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Controlled Breeding, Seed Production and Culture of Brackishwater Fishes

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Introduction

Aquaculture in marine/brackishwater ecosystems in coastal ponds, open sea cages and pens is assuming greater significance in recent years. Out of the total fish production of about 147 million tonnes, the contribution through culture has become half the mark, sharing annual increase between 8 and 10 %. Considering the capture fisheries' stagnations and the growing demand for fish as animal protein source, aquaculture plays an important role in augmenting production. In India, the contribution through aquaculture is 80 % in the freshwater sector and around 160,000 tonnes through coastal aquaculture. Aquaculture has developed rapidly over the last three decades and has become an important growing industry for generating the revenue, providing employment and nutritional security for the millions of people. The ever-increasing population and the rising demand for animal protein are causing pressure on fishery development globally. Fish and fishery products contribute around 15 % of the animal protein supporting the nutritional security. In the global fish production, Asian countries occupy the top eight, where India stands second position after China. China has produced 70 % of the global production which formed 50 % in value, whereas India is a distant second with 5 % production and 4 % in value. The global average per capita consumption of fish is around 15 kg. The present average per capita consumption in India is around 9 kg. In countries like Japan and some of the Southeast Asian countries, the average per capita consumption is more than 100 kg. Reaching the global average of 15 kg, taking into consideration that 50 % of the Indian population will be fish consumers, by 2020 the domestic requirement itself will be in the order of 9 million tonnes. By 2020, the coastal aquaculture in India is expected to support the tune of around 350,000 tonnes, from the current production of around 150,000 tonnes. This implies that a quantum jump has to be made in the ensuing years. Out of this, shrimp is expected to contribute around 250,000 tonnes and the rest has to come through fishes and other nonconventional groups.

Development of aquaculture has become imperative for the following reasons:

- Means of protein-rich fish production for 'nutritional security'
- Generation of employment – livelihood security
- Economic status and social upliftment – social security
- Reduce pressure on wild stock – conservation
- Biological indicator for water quality
- Culture of nutrient utilizers like seaweeds and molluscs improve water quality – environment security

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- Integrated farming like paddy cum fish culture – reduce other outputs

India is bestowed with a coastal line of 8,129 km; estuaries of 3.50 million ha; backwater of 3.90 million ha; mangrove of 0.40 million ha; potential brackishwater area suitable for aquaculture, about 1.19 million ha; freshwater reservoirs of 3.15 million ha; ponds and tank of 2.25 million ha; beels and oxbow lake of 0.82 million ha; medium and large reservoirs of 2.04 million ha; and irrigation canals of 146,000 km. These aquatic systems are either underutilized or unutilized. These areas can be brought into the aquaculture, and production and productivity can be increased.

Status of Coastal Aquaculture

Coastal aquaculture is a traditional practice in India. In the low-lying fields of Kerala (pokkali), West Bengal (bheries and gheries), Orissa, Goa (khzan) and Karnataka (kar) which experiences an influx of salt water, traditional farming of fish/shrimp was practiced. The practice is just allowing juveniles of fish/shrimp in the fields, allowing them to grow, feeding without any supplementary, facilitating water exchange through tidal waters and harvesting periodically at 3–4 months. With the improvement of technologies and realizing the importance of aquaculture, these practices were improved with the supplementary stocking of feeding with water quality management with higher production. The technology improvement made in the aquaculture sector opened new areas for the scientific farming which is called as semi-intensive and intensive farming following all the protocols for farming with production as much as 10 tonnes per ha per culture period of 4–5 months, mainly shrimp in the coastal area. The technology advancement helped in the establishment of more than 380 hatcheries with a production capacity of 5–300 million seeds totalling around 20 billion, and more and more areas were brought under shrimp farming. The present area of operation in the coast line is around 160,000 ha and producing around 160,000 tonnes of shrimp.

The coastal aquaculture witnessed a phenomenal growth during the 1980s and in the beginning of the 1990s. But the growth has not progressed as visualized from the later part of the 1990s due to socioeconomic environmental issues coupled with the outbreak of uncontrollable diseases like WSSV on shrimp. One of the reasons attributed for this is the unregulated development and unforeseen disease outbreaks. The coastal aquaculture in India was also solely dependent on a single group, the shrimp. The effect of this has brought the pronounced impact on the coastal farming sector questioning the very sustainability of the coastal aquaculture.

Diversification in the Coastal Aquaculture

For the sustainable eco-friendly aquaculture practice, diversification to other species is considered as one of the important components. Fishes like the Asian seabass (*Lates calcarifer)*, grouper (*Epinephelus tauvina)* and snappers (*Lutjanus* sp.) which are high-value carnivorous fishes and grey mullet (*Mugil cephalus)*, milkfish (*Chanos chanos)*, pearlspot (*Etroplus suratensis)* and rabbitfish (*Siganus* sp.) which are herbivorous/omnivorous and farmed in the coastal ecosystem are available. The species like cobia (*Rachycentron canadum*) and silver pomfret are being considered as candidate species for farming. Efforts have been made to develop comprehensive technology packages for seed production under controlled conditions and farming for these candidate species. Technologies have been developed elsewhere in the world.

In the Indian scenario, successful technology has been developed by the Central Institute of Brackishwater Aquaculture for the seed production of Asian seabass, *Lates calcarifer*, under controlled conditions and farming. The controlled breeding of groupers *Epinephelus tauvina*, grey mullets *Mugil cephalus* and pearlspot *Etroplus suratensis* has also been successful. The development of broodstock for the captive seed production of milkfish is in progress. Cobia and silver pomfret have been taken up as priority species owing to their high value in the domestic and international markets.

Technology Development for Fish Culture in Coastal Waters

The following discussion will be on the recent technologies developed on the seed production of Asian seabass *Lates calcarifer* which can be a model for the production of marine finfish seed under controlled conditions.

Seed Production Technology for Asian Seabass, *Lates Calcarifer*

Successful seed production in the hatchery depends upon the availability of healthy matured fishes. For selecting potential breeders, viable broodstock under captive conditions has to be developed. Adult and subadult seabass can be procured from wild catch or from farm-reared stock. The fish procured for broodstock should be devoid of external injuries or internal haemorrhage. The fish should be healthy and free from any parasitic infection. The fish can be treated with acriflavine (1 ppm) for 10 min and later with antibiotic, furazolidone (10 ppm), for 1 h as prophylactic treatment to avoid infection due to minor injuries if any during collection and transportation. The fish should be kept under hatchery condition for 3–5 days for close observation before shifting to broodstock-holding facility for further maintenance. Fishes can be maintained at 1 kg/m^3 in the broodstock tank. In the broodstock holding tanks, fishes are fed with trash fish at 5 % of the body weight in frozen form. Fresh low-cost fish like tilapia (*Oreochromis mossambicus*), sardines (*Sardinella* sp.), horse mackerel (*Decapterus* sp.), etc. can be given to the fish. The broodstock tanks are to be disinfected once in 3 months to avoid contamination. From a well-maintained broodstock of fishes under a controlled condition providing good water quality and feed, healthy gravid fishes can be obtained in 6–8 months.

Asian seabass (*Lates calcarifer)*

Captive Maturation and Spawning

The Asian seabass, *Lates calcarifer*, can be made to breed under controlled conditions both spontaneously (natural spawning) and by induced spawning with exogenous hormone administration.

Natural Spawning

This can be achieved by the manipulation of some of the important water quality parameters like salinity, temperature, pH, etc. required for the maturation process, stimulating the conditions prevailing in the marine environment with a flow-through arrangement wherein the seawater pumped into the broodstock maturation tanks is recycled using the biological and pressure sand filters so that the water conditions are stable. With this process, the fish could be made to spawn spontaneously throughout the year, even beyond the normal spawning seasons. This has paved way for the production of seed under controlled conditions throughout the year.

Induced Spawning

Selection of Spawners and Sex Ratio

Matured female fishes will have ova with a diameter more than 450 µ. Males will ooze milt if the abdomen is gently pressed. The gonadal condition is assessed by ovarian biopsy (Szentes et al. 2012). Brood fishes selected for induction of spawning should be active, free from disease, wounds or injuries. Female fishes will be around 4–7 kg and males will be 2.0–3.0 kg. Since seabass spawning is found to have lunar periodicity, days of the new moon or full moon or 1 or 2 days prior or after these days are preferred for inducing the spawning. Female seabass are generally larger (more than 4 kg.), and the males are smaller (in the size of 2.0–3.0 kg) (Davis 1982). To ensure proper fertilization normally two males are introduced for one female in the spawning tank.

Induced Spawning by Hormone Injection

The commonly used hormones in the finfish hatcheries for induced spawning are LHRHa (luteinizing hormone-releasing hormone analogue, available with Sigma Chemicals, USA, and Argent Chemicals, USA), HCG (human chorionic gonadotropins, available in Pharmacy-Medical shops), OVAPRIM, Puberogen, carp pituitary gland extract and pimozide. After selecting the gravid fishes, the requirement of hormone to be injected is assessed. The dosage level has been standardized as LHRHa at 60–70 μg/kg body weight for females and 30–35 μg/kg body weight for males. Since the spawning normally occurs in the late evening hours, when the temperature is cool, the hormone is injected normally in the early hours of the day between 0700 and 0800 h.

Spawning

For fishes injected with the LHRHa hormone, response for spawning was after 30–36 h of injection. Spawning normally occurs late in the evening hours (1900–2000 h). At the time of spawning the fishes will be moving very fast, and in the water surface a milky white substance will be seen. There will be a fishy odour which can be smelled few metres away. Prior to the spawning activity, the males and the female will be moving together exhibiting courtship. The spawning activity in seabass coincides with lunar periodicity. During full moon or new moon days, the activity is found to be in peak. However, with the recirculation system CIBA's seabass hatchery could achieve spawning in any time of the month. Hence, induced spawning is done during new moon/full moon or 1 or 2 days prior or after these days. Seabass has high fecundity. It is a protracted intermittent spawner, and in one spawning the fish may release 1.0–3.0 million eggs (Guiguen et al. 1994). The process of spawning will follow during subsequent days also. If the condition is good, both female and male respond simultaneously resulting to spontaneous natural spawning, and fertilization is affected.

Fertilization

Fertilization is external. In natural spawning of seabass in good maturity condition, fertilization will be 70–90 %. The size of the fertilized eggs will be around 0.75–0.80 mm. The fertilized eggs will be floating on the surface and will be transparent. The unfertilized eggs will be opaque and slowly sink to the bottom. After spawning and fertilization, the water level in the spawning tanks can be increased and allowed to overflow through the overflow outlet. The eggs will be pushed by the water flow. Below the overflow pipe a trough covered with bolting cloth of mesh size 150–200 μm is kept. The water with the egg is allowed to pass through. The eggs are collected in the next bolting cloth washed and transferred to the incubation tanks. Since fertilized eggs will be floating on the surface, a bolting net cloth of 150–200 μm mesh size can be used for collecting the eggs from the surface. The cloth is stretched as net and towed along the water surface. The collected eggs after washing are transferred to the incubation tanks. The water in the spawning tank is siphoned into a small tank covered with collection net cloth through which the water will be allowed to pass through. The eggs collected in the net cloth are transferred periodically to incubation tanks.

Incubation and Hatching

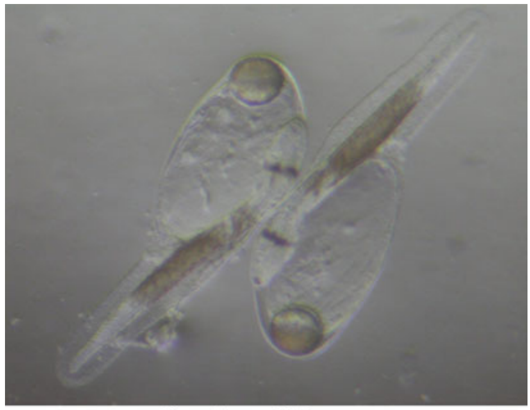
The eggs collected from the spawning tank are washed to remove the debris that would have adhered to and transferred to the hatching tanks for incubation and hatching. The hatching incubation tanks can be 200–250 l capacity cylindroconical tanks. The eggs are kept at 100–200 nos./l density. Continuous aeration is provided. A temperature of 27–28 °C is desirable. The eggs will hatch out in 17–18 h after fertilization. After hatching the larvae are transferred to larval rearing tanks. The unfertilized eggs in the incubation tank can be removed by siphoning (Patnaik and Jena 1976). The larvae are scooped gently using a scoop net and transferred into buckets of known volume. After taking random sample counting depending upon the number required to be kept in the rearing tanks, the larvae will be transferred to rearing tanks.

Larval Rearing for Finfishes in India

Rearing of hatchlings through various developmental stages providing required environmental parameters and feed is the most important phase in the seed production technology. This is still more significant in marine fishes like seabass, grey mullet, grouper, cobia, etc. The seabass larval phase extends up to 21 days, and during this time, the feed requirement, type of feed, quantity, etc. also vary with every stage.

Larval Rearing Tanks and Stocking Density

Tanks in the size of 4–5 tonne capacity are preferable for operational convenience. Freshly hatched larvae from the incubation tanks are transferred carefully to the rearing tanks. Larvae are stocked initially at 40–50 nos/l. Depending upon the age and size, the larval density is reduced to 20–25 nos/l on the tenth day or later, and after 15 days, the density is maintained around 10–15 nos/l.



One day old Larvae

Larval Rearing tank

Feed and Feeding During Larval Rearing

Green unicellular algae like the *Chlorella* sp., *Tetraselmis* sp., *Nannochloropsis* sp. or *Isochrysis* sp. are needed for feeding the live feed (zooplankton), rotifer, and for adding to seabass larval rearing tanks for water quality maintenance. Either the rotifer *Brachionus plicatilis* or *B. rotundiformis* is the most preferred diet for the fish larvae in their early stages. The size of the rotifers varies from 50 to 250 μm. The early stage larvae (up to 7 days) are fed with small-sized rotifers, i.e. less than 120 μm, and later assorted-sized rotifers can be fed. Brine shrimp, *Artemia*, in the nauplii stage are required for feeding the larvae from day 9 to day 21, and afterwards *Artemia* biomass can be given. Rotifer (*Brachionus plicatilis*) is given as feed to the larvae from the third day. Rotifer is maintained in the larval rearing tanks at a concentration of 20 nos./ml initially. From the 4th to 15th day, the rotifer concentration is increased to 30–50 nos./ml gradually. And concentration is increased to 6–10 nos/ml from the 9th to 15th day of rearing. Every day after water exchange, the food concentration in the tank should be assessed, and fresh rotifers should be added to the required concentration. *Artemia* nauplii are given as feed along with rotifers and green water from the tenth day. By this time the larvae will be around 4 mm TL in size. Larvae can be fed exclusively with *Artemia* from the 16th day to 24th day. The density of the brine shrimp nauplii in the rearing medium is maintained at 2,000 nos./l initially and gradually increased to 6,000/l as the rearing days progress. The daily ration of *Artemia* nauplii feeding is adjusted after assessing the unfed *Artemia* in the rearing tank at the time of water exchange and the larval density.

Water Exchange

To maintain water quality in the larval rearing tanks, 30–40 % water change is done daily. The salinity should be maintained around 30 ppt. And the desirable range of temperature is 27–29 °C. The water level reduced (30–40 %) in the rearing tank is levelled up with filtered quality seawater and green water after taking cell count of the algae in the rearing tank. Algal water is added daily up to the 15th day. After bottom cleaning and water reduction, while water change is done, algal water is also added depending upon the concentration (around 20,000 cells/ml in the rearing tank).

Nursery Rearing

Nursery Rearing in Hatcheries

Seabass fry of 25–30 days old in the size of 1.0–1.5 cm can be stocked in 5–10 tonne capacity circular or rectangular (RCC or FRP) nursery tanks. Outdoor tanks are preferable. The tanks should have water inlet and outlet provision. Flow-through provision is desirable. In situ biological filter outside the rearing tanks would help in the maintenance of water quality. The water level in the rearing tanks should be 70–80 cm. Good aeration facility should be provided in the nursery tanks. Nursery tanks are prepared a week before stocking. After filling with water 30–40 cm, fertilize with ammonium sulphate, urea and superphosphate at 50, 5 and 5 g (10:1:1 ratio) per 10 tonnes of water, respectively. The natural algal growth would appear within 2–4 days. In these tanks freshly hatched *Artemia* nauplii at 500–1,000 l are stocked after levelling the water to 70–80 cm. The nauplii stocked are allowed to grow into biomass (refer to biomass production of *Artemia*) feeding with rice bran. When sufficient *Artemia* biomass is seen, seabass fry are stocked at 800–1,000 nos/m^3. The preadult *Artemia* would form good food for seabass fry. The fry would not suffer for want of food in the transitional nursery phase in the tank since the larvae are habituated to feed on *Artemia* in the larval rearing phase. Along with '*Artemia* biomass' available as feed inside the tank, supplementary feed mainly minced fish/shrimp meat is passed through a mesh net to make each particle size of around 3–5 mm, and cladocerans like *Moina* sp. can also be given. The fish/shrimp meat feeding has to be done daily three to four times. Feeding rate is 100 % of the body weight in the first week of rearing. This is gradually reduced to 80, 60, 40 and 20 % during the second, third, fourth and fifth week, respectively. Regular water change to an extent of 70 % is to be done daily. The leftover feed and the metabolites have to be removed daily, and aeration should be provided. In a rearing period of 4–5 weeks in the nursery, the seed will be in the size of 1.5–3.0 g/4–6 cm with a survival rate of 60–70 %. Adopting this technique at a stocking density at 1,000 nos/m^3 in the hatchery, a survival rate of up to 80 % has been achieved.

Nursery Rearing in Ponds

Nursery ponds can have an area of around 200–500 m^2 with a provision to retain at least 70–80 cm water level. The pond is prepared before stocking. If there are any predator/pest fishes, they have to be removed. Repeated netting, draining and drying of the pond are done. In case where complete draining is not possible, the water level is reduced to the lowest extent possible and treated with derris root powder at 20 kg/ha added or mahua oil cake (MOC) at 200–300 kg to eradicate unwanted fishes. The use of other inorganic chemicals or pesticides is avoided because these may have a residual effect. After checking the pond bottom quality water is filled. If the pond bottom is acidic, neutralization is done with lime application.

In order to make the natural food abundant, the pond is fertilized with chicken manure at 500 kg/ha keeping the pond water level at 40–50 cm. The water level is gradually increased. After a 2–3-week period when the natural algal food is more, freshly hatched *Artemia* nauplii are introduced. Normally 1 kg of cyst is used for a 1 ha pond. These stocked nauplii grow and become biomass in the pond forming food for the seabass fry. Seabass fry are stocked at 20–30 nos/m^2. Stocking should be done in the early hours of the day. Fry should be acclimatized to the pond condition.

Nursery Rearing in Cages/Hapas

Floating net cages/hapas can be in the size of $2 \times 1 \times 1$ to $2 \times 2 \times 1$ m depending upon necessity. Cages are made with nylon/polyethylene webbing with a mesh size of 1 mm. Fry can be stocked at 400–500/m^2. The feeding rate can be as that described to tank nursery. The net cages have to be checked daily for damages that may be caused by other animals like crabs. The net cages will be clogged by the adherence of suspended and detritus materials and siltation or due to foulers resulting in the restriction of water flow. This would create confinement in the cages and unhealthy conditions. To avoid this, cages/hapas should be cleaned every day. Regular grading should be done to avoid cannibalism and increase the survival rate. Even in higher stocking density at 500/m^2, a farmer could get a survival rate of 80 % in the farm site when the fry were reared in hapas adopting the trash fish feeding and other management strategies mentioned above.

Farming

Traditional Coastal Aquaculture in India

Seabass is cultured in the ponds traditionally as an extensive-type culture throughout the areas in the Indo-pacific region where seabass is distributed. In low-lying excavated ponds, whenever the seabass juveniles are available in the wild seed collection centres (e.g. April–June in

Hapa Nursery

West Bengal, May–August in Andhra Pradesh, Sept–Nov in Tamil Nadu, May to July in Kerala and June–July in Maharashtra), juveniles of assorted size seabass are collected and introduced into the traditional ponds which will be already with some species of fish, shrimps and prawns. Forage fishes like tilapia will also be available in these types of ponds. These ponds will have water source from adjoining brackishwater or freshwater canals or from monsoon flood. The juvenile seabass introduced in the pond will prey upon the available fish or shrimp juveniles as much as possible and grow (Ravisankar and Thirunavukkarasu 2010). Since seabass by nature is a species with different growth that are introduced into the pond at times of food scarce, the larger ones may resort to feed upon the smaller ones reducing the number.

Seabass are allowed to grow for 6–7 months of the culture period till such time when water level is available in these ponds and then harvested. At the time of harvesting, there will be large fishes of 4–5 kg as well as very small fishes. This is a common scenario in many coastal areas. In this manner production up to 2 tonnes/ha/7–8 months have been obtained depending upon the number and size of the fishes entered/introduced into the pond and the feed available in the pond. However, this practice is highly unorganized and without any guarantee on production or return for the aquaculturists. With the advances in the technology in the production of seed under captivity assuring the supply of uniform-sized seed for stocking and quality feed for feeding, the seabass culture is done in Southeast Asian Countries and Australia in a more organized manner.

Pond-Based Fish Farming

Seabass seed can be stocked in a prepared pond at 10,000/ha. The seed size of 2.0 g and above is preferable for stocking in the growout farms. Water depth should be maintained not less than 1.0 M. Seabass fishes stocked can be fed with minced meat of trash fish. Cheaper fishes like tilapia, sardines and horse mackerels which may not fetch more than Rs. 5/per kg can be bought from the commercial fish landing centres, washed and frozen in cold storages as required. The fish can be taken out an hour prior to feeding, thawed and minced as meat using meat mincer. Feed can be made as dough ball like paste and placed in trays, kept hanging in four or five places in the pond. The feeding rate is ad libitum in any case not more than 100 % body weight on wet weight basis of the biomass initially and gradually reduced to 10 % at the last phase of the culture period. Feed rations can be given in two doses in the forenoon and afternoon.

Fish Farming with Formulated Feed

Seabass is cultured with extruded floating pellets in Australia, Thailand, Malaysia and Singapore. Being a carnivorous fish seabass needs a high-protein diet. Normally, in the preparation of diet for seabass, the animal ingredients are added more than 60 % so that the required protein levels can be kept. The nutritional requirements of the seabass are as follows: protein around 55 %, lipid 15 %, fatty acids 2 % and carbohydrates 15 %. Since seabass is a fish feeding mainly on the fishes and shrimps moving in the water column (pelagic), the pellet should be slow sinking and should be in the column for a reasonable time so that the fish can ingest the food before it reaches the bottom. The extrude pellets will have reduced loss, the digestibility will be good due to precooking, the feed mixture can be with higher moisture and the flavour of feed also can be retained with the addition of excess fish oil. The pellet size should be from 2.0 to 6.0 mm as per the size of the fish.

Growout Culture of Seabass in Cages

Fish culture in cages has been identified as one of the eco-friendly at the same time intensive culture practice for increasing fish production. Cages can be installed in open sea or in coastal area. The former is yet to be developed in many countries where seabass is cultured, but coastal cage culture is an established household activity in Southeast Asian countries. There are abundant potential as in India also for cage culture in the lagoons, protected coastal areas, estuaries and creeks. Since cage culture of seabass has been proved to be a technically feasible and viable proposition, this can be taken up in a large scale in suitable areas. The cage culture system allows high stocking density and assures high survival rate. It is natural and eco-friendly and can be adopted to any scale. Feeding can be controlled and cages can be easily managed. Fishes in the cages can be harvested as per the requirement of the consumers, which will fetch high unit price. Above all, cage culture has got low capital input, and operating costs are minimal. Cages can be relocated whenever necessary to avoid any unfavourable condition.

Stocking Density

In the cages, fishes can be stocked at 25–30 nos/m^2 initially when they are in the size of 10–15 g. As they grow, after 2–3 months culture, when the fish attained a mean body weight of 150 g, stocking density has to be reduced to 10–12 nos/m^2 for space. Cage culture is normally done in two phases – till they attain 100–150 g size in 2–3 months and afterwards till they attain 600–800 in 5 months.

Feeding in Cages

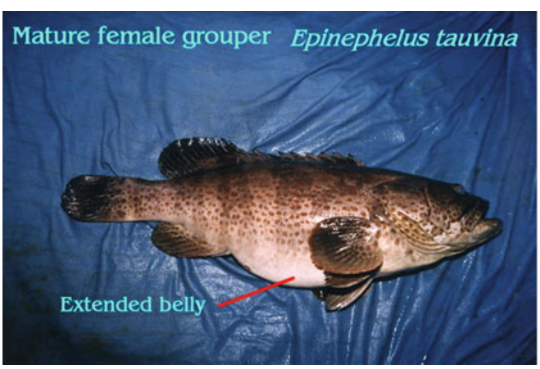
Fishes in the cage can be fed with either extruded pellets or with low-cost fishes as per the availability and cost. Floating pellets have advantages of procurement, storage and feeding. Since a lot of low-cost fishes are landed in the commercial landings in the coastal areas which are fetching around Rs. 3–5/kg, they are only used as feed for seabass culture. Low-cost fishes also serve as feed for seabass in ponds and in many cage culture operations. The rate of feeding can be maintained around 20 % initially and reduced to 10 and 5 % gradually in the case of trash fish feeding, and in the pellet feeding, the feeding rate can be around 5 % initially and gradually reduced to 2–3 % at a later stage.

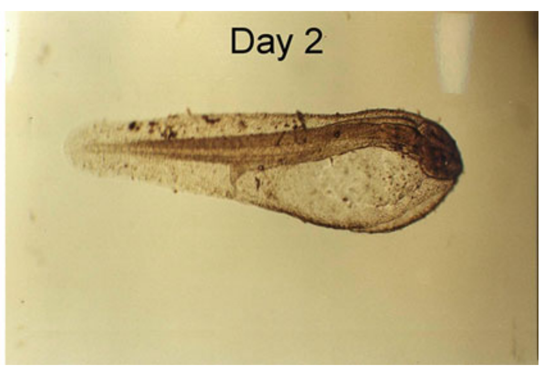
In the feeding of low-cost fish, the feed conversion ratio (FCR) works out around 6 or 7. In the case of pellet feeding, the FCR is to be 1–1.2 in Australia. However, the cost-effectiveness of the pellet feeding for seabass in growout culture has to be tested.

Groupers

Groupers also migrate for maturation and spawning to deeper waters in the sea. The groupers attain maturity after 2 years at their age when they are around 2–3 kg in size. Groupers are protogynous and herbivorous where many are females in the early period and reverse to male when they are larger in size. In hatchery operations, obtaining males sometimes require intervention through exogenous hormone administration. Successful breeding of some species of groupers has been reported from different R&D institutions like CMFRI, CIBA and RGCA.

The techniques for reverting female to male and retaining them as male have been developed in CIBA through oral administration (through feed) of 17 -methyl testosterone hormone in





doses of 2 mg/kg body weight on alternate days. The breeding protocols include the selection of females with ova diameter of above 450 μm and administration of HCH hormone at 750–1,000 IU/kg body weight for females and LHRHa at 40 μg/kg body weight. Successful spawnings were observed after 72–144 h of hormonal administration. Hatching took place after 22–24 h of incubation. Rearing the larvae feeding with rotifers SS strain where the size is less than 80 μmm following green water technology has been successful. However, the survival rate is very low (around 5 %) in many cases for a month's rearing.

Grey Mullet (*Mugil Cephalus*) Breeding and Seed Production

Grey mullet *Mugil cephalus* is a herbivorous fish. Considering its high potentiality for farming along with other fishes and shell fishes with low-cost inputs, there is good market demand in some parts of India like Kerala and West Bengal. It is felt that it will be highly useful for sustainable farming in traditional coastal farms. However, breeding of grey mullet under controlled conditions, though being attempted for some years, is yet to take off as a standardized technology for commercial venture.

Grey mullet in the size of 300 g–1.5 kg collected from wild catch or farm-reared stock could be maintained in earthen ponds or broodstock holding tanks feeding with formulated feed at 2–3 % of body weight daily providing with quality seawater with the desirable parameters prevailing in the open sea and taking care of the regular health monitoring protocols. Matured fishes could be obtained during the spawning season, normally in the months of October–-January. Breeding protocols include selection of females with ova diameter around 0.58–0.6 mm and administration of a prime dose of HCG at 1,000 IU and a resolving dose of LHRH at 40–50 μg/kg body weight, and half the dose for the males was found to make successful spawning. The larvae also could be reared following the protocols as for other marine fish larvae. In India though success in captive broodstock development, maturation and spawning has been achieved, the technology for commercial venture is yet to be developed.

Milkfish (*Chanos Chanos)*

Milkfish breeding and seed production have become a household activity in countries like the Philippines, Indonesia and Taiwan. However, in Indian context, breeding of milkfish under

Gravid Fish ready for spawning

Hatched out larvae

captivity is yet to make a beginning. Captive broodstock of milkfish which developed after being fed with formulated feed at 2–3 % body weight and after 5 years of being held under captive conditions have shown male maturation, and the female fishes have not attained gonadal maturity.

Milkfish brooders

Pearlspot (*Etroplus suratensis)*

Pearlspot *Etroplus suratensis*, an indigenous cichlid having a high market value in some parts of India like Kerala, is considered as a highly suitable table fish which can be farmed in ponds or cages with low input in shallow/freshwater/brackishwater systems. Pearlspot breeds in confinement (Padmakumar et al. 2009). After pair formation and selecting a suitable hard substrate, the eggs are laid in a mosaic manner by the female and fertilized by the sperm released by the males by following the course of the female. The eggs are guarded and cleaned periodically for a period of 6–7 days after which they are transferred to nests (pits), at the time of hatching; the hatchlings subsist with yolks for 3–4 days after which they are guarded by the parent fishes till they attain the advanced fry or fingerling stage. To increase the survival rate in the early stages, the eggs at the time of hatching are transferred to tanks and maintained with good aeration through which the hatching rate is improved. Afterwards the juveniles are fed with live zooplankton initially and/or later with egg custards and formulated feed.

Cobia Breeding

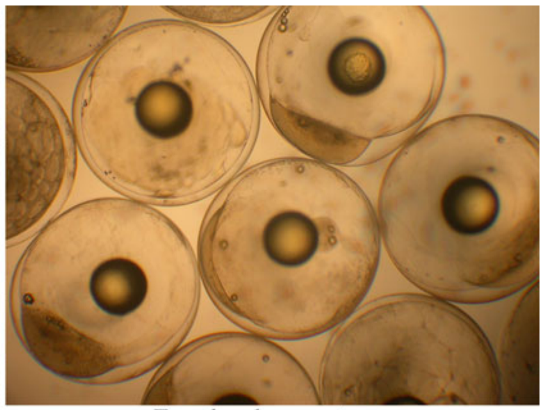
Cobia, *Rachycentron canadum*, has also been identified as a potential candidate species for farming in cages in the open waters. Initial trials have shown encouraging results. In India, within 8 months' duration a marketable-sized fish could be grown. Considering the palatability, texture

Pearlspot (*Etroplus suratensis*)

and the market demand, interest is shown by many for the farming of Cobia. A national collaborative project involving CIBA, CMFRI and Fisheries College, Tuticorin, has been launched with the objective of developing broodstock in different ecosystems like open sea cages, earthen ponds and polythene-lined ponds and developing a viable technology for seed production by entrepreneurs (Benetti et al. 2008). Initially success has been achieved by CMFRI using a cage-reared stock wherein females with ova diameter more than 0.7 mm has been selected and induced through hormonal administration.

At CIBA matured fishes could be obtained from the broodstock maintained in earthen pond conditions wherein the routine protocols like water exchange to the extent of 30 % daily feeding with forage fishes at 5 % of body weight and the routine health management protocols for ectoparasitic infection through treatment with 100–150 ppm formalin for one hour and/or dip treatment in freshwater for 5 min providing water quality conditions of salinity ranging from 24 to 32 ppt, pH 7.5–8.2, ammonia less than 1.5 ppm and dissolved oxygen 4.8–6.2 ppm are followed. Fishes in the size range of 5–15 kg were maintained in an earthen pond at the density of 1 kg/m^3. Fishes of size 12 kg introduced in the pond during the month of March 2010, after 8 months of maintenance, following the above-mentioned protocols, showed maturity, where females with ova size of 0.5–7 mm and oozing males could be obtained. An effort made under controlled breeding with exogenous hormone of HCG administration at 300 IU intramuscularly in a fish with ova diameter of 0.7 as a priming dose and after 36 h with a resolving dose of LHRH hormone at 10 μg/kg body weight for females and a single dose of LHRH at half the rate for that of females yielded successful spawning after 20 h of hormonal administration where about a million eggs were spawned with 30 % fertilization. This success has showed that broodstock can be maintained in small ponds also which will simplify the operation of hatchery for Cobia.

Pond reared Cobia broodstock


Egg development

The protocols developed in some of the above-mentioned species can be applied for similar species with modifications as per the requirement.

Conclusion

Coastal aquaculture has become an important source for the production of food for the alleviation of poverty and generation of employment and wealth for the people living in coastal areas many of whom are underprivileged. The assurance of comprehensive technology puts alone support to sustainable aquaculture in the future. The future areas of research and development must focus on the following to achieve sustainability of aquaculture in the long run:

- Captive broodstock development, captive maturation and induced breeding technology of different cultivable marine finfish
- Live feed culture technology development (Rotifer, *Artemia*, *Moina*, *Daphnia*, Copepod, etc.)
- Health management in broodstock development and post hatching phase
- Genetic improvement and selective breeding
- Development of transgenic fishes for better growth and health
- Feed development for maturation process of fish and different fish larvae
- Development of pen and cage culture system for finfish
- Bio-security in hatchery and farming system

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