. The females usually release about one million eggs each on the average. The larger the specimen, the larger the number of eggs released. The eggs (Fig. 2) are white, spherical and visible to the naked eye. Soon after fertilization, cell division starts and dipleurula is formed on the next day. It floats and exhibits slight movements with the formation of a single band of cilia.

Fig. 1. Male **Holothuria scabra** *spawning.*

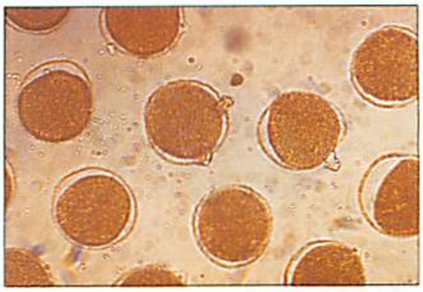


Fig. 2. Eggs of **H. scabra.**

Water Quality

The quality of water is of paramount importance since the larvae and the seeds are very sensitive to environmental changes. The larvae are subjected to attacks by copepods, ciliates and *Vorticella*. If these enter the culture medium, the experiment has to be terminated since they kill all the larvae. Therefore, it is essential to filter the seawater used as rearing medium through a one micron filter to eliminate all undesirable organisms. Care is taken not to take any raw seawater into the hatchery. All glassware used in the hatchery operations are sterilized. The plastic articles are washed with bleaching powder and put

Fig. 3. Auricularia larva.

Fig. 4. Doliolaria.

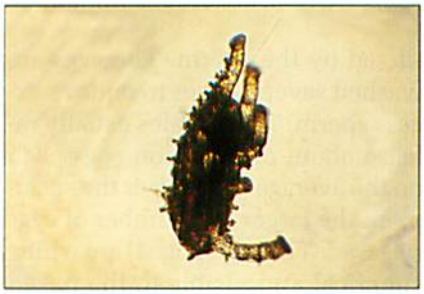


Fig. 5. Pentactula.

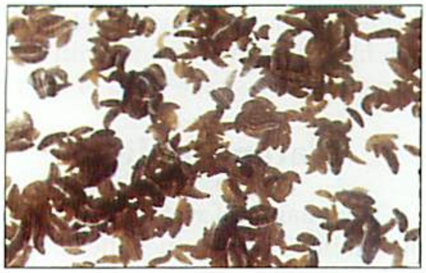


Fig. 6. Seed of H. scabra *produced in the hatchery.*

out in the sun for drying. The ideal environmental parameters are: water temperature 27-29°C; salinity 26.2-32.7%; dissolved oxygen 5-6 ml/l; pH 6-9; and the ammonia content of the water 70 mg to 430 mg/m^3.

Larval Rearing

On the third day the auricularia larva (Fig. 3) is formed. It is slipper-shaped, transparent and pelagic in habit. It has a preoral anterior loop and anal posterior loop. These ciliary bands help in locomotion. The digestive tract consists of a mouth, an elongated pharynx and a sacciform stomach. The early auricularia larva measures 563 μ on an average. The late auricularia has an average length of 1.1 mm. On the tenth day the auricularia larvae metamorphose to doliolaria larvae. The dololaria (Fig. 4) is barrel-shaped with five bands around the body. These larvae measure 460-620 μ. Rapid changes occur inside the body and all adult features of the holothurian set in. This stage is short and last only for two or three days. Subsequently they transform into a creeping stage known as pentactula. The pentactula (Fig. 5) is tubular with five tentacles at the anterior end and a single tubefoot at the posterior end. This helps in locomotion. The pentactula creeps over the sides and bottom of the tank. They actively feed on benthic algae and other detritus matter. The pentactula measures 600-700 μ. It grows rapidly and settles down at the bottom of the tank as seed (Fig. 6). The seed shows differential growth. The fast growing shooters are removed and reared separately. Again shooters develop from the original stock.

Rearing tanks and other tanks used in the hatchery, especially the new ones, are scrubbed clean and filled with seawater for 10 days. During this period the water is changed daily in order to lower the pH below 8.5. The tanks are scrubbed again and filled with seawater containing 40 ppm bleaching powder and then washed clean with filtered seawater before the larvae are released.

Strict control of the rearing density of larvae has to be observed. The larvae can be reared in still water or running water. If the density of the larvae is too high, they will form a ball, sink and die. The rearing density is controlled to ensure a better survival rate. The desirable density of the larvae is 300-700 per liter. In a one ton tank with 750 l of water, up to 375 000 larvae can be stocked.

Suitable and high quality microalgae and correct feeding rates are important for successful rearing. As the larvae progress in development the alimentary canal is well formed and the larvae must be fed 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 swaying of the hair-like structures round the mouth. The effectiveness of various microalgae has been tried. The best growth rate of the larvae has been attained by feeding on the microalga *Isochrysis galbana*. The mortality rate is also lower when fed with this microalga. After one week the larvae are also fed with mixed culture consisting mainly of phytoplankton.

The larvae require different quantities of diet during the different developmental stages. Unicellular algae are fed twice a day, but the quantity given each time depends on the particular stage of larvae. When the bloom is good the concentration of the cells reaches 6-8 million/ml. The quantity of diet should be increased or decreased depending on the quantity of the food in the stomach of the larva. This can be visually checked before every feeding. Unicellular algae are the most preferred diet during the peak period of reproduction.

When the pentactular stage is reached, the best diet for rapid growth is an extract of mixed phytoplankton culture. A mixed culture of *Chaetoceros calcitrans* and *Tetraselmis chuii* cultured in 100-ml perspex tanks is used. When full bloom is developed the color of the water in the tank turns deep yellow. Two liters of freshwater heated to 40°C is poured into these tanks in the morning. By evening all the algae die and settle at the bottom of the tank. This extract is fed to the pentactula which has settled at the bottom of the tank. At this stage the bottom of the tanks are not cleaned. This extract is given daily. The seed grow well on this diet and reach a length of 4-5 mm within one week. The water in the larval tanks is not drained out. Water is added slowly at the top of tank and the residual water is slowly drained out. This ensures that the larvae that stick to the sides of the tank do not die. When the seed reach a length of 10 mm they are given algal extract. *Sargassum* spp. is collected and washed thoroughly in seawater to remove all the organisms living on it. Then the alga is cut into small bits and made into a fine paste. This paste is mixed with seawater and filtered through a 40 micron filter. This extract is then boiled and allowed to cool to room temperature. It is given daily to the juveniles. They grow very fast on this extract and in two months they reach a length of more than 20 mm. They are then transferred to growout farms.

Culture

Although the seed of sea cucumber *A. japonicus* was produced more than 60 years ago (Inaba 1937), no culture methods have evolved for sea cucumbers as they are slow growing animals. In China and Japan the seed produced are sea ranched in natural habitats to enrich the populations. However, no studies have been made on the effect of sea ranching operations on the landings of sea cucumbers. In India the seed produced in hatcheries is grown in rectangular cages, velon screen cages, netlon cages, concrete rings and also in prawn farms (James 1996).

The rectangular cages (Fig. 7) are made of iron rods of 7 mm diameter. They are three feet long and two feet wide and are in the form of a box with a lid. On the outer side of the cage a nylon rope of 2 mm thickness is knotted to the frame. The distance between two knots is 30 mm. The cage is lined with a fine velon screen inside to prevent the mud going out. The cage is fixed to the bottom of the sea at a depth of one meter with the help of four casurina poles.

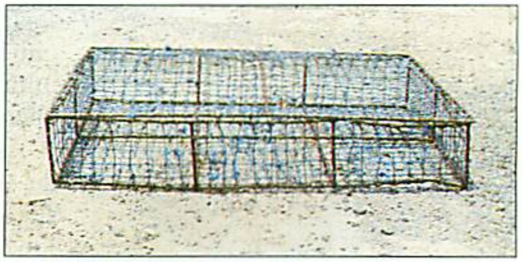


Fig. 7. Rectangular cage.

The velon screen cage (Fig. 8) is 2 m^2 in area. It is made of velon screen of 4 mm mesh to allow for a free flow of water. The length and breadth of the cage are 2 m and 1 m, respectively. The height of the cage is 2 m. The cage is fixed at the depth of 1 m on an algal bed. The bottom of the cage also has a velon screen for easy and total retrieval of the juveniles. The cage is fixed to the ground by four poles, one at each corner of the cage. The cage is further strengthened by four more poles one at the middle of the four sides to keep it in position during gales. Four big stones are kept at the four corners to keep the bottom of the velon screen stable. After the juveniles are stocked, the top of the cage is covered by a velon screen and stitched so that fish and crabs do not enter the cage.

Fig. 8. Velon screen cage.

Fig. 9. Netlon cage.

The netlon cage (Fig. 9) is cylindrical in shape with an area of 1.65 m^2. The diameter of the cage is 1.5 m and height is 1.3 m. The mesh size is 5 mm. The netlon cage is erected in the sea at a depth of 1 m. The cage is fixed to the bottom with the help of four stout casurina poles. The top of the cage is closed with a velon screen, stitched on to prevent the entry of fish and other organisms. Every week, during low tide, two buckets of surrounding mud are put into the netlon cage. The juveniles thrive on the organic matter present in the mud. They are removed every month to measure weight and mortality.

Since the rectangular cages are made of iron rods, they rust on coming in contact with seawater. The velon screen cage gets clogged with algae and mud, and this has to be brushed periodically to keep the mesh free to allow free flow of water. The netlon material becomes brittle in seawater. Juveniles are also grown in old one-ton tanks. An old tank is taken and filled with mud to a height of 200 mm. This is fixed at a depth of 1 m with the help of four poles, one at each corner. The top of the tank is covered by a velon screen of 5 mm mesh to allow good circulation of water and also to prevent the entry of fish and crabs into the tank. Every week the velon screen covering the tank is cleaned with a brush to remove the

Fig. 10. Concrete ring covered with velon screen.

settlement of other marine organisms. Since the height of the FRP tanks is 50 cm there is not much circulation of water inside the tank, resulting in the formation of hydrogen sulfide. An artificial feed is prepared with soya bean powder (3.5 g), rice bran (12.0 g) and prawn head waste (10.6 g). This feed is used for the juveniles in all the experiments and encouraging results have been obtained. The results of the experiments on rearing of the juveniles of *H. scabra* produced in the hatchery are given in James et al. (1994a).

Take-off in Technology

The juveniles produced in the hatchery have been grown on a prawn farm with spectacular results. It is well known that much of the feed given to the prawns goes as a waste enriching the farm soil and at the same time polluting the environment. The sea cucumbers are detritus feeders, subsisting on the organic matter present in the farm soil. They convert organic waste into body protein and grow fast. The presence of sea cucumbers at the bottom of the prawn farm in no way affects the activities of prawn rearing. In fact the prawns grow faster since pollution is reduced and the environment is kept clean. It is an ecofriendly practice which is beneficial to both prawns and sea cucumbers. In recent years the prawn farming industry has been rocked by disease and legal problems in India. The culture of sea cucumbers comes as a boon for the prawn farmers.

As a test case, the sea cucumber seed was grown in a concrete ring (Fig. 10) used in the construction of a well, with 70 cm diameter and 30 cm height. The concrete ring was placed in the corner of the farm at a depth of 1 m. A velon screen was tied at the bottom of the ring to prevent burrowing and escaping of juveniles. After setting the ring, the surrounding pond mud was scooped out and filled into the ring to three-fourths of its height. The top portion of the ring was also covered to prevent entry of prawns and other organisms. The prawn farm selected for the experiment to grow the hatchery produced seed is Eastern Aquafarm in Tuticorin. It is a modified extensive shrimp farm with four ponds of different sizes. The farm was stocked with the tiger prawn *Penaeus monodon*. They were fed on a pelleted diet with 40-42% protein. The prawns were fed daily with 15 kg ULTRA-TWL feed with a composition of 42% protein, 30% lipid and 13% ash. The organic carbon content of the bottom soil used in the ring was 0.885 %.

The average weight of the juveniles stocked in June 1998 was 67 g. This increased to 284 g by the end of December 1998. They are expected to reach their full weight in eight months on the farm and be ready for harvest and for processing. It is advisable to stock seed at the rate of 30 000 per ha. The growth on the prawn farm is expected to be much higher than in other locations.

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