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Breeding and Culture of *Macrobrachium rosenbergii*; Giant Freshwater Prawn (Scampi), Practiced along the Coast of Kerala, India

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Abstract

The Giant freshwater prawn, *Macrobrachium rosenbergii* (De Man, 1879), commonly known as Scampi, is one of the most important freshwater prawn species widely cultured in several tropical and sub-tropical countries around the world. It has several attractive attributes as a candidate species viz., fast growth rate, compatibility to grow under poly-/mixed-culture, hardy nature, high market price and demand in both domestic and export markets. Besides, it can also be cultured in low saline brackish water areas (salinity < 10 ppt). It is an indigenous species of India and is naturally occurring in most of the river systems along both coasts of India. It can be cultured alone or with compatible fish species such as Catla (*Catla catla*) and Rohu (*Labeo rohita*). It is also a suitable species for incorporating in paddy-cum-fish culture (rice-prawn farming) system. Culture of Scampi can be carried out in earthen ponds, cement tanks and pens.

Keywords: *Macrobrachium rosenbergii, Broodstock culture, Seed production, Management*

Introduction

The species is characterized by the overlapping of pleura of second abdominal segment over those of first and third segment [1]. It can easily be identified by its large second pair of thoracic legs in male. Rostrum is long and is bent in the middle and upturned distally. The rostral teeth formula is 12-13/11-13 (most common). There are distinct black bands on the dorsal side at the junction of all abdominal segments. In the juveniles, on the lateral sides of the carapace, several horizontal blue/black bands are characteristics of this species (Figure 1) [2-14].

Distribution

Macrobrachium rosenbergii, a tropical species, is widely distributed in the Indo-Pacific region, ranging from the Indus River Delta through India, Shri Lanka, Bangladesh, Myanmar, Malaysia, Thailand, Vietnam, Indonesia and the Philippines, to Australia and New Guinea. Natural distribution of the species is limited to estuarine and freshwater zones of river mouths and backwaters having temperature usually ranging from 25-34°C and salinity from 0-20 ppt. The species is distributed in the lower stretches of most of the river systems of both the coast of India. It has been introduced in many parts of the world for commercial farming [13].

Figure 1: External appearance of *Macrobrachium rosenbergii.*

Habit and Habitat

It is benthic in its habit, sluggish by nature and hides under shades and shelters in the shallow areas of rivers, canals, lakes and ponds during day time to avoid direct sunlight and is very active during night time. It moves slowly and continuously and with slight disturbance jerks backwards and retreats. It is omnivorous, becomes cannibalistic when hungry and has territorial instincts [1,10].

Life Cycle

The giant freshwater prawn has five distinct phases in its life cycle: egg, larva (zoea), post-larva, Juvenile and adult. In nature, juvenile to adult stages are spent in freshwater habitat. Attainment of maturity and mating takes place in freshwater/habitat [1,6]. The egg-bearing (berried) females migrates to brackishwater environment for incubation of fertilized eggs and embryonic development. Hatching and growth of larvae through eleven stages, till they metamorphose to post-larvae, takes place in brackishwater environment. The post-larvae/juveniles ascend to the freshwater zones of the rivers, backwaters, lakes, canals, etc., which are subjected to the tidal influence.

Materials and Methods

Hatchery Production of Seed

Good quality seed is the single most critical input in successful prawn farming as the survival, growth and overall production depends on it. Due to the obligatory requirement of brackish water for hatchery operations, most of the prawn hatcheries are located nearer to the coast. Inland hatcheries mostly use diluted brine (concentrated seawater transported from salt-pans) or synthetic salts to prepare artificial brackish water. After the breakthrough in closing the life cycle of the species in captivity by Dr. SW Ling in 1962, several researchers have developed different types of larval rearing techniques for hatchery production of post-larvae (PL). The most widely used method is clear water technique originally developed by AQUACOP [2-5,8].

ICAR-CIFA has developed and standardized a semi-closed two-phase clear water technology for larval rearing of Scampi. In this technique larval rearing is carried out in two phases (9). In the first phase high density (>200-300 larvae/l) rearing is carried out in smaller tanks (500-1000 L) for 10 to 12 days. In second phase low density (50-60 larvae/l) rearing is carried out in larger tanks (>2000 L) till the entire batch metamorphoses to post-larvae (in 20-25 days). During the first phase the larvae are fed exclusively on live feed *Artemia nauplii*, whereas during the second phase the dominant feed item is the inert feed such as egg custard, while live-feed is a minor component. Water is exchanged at 50% once every alternate day to maintain water quality. This technique is simple to operate and helps in optimum utilization of space and feed and gives good results with PL output of >35/l.

Steps Involved in Establishing a Hatchery

The following section gives a brief account of the steps involved in establishing a Scampi Hatchery.

Site Selection

A careful selection of site is essential for the successful operation of hatchery in a particular locality. It is also equally important to consider the following essential factors to ensure success in achieving the production target.

Climatic Conditions

Temperature is a key environmental factor for successful operation of hatchery as Scampi is a tropical species. Since the optimum temperature range required during seed production is 28-31°C, the hatchery should be located in tropical or sub-tropical zones. Area selected should have temperature near the optimum range over a minimum period of eight months for profitable operation of hatchery. Besides temperature, rainfall, sunlight, humidity and wind speed at the site are also considered before selecting it for hatchery. Areas vulnerable to natural calamities such as floods, cyclones and earthquakes are not suitable for hatchery construction.

Topography

Assessment of transects, evaluation of slope and determination of the most economic way of constructing hatchery are important. Flat or slightly sloping lands are good and slope close to 2% minimizes the construction cost for broodstock ponds associated with hatcheries. In addition, gravity water-filling and draining from the pond becomes cost-effective and easy.

Soil

Soils that sustain biological activities and have water retention capacity apart from structural stability are considered suitable.

Availability of Adequate Freshwater and Seawater

The hatchery site should preferably be near the coastal areas. Seawater used in the hatchery should be free from pollutants. Seawater can be pumped from surface of the sea or estuary during high tide phases through an in situ filter bed [5]. Saltwater also can be drawn from underground source by sinking deep tube-well fitted with suitable pumps. Freshwater can be drawn from a river/canal/shallow groundwater source. Un-contaminated freshwater is essential for hatchery operations, mainly for broodstock management, for diluting seawater (larval medium) and for general use.

Good Physical Access to the Site

Site should have good all-weather approach-road for facilitating easy and low-cost transportation of construction material, pond and hatchery inputs and for marketing seed.

Uninterrupted Power Supply

Adequate power supply is most important consideration during hatchery activity. Therefore the site should have good proximity to uninterrupted power source.

Hatchery Facilities

The following section give a brief account of the facilities required for a Scampi Hatchery:

Hatchery Building

A proper building or shed based on the scale of operation to house the larval rearing tanks, post-larval holding tanks and Artemia tanks is essential for the successful operation of the hatchery. Small hatcheries may be set up in a shed made up of palmyrah trunk and leaves, or a bamboo framework, but large hatcheries are to be constructed in permanent shed. A low-cost permanent shed should have side walls of brick and cement and flooring with proper drainage facility and should have a mix of asbestos- and translucent fibre-sheets fitted over the roof. The translucent sheets meant for good light penetration should cover around 15% of the total roof area. A common drain of around 24" to 30" wide and 15" to 20" deep may be constructed to drain water from all the tanks by gravity.

Water Storage Tanks

Separate cement tanks for storing seawater, freshwater and mixed water (larval rearing water) are required. The tanks for the first two types of water may be constructed outside the hatchery shed, whereas the tank(s) for larval rearing water (salinity 12 ppt) are better located either under a temporary shed or even inside the hatchery proper (in small hatchery) to get water of ambient temperature in the larval rearing tanks. The size and capacity of above three types of tanks will depend on the overall production capacity of the hatchery. Huge quantity of larval rearing water is normally required in a flow through hatchery. Larval rearing medium of about 12-times the total volume of rearing tanks are required for each seed production cycle. The hatchery should have water storage facility of at least 3-times the volume of its larval rearing tanks to allow for adequate water storage, treatment and mixing time for preparation of larval medium. To minimize the costs, tanks are better constructed at ground-level and provision for pumping the water at required place should be made.

Broodstock Holding Unit

Broodstok holding facility may comprise of FRP or cement tanks, the size depends on the capacity of hatchery. These tanks inside the hatchery are for keeping both mature male and female prawns for breeding and for final maturation of eggs, or keeping berried females collected from the wild/grow-out facilities for acclimatization to hatchery conditions. This facility should be separate and away from the larval rearing unit as prawns collected from outside may be infected and need to be given prophylactic treatments.

Larval Rearing Unit

Larval rearing unit should be established as a separate unit so that it is safe and free from any likely outside infection. In large hatcheries, several such small units may be established instead of making a single very large unit to prevent spreading of infection. Larval rearing unit may comprise of large number of tanks made up of FRP, ferro-cement, or cement. Tanks can be circular, rectangular or cylindrico-conical in shape. Usually rectangular tanks of 2 to 10 t capacity are preferred. All right-angled corners should be rounded off to facilitate cleaning and to prevent algal growth. The tank bottom should preferably be ‘U-shaped’ and have sufficient slope so as to drain completely. The interior of the tanks should be painted with several layers of dark coloured pure epoxy resin to prevent leaching of toxic chemicals and to provide smooth surface. The depth of the tanks should be approximately 1.0 m and the water column not more than 0.9 m. The number of larval rearing tanks (LRTs) depends on the hatchery capacity.Tanks should be provided with vigourous aeration from a grid of air-blowers and pipes. The air-stones of all the aeration points should be close to the tank bottom. The tanks should have provision for inlets to receive larval rearing water through pipeline from the larval water storage tanks [6,7,11].

Post-larval Holding Tanks

Rectangular cement or concrete tanks of 2 to 10 t capacity are suitable for holding post-larvae till disposal. The number of such tanks depends on the hatchery capacity. Post-larval Rearing Tanks (PLRTs) also can function as broodstock holding tank. These tanks are better placed outside the main hatchery building to reduce and offset the construction cost, but should be provided all around with green shade-netting (commonly used in green-houses) and covered over a pipe framework fitted at a height of approximately 8-10 feet. Such arrangement will keep tank water free from algal growth and also from dust. The tanks should be provided with separate inlets for freshwater supply and an aeration system.

Artemia Cysts Hatching Tanks

Artemia or Brine Shrimp cysts are a source of pathogens and hence there should be a separate unit for their hatching. The size of the tanks depend on the overall requirement of Artemia nauplii (AN) per day in the hatchery. Cylindro-conical shaped tanks are better from operational point of view. They should have transparent bottom where nauplii could be easily attracted by artificial light (lamp) and drained from bottom outlet. Cylindrico-conical fibreglass reinforced plastic tanks of 100 to 500 litre capacity with a central drain and water control structure can be used as Artemia cysts hatching tanks.

Aeration System

A reliable 24-hour oil-free aeration system is essential for hatchery in order to maintain dissolved oxygen levels in excess of 5 ppm in various units of the hatchery. The air supply is essential in all the tanks used for broodstock holding, hatching, larval rearing, post-larval rearing and Artemia hatching. Although majority of the units require mild aeration, it should be vigorous or rather bumping particularly in larval rearing and Artemia hatching tanks. Three-phase electrically operated air-blowers both roots-type and fan-type can be used but fantype provide better aeration and create relatively less noise. Diesel operated air-blowers could also be used where power supply is either not available or there is frequent failure. The capacity of air-blower should depend on the overall requirement of air in different units or the size of the hatchery. A 200 CFM (5.66 m3/minute) air-blower is sufficient to supply air for a hatchery capable of producing 20 million post-larvae/year. The air-blower or a set of air-blowers should be used at a stretch for a maximum period of 8 hours and switched off, followed by supply from a second set of similar blowers. This practice reduces losses from early wear and tear and avoids sudden aeration failure in the hatchery. The aeration pipeline grid should be installed in such a way and place that it cannot breakdown due to movement of people and other hatchery items. It is better to arrange pipelines overhead and each tank may be provided separate pipeline of smaller diameter pipe of 0.5 to 1.0 inch PVC pipe (dropping from the main pipeline). Each dropping pipeline in turn ought to be provided with small holes for fixing plastic joints and fixing aeration tubings of 1/8 inch diameter, which are provided with air-stones and dropped into the tanks for aeration.

Water Supply System

A separate pipeline both for freshwater and larval-rearing water is essential in the hatchery. Freshwater is required in almost all the hatchery sections, i.e. broodstock holding tanks, hatching tanks, larval-rearing tanks and post-larval tanks for use as media and also for washing the tanks, whereas, larval-rearing water of 12 ppt salinity is required only in the larval tanks (LRTs). Accordingly, separate pipeline for both types of waters would be required with provision for separate inlet near one side of the tank. The pipeline and all other fittings including ball valves should be made up of PVC rigid pipe as metal pipes and fittings are likely to be corroded by saline water and leaching of metal ions may take place in the tanks which may harm the prawn larvae.The diameter of water pipeline shall depend on the volume of water required every day in the hatchery. As a thumb rule, initially from pump side, it may start with 3-6 inch diameter pipe and subsequently reduced to 1-2 inches at the tank inlet. Complete pipe line is to be laid inside the hatchery building so that temperature fluctuations are minimized.The water system is simple and all the storage tanks should be sufficiently elevated above the larval rearing tanks (LRTs) so that brackish water can be introduced by gravity.

Power Back-up System

The hatchery needs round the clock power supply for the operation of aeration and water grids. Power breakdown even for a short duration may cause mortality of hatchery live-stock. Therefore, a back-up power system of sufficient capacity is essential for the hatchery. The diesel generators can support power back-up for sufficient duration. The generators are to be installed at a suitable place slightly away from the main hatchery building to minimize sound and air pollution.

Laboratory

A small laboratory, having working platform for keeping equipment/chemicals/glassware/plasticware, should be established possibly within the main hatchery building for easy approach. The laboratory should be provided with necessary equipment and facilities like refrigerator, salinity refractometer, pH meter, dissolved oxygen (DO) meter, weighing scales (chemical/digital/dial/spring balances), hand lens, different types of microscopes (field/dissection/low-power binocular/compound), pressure cooker, mixie, necessary glassware, plastic-ware and chemicals for estimation of DO, hardness, alkalinity, etc.

Broodstock Management

Scampi broodstock may be procured both from wild and grow-out ponds, in later case, care should be taken that the stock is not under severe inbreeding depression. Raising healthy brooders in the close vicinity or at the hatchery site is ideal. If reared at the hatchery site, the stocking density should be <10,000/ha. Half of the feed ration may be substituted with the equivalent amount of pieces of fresh feeds, such as mussels flesh, cut to the appropriate size, at least twice per week. 1 kg of wet feed is roughly equivalent to 200 g of pellet diet. The feed ration should be given in two equal portions, normally early in the morning and late evening. The pond water should maintain optimum water conditions with partial exchange (30-40%) every fortnightly in case of earthen ponds.

Only berried females in an advance stage of egg-incubation (those carrying grey egg-mass) should be brought to the hatchery for hatching eggs so as to minimize cost of maintenance at the brood holding tanks. The berried females having entire egg mass should be selected and stocked in these tanks .The size of the brood prawn should preferably be 60-100 g in weight. It should be apparently healthy and free from diseases particularly from epibiont fouling, lesions, spots, infected appendages, etc. Brooders should be procured and transported with utmost care so that it does not lead to injury and loss of egg mass. Transport of berried females over shorter duration can be undertaken in buckets or tubs containing water of the same pond. For two to three hours journeys, the broodstock can be transported in open containers having water of the same pond along with some aquatic weeds. The container(s) may be provided aeration from a battery operated portable aerator. For long distance transportation (>12 hours), brooders may be packed in 9 inches (23 cm) long 50 mm dia slotted PVC pipes, tide on both ends with meshed cloth. 3-5 such pipes may then be kept in one polythene bag having 5-6 litre of water and packed with oxygen and transported in a carton. It is recommended to transport the bags in insulated containers to avoid temperature fluctuations and movement. The temperature should be maintained at 25-27°C. The rostrum of each prawn should be blunted with scissors or a rubber cap should be placed on it so that the polythene bag does not get punctured. For transporting in PVC tanks with aeration, a maximum stocking rate of one prawn per 40 litre of water should be maintained.

The berried females should be handled with utmost care after their arrival in the hatchery and also while shifting from one tank to the other. The female should be caught under water using a bucket and keep them immersed in water while shifting to the other tanks. Catching with hands or scoop net result in shedding of egg mass and injury to the female and hence poor hatching performance. The female should be disinfected with formalin (@ 50 ppm) under vigorous aeration for 8-10 hours followed by complete change of tank water for the control of epizoan parasites before putting them in the hatching tank.

Hatchery Operation

Operation of hatchery involves different activities starting from preparation of water till post-larval disposal. The following section briefly describes the steps involved in hatchery operation.

Preparation of Larval Rearing Water

Seawater for larval rearing should preferably be collected from a sea coast having little pollution impact. For transportation of seawater, plastic barrels or FRP tanks are desirable. Transporting by truck-tankers having tank made up of iron may increase iron contents in the water and hence should be avoided. Seawater need to be disinfected for probable pathogens by active chlorine and potassium permanganate @ 5 ppm and 2 ppm respectively after shifting into the treatment tanks under vigorous aeration. Good quality freshwater is also required for preparing larval rearing water of 12-13 ppt salinity from seawater. The prepared mixed water should be disinfected with active chlorine @ 5 ppm under vigorous aeration for at least for 48 hours and the residual chlorine may be removed by adding sodium thiosulphate. The water should then be filtered with 5µ bolting silk cloth bag and used in the larval rearing tanks.

Larval Production and Rearing

The usual practice followed in most commercial hatcheries is stocking a large number of berried females of similar egg colour for hatching in a large tank. However, this is unsafe for many reasons particularly heterogenous size of larvae (zoea), disease spreading, mixing of healthy and unhealthy larvae that would cause problems at later stages. Hence only few berried females required to supply enough larvae for larval rearing tanks should be kept in each hatching tank for minimising chances of spreading pathogens and for production of healthy batch of larvae [11,12].

Hatching tanks should be provided aeration round the clock. Hatching generally takes place in the night and hence freshly hatched larvae (length about 2 mm) are to be harvested as soon as possible through siphoning as the female may consume them if kept for prolong period. Fresh or low salinity water (salinity 3-4 ppt) having pH below 8.3 and temperature 28-3°C should be used in these tanks. The larvae should be disinfected with 15 ppm formalin for 5-10 minutes before shifting to larval rearing tanks.

Larval rearing tanks (LRTs) should be thoroughly cleaned and disinfected with bleaching powder at least two days prior to larvae stocking. The tanks are filled with filtered larval water (salinity 1213 ppt) prepared at least 48 hours before use preferably in indoor conditions of the hatchery. The tanks should be provided with vigorous aeration throughout the tank area and care should be taken to minimize dead ends. This practice helps in uniform circulation of food particles in the tank for easy feeding by the larvae as well as to reduce larval cannibalism due to continuous movement. The stocking density of larvae in the tanks will depend on the rearing methodology adopted. In single stocking method in which zoea larvae are reared to post-larvae, they are stocked at 50-60/litre; in two-phase stocking method, initial larval stocking density is 100 larvae/litre, which is reduced to 50-60/litre, by thinning/shifting, when they reach Stage-V Zoea. Freshly hatched Artemia nauplii (AN) should be fed all the time to all the eleven Zoea Stages (I-XI); however, feeding exclusively nauplii may be cut down after Stage-V Zoea, when egg custard is incorporated in the diet. The quantity of Artemia nauplii and egg custard should be given according to the area of the tank and not by the number of larvae being reared. This is essential because the larvae prey on the food by touching and not by seeing.

The larval tanks should be cleaned daily to remove accumulated debris, left over feed and faecal matter through siphoning. Around 50% of the tank water should be replaced with fresh larval water after cleaning. The larval tanks may be provided with 5-10 g of EDTA (Ethylene diamine tetra acetic acid) per tonne of water for chelation of heavy metals after every 3-5 days. Antibiotics should not be used in the larval tanks and instead use of probiotics is considered ideal. Both live and formulated diets are used in the hatchery for feeding larvae and post-larvae. The live feed used in prawn hatchery are Artemia nauplii and Moina macrura. The later is used only in few hatcheries, where it is cultured in the pure form separately. The formulated diet comprises of egg custard.

Preparation of Live Feed (Artemia nauplii)

Artemia, commonly known as Brine Shrimp, is a small crustacean living in salt pans and high saline water bodies. During unfavourable conditions they produce hard shelled cysts (fertilized eggs). These cysts hatch when provided with favourable conditions. Newly hatched microscopic free-swimming larvae are called nauplii. They form a highly nutritious live diet containing more than 50% crude protein and 12% lipid. The size of nauplii is important for proper use in the larval tanks. Nauplii of Artemia salina of San Francisco Bay and Great Salt Lake (USA) are comparatively very small (~400 µm in length) and considered best for use in the prawn hatchery. Artemia cysts are sold in the market in tin packs of generally one pound weight (454 g). Based on the hatching rates, it is categorized generally into three qualities ranging from 70-95%. Better the hatching rates, less the chances of contamination. Artemia cyst tins are to be stored in deep freezer immediately after the procurement otherwise its nutritional and hatching quality get deteriorated.

Artemia cysts are usually contaminated with bacteria, fungal spores, other micro-organisms and organic impurities that may infect the water of larval rearing tanks if not treated properly. Hence, cysts need to be disinfected before stocking for hatching. The disinfection eliminates the chances of infection. The number of Artemia per unit weight depends on the type of artemia. On an average, Artemia of Great Salt Lake may yield 2.7 lakh and that of San Francisco Bay 3.2 lakh nauplii per gram weight. Find out the hatching rate of Artemia from instructions written on the tin for the first time and subsequently after observing the hatching percentage by manual counting. The Artemia cysts are stocked in the hatching tanks @ 2 g/l seawater, where they hatch out between 12-24 hours. After harvesting, nauplii need to be acclimatized to the salinity of larval rearing water by gradually mixing freshwater. The nauplii should also be treated with 15 ppm formalin for disinfection. Freshly hatched nauplii are to be fed to the prawn larvae as they are rich in nutritional contents in the beginning which gradually reduces with time.

Artemia Enrichment

The nutritional quality and physical size of nauplii vary enormously from source to source and even between individual batches from a single source. Of particular importance is the level of essential polyunsaturated fatty acids, eicosapentaenoic acid (EPA, 20:5n-3) and docosahexaenoic acid (DHA, 22:6n-3), which depends on the composition of primary food available to the brine shrimp in the locations where they originate and is generally found low. In order to provide sufficient quantity of these essential fatty acids, the nauplii are to be enriched with both EPA and DHA. There are various enrichment products available in the market, such as Super Selco, DHA Selco (INVE, Aquaculture), Super artemia (Catvis BV., 5222 AE, Netherland), Super HUFA (Salt Creek Inc, USA), Algamac-2000, Algamac-3050 (Biomarine Inc., USA). The methodology for enrichment is provided with these products.

Egg Custard

Egg custard is provided to advanced larvae (Zoea Stage-V and above). A good quality egg custard can be prepared by mixing whole egg, skimmed milk powder, corn flour/wheat flour, mussel/shrimp/prawn/squid meat, yeast, agar, cod liver oil and vitamin-mineral mixture. All the ingredients are blended in a mixer-grinder and cooked under steam in a pressure cooker for maximum of 15-20 minutes. It should not be over cooked as it will lose its flavour and nutritional quality. The egg custard should be used within 4-5 days of its preparation and the left over portion to be kept in a refrigerator. A measured quantity of egg custard is seived through strainers of different mesh sizes.

The mesh of sieve may be selected from fine to coarse depending on the mouth size of the larvae. Smaller larvae need smaller particles whereas larger larvae require bigger particles of egg custard and accordingly selection of sieve is done. The egg custard is then pressed through the sieve held in some water, just sufficient to accommodate the sieve mesh. Water is then drained leaving particles of egg custard in the container. The particulated custard is again washed with freshwater so that finer particles are drained off completely. Vitamin-mineral mixture is added to the egg custard mash and feed to prawn larvae. Egg custard should be fed 3-4 times during day time and left over particles should be drained out in the evening so that they do not foul the water during long stay in the tank.

Collection of Post-larvae from Larval Tanks

The first post-larva (PL) could be seen in the tank (LRT) after around 18 days of rearing; however, majority of them appear after 25 days depending on the water temperature. When sufficient numbers of Zoea Stage-XI larvae (say 40%) metamorphose to post-larvae they should be harvested and stocked in the post-larval tanks. Delay in harvesting results in cannibalism of the larvae by the post-larvae which are highly cannibalistic in nature. Post-larvae have to be harvested from the larval rearing tanks whenever sufficient numbers appear in LRTs. For collection of postlarvae from the larval tanks, aeration in the larval tanks is to be stopped. By doing this, all the larvae will come to the surface and post-larvae being photo-negative will settle at the bottom from where they could be siphoned out with the help of a flexible tubing. Post-larvae have to be checked for any probable infection at the time of harvesting and if stock is found free from any infection, they should be released in the post-larval tanks. After harvesting from the larval tanks, the postlarvae need to be acclimatized to freshwater conditions gradually.

Post larvae (PLs) should be reared in freshwater tanks (PLRTs) till they attain the desired size/age. They may be fed on commercial prawn starter diet specially prepared for them. Around 50% tank water is to be changed daily and all leftover feed, faecal matter and debris to be removed at the same time. The growth of post-larvae may be checked by observing their moulting on a regular basis. Harvesting of post-larvae should be done when they attain the desired size in terms of length. The post-larvae of size above 10 mm is considered ideal for harvesting and stocking in the nursery ponds. The seed of more or less same size should be supplied for stocking in the nursery pond. Post-larvae can be packed in polythene bags containing 4-5 litre water and oxygen and kept in cardboard cartons for transport. For long distance transportation of >12 hours, a sachet of cooling gel is placed in each seed pack container for maintaining temperature.

Hatchery Hygiene and Prophylactics

Prawn larvae are highly susceptible to pathogens and lot of mortalities are often observed in the hatcheries.

Therefore, strict surveillance is needed to avoid entry of pathogens that come both from outside and inside. As a first and foremost control measures, the entry of people in the hatchery should be restricted only to the workers of the hatchery. Soak pits to be constructed at all the entry points which are cleaned daily and filled with water containing disinfectants like bleaching powder. Similarly, wash basins containing sanitizers should also be available at the entry points. Everyone should wash their hands and feet before entering the hatchery. Lot of tools like hapa, hand nets, sieves, cloth pieces, etc, which are used in the hatchery tanks should be washed and disinfected before using in other tanks. The entry of such items should be limited to one unit of the hatchery only and should not be allowed to be used in the other unit. All the tanks of the hatchery should be washed before and after use with clean freshwater and disinfected with bleaching powder or iodophor substances. The components and equipment used in the hatchery should be washed and disinfected after every use.

V. Grow-out Culture

Scampi can be cultured either alone (mono culture) or in combination with compatible fishes like Carps, Tilapia, etc (polyculture). Culture can be carried out by direct stocking of post-lavae or stocking juveniles after a nursery phase of 45-60 days. Incorporating a nursery phase has shown improved survival and production during grow-out culture (Figure 2).

Nursery Phase

Nursery is the intermediate phase between hatchery and grow-out of freshwater prawn. It involves rearing of the delicate 25-day or older post-larvae (10-20 mm), obtained from hatcheries, in well prepared earthen ponds (0.01 to 0.1 ha) or concrete tanks for a period ranging from 45-60 days till they grow to juveniles (1-2 g). Stocking density ranges from 20 to 50/m2. Higher stocking densities would require aeration or water exchange. Stocking nursery reared larger juvenile prawns in grow-out ponds gives better yield and predictable production than direct stocking of post-larvae. Hence nursery rearing phase is always recommended prior to grow-out culture. Pond preparation and management are similar to that of grow-out ponds except that hide-outs are not provided in nursery ponds. Floating aquatic plants such as Eichhornia sp. may be introduced in a floating bamboo or PVC frame to cover 5-10% of pond surface area. The dense root system of these plants provides shade, shelter and food to

Figure 2: Grow out culture ponds with paddle wheel aerators.

growing post-larvae. Good quality commercial pellet feed (Starter-I) is recommended for feeding the post- larvae twice daily. If it is not available, then powdered oilcake and ricebran mixture can also be fed to post-larvae at 100% biomass per day for the first 10 days and slowly reducing the quantity as the prawns grow. Survival rates of 75 to 80% can be achieved during nursery phase under good management practices.

Grow-out Phase

Grow-out phase follows nursery phase where the juveniles harvested from nursery ponds are stocked in well prepared earthen grow-out ponds at a stocking density of 3/m2. As stocking density shows a strong negative relationship with growth, lower stocking densities are preferred if the farmer wishes to harvest larger prawns. Higher stocking densities (>5/m2) will lead to smaller prawns at harvest. The prawns are fed daily with formulated pellet diet (2-3 mm) at 10% of the biomass initially and then reduced to 3% of the biomass at the end of culture period. Monitoring important water quality parameters such as dissolved oxygen, pH and temperature is recommended to prevent loss of stock due to poor water quality. Regular monthly sampling needs to be carried out to assess the growth and health of the prawns as well as to revise the feed ration. After four months, marketable size prawns (>40 g) may be harvested by using large mesh net and this selective harvesting should continue once every 3-4 weeks for another 3-4 months and finally the prawns can be harvested by completely dewatering the pond.

Site Selection

The selected site should have warm climate for nearly 6-8 months (temperature >20°C). It should have a supply of good quality, pollution free freshwater or brackish water (<7 ppt) for at least 6 months. It should have soil with good water retention capacity.

Pond Construction

- Ponds should preferably be embankment-type that can be fully drained by gravity.
- Ponds should have an inlet and outlet.
- Pond bottom should have a gradient/slope (1:200) towards the outlet.
- Pond bund should have a suitable slope (1:2, 1:3).
- Water control structure should be installed at inlet and outlet to aid water exchange.
- Pond size – 0.2 to 1.0 ha (preferably 0.2-0.5 ha).
- Rectangular shaped ponds with the long axis oriented in the direction of prevailing wind are most suitable.
- Soil – clayey loam, sandy loam. Depth – 2 m.

Eradication of Competitors and Predators

- This step may not be necessary in newly constructed ponds but in old ponds, all unwanted species such as predatory fishes, weed fishes and aquatic weeds should be removed.
- Drying and exposing the pond bottom until cracks developed is the best way of eradicating predators and competitors.
- Drying and exposing the pond bottom also kill pathogenic microbes and helps in oxidizing the pond bottom.
- Poisons of plant origin such as mahua oil cake, tea seed cake or derris root powder may be applied in un-drainable ponds to kill predators and unwanted fishes.

Liming

- Liming is an important step in pond preparation and is done after drying the pond by spreading the lime uniformly on the pond bottom.
- The rate of application varies with soil pH; to a pond having soil pH above 6 agricultural lime (Calcium carbonate) is applied @ 200250 kg/ha.
- Application of lime helps to correct pH; increases the buffering capacity of water; disinfects the pond bottom as well as acts as a source of calcium which is important for exoskeleton formation in prawns.

Fertilization

- After liming, the pond is filled with water up to 1-2 feet and manure or fertilizers are applied for development of plankton.
- Surface waters from rivers, canals or reservoirs or groundwater from bore-well may be used for culturing freshwater prawns.
- A fine-mesh net should be used to screen the inlet water to prevent entry of eggs and larvae of predatory and weed fishes that may colonize the pond and lead to poor growth and survival of the stocked prawn juveniles.
- Cow dung @1000 kg/ha or poultry manure @500 kg/ha and super phosphate @100 kg/ha may be applied to initiate plankton development.
- The pond can be filled up to the desired level (4-5 feet) after initial manuring.
- Manures or fertilizers helps in development of phytoplankton which in turn prevents development of benthic algae and rooted vegetation.
- It also helps in development of bottom living animals on which the prawn feeds.

Provision of Hideout and Bird Netting

- Prawn needs shelter/hideout during moulting to avoid predation by other prawns. Hence cut branches of trees, nylon screen, earthen pipes etc can be provided as hideout. Hideout materials also provide more surface area for the prawns.
- Birds are one of the major predators and can cause significant reduction in survival, so tying nylon ropes or large mesh gill net above the water surface provide some protection from bird predation.

Stocking the Pond

- Ponds can be stocked with post-larvae or juveniles after preparing and laying hideouts.
- Prawn seed from hatchery needs to be acclimatized at the farm site by floating the transport bag in the pond for 15 minutes. After opening the bag, pond water should be allowed to flow into the bag and post-larvae/juveniles should be slowly released into the pond.
- Stocking should be done early morning or late evening which is the ideal period.
- A stocking density of $3/m^2$ is desirable, which however may be reduced to 50% in polyculture pond with compatible fish species such as Catla, Rohu, Silver Carp and Grass Carp.

Water Quality Management

- Visibility/transparency and colour of the pond is an important indicator of the health of pond ecosystem. In unproductive ponds the visibility can be up to the bottom which will lead to growth of bottom algae that adversely affect the growth and survival of prawns. Low visibility (<10 cm) indicate high blooming or turbidity that could cause problem of oxygen depletion and mortality of stocks. Ideally, the visibility should be maintained in the range of 30-40 cm to avoid water quality deterioration.
- Daily monitoring of water quality parameters such as dissolved oxygen, pH and temperature is recommended to prevent loss of stock due to poor water quality. Loss of prawn is usually associated with low dissolved oxygen level in the pond. Therefore it is essential to maintain dissolved oxygen at optimum level of >4 ppm at all times. Provision of aerators (paddle wheel or any other such devices) is recommended especially during the final 2-3 months when the biomass in the pond is high. When the oxygen level in the pond is critically low, the prawns come to the surface along the periphery which indicates the need for taking immediate remedial measures such as water exchange or operation of aerators to avoid mortality of stock.
- Water should be free of pollutants and toxic chemicals and the optimum ranges for a few most important water quality parameters for freshwater prawn culture are as follows (Table 1)

Feed Management

- Freshwater prawns are omnivorous and feed on both animal and plant materials, found on the pond bottom, such as algae, aquatic insects and their larvae, worms, crustaceans, small mollusks, etc.
- Farmers may use commercial pellet feed having good water stability or farm made feed. Most commonly used ingredients for farm made feed includes ricebran, broken rice, groundnut oil cake, tapioca powder, fishmeal, apple-snail meat, etc.
- Prawns are fed daily at 25% of the biomass during the first two months which is gradually reduced to 3% of the biomass at the end of culture period.
- Although feed is usually broadcasted around the periphery of the pond in shallow area, providing of feed in checktrays kept in different areas of the pond will help in determining the quantum of feed required per day.
- Feeding should be done during late evening or early morning since prawns are more active during night time.
- Feed rate should be revised once every three weeks depending on the average body weight obtained during monthly sampling. Weight dependent feeding rates is given in table as follows (Table 2)
- Regular sampling of prawns using cast net or small mesh seine net at 3-4 week interval is essential to assess the growth of prawns. Feed rate is revised after every sampling based on the body weight and estimated biomass in the pond.

Health Management

- Diseases in freshwater prawn grow-out culture are usually found to be associated with poor rearing conditions (over-feeding, water shortage, silting etc).
- Bacteria and fungus are the most common disease causing organisms. Loss of appendages, brown or black colouration of exoskeleton, fouling on the body are some of the symptoms seen in diseased prawns.
- If disease symptoms are noted, water should be replaced, water quality should be tested and necessary steps should be taken. Immediate consultation of experts will help in avoiding loss of stock due to diseases.
- Following good rearing practices mentioned below will help avoid diseases to a great extent:
- Use good quality seed and avoid high density stocking.

Table 1: Optimum Water Quality Parameters for Scampi Farming.

Water Parameter	Optimum Range
Temperature (°C)	28-31
Salinity (ppt)	Freshwater/low-saline (<7 ppt)
pH	7.0-8.5
Dissolved Oxygen (ppm)	>4.0
Total Hardness (ppm)	40-100

Table 2: Optimum Feeding Rate for Scampi in Grow-out Pond.

Body Weight of Prawns (g)	Feeding Rate (% Prawn Biomass)
< 2	> 25
2-5	10
5-10	8
10-15	6
15-20	4
20-25	2.5
25-30	2
> 30	1

- Use good quality pellet feed, monitor the feeding using check-tray and avoid overfeeding.
- Dry out the ponds between production cycles so that the pond bed can be reoxidized.
- Water exchange (30-50%) helps in rinsing the pond and induces moulting.
- Regular monitoring of water quality especially dissolved oxygen is essential.

Yield and Production Cost

- Good quality post-larvae stocked at moderate density 3/m2 and fed with good quality pellet diet will grow to an average size of 50-60 g in 6-8 months.
- Periodic harvesting of prawn is always suggested due to heterogeneous growth among prawns. Large prawns (>40 g) may be harvested using seine net of suitable mesh size after four months of culture, which should continue once every 3-4 weeks thereafter for the next 3-4 months.
- Final harvesting of the prawns may be done after 8 months of culture by complete dewatering and the pond should be freshly prepared for the next production cycle.
- A survival rate of 65 to 70% is expected and prawn yield may range from 800 to 1000 kg/ha (320 to 400 kg/acre).
- The cost of production per kg of prawn may range from Rs.150 to Rs.175/-. Major components of cost of production include cost of seed, pellet feed, energy and labour (Figure 3).

Post-harvest Handling

- Processing yield (tail weight percentage) of freshwater prawns (<50%) is less than that of marine shrimps (>60%) and decreases with the increase in size of the prawn and is better for females than males.
- Prawns are sold either head-on or head-less. Sometimes they are sold live also. Ice-chilled uncooked prawns have a short shelf life (3 days) before they become mushy. 'Kill chilling' by dipping prawns in iced water prior to blanching at 65°C for 15-20 sec before icing for transport to market, significantly improves quality.

Figure 3: Post-harvest quality *Macrobrachium rosenbergii* brooders.

- Usually harvested prawns are washed and iced immediately to prevent quality deterioration. In the processing plants they are removed from ice and washed again. The washed and drained prawns are weighed and sent for de-heading.
- The iced headless prawns are then size-graded by weight.
- After size-grading the product then goes for further value addition according to the requirement of the buyer, such as 'peeled and deveined' (PD) and 'peeled deveined tail-on' (PDTO). Most of the Giant Freshwater Prawn farmed in India is exported in a headless tail-on style.
- Prawns are either bulk frozen or individually quick frozen at -40°C. Packed material is finally stored at -20°C.
- Removal of head and intensive washing decreases initial microbial load and improves the post-storage quality of prawns which can be stored frozen for up to six months without any deterioration of flavour.

Results and Discussion

Constraints – Pitfalls and Precautions

- The major problem during freshwater prawn culture is size heterogeneity in harvested crop, which demands additional effort to market them.
- Tail yield of freshwater prawns (40-50%) is less than that of marine shrimp (60%)and freshwater prawns require more care in processing than marine shrimp.
- There are reports of reduced growth rate in grow-out phase from some parts of India which has been attributed to 'inbreeding depression'.
- Freshwater prawns are very sensitive to low dissolved oxygen levels and mortality of stock due to low levels of oxygen in the pond is one of the major reasons of low yield.
- Body weight of this prawn shows a very strong negative relationship with stocking density. Therefore, this species cannot be stocked at higher densities and moreover the price is sizedependent.
- Low seed quality from hatcheries has resulted in low production.

Polyculture

- Freshwater prawns can be easily integrated with existing carp culture bringing additional income to farmers without much additional cost.
- Macrobrachium rosenbergii (Scampi) can be cultured with compatible fish species such as Catla (Catla catla), Rohu (Labeo rohita), Silver Carp (Hypophthalmichthys molitrix) and Tilapia.

- Polyculture of carp and prawn has the advantage that both prawn and carp can utilize different food niches in the pond efficiently.
- Polyculture of prawn without bottom feeders like Common Carp and Mrigal allows the prawns to obtain their share of the pellet feed that will sink to the bottom. In addition, it allows the prawn to graze on bacterial films on the bottom substrate which results in better growth performance of prawn. Further, polyculture improves the ecological balance of the pond water, preventing the formation of massive algal blooms.
- Polyculture of Scampi can be carried out in earthen ponds and pens of varying sizes.
- Stocking size of prawn should preferably be 2-5 g for better yield and income.
- Stocking density of prawn recommended in polyculture range from 10,000 to 15,000/ha or 1 -1.5/m^2 and that of fish range from 6,000 to 8,000/ha.
- Fish can be fed with traditional feed (mash feed of ricebran and oilcake) or floating pellet feed. The prawns need not be fed separately as they will consume the left over feed that finally sink to the pond bottom.
- Monitoring of important water quality parameters such as dissolved oxygen, pH and temperature is recommended to prevent loss of stock due to poor water quality especially during last 3 to 4 months of culture.
- After four months, marketable size prawns (>40 g) may be harvested by using large mesh cast net or bag net and this selective harvesting can be continued once every 3-4 weeks for another 3-4 months.
- Fish can be harvested by netting after 8-10 months and finally the prawns can be harvested by complete dewatering.
- At 8,000/ha stocking density the average final size of fish after 10 months of culture would range from 800 g, to 1 kg at a survival rate of 70-75%. The expected production of fish would be 5,000 kg/ha.
- At 1/m^2 stocking density the average final size of Scampi after 8 months of culture would be 50 to 80 g if good quality scampi seed are used. Final survival rate of 60 to 70% is expected and the production of Scampi may range from 480 to 600 kg/ha (200 to 250 kg/acre).

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