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DEPERTMENT- AQUACULTURE

SEMESTER-IV

PAPER IV–FRESH WATER & BRACKISH WATER AQUACULTURE

UNIT-I

* STATUS AND SCOPE OF FRESH WATER AQUACULTURE IN INDIA*

Scope for Aquaculture in India

The freshwater aquaculture systems in the country has primarily confined to three Indian major carps, viz., rohu, catla and mrigala, with exotic species: silver carp, grass carp, and common carp forming the second important group.

- Among the catfishes, magur (Clarias batrachus) has been the single species that has received certain level of attention both from the researchers and from farmers due to its high consumer preference, high market value and most importantly its suitability for farming in shallow and derelict water bodies with adverse ecological conditions.

Recent years, however witnessed increasing interest for farming of Pangasius spp., especially in Koleru lake region of Andhra Pradesh due to its higher growth potential and ready market. Other potential species include Labeo calbasu, Labeo gonius Labeo bata, Labeo dussumeri, Labeo fimbriatus, Barbodes carnaticus, Puntius pulchellus, Puntius kolus, Puntius sarana, and Cirrhinus cirrhosa.

- Some of these species are being cultured at a very low level in different parts of the country, mostly based on wild seed collection. The freshwater air-breathing and nonair-breathing species, Channa marulius, Channa striatus, Channa punctatus, Channa
- gachua, Channa stewartii have not been taken up for the aquaculture activities in serious way.
- With the technology available for seed production and culture of air breathing (Clarias batrachus, Heteropneustes fossilis) and non air breathing catfish like (Wallago attu, Mystus

seenghala, Mystus aor, Horabagrus brachysoma, Pangasius pangasius), scientific organized catfish farming can be taken up in extensive and semi intensive way (Ponniah and Sundaray, 2008).

- The giant freshwater prawn, Macrobrachium rosenbergii has been the principal species, adopted both under monoculture and under mixed farming of freshwater prawn production of about 43,000 tonnes in the country at present. However, M.malcomsonii and M. gangeticum havenot been taken up in a big way

In the brackishwater sector, the aquaculture development is mostly contributed by shrimp, Penaeus monodon culture only.

- The other shrimp species like Fenneropenaeusindicus, Fenneropenaeus merguiensis, Penaeus pencillatus, Marsupenaeus

japonicus and Penaeus semisulcatus are not cultured on a commercial level large-scale culture. Recently Fenneropenaeus vannamie culture is developing in India. The finfish species like the seabass (Lates calcarifer) and grouper (Epinephelus spp.), grey mullet (Mugil cephalus), pearl-spot (Etroplus suratensis), milk fish (Chanos chanos) which are promising and ideal for aquaculture has not been exploited. The potential marine finfish species are Epinephelus malabaricus, Epinephelus coioides, Epinephelus tauvina, Epinephelus fuscoguttatus, Epinephelus polyphekadion, Cromileptis altivelis, Rachycentron canadum, Seriola quinqueradiata, Trachinotus blochii, Coryphaena hippurus, Psettodes erumei, Lutjanus argentimaculatus, and Pampus argenteus.

- Mariculture is expected to be a major activity in the Indian coastal areas in the years to come. Given the wide spectrum of cultivable species and technologies available, the long coastline and favorable climate, mariculture is likely to generateconsiderable interest among the coastal population and entrepreneurs.

In the present era of food insecurity, aquaculture shows enormous potential to feed not only the ever increasing human population but also the aquaculture products can be utilized as a feed ingredient in the diets of different domesticated animals of high commercial value.

- The aquaculture sector has become a modern, dynamic industry that produces safe, high valuable andhigh quality products, and has developed the means to be environmentally sustainable Sustainable aquaculture is currently the need in India as elsewhere.
- Eco-friendly aquaculture in harmony with environmental and socioeconomic needs of the society has to be evolved.

*FRESHWATER AQUACULTURE SYSTEMS *

Cultivable organisms are cultured in different types of culture systems. Many culture systems are based on traditional ideas that have been used for years, but some encompass new and some times radical concepts that make them unique.

There are three major culture systems – open, semi-closed and closed culture systems. Each has its special characteristics, advantages and disadvantages.

The choice of system is largely dependent on the function of the organisms to be grown and the resources and ideas of the farmer.

Pond Culture: Pond culture is a very popular aquaculture production method with many aquatic species cultured in ponds.

To have successful pond production, ponds must be properly sited and built, with careful assessment of water availability, quantity, and quality.

There are twomain types of pond systems: watershed and levee systems The climate and topography of the region in which you are located will determine which type of pond system is appropriate.

Areas that have enough rainfall to fill and keep ponds filled will be more suited to watershed pond systems. In an area where the main water source is groundwater, then a levee pond may be moresuitable

Watershed Pond Systems

With both watershed and levee ponds systems, it is critical to properly site the pond. Soil type, topography, characteristics of the watershed, water quality, access to utilities (electricity and roads), and safety all need to be considered.

Soil type will determine how well the ponds will hold water; clay and clay-silt type soils are preferred for ponds because they prevent leakage Levee Pond Systems

Levee ponds are typically suitable for flat land areas where there is insufficient water from the watershed to fill the ponds. These are quite common throughout the Mississippi Delta region where tens of thousands of acres of ponds are used for culturing catfish (Steeby and Avery 2002).

Groundwater is the typical water source for levee pond systems because of availability and the low likelihood of containing contaminants such as diseases, other fish, high levels of nutrients, or pesticides (Avery 2010).

Water quality is a key factor in any culture system, and it is very important to determine the availability and quality of the water before investing in a production system

The majority of aquaculture throughout the world is conducted in ponds.

Earthen ponds or reinforced concrete ponds are used for culturing the fish, shrimp, prawn, etc. in both freshwater and brackishwaters.

Raceway culture:

A raceway in its simplest form is just a flume for carrying water. Raceways for fish culture are tanks which are relatively shallow and rely on a high water flow in proportion to their volume in order to sustain aquatic life.

Flow-through fish culture systems pass water through the systems once, provide waste treatment as required, and then discharge the water rather than treating and recirculating it.

For successful aquaculture, the inflowing water must be within the temperature tolerance of the species being cultured and should match the optimal temperature for the target species as closely as possible.

Oxygen is also provided by the incoming water and is removed bythe fish as the water progresses down the raceway.

In most raceway systems, dissolved oxygen isreplenished by allowing the water to fall into subsequent tanks within the raceway

Depending on the water chemistry, the depletion of oxygen and the accumulation of ammonia, carbon dioxide, or fine particulates can eventually become limiting to fish production within the system.

No natural foods are generated in these systems, and nutritionally complete diets are anessential requirement for successful raceway aquaculture

A series of earthen or cement tanks are constructed along the course of a river or stream and are used for fish culture.

Raceway is a culture chamber that is generally long and narrow.

Water enters at one end and leaves through the other end in most cases.

Water recirculation systems:

Re circulating Aquaculture Systems

For commercial aquaculture, recirculating aquaculture systems have certain advantages and disadvantages over other production systems such as ponds and raceways.

The main disadvantage is that they are more costly to start up and have higher operating costs (Lazur 2003). The advantages of recirculating aquaculture systems are that they:

- require significantly less water than that of ponds or raceways,
- can be located in more areas,
- can be more intensive (culturing more product in a smaller volume),
- can produce year round,
- are more environmentally compatible, and
- are expandable (Losordo et al. 1998, Timmons et al. 2002, Lazur et al. 2003).

small recirclating aquaculture system at Ohio State University South Centers (photo courtesy of Laura Tiu, Ohio State University)

One of the key factors in development of a recirculating aquaculture system is the management of water quality. Adequate filtration is critical to maintaining a healthy environment for the product being produced. Healthy water equals healthy fish. If water quality is not properly maintained, it can reduce growth and stress the animals. Stress on fish will increase time to market, can cause losses due to diseases and mortalities, and decrease feed efficiency. Because recirculating aquaculture systems are intensive, the amount of feed going into the system and wastes coming out need to be managed to maintain optimal water quality.

The management of recirculating systems relies heavily on the quantity and quality of feed and the type of filtration. Numerous filter designs are used in recirculating systems, but the overall goal of all filtration is to remove metabolic wastes, excess nutrients, and solids from the water and provide good water quality for the aquatic organisms. It is important to consider all factors when designing and investing in aquaculture systems.

Here the water is conserved throughout most or all of the growing season by circulating in the culture tanks after purifying it through biological filters.

Closed recircu-lating water systems are being used primarily for experimental work and for the rearing of larval organisms in commercial or research facilities.

Closed systems are generally comprised of four components;

the culture chambers, a primary settling chamber, a biological filter (biofilter) and a final clarifier or secondary settling chamber for purification of water for reuse.

CAGE CULTURE- ADVANTAGES AND DISADVANTAGES.

Today cage culture is receiving more attention by both researchers and commercial producers. Factors such as increasing consumption of fish, declining stocks of wild fishes and poor farm economy has increased interest in fish production in cages. Many small or limited resource farmers are looking for alternatives to traditional agricultural crops. Aquaculture appears to be a rapidly expanding industry and it offer opportunities even on a small scale. Cageculture also offers the farmer a chance to utilize existing water resources in which most cases have only limited use for other purposes.

The right choice of site contributes significantly in the success of cage farm. Site selection is vitally important since it can greatly influence economic viability by determining capital outlay, by affecting running costs, rate of production and mortality factors.

- Site selection is a key factor in any aquaculture operation, affecting both success and sustainability.
- Circular cages of different diameter ranging from 2 m to 15 m, designed for the culture of fishes such as milkfish, mullet, cobia, pompano, sea bass, pearl spot, shellfishes such as shrimps, crabs and lobsters were experimented and demonstrated successfully in India by Central Marine Fisheries Research Institute (CMFRI).
- Stocking of right sized fish juveniles in adequate stocking density is another factor which determines the success of farming. The stocking density and size of stocked fishes varies with different species.
- Proper feeding of quality feeds, periodic monitoring and cleaning of cages contributes immensely to the success of cage farming.
- With proper management of cage erected at an ideal location can yield a production of20-40kg/m^3 with various species of fishes.

Cage aquaculture involves the growing of fishes in existing water resources while being enclosed in a net cage which allows free flow of water. It is an aquaculture production system made of a floating frame, net materials and mooring system (with rope, buoy, anchor etc.) with a round or square shape floating net to hold and culture large number of fishes and can be installed in reservoir, river, lake or sea. A catwalk and handrail is built around a battery of floating cages. There are 4 types of fish-rearing cages namely: i) Fixed cages, ii) Floating cages, iii) Submerged cages and iv)Submersible cages. Economically speaking, cage culture is a low impact farming practice with high returns and least carbon emission activity. Farming of fish in an existing water body removes one of the biggest constraints of fish farming on land, ie., the need for a constant flow of clean, oxygenated water. Cage farms are positioned in a such way to utilize natural currents, which provide the fish with oxygen and other appropriate natural conditions.
In view of the high production attainable in cage culture system, it can play a significant role in increasing the overall fish production in India. Suitable locations in Indian's long coastline, vast brackish water areas available in coastal states and other underutilized water bodies can be better utilized by adopting cage culture. Since the investment is low and requires very little / no land area, this farming method is ideal for small scale fisher folks as an alternative income source. This can be taken up as and house hold / women activity since labour involved is minimal and can be managed by a small family. The design of the cage and its accessories can be tailor-made in accordance to the individual farmer's requirements.

Advantages and disadvantages of Cage culture

Cage culture of fish has advantages and disadvantages that should be considered carefully before cage production becomes the chosen method. A potential fish farmer can produce fish in an existing pond without destroying sport fishing; does not have to invest large amounts of capital for construction or equipment; and can, therefore, try fish culture without unreasonable risks.

Advantages

Cage culture has advantages which include:

- Many types of water resources can be used, including lakes, reservoirs, ponds, strip pits, streams and rivers which could otherwise not be harvested.
- A relatively low initial investment is required in an existing body of water.
- Harvesting is simplified.
- Observation and sampling of fish is simplified.
- Allows the use of the pond for sport fishing or the culture of other species.
- Less manpower requirement.
- Generation of job opportunities for unemployed youth and women.
- Additional income to fishers during closed seasons.

Disadvantages

Cage culture also has some distinct disadvantages. These include:

- Feed must be nutritionally complete and kept fresh.
- Low Dissolved Oxygen Syndrome (LODOS) is an ever present problem and may require mechanical aeration.
- Fouling of net cage.
- The incidence of disease can be high and diseases may spread rapidly.
- Vandalism or poaching is a potential problem.
- Navigation issues.
- Accumulation of unused feed and excreta will lead to water pollution as well as eutrophication.
- Change in water quality parameters.
- Conflicts within the local community.
- Predation by aquatic mammals and birds.
- Escapement.
- Overcrowding of aquatic organisms in cages.

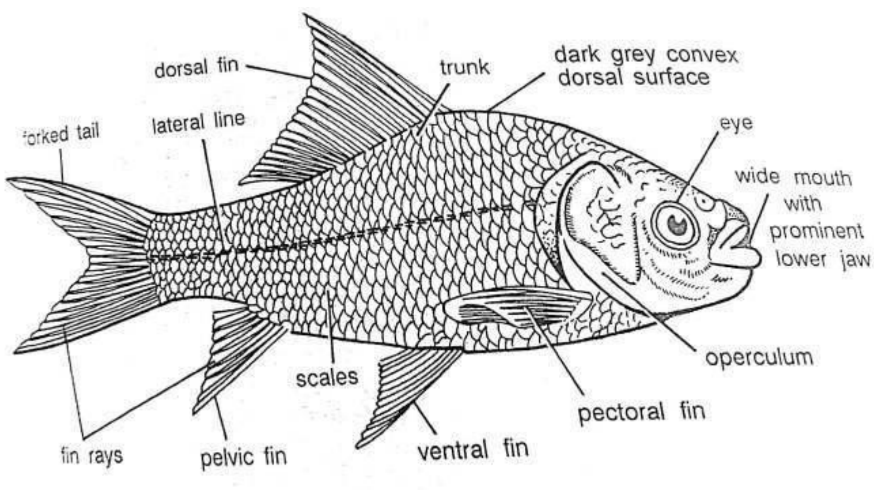
UNIT-II

* IDENTIFICATION AND BIOLOGICAL CHARACTERS OF INDIAN MAJOR CARPS*

1.CATLA CATLA

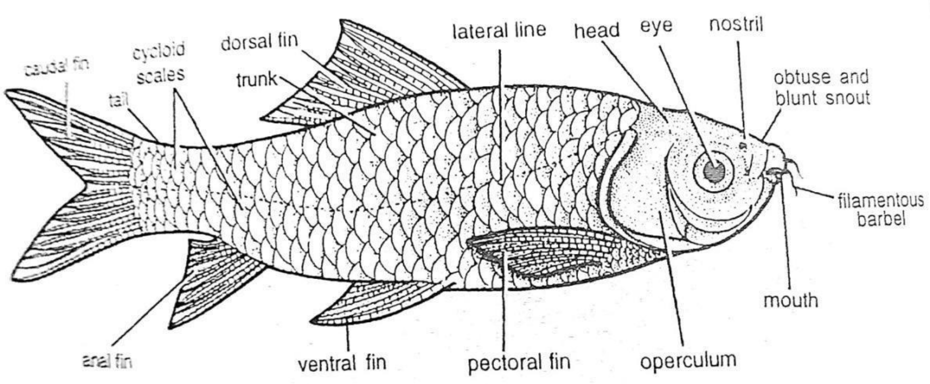
- Generally called krishna Bocche.
- Body broad, specific head, mouth on dorsal side at the tip, clear lips with folding Dorsalfin with 17-19 rays are identification characters.

- This live on Surface waters and take planktons, algae, plants etc.
- Development rate is very fast, attain maturity at 2 years age.
- Generally Cultured in India, Pakistan, Barma, Bangladesh.
- In ponds attain weight 6-l4 kg while in reservoir attain 57-66 Kgs.



2. LABEO ROBITHA:

- Generally called Rohu, selavathi, Ragadhi.
- Body is tall, with less breadth, mouth is broad, lips fat with Lower lip folded. Short barbels, dorsal fin with (12-16) fin rays.
- Lives in middle region of ponds and depends on micro-organisms, water plants, organic matter, planktons etc.
- This can even less salinity water conditions.
- Developmental rate is more in second year than first year.
- Attain.2 years age grow to 1 meter length.



3 CIRRHINUS MXIGALA:

- Generally called erramosa.
- Body lengthy, soft, head small, snout round 1pair of barbels, at the tip of mouth is Surrounded by lips, tightly bifurcated Caudal tip dorsal fin with 15-16 rays.
- Bottom dwelling depending on plankton, algae, decaying matter etc.
- It is an Omnivore.
- Attain maturity at 2 years of age.

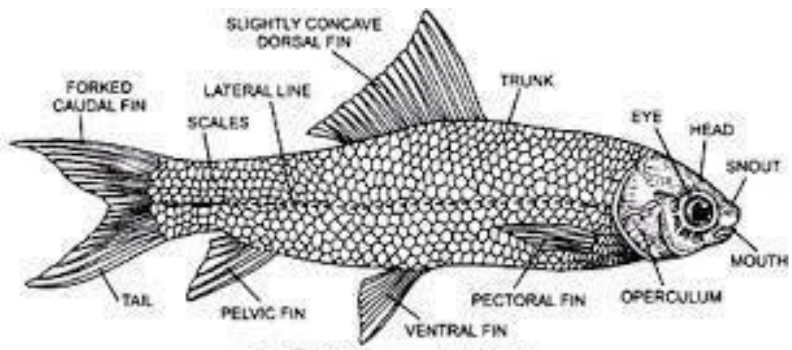


Fig. 9.4. Cirrhinus mrigala (Nain)

- Grows to a length of around1 mts and weight around 13 kgs.

* EXOTIC FISH SPECIES IN INDIA*

Ans; India has abundant water resources in which several species of indigenous variety of fishes survives successfully. Until now the fish culture in India was mainly dependent upon the culture of some of the most common Indian species like Labeo, Catla and Mrigal.

But it has been found in recent years that the introduction of the foreign breeds of fishes to Indian fresh water ponds and reservoirs and their culture in isolated condition or in suitable combination with the Indian counter-parts yields a higher production. In this view a number of fish species have been imported from foreign countries and introduced into Indian fresh water. Since, these fish are not the natives of this country, are called as exotic fishes.

1. Carassius carassius:

It is commonly called as crucian carp or golden carp. It was brought to India from central Europe in 1874 and was first introduced by Maclvor in the Ooty Lake. Later on, it was transplanted to other places in Nilgiris and to Sunkesula fish farm of Andhra Pradesh. The purpose of its import is to use as food fish. These are fresh water river fish but survive and reproduce in confined water, too. In tropics, its breeding season extends throughout the year. Its growth rate is quite slow and attains a maximum length of 45 cm and a weight of 1.4 kg as recorded in Ooty Lake.

Gold carp feeds on insects, Cladocerans and Crustaceans. They attain sexual maturity in the first year of their life. The eggs remain attach to aquatic weeds till hatching. The culture of this fish is of little significance as its growth rate is low and the flesh is also not well relished. However, when it is cultured along with other species the yield increases. They help to control predators and weeds in the pond.

2.* Cyprinus carpio*:

Cyprinus carpio, which is commonly called as "common carp" is a native of temperate Asia but now it has a world-wide distribution. It was initially, imported in 1939 from then Ceylone and was transplanted in Nilgiri. However, another variety (scale carp) was brought from Bangkok to Cuttack (Orissa) in 1957. In India, it is being cultivated for quit long, either, singly or along with other Indian major carps. The fish has considerable food value. The fish is ideal for culture in both cold and warm water of India however the optimal water temperature ranges between 20 – 25°C.

The fish has a moderately compressed oblong body. The protractile mouth bears smooth simple lips. Two pairs of barbels are present, of which one pair is rudimentary. The dorsal fin is long which originates opposite to the ventral fin. The body colour, scales and size of the body varies in different varieties of common carp.

The three varieties of this fish are Cyprinus carpio var. Communis (scale carp), Cyprinus carpio var. Specularis (mirror carp) and Cyprinus carpio var. Nudus (leather carp). Mirror carp possess large, shiny, yellowish scales, scale carp bears small scales covering whole body while, leather carp is devoid of scales giving leathery appearance.

Cyprinus carpio is voraciously omnivorous, grows very fast, have the capability of efficiently converting food into flesh. In culture, they thrive well on artificial food. In the plains of India the fish attains maturity within six month of hatching but it takes about an year in upland lakes. In natural conditions the carps breed in confined water, in shallow, marginal, weed infested areas. They breeds twice a year. In India the season is July to August and January to March. The eggs are released on plant roots hanging below water surface. Hatching occurs in 2 to 3 days. Fry feeds on the zooplanktons and later shift on all kinds of food available in the pond.
In India, prior to breeding the males and females are segregated few months earlier and stocked in separate ponds, prefrebly free from other fishes. The breeders are regularly fed on artificial food which is mixture of oil cake and rice bran in the ratio of 1:1. Breeding is done in hapas or in cement hatcheries or in ponds.

One female and two or three males comprises one set of brood. Hydrilla and Najas, which act as egg collector are released in the hapas or cement hatcheries at the rate of 2 kg per kilogram weight of the female. About 40,000 to 100,000 eggs gets adhered to about 1 kg of aquatic weeds. Larvae hatches in 4-5 days. Such larvae are transferred to nurseries. The nursery and rearing ponds for spawn are prepared as those prepared for Indian major carps.

Common carps are generally cultured in combination with Indian carps. The growth rate depends upon enviornment and temperature. In India, at a stocking density of 2,500/ha the growth of common carp in manured pond withoutt artificial food and with artificial food in one year, the weight becomes 600 – 800 g and 1 kg, respectively. In second year, the weight of individual fish, becomes 1500 g to 2000 g at a stocking density of 1500/ha. Alikunhi (1966) recorded fish with ten kilogram weight after 30 months at Barang Fish farm in Orissa. Common carps are probably the easiest fish to culture. A matured fish breeds upto five years of age.

3. Hypothalmichthys molitrix:

It is commonly called as “silver carp”. This exotic species is a natural inhabitant of Amur basins of Russia and river systems of China. Its culture is extensively practiced in China, Thailand, Taiwan, Malaysia, Japan, Sri Lanka, Russia and now in India, Pakistan, Nepal and Philippines. Owing to its rapid growth and valued flesh, the fish is becoming popular in many parts of the world. In India, for the first time 360 fingerlings of silver carp was brought from Hongkong in 1959 to the pond culture division of CIFRI, Cuttack, Orissa. These fingerlings were cultured and successfully bred by induced breeding techniques to raise the population.

The adult fish bears an oblong and slightly compressed body with pointed head. Lower jaw is little protruding and the eyes are small. Body is covered by small scales. Abdominal keel is present. Silver carp is a pelagic and planktophagus species. According to Nikolskii (1961) post larvae feed, on zooplankton and on reaching 1.5 cm of length, “the fry begins to feed on phytoplankton. The adult subsist on protozoa, rotifers, decayed macro-vegetation and detritus. Hora and Pillay (1962) noticed that during culture, they survive well on artificial food like rice bran, bone meal etc. Kuronuma (1968) reported that in wild the fish attains sexual maturity in 2 to 6 years, however Alikunhi (1965) found that the induced bred specimens in India becomes sexually mature in only eleven months.

Silver carp is a freshwater river fish but can survive in slightly brackish water. It does not naturally, breed in confined water but through induced breeding techniques breeding is possible even in confined water areas. The breeding technique is the same as that of other Indian major carps. For breeding, each set of breeders consists of one femal and two males. Both males and female are injected with pituitary extracts. The donars are usually Indian major carps or Chinese carps.

For rearing spawn of silver carps, nursery pond is prepared on the same pattern as those used for Indian major carps. At a stocking rate of 5 lakhs per hectare, silver carp spawn, with an average length of 7.4 mm, recorded a growth of 24 mm in length and 103.8 mg in weight with a survival of 42.5% during nine days of rearing. Survival rate upto 83% have also, been achieved in other nursery ponds. Rearing of silver carp fry and fingerlings along with other exotic species have been experimentally studied at Inland Fisheries Research Institute, Barrakpore. Six silver carps, five grass carps and five common carps at a stocking density of 93,750 fry per hactere gave 99.5% survival of silver carp fingerlings. Silver carp cultured along with Catla was experimentally observed by Sukumaran et. al., (1968) and it was found that silver carp develops faster than Catla. A stocking ratio of 2 silver carp: 1 Catla gave the highest production after six months.

* Composite fish culture systems of Indian major carps*

COMPOSITE FISH CULTURE SYSTEMS

Selection of Pond

- The main criteria to be kept in mind while selecting the pond is that the soil should be water retentive, adequate supply of water is assured and that the pond is not in a flood prone area.
- Derelict, semi derelict or swampy ponds can be renovated for fish culture by dewatering, desilting, repair of the embankments and provision of inlet and outlet.
- The pond may be owned by the individual or taken on lease in which case the lease period should be more or coterminous with the repayment period.
- Construction of new ponds in ideal sites is recommended keeping in view the above parameters.

Pond Management

Pond Management plays a very important role in fish farming before and after the stocking of fish seed. Various measures that are required to be undertaken in pre and post stocking practices are tabulated below:

1. Pre-stocking In case of new ponds, pre stocking operations starts with liming and filling of the pond with water. However, the first step for existing pond requiring development deals with clearing the pond of unwanted weeds and fishes either by manual, mechanical or chemical means. Different methods are employed for this.

i) Removal of weeds by Manual/Mechanical or through Chemical means.

ii) Removal of unwanted and predatory fishes and other animals by repeated netting or using mahua oil cake @ 2500 kg/ha metre or by sun drying the pond bed.

iii) Liming: The soils/ tanks which are acidic in nature are less productive than alkaline ponds. Lime is used to bring the pH to the desired level. In addition, lime also has the following effects –

a) Increases the pH.

b) Acts as buffer and avoids fluctuations of pH.

c) It increases the resistance of soil to parasites.

d) Its toxic effect kills the parasites; and

e) It hastens organic decomposition

The normal doses of the lime desired ranges from 200 to 250 Kg/ha. However, the actual dose has tobe calculated based on pH of the soil and water as follows:

Soil pH Lime (kg/ha) 4.5-5.0 2,000

5.1-6.5 1,000

6.6-7.5 500

7.6-8.5 200

8.6-9.5 Nil

The pond is required to be filled with rain water or water from other sources after liming in case it is a new pond.

iv) **Fertilisation/ Manuring**:

- Fertilization of the pond is an important means for intensifying fish culture by increasing the natural productivity of the pond.
- The fertilisation schedule has to be prepared after studying the quality of the pond soil.
- A combination of both Organic and Inorganic fertilisers may be used for best results.
- The fertiliser programme has to be suitably modified depending on the growth of the fish, available food reserve in the pond, physico chemical conditions of the pond and climatic conditions.
  a) Organic Organic manure to be applied after a gap of 3 days from the date of liming. Cow dung @ 5000 kg/ha or any other organic manure in equivalent manurial value.

b) Inorganic Inorganic fertilisation to be undertaken after 15 days of organic manuring. Requirement of nitrogenous and phosphate fertilisers would vary as per the nature of the soil fertility indicated below. However, any one of the nitrogen and phosphate fertilisers could be used as per given rate.

v) Inorganic Fertilizer Application (kg/ha/month) Soil fertility status	**Ammonium sulphate**	**Urea**
1. Nitrogen (mg/100g soil)		
i) High (51-75) 70 30	7o	30
ii) Medium (26-50) 90 40	90	40
iii) Low (up to 25) 140 60 2.	140	60

2.Phosphorus	**Single super phosphate**	**Triple super Phosphate**
15	i) High (7-12)	40
20	iiedium (4-6)	50
30	iii) Low (up to 3) 70 30 **(mg/100 gm soil)**	70

2. **Stocking** The pond will be ready for stocking after 15 days of application of fertilizers.

- Fish fingerlings of 50- 100 gm size (approx) should be used for stocking @ 5000 nos. per hectare.
- However, if fingerlings of smaller size are used, suitable allowance may be made accounting for mortality.
- The present model envisages stocking of advanced fingerlings and rearing for 10-12 months. Depending on availability of seed and market condition, stocking can be of 3, 4 or 6 species combination in the following ratio.

3. Post stocking

i .Supplementary feeding

- Fishes need much more food than what is available naturally in the pond. Fishes can be fed with a mixture of rice bran and oilcakes in the ratio 4:1. Due to the high cost of Groundnut Oil Cake (GOC) farmers have tried using alternate sources like Cotton seed oil cake which is comparatively cheaper than GOC.
- GOC and cotton seed oil cake can be mixed in equal proportions and fed to the fish and is reported to give almost the same growth rate as that of GOC.
- The feed should be placed on a feeding tray or in feeding bags and lowered to the pond bottom or it can be dispersed at the corners of the pond.
- After some time, the fishes will get used to this type of feeding and aggregate at the same place at particular time for regular feeding thereby reducing the feed losses.
- The recommended feeding rate is 5 - 6 % of the body weight up to 500 gm size of fish and then reduced to 3.5% of body weight from 500- 1000 gm size. The feeding is supplementary in nature.

ii. Manuring

i) Organic manuring may be done in monthly instalments @ 1000 kg/ha.

ii) Inorganic fertilization may be done at monthly intervals alternating with organic manuring.

However, the monthly rate of fertilization will depend on pond productivity and the growth of the fishes.

It should be ensured that excess fertilization does not take place which may result in eutrophication.

iii. Harvesting

- Harvesting is generally done at the end of 1st year, when the fishes attain average weight of 800 gm to 1.25 kg.
- With Proper management a production of 4 to 5 tons/ha can be obtained in a year.
- Harvesting is done by partial dewatering and repeated netting. In some cases, complete dewatering of ponds is resorted to.
- Some farmers resort to partial harvesting also depending on the season and demand for fish.

IMPACT OF EXOTIC CARPS ON INDIAN MAJOR CARPS IN POLYCULTURE

INTRODUCTION

- Poly-culture or composite culture is the system in which fast growing compatible species having different feeding habits are stocked in proportions in the same pond. Poly-culture management techniques are based on the relationships between organisms at different levels of food chain and environment.

- It is fact that poly-culture may produce an expected result if the fish with different feeding habits are stocked in proper ratios and combinations.

- Generally, three carp species such as rohu, catla and mrigal are cultured together in the farmers' pond in our country.

- Sometimes, calbaus (*Labeo calbasu*) is also used in the poly-culture. Recently, some Chinese carps have been introduced in the polyculture system in our country for their rapid growth and favorable food habits.

- These Chinese carps are silver carp, grass carp, bighead carp and mirror carp. stated that poly-culture of major carps with exotic carps had laid the foundation of silver revolution of India.

- He also observed that exotic carps have higher growth rates and attain marketable size much earlier than our endemic major carps.

- Due to fast growing, the exotic carps should be harvested at the earliest possible time and ensure multiple cropping for higher rates of production.

- So, the acceptance and popularity of these exotic carps are gradually increasing in our country.

- Polyculture is possible through proper understanding of the various ecological factors which are responsible directly or indirectly for the production of biomass in a water body.
- Among the various ecological factors, food and feeding habits of fishes is a pre-requisite to understand the interspecies relationship for efficient management of any culture system.
- The knowledge of food competition between interspecies is helpful to select the species combination for the scientific fish culture.
- Food competition between silver carp and rohu was occurred but not serious.
- The feeding habits of surface feeder silver carp and column feeder rohu somewhat different and these two species are considered as quite compatible species and recommended as composite fish culture.
- reported that dietary overlap was observed between catla-rohu and between silver carp-bighead carp were found in Bangladesh ponds.
- He also reported that greatest overlap was occurred between catla-silver carp and catla-bighead carp in the ponds of Bangladesh.
- It was also found that bighead carp is a filter feeding fish and feeds on free floating swimming organisms throughout its life.
- Onthe other hand reported that bighead carp consumed large quantities of zooplankton and detritus in addition to phytoplankton.
- To reviewed the food and feeding habits of fishes it was found that the gut contents of Mrigal were composed of Cyanophyceae, Chlorophyceae, Bacillariophyceae, rotifers, cladocerans and debris.
- Our knowledge regarding food competition between endemic carps and Chinese carps under natural condition is very poor and insufficient. Extensive work have been done on the food and feeding habits of various fishes but few studies have so far been reported on food electivity, dietary overlap and food competition between endemic major carps and Chinese carps.
- But it is very important to study the food electivity, dietary overlap and food competition among the endemic major carps and Chinese carps.
- Therefore, the present study is undertaken to find out the electivity, dietary overlap and food competition between exotic carps i.e. silver carp (*Hypophthalmichthys molitrix*, bighead carp (*Aristichthys nobilis*), mirror carp (*Cyprinus carpio*) and endemic carps i.e., rohu (*Labeo rohita*), catla (*Catla catla*) and *mrigal (Cirrhinus mrigala*)

MATERIALS AND METHODS

Study area and duration: The experiment was conducted in a rain fed artificial pond situated at the experimental pond area of the Department of Aquaculture, Bangladesh Agricultural

University (BAU), Mymensingh for a period of nine months from April 2009 to December 2009. The size of the pond was 0.06 hectare with an average depth of 1.5 m.

Pond preparation: The pond was prepared by removing the bottom mud and raising the height of embankments. After that, lime was applied at the rate of 250 kg ha^{-1}. Before being used lime was diluted with water and then broadcasted over the bottom of the pond. After 15 days of lime application pond was filled up with water with a depth of 1.5 m. After that, 4,500 kg ha^{-1} cow dung, 125 kg ha^{-1} urea and 62.5 kg ha^{-1} Triple Super Phosphate (TSP) were applied in an initial dose. After diluted of urea and TSP were broadcasted throughout the pond and cow dung was applied the pond corners.

Stocking the pond: After seven days of fertilization, ponds were stocked with the fingerlings of six carp species of both indigenous and exotic origin, namely rohu (*Labeo rohita*), catla (*Catla catla*), mrigal (*Cirrhinus mrigala*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Aristichthys nobilis*) and mirror carp (*Cyprinus carpio*). These fishes were stocked at the rate of 10,000 (No. ha^{-1}) with 100 rohu, 100 catla, 100 mrigal, 100 silver carp, 100 bighead carp and 50 mirror carp. In stocking time the number, length (cm) and weight (g) of each species were recorded. All fingerlings were collected from the specific hatcheries. Transportation of fingerlings was done very carefully as much as possible in order to minimize the mortality. Before stocking the fingerlings were acclimatized for three hours.

Application of fertilizers: The pond was fertilized fortnightly throughout the experimental period with cow dung, urea and TSP at the rate of 4,500, 62.5 and 31.25 kg ha^{-1}, respectively. Cow dung was always applied at the pond corners but the urea and TSP were spread throughout the pond after diluted.

Collection and preservation of planktonic samples: Ten liter samples of water were collected from different areas and depth of the pond fortnightly and filtered through a fine mesh phytoplankton net. Filtered sample was taken into a plastic vial and carefully make up to a standard volume with distilled water. With a series of settling and re-suspension procedures, plankton were concentrated into 50 mL and preserved using 5% formalin in small plastic bottles for subsequent studies.

Identification and enumeration: Using a Sedgwick-Rafter cell and a binocular microscope (Olympus model-BH-2, with phase contrast facilities), 1 mL sub-sample was examined from each 50 mL preserved sample. All organisms, present in 10 cells other 5-R cell chosen at random were counted and identified up to genus level. Identification of plankton was made with the help of Then, plankton population as cell/1 was determined. The percentage composition of each genus and family was then calculated from the raw data.

Collection of fish sample: Fishes were collected by using a cast net. Fortnightly, sampling of fish was done throughout the experimental period. Sample of five fish from each species except mirror carp was collected at each sampling date. Only three mirror carp was sampled due to its small stocking number.

Stomach contents analysis: The abdomen of the individual fish was cut open and the gut contents were taken out carefully and then put into a clean petri dish. Only the anterior portion ofthe digestive tract lying between the esophagus and the small intestine has been used for the present study.

UNIT-III

RECENT DEVELOPMENT IN CULTURE OF CLARIUS BATRACHUS

- Among these, Clarias batrachus is a preferred medium-sized cat fish for pond culture. Clarias batrachus, popularly called "magur" in India, is in high demand for its taste and therapeutic value.
- Magur fetch a higher market price than carp and are sold fort US$ 4-8/kg in India. Magur generally is stocked at densities that are 5-10 times greater than carp stocking densities because its hardy and air-breathing nature is favorable for high-density culture.
- **Broodstock Management**
- Maintenance of healthy broodfish is a prerequisite for successful seed production in captivity.
- Magur attains maturity in thef irst year.
- Broodfish of 100-150 g weight, commonly preferred for breeding, are raised in earthen ponds at 2-3/m2 .Sometimes, broodfish are transferred to soil-based cement tanks prior to the monsoon season.

INDUCED BREEDING OPERATION

- Magur matures and breeds from June to August when there is ample accumulation of rainwater in conined water bodies, coupled with favorable temperatures and other natural conditions in the environment.
- The fish digs crevices below the bunds of ponds to deposit eggs. The fish is considered monogamous.
- Breeding activity and natural spawning continues for 10-12 h or more.
- The incomplete release of eggs has become a constraint for mass-scale seed production, although some claim better growth of larvae produced by this breeding technique.
- This may not be a procedure to depend on to produce a huge supply of seed to farmers. Researchers have shifted to concentrate on induced breeding for mass-scale seed production in hatchery conditions.

- When gravid females have round and bulging abdomens with pinkish button-shaped genital papilla and males have pointed papilla, they are considered suitable for induced breeding operations in captive conditions.
- Researchers and farmers usually use commercially available synthetic hormones (Ovaprim/Ovatide/ WOVA-FH) at 1.0-1.5 mL/kg body weight as an agent to induce ovulation
- Apart from this, other inducing agents, such as conventional carp pituitary extract at 30-40 mg/kg body weight and human chorionic gonadotropin at 3000-4000 IU/kg body weight have been used successfully for experimental purposes
- Male broodish do not ooze sperm on their own, unlike carp varieties and do not receive injections, as do the female brood fish. Testes are removed and macerated in normal saline (0.9 percent sodium chloride) to prepare a sperm suspension that is required for fertilization of ovulated eggs.
- Often some farmers inject males with half a dose of the hormone (0.5 ml/kg body weight) to obtain better milt quality. However, males do not require hormonal induction of spawning.
- Hatchery operators undertake stripping of females after a latency period of 16-17 h to get the best-quality eggs.
- Fecundity is about 5,000-6,000 eggs per 150-g female.
- Eggs are fertilized with a sperm suspension, followed by a thorough washing of fertilized eggs before transferring to the low-through hatchery for incubation

Types of Hatcheries

- Different types of egg incubation devices are seen for incubating the fertilized eggs of magur.
- A low-through hatchery consists of a cement platform on which plastic tubs are placed (Fig. 2). Water is provided from an overhead tank through a common pipe to each tub with individual control taps.
- Each tub has a provision for an outlet at a water level of about 4-5 cm.
- A row of small tubs of 12-cm diameter with 6-cm height is placed under separate taps.
- Each plastic tub can accommodate approximately 1,000 eggs
- For large-scale incubation, an improvised Portable FRP Magur hatcheryTM was developed by ICAR-CIFA (Fig. 3).
- The system consists of a circular tank of 2-m diameter with Five to six inlets at the junction of the tank wall and bottom surface.

- Some progressive farmers have imitated models of the two hatchery designs described previously.
- Larvae to Fry Production
- Because larvae are small and delicate (4-5 mm length and 2-3 mg wet weight), they require captive rearing in indoor systems.
- Many times, hatchery producers release larvae directly into nursery ponds or after nursing a few days in indoor systems.
- The aquatic environment and water quality plays a major role in successful nursing of larvae.
- Rearing tanks must be provided with continuous aeration, inasmuch as aerial respiration commences 10- 11 days after hatching.
- Tiny yolk sac larvae are able to accept feed on the fourth day because the yolk sac is absorbed during the third day.
- By this time, hatchlings became longer, with prominent barbells jaws, opercula and gills. Some hatchery operators also feed larvae on the third day.
- Live mixed zooplanktons (rotifer, copepod, Daphnia and Moina) are fed to larvae; in some cases, larvae are fed Artemia nauplii, tubifex worms and egg custard (Srivastava et al. 2012, Saxena 2014).

Fry to Fingerling Production

- The release of fry directly into ponds results in lower recovery related to natural mortality or predation.
- It is recommended to rear fry in small cement tanks of 10-20 m2 for better survival and easy management.
- These tanks are provided with 2-3 cm of soil and a water level of 25-30 cm. Fry can use live feed until they are habituated to compound feed (30-35 percent protein) during rearing.
- Fry usually grow to around 1 g in 40-45 days. Fry are segregated and stocked again at 50-100/m2 for further rearing, until they reached 4-5 g in another 60-70 days.

* SEED COLLECTION AND FEEDING MANAGEMENT OF AIR BREATHING FISHES*

Introduction:

- Air breathing fishes are characterised by the possession of an necessary respiratory organ.This organ enables the fishes to remain for hours out of water or for indefinite period in oxygen poor waters and even in most mud. They are extremely hardy with respect to all environmental parameters and are suited to shallow foul waters, weedy waters of ponds a These fishes have commercial value as they are marketed in living condition and hence they are also referred to as ` live fish ` or `jeol fishes`. The air breathing fishes are highlypriced and are well _ known as for their high protein, high iron, low fat- content and easy digestability and are thus recommended by physicians as diet durng Convalescence.
- **Advantages of Culturing Air-Bre thing Fishes: Air-breathing carnivorous fishes a cultivated due to the following reasons**: (1) They have high protein, high iron and low fat content and
- are thus more nutritious and of high medicinal value.
- (2) They have a high market demand and fetches a high price than other edible fishes.
- (3) As air-breathing fishes have accessory respiratory organs, their culture can be undertaken in rejected foul water of shallow ponds, swamps, weedly waters and other kinds of oxygen depleted water bodies.
- (4) They are hardy fishes and can adjust to any environmental conditions.
- (5) They require little rearing
- 16) Their culture involves less risk,
- (7) Their culture management is simple without much complications.
- (8) They grow faster (particularly the ever le magur) whet sufficiently fed.
- **A).Seed Collection of Murrel**
- Murrels attain matarity in about two years. As they are knows to breed throughout the year, the fry (2-4 cm) can be collected round the year from rain-fed ditches and shallow water bodies atong abundant weeds. Their peak spawning occurs however, during April to June with the onset of monsoon.
- As the hatchlings move in schools, their collection in large numbers is always possible. It may be noted that when the fry reaches the fingerling stages they do not move in schools Collection of marvel seed is generally made during mon
- Murrel seed can also be produced by induced breeding, but the difficulty lies in maintaining the spawn and growing them to fry stage. As the spawns after emergence from eggs do not feed on anything for about two days, their survival rate will generally be poor. For this, the hatchlings are required to be reared in suitable cemented ponds or plastic pools and have to be trained to take supplementary feed.
- nd swamps.

- **(b) Seed Collection of Catfishes:**
- The matured male of magur possesses a pointed anal papilla. while that in female is oval in shape. Though cat-fishes breed throughout the year, the peak season for the collection of seed is pre-winter period when paddy is harvested and the low lying fields get exposed. Spawning generally takes place in fairly deep waters. The female makes a hole of 20 em diameter and 25 cm deep on the bottom.
- The fertilised eggs measuring 1-1.5 mm (diameter) are yellowish-brown in colour and adhere to grasses. The males guard the eggs till it hatches within 20 hours at a temperature of about 25-30°C. About 2000 to 15,000 fries per hole can be collected from natural areas with the help of a small fine- meshed hand-net. They are then reared in nurseries till they reach a length of 5 cm.
- **I case of pond breeding, comportments or enclosures of 1m x 1m are made of wire screen in the pond having water depth about 25 cm. At the center of each compartment a hole of 30 cm diameter is dug up to a depth of 25 cm.**
- The holes are provided with some aquatic plants. The matured male and female fishes suitable for breeding are put into each compartment and they spawn within a period of 10 days. A maximum of 5,000 fry are collected from each compartment.
- **Seeds of catfishes can also be collected through induced breeding. The effective dosage of pituitary extract for different sized fishes is as follows:** (1) For catfishes weighing less than 100 gm is 10 mg extract.
- (2) For catfishes weighing 100-150 gm is 25 mg extract.
- (3) For catfishes weighing 150-200 gm is 35 mg extract
- **Feeding and Feed Schedule:**
- To maintain an abundant food supply for the growing fingerlings of the air-breathing fishes, it is essential that the stocking pond be rich in animal food source such as tadpoles and trash fishes. In case these food sources are found to be inadequate, tilapia may also be grown, so that the young of tilapia (which is a fast breeder) may serve as a regular and staple food source for the fingerlings of cat fishes and murrels.
- In case of maritime states (West Bengal, Orissa, Kerala, Andhra Pradesh, etc.), abundant availability of dried marine trash fish would make the culture of air-breathing fishes more economical. However, in ponds where the above facilities are not available, then one has to resort to supplementary feeding.
- Artificial feeding for singhi and magur is undertaken using fish offal or slaughter house waste or dried silkworm pupae mixed with rice bran and oil cake in the ratio of 1:1:1.
- A mixture of rice bran, mustard oil cake and trash fish meal in the ratio 2:1:1; rice bran and poultry feed in 3:1; biogas slurry and rice bran in 1:2 or poultry dropping and rice bran in 1:2 ratio may also be given daily at the rate of 5-8 per cent of body weight of the fish fingerlings stocked.

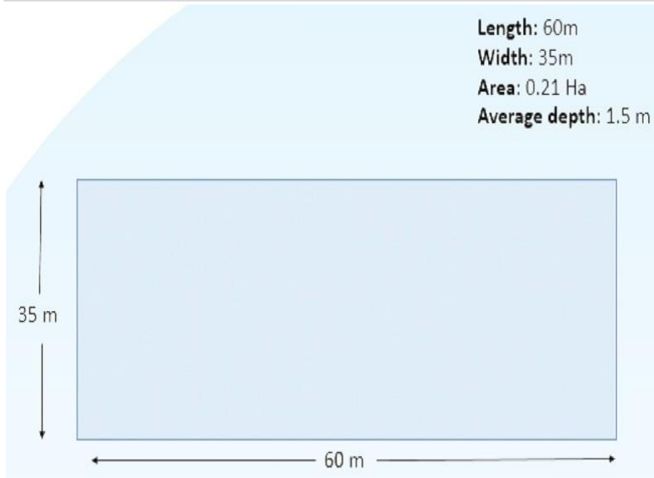
MURREL CULTURE

Introduction

Freshwater aquaculture is an economy generating and rural development tool. Murrel is considered to be the most economical freshwater fish species which can be cultured.
They belong to the family “Channidae” and is also called as snake-head fish. Murrel is one of the indigenous air breathing fish; there is a suprabranchial accessory respiratory organ in the murrel head.
It can even survive in lower dissolved oxygen levels.
This fish is identified by its dark brown colour with light black stripes over the body.
Murrel fish is one of the popular freshwater and tasty fish in India.
The fish has a lot of regional preferences.
While it is the State fish of Telangana, people prefer murrel over any other fishes in many States like Andhra Pradesh, Tamil Nadu, Punjab, Haryana and Bihar and North Eastern Region.
Andhra Pradesh is the second largest fish farming region in the country with 0.8 million hectares of inland water bodies producing 1.24 MT annually.
Murrel is predatory inhabit and feed on variety of fauna present in the water. However, the high demand and high market value and their capacity to withstand in adverse weather conditions make them suitable candidate species for aquaculture. The most important aquaculture species of murrel in India is the striped murrel (Channa striatus), the great snakehead murrel (Channa marulius) and the spotted snakehead (Channa punctatus). The culture technology is standardized for striped murrel. Murrel has high demand and high market value in India. It has a huge potential for murrel culture in freshwater areas when it is cultured with best management practises.
Local names of murrel fish in India

Murrai (Hindi), Korameenu, Koramatta (Telugu), Viral meen (Tamil), Korava, Vatton, Varal (Malayalam), Cheng, Shol (Bengali), Maral (Marathi), Hal (Assamese) and Gadisha (Oriya).
Salient features

- High value food fish in India and can be marketed in live condition
- Murrel culture can be done in small backyard, shallow or community ponds
- Value added products like fillets, pickle, curry etc. have high demand



Layout of the Pond

Grow out

Pond should be constructed in a place having good quality water. Pond size of 0.1-0.2 Ha is ideal for grow-out of striped murrel, with a water depth of 1 to 1.5m. Lining can be given to the pond bottom and the dyke in order to prevent the seepage of water. For grow out culture, the advisable stocking size is 5-8 cm or more with a stocking density of 10000/ha. The expected growth in a year is 600-700gm over a period of 8-10 months.

Water Temperature

For better growth of the fish and to improve the feed conversion efficiency, it is advisable to control the water temperature. Since murrel is air breathing fishes, they can survive in less dissolved oxygen level.

Seed

Weaned fingerlings of equal size 5-8 cm or more can be stocked in pond. Seed suppliers/farms are available in Telangana, who can provide quality weaned seed for rearing in the captive condition.

Feed requirement

As murrel are carnivorous, good quality protein rich pellets can be given to the weaned fish. Feeding can be done at the rate 5% of the body weight of fish during the initial period and 2-3 % during the later stage of culture.

Good quality feed for murrel is available in the local market with high protein level

Harvesting of fish

Harvesting can be done when the fish reaches to a size of 600-700 gm. Fishing nets can be used for the collection of fish from ponds.

Marketing

Murrel fish demand is very high in the market and can be sold in open markets at Rs.400-500 per kg. Consumer preferences, lucrative market value and their ability to withstand adverse water conditions make them suitable candidate species for freshwater aquaculture. It can be sold in live fish markets and hence it increases the interest among the customers.

* SPECIAL SYSTEMS OF AQUACULTURE*

AQUACULTURE SYSTEMS

Cage culture

Cage culture is rearing of fish from juvenile stage to commercial size in a volume of water enclosed on all sides including bottom, while permitting the free circulation of water. Cage culture is readily adapted to water areas which cannot be drained. Fish culture in cage is an innovative concept to exploit the potential of lakes, reservoirs and riverine pools. Cage culture of fish and other aquatic organisms is popular in many countries. Japan, South Korea, China, Philippines, Thailand, Malaysia, Germany, Norway, USA are some of the countries where cage culture is well developed. In principle, almost every cultivable species of fish can be cultured in cages, such as carps, tilapia, trout, catfishes, etc. depending on socioeconomic, ecological and technical suitability.

Advantages of Cage Culture

- Use existing waterbodies
- Technical simplicity with which farms can be established or expanded
- Lower capital cost compared with land-based farms
- Easier stock management and monitoring compared with pond culture

Disadvantages of Cage Culture

- Stock is vulnerable to external water quality problems eg. Algal blooms, low oxygen
- Stock is more vulnerable to fish eating predators such as water rats and birds
- Growth rates are significantly influenced by ambient water temperatures

Raceway culture

Raceway culture is defined as raising of fish in running water. It is a high production system in which fishes are grown in higher stocking density. Raceways are designed to provide a flow-through system to enable rearing of much denser population of fishes.

Raceway ponds are basically of two types:

Linear type : Ponds arranged in sequence. In a linear type, the volume of water entering each pond is larger and as the same water is used repeatedly from pond to pond, occurrence of disease in initial ponds may directly affect the other connected ponds

Lateral type : Ponds laid out in parallel.n a lateral or parallel type the volume of water entering each pond is smaller but a fresh supply of water is always ensured, and no transfer of disease from one pond to another.

RECIRCULATING AQUACULTURE SYSTEM (RAS)

A Recirculating Aquaculture System (RAS) can be defined as an aquaculture system that incorporates the treatment and reuse of water with less than 10% of total water volume replaced per day. The concept of RAS is to reuse a volume of water through continual treatment and delivery to the organisms being cultured. Water treatment components used in RAS need to accommodate the input of high amounts of feed required to sustain high rates of growth and stocking densities typically required to meet financial outcomes. Generally, RAS consist of mechanical and biological filtration components, pumps and holding tanks and may include a number of additional water treatment elements that improve water quality and provide disease control within the system.

UNIT-IV

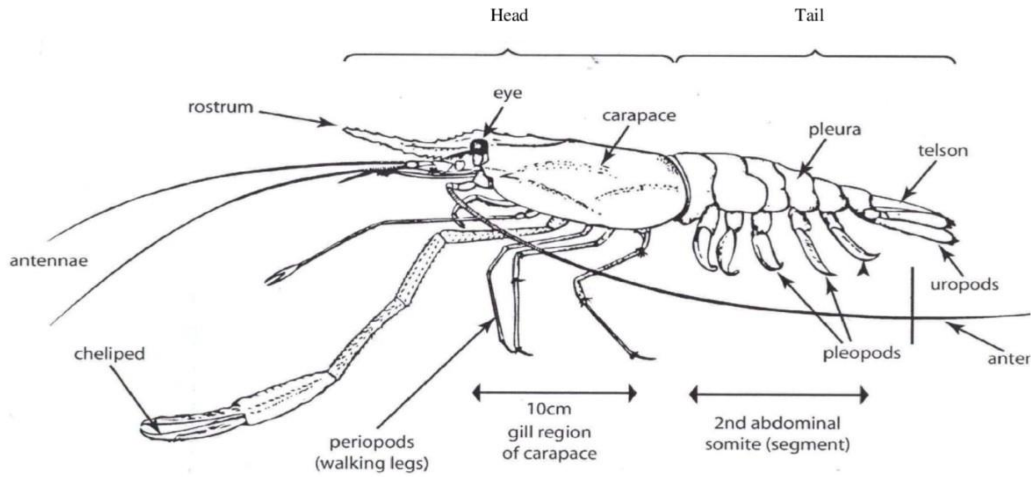
* IDENTIFICATION AND BIOLOGICAL CHARACTERS OF AND MACROBRACHIUMROSENBERGII AND M. MALCOMSNII*

Ans; Macrobrachium rosenbergii

- This species is suitable for culture in confined waters.
- Rostrum long, sword shaped 13-14 dorsal spines dorsally and 11 rostral spines ventarally.
- -the second pals of working legs of male develop abnormally with well developed chela and thus sexual dimorphism exhibitied.
- It occurs in rivers, estuaries and coastal areas migrates to estuaries during breeding season.
- lorgest among fresh water prawns, attains a maximum length of 32 cm (male) 25cm female.
- 3 It is an omnivorous, bottom, feeder, feeding on molluscs, worms, insects small crustaceans, vegetable matter, tender leaves, aquatic weeds etc
- The breeding season to east coast is from Dec-July with peak in march- may whereas in west coast it is from AUG-Dec. the sizee at first maturity 14 cm. fecundity 7000-5,00,000

Macrobrachium malcomsnii:

- commonly called Riven prawn
- -The rostrum is shost and straight. It bears 11 -12 dorsal spines and 4-5 ventral spines.
- the second pair of walking legs of male develop chela and thus sexual dimorphism is exhibited the second pots of legs are longer than the body and stout.



- They migrate in rivers to estuaries during breeding season.

- It occurs in rivers and attain a maximum length ao 23 cm (male) 20 cm (female)
- It is a benthophgic omnivores and feeds on worms, insects, molluscans, crustaceans. algae, vegetable matter and weeds
- It breeds during April - November with a peak period of June-July.
- -The size at first maturity is 4cm. The fecundity 4000-60,000

Macrobrachium rosenbergii

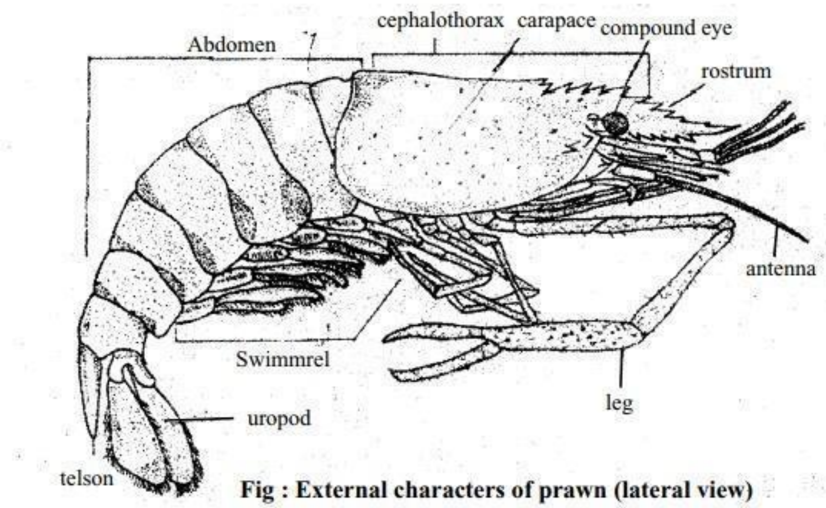


Fig : External characters of prawn (lateral view)

Macrobrachium malcomsni

SEED PRODUCTION OF FRESHWATER PRAWNS

Seed production

The berried female bearing dark grey coloured eggs are sourced from the brood stock pond or natural waters and is held in PVC pipes or cylinders capped on both sides with netting to prevent puncturing of the bag. The rostrum and telson are capped with protective rubber tubes. Temperature is controlled using ice bags in the container during transportation. Starving of prawn for a few hours before packing reduces accumulation of metabolites during transport. Immediately after arrival at the hatchery, the berried prawn is given a bath in 100 ppm formalin for 10 minutes followed by rinsing in freshwater to eliminate the epifauna, if any. The berried female is kept individually in separate FRP tanks of 500 l capacity with 300 l filtered water at 6 ppt salinity and fed with oyster or clam meat. Mild aeration is provided continuously. Left over feed and metabolic wastes are removed from the tank and half of the water is replaced during every morning hours.

Maturity stages

Initially, the colour of the egg is yellow, then it changes to bright orange to pale grey, and further it darkens to slate grey by the time of hatching. Once, the egg colour turns dark grey, hatching will be started within 48-72 hours at 26-3l^{0}C. The larvae are collected in the early morning using a scoop net. Soon after hatching, female is carefully shifted back to stock tank.

Rearing of larvae

The larva passes through 11 zoeal stages before metamorphosis into post-larva (PL) which is carried-out normally in an FRP tank of 500 1 capacity but varies as per convenience and capacity of the hatchery. The hatched larvae are stocked @ 100-300 no./1. Water quality parameters required for the larval rearing are given below.

- Temperature : 29 ± 2ºC
- pH : 7-8.5
- Salinity : 12±2ppt

- DO : >5 ppm
- Alkalinity : 80-100 ppm
- Photoperiod : 12/12 hr L /D
- Turbidity : Nil
- TAN : <0.1ppm
- NO_2-N : <0.01ppm
- Iron : <0.02 ppm
- Hardness : <120 ppm
- TDS : <200 ppm

Filtered seawater and freshwater are mixed to prepare 12 ppt saline water and it is chlorinated (35 ppt) with sodium hypochlorite solution, which is then aerated for 24 hours for de-chlorination. Excess chlorine is removed by treating with sodium thiosulphate, if necessary. The larvae are fed with live *Artemia* nauplii, egg custard and a formulated feed. Feeding is done with extreme care to avoid over/under feeding and the details of daily ration are given in Table 25.1. Daily, 60-80% of the water is replaced. On every morning, left over feed, metabolic wastes, detritus, shell and dead larvae are removed by turning-off the aeration and siphoning-out the settled particles from the tank bottom. The metamorphosis is non-synchronous and undergoes 11 larval stages within 16-28 days according to the temperature and water quality. Up to stage-V, the healthy larva swims at the water surface, while the un- healthy larva accumulate at the tank bottom.

Artemia nauplii requirement

DOC	No. of Artemia nauplii requirement/larva	Daily feeding frequency
3-4	10	Three
5-6	15	Five
7-8	20	Five
9-11	30	Six
12-14	40	Six
15-24	50	Seven
25-30	40	Seven
31-35	30	Seven

Rearing of Post-Larvae (PL)
The metamorphosed PL (7-9 mm) is more benthic and resembles the juvenile which rest or crawl on the tank surface. It is kept in cement tank (20 t capacity) with a stocking density of 40-60 no./1 with continuous aeration and gradually acclimatised to freshwater. Submerged artificial shelters (tiles, PVC pipes etc.) are provided to prevent cannibalism. It is fed with a pelleted feed in fine crumble form 3-4 times daily @ 10-20% of the body weight. Pelleted feed can be replaced with egg custard and minced fish/mollusc/shrimp flesh for 1-2 times daily. A water exchange of 60-80% should be done daily. It attains 16-21 mm size by next 15 days with a survival rate of 70-80%. Since the PL are cannibalistic in nature, proper feeding plays a key role.

Harvest and transportation
PL is harvested from the tank by scooping-out. The left-over PL get concentrated near the illuminated area of the rearing tank covered with dark sheets. Before packing, the salinity of the rearing tank is reduced to desired levels. The PL is spooned-out to polythene bag @ 1000-2000 numbers depending on size of PL and duration of transportation. Other aspects are similar to that of the tiger shrimp.

Pond Farming

Site selection and pond construction
Rectangular ponds of 0.2-0.4 ha area with a water depth of 100-150 cm is ideal for freshwater prawn culture. The pond should have a smooth bottom and gradual slope from water intake to outlet. Sandy- clay or sandy-loam soil is suitable for farming. The banks of the pond must be high enough to protect from floods. The intake water should be free from contaminants. Other aspects are almost similar to that explained for the major carps.

Preparation of pond
The pond after complete draining is dried under sunlight for about 2 weeks until the soil cracks which destroys pathogen and increase the soil fertility. The pond bottom should be tilled for the oxidation of organic matter and to enable the escape of foul gases. The rest of the pond preparation activities are carried out as explained for the farming of major carps.

* MAINTENANCE OF GROW OUT PONDS IN FRESH WATER PRAWN CULTURE*

Site Selection and Pond Design

Ponds used for raising freshwater prawns should have many of the same basic features of pondsused for the culture of channel catfish. A good supply of fresh water is important, and the soil must have excellent water-retention qualities. Well water of acceptable quality is the preferred water source for raising freshwater prawns. Runoff from rivers, streams, and reservoirs can be used, but quality and quantity can be highly variable and subject to uncontrollable change. The quality of the water source should be evaluated before any site is selected.

Locate ponds in areas that are not subject to periodic flooding. Before building ponds specifically for producing freshwater prawns, check the soil for the presence of pesticides. Prawns are sensitive to many of the pesticides used on row crops. Also, analyze the soil for the presence of residual pesticides. Do not use ponds that are subject to drift from agricultural spraysor to runoff water that might contain pesticides.

The surface area of grow-out ponds ideally should range from 1 to 5 acres. Larger ponds have been successfully used; ideally the pond should have a rectangular shape to facilitate distribution of feed across the entire surface area. The bottom of the pond should be completely smooth and free of any potential obstructions of seining. Ponds should have a minimum depth of 2 feet at the shallow end and a maximum depth of 3.5 to 5 feet at the deep end. The slope of the bottom should allow for rapid draining. You can obtain assistance in designing and laying out ponds by contacting a local office of the Natural Resources Conservation Service (formerly Soil Conservation Service).

Collect a soil sample from the pond bottom to determine whether lime is needed. Take soil samples from about six different places in each area of the pond, and mix them together to make a composite sample that is then air-dried. Put the sample in a soil sample box, available from your county Extension agent, and send it to the Extension Soil Testing Laboratory, Box 9610, Mississippi State, MS 39762, and request a lime requirement test for a pond. There is a charge of $3 per sample for this service.

If the pH of the soil is less than 6.5, you must add agricultural limestone to increase the pH to a minimum of 6.5, and preferably 6.8.

After filling the pond, fertilize the pond to provide an abundance of natural food organisms for the prawns and to shade out unwanted aquatic weeds. A liquid fertilizer, either a 10-34-0 or 13-38-0, gives the best results. Apply 1/2 to 1 gallon of 10-34-0 or 13-38-0 liquid fertilizer per surface acre to the pond at least 1 to 2 weeks before stocking juvenile prawns. If a phytoplankton bloom has not developed within a week, make a second application of the liquid fertilizer. Do not apply directly into the water because it is denser than water and will sink to the bottom; liquid fertilizer should be diluted with water 10:1 before application. It can be sprayed from the bank or applied from a boat outfitted for chemical application.

At least 1 or 2 days before stocking the juvenile prawns, check the pond for aquatic insect adults and larvae that might eat the juvenile prawns. You can control the insects by using a 2:1 mixture of motor oil and diesel fuel at the rate of 1 to 2 gallons per surface acre on a calm day. The oil film on the water kills the air-breathing insects and is more effective when applied on calm days.

If a water source other than well water is used, it is critically important to prevent fish, particularly members of the sunfish family (e.g., bass, bluegills, and green sunfish) from getting into the pond when it is filled. The effects of predation on freshwater prawns by these kinds of fish can be devastating. If there are fish in the pond, remove them before stocking prawns, using 1 quart of 5 percent liquid emulsifiable rotenone per acre-foot of water.

FRESH WATER PRAWN POND PREPARATION

Site Selection for Hatcheries and Nurseries

The site requirements for hatcheries and nurseries, which are normally associated with each other, are similar.

Availability of Quality Water

The hatchery and nursery should be located inland where there is ample supply of good freshwater. Saline water required for larval development can be transported and mixed with freshwater to attain the desired salinity.

The quality of intake water, whether it is saline or fresh, is of paramount importance for efficient hatchery operation.

Water quality is thus a critical factorin site selection. Hatchery sites should preferably be far from cities, harbours and industrial centres, or other activities, which may pollute the water supply.

In all cases, water supplies need careful analysis during site selection, to determine their physical, chemical, and biological characteristics, and the extent to which these may vary daily, seasonally, or through other cycles.

Special care is needed in hatcheries that are situated in or near areas where the use of pesticides, herbicides, and fertilizers is intensive.

Ideally, freshwater should be obtained from underground sources.

The brackishwater for use in *M. rosenbergii* hatcheries should be 12-16 ppt, should havea pH of 7.0 to 8.5, and contain a minimum dissolved oxygen level of 5 ppm.

High levels of heavy metals, such as mercury (Hg), lead (Pb) and zinc (Zn), should also be avoided, since theseare most likely to be caused by industrial pollution

.

Soil Characteristics

The ideal soil for freshwater prawn culture should be clay-silt mixture or sandy loam comprising of 60% sand and 40% silt with good water retention capacity.

There must be enough soil available for pond construction, whether the ponds are to be excavated or pond banks are to be erected above ground.

Although supplemental food is given to freshwater prawns reared in earthen ponds, a considerable amount of their food intake is from natural sources.

It is therefore preferable to site the farm where the soil is fertile, as this will reduce the need and costs of fertilisation.

Freshwater prawn ponds should be constructed on soil, which has good water retention characteristics or where suitable materials can be economically brought onto the site toimprove water retention.

Pervious soils, which are very sandy or consist of a mixture of gravel and sand, are unsuitable unless the water table is high and surrounding areas are always waterlogged.

Soils, which consistof silt or clay, or a mixture of these with a small proportion of sand, normally have good water retention characteristics.

Peaty soils are not suitable. The clay content should not exceed 60%; higher clay content soils swell when moist and crack during the dry season, thus making repairs necessary.

Other requirements for Hatchery sites

In addition to having sufficient supplies of good quality water, a good hatchery site should also have:

- A secure power supply, which is not subject to lengthy power failures. An onsite emergency generator is essential.
- Have good all-weather road access for incoming materials and outgoing PL;
- Have access to food supplies for larvae;
- Employ a high level of technical and managerial skills;
- Have access to professional biological assistance from government or other sources;
- Have its own indoor/outdoor nursery facilities or be close to other nurseries and
- Be as close as possible to the market for its PL. In the extreme case, it should not take more than 16 hours of total transport time from the furthest farm to the market.

Site Selection for Outdoor Nurseries and Grow-Out Facilities

The success of any nursery facility or grow-out farm depends on its access to good markets for its output. Its products may be sold to other farms (in the case of nurseries), directly to the public, to local markets and catering facilities, or to processors or exporters. The needs and potential of each type of market need to be considered.

It also important to consider other factors to ensure success, including the:

- Suitability of the climatic conditions;
- Suitability of the topography;
- Availability of adequate supplies of good quality water;
- Availability of suitable soil for pond construction;
- Maximum protection from agricultural and industrial pollution;
- Availability of adequate physical access to the site for the provision of supplies and the movement of harvested animals;
- Availability of supplies of other necessary inputs, including postlarval and/or juvenile prawns, equipment, aquafeeds or feed ingredients, and power supplies;
- Availability of good skilled (managerial) and unskilled labour;

Topography

Farms must be close to their market so the road access must be good. Large farms will need to have local access for heavy trucks be able to reach the farm easily, for the delivery of supplies and the efficient collection of harvested prawns.

A survey is necessary, to assess the suitability of a site from a topographical point of view. It is important to minimize the quantities of earth to be shifted during pond construction. Flat or slightly sloping lands are the most satisfactory. The ideal site, which slopes close to 2% (2 m in 100 m), allows good savings on earth movement. Care should be taken to ensure that pond sizes and alignments allow efficient construction, and at the same time permit good access and effective water supply and drainage.

Climate

The meteorological records such as temperature, the amount and seasonality of rainfall, evaporation, sunlight, wind speed and direction, and relative humidity should be studied for site selection. Avoid highly unstable meteorological regions. Strong storms and winds increase the risks of flood and erosion damage, and may lead to problems with transport access and power supply.

Temperature is a key factor. Seasonal production is possible in semi-tropical zones where the monthly average air temperature remains above 20°C for at least seven months of the year. The optimum temperature range for year-round production is between 25 and 31°C, with the best results achievable if the water temperature is between 28 and 31°C. The temperature of the rearing water is governed not only by the air and ground temperature but also by solar warming and the cooling effects of wind and evaporation. The rate by which pond water is exchanged and the temperature of the incoming water are also important considerations.

Rainfall, evaporation rates, relative air humidity and wind speed and direction also need to be investigated. Ideally, evaporation losses should be equal to or slightly lower than rainfall input, to maintain an approximate water balance. Mild winds are useful to promote gas exchange (oxygenation) between water and the atmosphere. However, strong winds can increase water losses by evaporation and may also generate wave action, causing erosion of the pond banks. Avoid areas where it is constantly cloudy because this makes it hard to maintain a steady water temperature, as it interferes with solar penetration. Periods of cloud cover of several days' duration may also cause algal blooms to crash, which in turn lead to oxygen depletion.

Nursery Phase

The nursery can be either indoor or outdoor. The selection of sites for indoor nurseries should follow the same pattern as for hatcheries. Site selection for outdoor nursery facilities should be similar to that for grow-out ponds.

Holding Tanks

After rearing freshwater prawns in hatchery, hold them until ready for stocking in ponds. Concrete tanks of 50 m3 are convenient for holding postlarvae (PL) prior to transport for stocking in ponds. Use nets suspended from floats in the tanks to increase the surface area available to the PL but this may make the normal operations of feeding, cleaning etc. more difficult.

Indoor Nursery Facilities

Tanks for indoor freshwater prawn nurseries can be constructed from concrete or fibreglass. The use of asbestos cement tanks is not recommended. The shape of nursery tanks is not important and their size, usually from 10 to 50 m2 with a water depth of 1 m. The best stocking density for indoor nursery tanks depends on the length of time the animals will remain in the tanks before transfer to an outdoor nursery or grow-out facility. It is recommended not to exceed a stocking density of 1000 PL/m3 in tanks without substrates.

Artificial substrates of various designs and materials can be used to increase surface area; these provide shelter and increase survival rates. Layers of mesh can therefore be used to increase the amount of surface edges available to the prawns in both vertical and horizontal planes.

The water supplies for indoor nurseries can be flow-through or recirculating. For flow-through, water is allowed to continuously enter from above the tank and exit from the lowest part of the tank through a vertical standpipe. Standpipes are covered with a 1.0 mm mesh screen to prevent PL and juveniles from escaping. This drainage system draws water from the tank bottom where food waste and detritus settle.

Outdoor Nursery Facilities

Nursery ponds are similar to grow-out ponds in design and facility requirements. They usually vary in area from 300 to 2000 m2 . Artificial substrates can be used to increase the surface area available to the prawns. PL is retained in holding tanks for more than a week or two prior to stocking in nursery facilities, grow-out ponds.

Whilst the PL are in the holding tanks water is exchanged at a rate of 40-50% every 2-3 days and provide aeration.

PL is at densities of up to 5000 PL/m2 for one week, or up to 1500-2000 PL/m2 for one month under these conditions. If you need to hold them for one month, you could improve survival if you reduce the density to 1000/m2.

Using substrates can help you maximize the stocking density, thus reducing other equipment and labour costs.

Water Management

Water quality and supply

Freshwater is normally used for rearing freshwater prawns from postlarvae to market size. Water of 3-4 ppt salinity may be acceptable for the culture of *M. rosenbergii*. The reliability of the quality and quantity of the water available at the site is a critical factor in site choice. However, as in the case of hatchery water supplies, the absolute ‘ideal' for rearing sites may be difficult to define; a range of water qualities may be generally suitable. As for hatchery water, the level of calcium in the freshwater seems to be important. Growth rate has been reported to be lower in hard than in soft water. It is recommended that freshwater prawn farming should not be attempted where the water supply has a total hardness of more than 150 mg/l (CaCO3).

Water quality requirements for prawn nursery and grow out

Variables	Recommended range
Temperature (oC)	28-31
pH	7.0-8.5
Dissolved oxygen(ppm)	3-7
Salinity (ppt)	<10
Transparency (cm)	25-40
Alkalinity (ppm)	25-60
Total hardness (ppm)	30-150
Ammonia (ppm)	<0.3

Nitrite (ppm)	<2.0
Nitrate (ppm)	<10
Boron (ppm)	<0.75
Iron (ppm)	<1.0
Copper (ppm)	<0.02
Manganese (ppm)	<0.10
Zinc (ppm)	<0.20
Hydrogen sulfide (ppm)	Nil

UNIT-V

* HATCHERY MANAGEMENT OF P.MONODON*

Penaeus monodon Marine Crustacean Life span: 1-2 yrs Scavenger Nocturnal Main

producer countries:

Lateral view of P.Lateral view of P. monodonmonodon showingshowing important partsimportant parts

Sexual dimorphism:

Life cycleLife cycle

World Shrimp Aquaculture ProductionWorld Shrimp Aquaculture Production

Black tiger shrimp productionBlack tiger shrimp production

1. Shrimp farming area & production Shrimp hatcheries India : Status of Shrimp Production
2. Broodstock Management And Hatchery Development • Broodstock management involves manipulation of environmentalBroodstock management involves manipulation of environmental factors.factors. • Major advantage:Major advantage: Holding broodstock in an accessible pond or tankHolding broodstock in an accessible pond or tank offers readily available breeding adultsoffers readily available breeding adults whenever required.whenever required. • Hatchery development involves cultivation and breeding of largeHatchery development involves cultivation and breeding of large number of fishes in an enclosed environment.number of fishes in an enclosed environment. • In a hatchery mostly care for the young animals in their first few daysIn a hatchery mostly care for the young animals in their first few days or weeks of life is taken, until they are healthy and old enough to beor weeks of life is taken, until they are healthy and old enough to be shipped to another location.shipped to another location.

MAJOR REQUIREMENTS FOR EFFECTIVE HATCHERY PRODUCTION

(1) Essential infrastructure: • Separate facilities for quarantine, maturation, spawning, hatching, larval and PL rearing, indoor and outdoor algal culture, hatching of Artemia and feed preparation. • Additionally there will be supporting infrastructure for the handling of water, laboratories for disease diagnosis/bacteriology as well as areas for maintenance, packing of nauplii and PL, offices, storerooms and staff living quarters.

(2) Facility maintenance To achieve consistent production of high quality larvae, the production facilities must be maintained in optimal condition. Such maintenance includes

maintenance of machinery, regular cleaning and disinfection water, aeration and drainage pipelines, maintenance of tanks and filters.

(3) Inlet water quality and treatment • Sea water intake- intertidal bore wells/inshore open wells. • Seawater used inside hatchery should be free from suspended solids, living organisms and chemical contamination. Ideal water quality parametersHatchery seawater intake and treatment

3. (4) Waste water treatment Proper treatment and disposal of hatchery discharge will help ensure sustainability of the industry, reduce disease problems within the hatcheriesand help avoid conflicts over water use with other industries and users. A well-run hatchery must ensure that all water discharged from the facility is free from pathogens. Wastewater from each facility will be released into special concrete or sedimentation tanks. From there it overflows into treatment tanks where the water will be chlorinated and dechlorinated through aeration.
5)Algal and Artemia culture unit Algal culture Maintained in indoor, temperature controlled rooms and used as started culture for outdoor mass culture. To prevent contamination UV-treated water for pure culture of algae is used. The quality of mass culture should be tested before adding into larval rearing tanks. Artemia hatching: Commercially available Artemia cysts are used. Cysts should be disinfected before keeping them for hatching. Hatched Artemia nauplii should be segregated from cyst wall and unhatched cysts, before being used as feed in larval rearing tanks.
6) Induced maturation Technology of induced maturation system of P. monodon hasbeen standardized and is being adapted by many hatcheries. The basic requirements and technology involved are summarized as:
(7) Maintenance of biosecurity To reduce the probability of a pathogen introduction and its subsequent spread from one place to another, shrimp hatchery should include biosecurity programme, which has following elements: use of disease-free healthy or SPR shrimp stocks analysis of all incoming stock for disease treatment of all incoming water sources to eliminate pathogens sterilization /maintenance of clean equipment and materials use of personal hygiene measures knowledge of potential pathogens, the sources of risk and methods for their control / eradication maintenance of optimal environmental conditions within the facility application of immune enhancers /probioticsin order to enhance the ability of the stock to resist or tolerate diseases.
(8) Responsible use of chemicals Chemicals must be used responsibly during the hatchery production process. Chemicals (e.g. disinfectants, drugs, antibiotics, hormones etc.) have many uses in the hatchery production process, where they may increase production efficiency and reduce the waste of other resources. Chemical use must be minimized and where essential, must be done in a responsible manner. (9) Development of Standard Operating Procedures (SOPs) The SOPs is a comprehensive document outlining the control protocols for each stage or process of the production cycle occurringin the hatchery. The document should include details of all of the critical control points and describe how to perform each task to control the associated risk.
(10) Consideration of the Hazard Analysis Critical Control Point (HACCP) approachThe HACCP approach is a preventive risk management system based upon a hazard analysis and has been widely used to identify and control risks to human health in food-processing systems. (11) Assessment of health status of stocks through laboratory testing-

4. **BROODSTOCK & HATCHERY MANAGEMENT IN P. monodon** Pre- spawning procedures 1. Broodstock capture/ selection 2. Broodstock maturation 3. Brooder Nutrition 4. Broodstock Spawning 5. Egg hatching 6. Disease test and transfer of eggs Post-spawning procedures 1. Larval rearing unit preparation & management
2. Larval nutrition and health management

3. Testing/selection of PL for stocking

4. PL harvest/transportation

5. Pre- spawning procedures (1) Broodstock capture/selection Wild broodstock is obtained as by-catch from shrimp trawling and by the use of specialized traps. Broodstock collected should be placed individually immediately in disinfected water aftercapture and brought to land with minimal stress. Undue delay at the landing site should be avoided and the broodstock should be transported to hatchery in disinfected waters/plastic bags with oxygen at low temp.
6. Broodstock selection criteria- – clear gill coloration – Lack of red coloration – absence of black spots – absence of gill fouling – no obvious white spots Prophylectic treatment of spawners with formalin at 50 ppm (or antibiotics at the dose of 4 ppm) for 1hr under strong aeration should be done before introducing the stock into hatchery maturation system.
7. water exchange - 100-200% per daypH - 8.0-8.2 salinity - 30-35 ppt water temp - 28-290 C water depth - 0.5-0.7 m (2) Broodstock Maturation The maturationroom should have rounded/square tanks that are dark colored, smooth sided and of at least 0.4 m2 area for individual holding . Light intensity should be low and ablated shrimp should not be disturbed by any movement near the tank. The environment conditions in maturation tank
8. Hard shelled healthy females having spermatophore in thylacum should be selected for eyestalk ablation. Eyestalk ablation is to be avoided for newly moulted and ready to moult female shrimps. Female should be above 100 g in weight for insuring good qualityeggs. Ablated females are stocked in maturation tanks with unablated male@ 4nos/ m2 . Stocking of female and males in 2:1 ensures best mating success.
   Due to the high feeding rates employed, the maturation tanks require daily siphoningof uneaten food, faeces and moults. Alternatively artificial/formulated feeds with vitamin, mineral, pigment (astaxanthin or paprika), immunostimulant and PUFA supplements may also be offered to ensure good egg quality. Offered to the broodstockthroughout the day and night at least six times per day. Fresh feeds need to be choppedto a size suitable for ingestion by the broodstock and washed with clean water and weighed prior to feeding. frozen adult Artemia biomass and krill. fresh high quality feeds: live polychaete bloodworms (10–12 %/d), plus fresh squid (6–10 %/d), plus live but deshelled bivalve molluscs (4–8%/d), at a total of 20–30 % of wet body weight/d. Feeds (3)Brooder diet:
9. (4) Broodstock Spawning Matured female from induced maturation tanks are treated with formalin (50 ppm, under strong aeration for 30 min). Placed individually in 500 litreFRP tanks for spawning. Spawning tanks may be flat bottomed, but if they are slightly conical or at least angled to the outlet, it allows easier and less damaging harvesting of allthe eggs. In spawning tanks, no feeding is done. The room is kept in dark, without disturbance to spawners. Continuous aeration is maintained in tank. Spawning generally happens during night. In the morning, eggs should be collected, washed, disinfected and resuspended in fresh sea-water for hatching.

5) Egg hatching The eggs are transferred to the hatching tanks, which are prepared with 5–30 ppm EDTA and 0.05–0.1 ppm Treflan to remove heavy metals and fungi, respectively. Egg hatching tank should be away from the maturation and spawning tanksto avoid contamination. Water quality is maintained at 29–32°C and 32–35 ppt salinity for optimal hatching. Very slight aeration until the nauplii hatch. Prior to harvesting, aeration is stopped and hatching tank is exposed to light for few minutes. Nauplii displaystrong positive phototaxis. Healthy nauplii (stage VI) can be harvested using a light to attract them to the water surface.

(6) Disease Testing Once the healthy nauplii have been harvested, they can be checked for disease.

WSSV-positive nauplii should be rejected and destroyed by chlorinating at 500–1000 ppm. The temperature and salinity in the holding tanks shouldbe checked. The nauplii are then ready to be transferred to the larval-rearing tanks.

10. Post- spawning procedures: (1) Larval rearing unit preparation & management Stocking tank should be cleaned, disinfected and washed with fresh water. Before stocking filtered seawater is released in the tank and prophylactic treatment with fungicide and antibiotic is done. Addition of algal feed at a density of 1,00,000 cells/ml. Stocking density of nauplii (stage VI) should be at 50 nos/litre in the tank. Water qualitymonitoring- temperature, salinity, pH (7.8–8.2), ammonia(<0.1 ppm) , nitrite (<0.1 ppm)and bacterial concentrations. Aeration to keep larvae and algal feed to be distributed uniformly. Siphoning of wastes without stressing larvae.
11. 2) Larval nutrition and health management Unicellular Chetoceros and Isochrysis isgiven to Protozoea (stage I to III) two times a day with 30-50% of water exchange. Artemia nauplii/ flake diets is used for Mysis (stage I to stage III) along with algal diet (generally 1 nauplius/4ml to 1 nauplius/2ml). Antibiotic (or Probiotics) and antifungal treatment is done once in every 2 days. As Mysis grows to Postlarvae ,water exchange can be 100% and algal feeding is reduced to 60,000 cells/ml. Artemia nauplii feed may be increased to 1 nauplius/ml. During later stages, along with Artemia nauplii, other livefeed (clam meat, balanced compounded feed) can be used. At PL5, larvae should be collected from larval rearing tanks, disinfected and distributed in outdoor nursery tanks@15-20 nos/litre. PL15-20 - 25g/feed, 3 times daily PL11-15 - 25g/feed, 3 times daily PL8-10 - 15g/feed, 2 times daily Egg custard is fed from PL8 onwards as shown below- In addition to Artemia nauplii, artificial feed can also be given such as microencapsulated feed and egg custard @0.5g per ton. PL13-20 - @3 nauplii/ml, once daily PL7-12 - @3 nauplii/ml, 3 times daily PL3-6 - @2 nauplii/ml, 3 times daily Feeding regime ofPL- Outdoor nursery tank should have facilities for water exchange, Aeration and Feeding of larvae. Outdoor rearing of postlarvae:
12. (3) Testing/selection of post larvae • Only PL20 larvae should be sold to farmers after testing its health quality. • The PL quality assessment involves five main areas:: Gross examination : Size, color, activity, behavior, feeding and gut fullness Microscopic examination : Gut condition, fouling, deformity Stress test : Salinity = 28–32 ppt Vibrio test : To check for potentially harmful Vibrio spp. in the PL PCR screening : Testing for WSSV

    4) PL harvest and transportation Done gradually and with minimal stress. If possiblethe PL should be acclimated in the hatchery to the expected salinity in the on-growing farms (reduce the stress on stocking). Methods for PL transportation from the hatchery to

the farm: a) transported free in large, aerated tanks. b) packed into plastic bags with oxygen. Temperature -low. PL ready for packing Acclimatization of PL in a tank

(6) Documentation and record keeping • For reasons of biosecurity and good management of shrimp hatcheries, a comprehensive system of documentation and recordkeeping should be established. • This should include indications of - • daily shrimp numbers • larval health • treatments/chemicals used • water quality • other relevant information for each tank stocked • This will help determine the cause of any problems and any remedial actions required.

Economics of P. monodon seed production (20 million per annum post larve capacity).

* BACTERIAL AND VIRAL DISEASES WHICH OCCUR IN PRAWN*

In this regard, information on various kinds of diseases and their prevention procedures are useful.ϖ The best way to get rid of diseases is by practicing good farm management or prevention. ϖ Treatment cannot be carried out effectively when shrimp diseases occur in a pond. ϖ Non Infectious diseases are mainly are caused by adverse environmental conditions, nutritional disorders, or genetic defects. ϖ Infectious diseases arecaused by viruses, bacteria, fungi and certain parasites. ϖ Cultured shrimps suffer from various diseases due to infectious and non-infectious causes. ϖIntroduction

Infectious disease Infectious disease are due to hostility of bacteria, fungi, virus, protozoaand Protista. These pathogen cause severe effects in the health and appearance of the shrimphence, deteriorating their quality.

VIRAL DISEASES

MONODON BACULOVIRUS DISEASE ETIOLOGICAL AGENT MBV-type or PmSNPV is a type A occluded monodon baculovirus CLINICAL SIGNS Lethargy, anorexia,poor feeding, dark colouration and reduced growth rate. Infected shrimps are often associatedwith fouling of gills and appendages by ciliates such as Zoothamnium spp. and Vorticella spp. Acute infection leads to loss of epithelial cells of hepatopancreas. TREATMENT OR PREVENTION No treatment yet but there is little information on prevention and control of the MBV infection in shrimp pond culture. The prevention method for the mbv infection is possibly through avoidance by screening the pl's before stocking shrimp in the pond

HEPATOPANCREATIC PARVO-LIKE VIRUS (HPV) DISEASE ETIOLOGICAL AGENT CLINICAL SIGNS TREATMENT PREVENTION AND CONTROL HPV is caused by a small parvo-like virus, 22-24 nm in diameter No information is available on the prevention and control procedures for HPV infection. However, screening the PLs before stocking shrimp by routine histology or the Giemsa-impression smear method is recommended. Reduced feeding, poor growth rate, body surface and gill fouling with ciliatesand occassional opacity of abdominal muscles. Severe infections may include a whitish and atrophied hepatopancrease, anorexia and reduced preening activity. Losses may be occur dueto the increased occurance of surface and gill fouling organisms and secondary infections bythe opportunistic Vibrio spp. No treatment available for HPV infection

YELLOW HEAD DISEASE ETIOLOGIC AL AGENT TREATMEN T CLINICAL SIGNS PREVENTI ON & The reliable method to prevent the occurrence of YHD is possibly through avoidance, such as careful selection of post larvae, reduction or eliminationof horizontal transmission including carriers, disinfection of contaminated ponds or equipment with 30 ppm; and chlorine, providing shrimp with good waterquality and proper nutritionλ No treatment is available for YHV infection. λ The animals have pale bodies, aswollen cephalothorax with a light yellow to yellowish hepatopancreas and gills. A high mortality rate may reach 100% of affected populations within 3-5 days from the onset of disease λ Following this, a few moribund shrimp will appear swimming slowly near the surface of the pond dike and remain motionless. λ The affected shrimp shows a marked reduction in food consumption. YELLOW HEAD VIRUS is a ssrRNA , rod shaped, enveloped virus with two rounded ends. λCONTROL

INFECTIOUS HEPATOPANCREAS AND LYMPHOID ORGAN NECROSIS (IHLN) ETIOLOGICAL AGENT The primary cause of the disease is attributed to viral etiology. CLINICAL SIGNS • Light pinkish to yellowish discolouration of the cephalothorax region. • Often fouling by ciliate protozoan Zoothamnium seen. • Blackened and necrotic hepatopancreas. • Secondary bacterial infection from bacteria such as Vibrio alginolyticus seen. TREATMENT PREVENTION AND CONTROL No treatment is available for IHLN infection. • Keep the physico-chemical condition of pond environment within acceptable levels. • To avoid bacterial and viral pathogen entering from outside, closed culture could be useful in prevention of IHLN disease.

WHITE SPOT DISEASE Etiological Agent The disease is caused by the dsDNA virus, Systemic Ectodermal and Mesodernal Baculovirus (SEMBV). Clinical Signs: Clinically affected shrimp were first seen to swim to the water surface and congregate at the pond dikes.Typical clinical signs include white spots or patches, 1-2 mm in diameter, on the inside of theshell and carapace, accompanied by reddish discoloration of the body. SEMBV is able to cause acute epizootics of 5- 10 days duration with mortality rate from 40% to 100%. Treatment No treatment is available for SEMBV infection. Diagnosis Procedure The diagnosis procedure of SEMBV infection is based on the appearance of the intranuclear hypertrophy in stained histological sections and the presence of virus particles in the nucleus of the infected cells observed under the electron microscope. PCR technique is recently used to detect SEMBV in shrimp larval and other stages, including broodstock and subclinical virus carriers. Prevention and Control Prevention practices through avoidance are strongly recommended for the farmers, involving the combinations of efficient pond management, useof proper feed, selection of good quality of PL, reduction of possible carriers, avoidance of introduction of contaminated water into the

BACTERIAL DISEASES

LUMINOUS VIBRIOSIS ETIOLOGIC AL AGENT TREATMEN T CLINICAL SIGNS PREVENTI ON & Proper pond and water management. Utilization of reservoir for intake water.λ Administration of Oxolinic acid (0.6 ppm) and Sarafloxacin (5mg/kg) through feed for 5 days. λ Disinfection of intake water with Formalin (100-200 ppm). λ Vertical swimmingbehavior immediately before onset of acute mortality. Presence of luminescent shrimp in ponds. λ Moribund shrimp hypoxic often come to the pond surface and edges of pond. λ High mortality rate in young juvenile shrimp (one month syndrome). λ Vibrio vulnificus λ Vibrio harveyi, λCONTROL

VIBRIOSIS Vibrio vulnificus, V. parahemolyticus, V. alginolyticus, V. anguillarum, V. damsella, V. fluvialis and V. mimicus. High mortality rates, particularly in young juvenile shrimp. Moribund shrimp with corkscrew swimming behavior appear at edge of pond. Reddish discoloration of juvenile shrimp. Black spots, chronic soft shelling. Disinfection of intake water i.e. formalin 100-200 ppm. Anti- microbial preparation application through feeds (Oxolinic acid 0.6 ppm and Sarafloxacin 5 mg/kg). Proper pond and water management

* L.VANNAMEI CULTURE*

Penaeus Vannamei Grow-out Culture Whiteleg Shrimp

Introduction Penaeus vannamei also known as the pacific white or whiteleg shrimp is native to the Pacific coast of Mexico southward to Peru. Whiteleg shrimps occur in tropical marine areas with water temperatures normally higher than 20ºC throughout theyear. They are highly euryhaline and can withstand salinities ranging from 0 to 55ppt. Adults live and spawn in the open ocean whereas postlarvae migrate inshore to spend their juvenile, adolescent and sub-adult stages in coastal estuaries, lagoons or mangroveareas.

Taxonomic Classification Kingdom: Animalia Phylum: Anthropoda Subphylum: Crustacea Class: Malacostraca Subclass: Eumalacostraca Order: Decapoda Suborder: Dendrobranchiata Superfamily: Penaeidae Family: Penaeidae Genus: Penaeus Species: Vannamei

.Biological Features Rostrum moderately long with 7-10 dorsal and 2-4 ventral teeth. In mature males petasma symmetrical and semi-open. Spermatophores complex, consisting of sperm mass encapsulated by sheath. Mature female has open thelycum. Maximum size23 cm, with maximum CL of 9 cm.

Biology Males become mature from 20g and females from 28g onwards at the age of 6-7 months P. vannamei weighing 30-45g will spawn 100-250,000 eggs of approximately 0.22mm in diameter. Hatching occurs about 16hrs after spawning and fertilization.

7. Site Selection Topography and Climate Condition - Topographically, the best areas for shrimp culture are those with average natural ground elevations of about 1-3 m above mean sea level or at least 1 m above the highest high tide level to allow drainage and harvesting. - The sites should have minimum vegetative cover, be near the sea or other natural waterways such as rivers and streams, have easy access to roads, a sparse population and be nearly square or rectangular in shape.

8. - In terms of climatic conditions, areas having short and not as pronounced a dry season with moderate rainfall distributed throughout the year are the best suited for shrimp farming. A pronounced long dry season may cause an increase in water temperature and salinity, which will promote excessive growth of algae and result in oxygen depletion at night.

9. Infrastracture Accessibility - The farm must have good accessibility either by road or water, and communication systems throughout the year in order to facilitate supervision and transport of materials and products. - It is important that the farm be within 3-6 hrs traveling time from the hatchery to avoid excessively long transportation time of the larvae and should be within 10 hrs from the processing plant to avoid deterioration of theproduct

10. Electricity - Availability of relatively cheap and reliable power source is a major consideration in site selection. In areas where electricity supply exists, it is practical and beneficial to utilize electric power to run the farm, especially for the intensive culture system. It is advisable to have a back- up electricity generator as a secondary power source.

11. Security - Areas free from security risks result in favorable working conditions, productivity and less extra costs. Availability of Labor and Other Factor -The availabilityof labor, equipment and commercial feed and supplies ensure smooth operations and successful crop.

12. Water Supply - Site should have good pollution free water supply of both freshwater and brackish water. Soil Conditions - The type of soil is the most critical in site selection, since the shrimp will spend most of their time on the pond bottom during the culture period. Usually, clay or loam-based soil containing more than 90% clay and pH between 6.5-8.5 is preferable.

13. On-Growing techniques Extensive Semi-intensive Intensive Super-intensive

14. Extensive Conducted in tidal areas where minimal or no water pumping or aeration is provided. Ponds are irregular shape, usually 5-10 ha (up to 30 ha) and 0.7-1.2 m deep. Shrimp feed mainly on natural foods enhanced by fertilization and once daily feeding with low protein formulated diets.

15. Despite low stocking densities , small shrimp of 11-12 g are harvested in 4-5 months. The yield in these extensive systems is 150-500 kg/ha/crop with 1-2 crops per year

16. Semi-Intensive Stocked with hatchery produced seeds at 10-30 PL/m2 Regular water exchange is by pumping, pond depth is 1:0m-1.2m and aeration is at best minimal. The shrimp feed on natural foods enhanced by pond, fertilization supplemented by formulated diets 2-3 times daily.

17. Production yields in semi-intensive ponds range from 500-2000 kg/ha/crop with 2 crops per year.

18. Intensive commonly located in non-tidal areas where ponds can be completely drained, dried and prepared before stocking Ponds are earthen but liners are used to reduce erosion and enhance water quality.

19. Pond are generally small (0.1-1.0 ha) and square or round. Water depth is usually >.15 m. Stocking densities range from 60- 300 PL/m2. Heavy aeration at 1HP/400-600 kg of harvested shrimp is necessary for water circulation and oxygenation.

20. Feeding w/ artificial diet is carried out 4-5 times per day. In the "bacterial floc" systems, the ponds (0.07-1.6 ha) are managed as highly aerated, recirculating, heterotropic bacterial systems. Low protein feeds are fed 2-5 times per day, in an effort toincrease the C:N ratio to >10:1 and direct added to nutrients through bacterial rather thanalgal pathways.

21. Stocking at 80-160 PL/m2, the ponds become heterotrophic and flocs or bacteria are formed, which are consumed by the shrimp, reducing dependence on high protein feedsand FCR and increasing cost efficiency.

22. Super Intensive Enclosed in greenhouses, using no water exchange only the replacement of evaporation losses) or discharge, stocked w/ SPF PL. Stocking 28m2 raceways w/ 300-450 0.5-2g juveniles/m2 and on growing for 3-5 months has realized production of 28,000-68,000 kg/ha/crop at growth rates of 1.5g/week survivals of 55-91 % mean weight of 16-26g.

23. Harvesting Techniques Extensive and semi-intensive ponds are harvested by drainingthe pond at low tide through a bag net installed in the outlet sluice gate. If the tide does not allow harvesting, the water can be pumped out. In some larger farms harvesting machine pumps shrimp and water up to the pond bank where they are dewatered

24. Intensive ponds may be harvested similarly and small 2-6 man seine nets are dragged around the pond to corral shrimp to the side of the pond from where they are removed by cast or dip net or perforated buckets. Partial harvesting after the first three months. In super-intensive systems, the shrimp are simply harvested with large scoop nets when required for processing.

25. Handling and Processing If shrimp are sold directly to processing plants, specialized teams for harvesting and handling are commonly used to maintain shrimp quality. After sorting, shrimp are washed, weighed and immediately killed in iced water at 0–4 °C.

Often sodium metabisulphate is added to the chilled water to prevent melanosis and red-head.

26. Shrimp are then kept in ice in insulated containers and transported by truck either to processing plants or domestic shrimp markets. In processing plants, shrimp are placed in iced bins and cleaned and sorted according to standard export sizes. Shrimp are processed, quickly frozen at -10 °C and stored at -20 °C for export by ship or air cargo.

27. Diseases and Control measures Thorough drying/scraping of pond bottoms between cycles. Reducing water exchange and fine screening of any inlet water. Use of bird netting or scarers. Putting barriers around ponds. Sanitary procedures.

28. Once viruses do enter the ponds, there are no chemicals or drugs available to treat the infections, but good management of pond, water, feed and the health status of stocks can reduce their virulence

* CONSTRUCTION AND MANAGEMENT OF PENAEUS VANNAMEI HATCHERY*

Construction and management of Penaeus vannamei hatchery Shrimp

pond management can be studied under the following heads: 1.Site

selection

2. Pond design and construction

3. Pond preparation and filling

4. Water culture

5. Stocking

6. Feeding

7. Water quality management

6. Aeration

9. Harvest

10. Effluent treatment.

1. Site selection: Some soils are considered good and some are bad in terms of pond productivity. It all depends on site selection. Good sites are those where estuarine water of high productivity (natural food) is available. Land should be sufficiently elevated from water source i.e., with low flood risk and draining is possible even during high tides. A site with gentle slope of less than 2% is desirable.

Soil: One of the most important criteria is the ability of the soil to hold water. Good soll should contain clay and silt mixes to prevent excessive seepage: Excess sand disqualifies the site for pond construction. Clay loamy soils are best suited. After construction of a pond the soil should withstand the hydrostatic pressure exerted by filled in water and should resist water flow.

Water: While selecting a site seasonal and yearly fluctuations in water quality and availability should be carefully considered. Water with 10-25 ppt salinity round the year is preferred.

Climate: An average air temperature of 28°C and water temperature less than 30°C is needed for shrimp culture. Good levels of solar radiation, average rain fall, low cloud levels and good wind flow is needed Low evaporation rate (ambient temperature and humidity) is also preferred. Most of the sub-tropical coastal areas provide such suitable climate for shrimp culture.

2. Pond design and construction: With a gentle slope and good soil, an efficient aquaculture pond can be constructed at low cost. Ponds are constructed by excavating top soll to construct the embankments (dykes).

If the available site has soil with excessive permeability, then seepage from bottom or sides should be minimised by compaction / consolidation, clay blankets or polyethylenelining. The dykes should be strong.

Ponds should be designed with a bottom slope towards the drain. The slope should be above 1000 1 and below 1000: 4. The slope should be even and smooth so as to drain The pond completely within 5 hrs.

Before constructing ponds, all rocks and vegetation in the site have to be cleared, followed by careful surveying. Proper planning has to be done with reference to roadways. feeder canal and drainages.

Pond size: Depending on the stocking density the pond sizes are fixed / designed. Extensive ponds can be large in size that is, more than one hectare area. Semi intensive ponds are about one hectare size and intensive ponds are 0.4 to 0.5 ha size.

Drainage: Proper maintenance requires thorough drying of the pond bottom after harvest Good drainage is an important part of good water management and disease control. A rain time of less than 5 hours is most desirable during harvest. So drains should be fa Below the level of pond bottom (at least 0.5m).

Sluice gates: These control gates allow greater control over pond productivity. management and harvest. Ferro-cement sluices are more popular now. The pipe with enough diameter should be laid for drainage and should facilitate letting out top water as well as bottom water. Sluice gate should contain grooves to fix mesh screens and wooden shutters

3. Pond preparation and filling: Ponds are sun dried thoroughly to eliminate predators competitors. It also helps in mineralization of organic matter on the pond bed an accomplishes disinfection.

Filling: Before pumping the water into the pond all inlet filters / screens and out let should be checked for leakages and closed properly. The screens should be fixed in the grooves of sluice collars . Water is filled 4-7 days prior to stocking, to facilitate water culture.

Liming: Treatment of pond soil with agricultural lime (Ca CO) or burnt lime (CaO) is essential aspect of pond preparation. The quantity and quality of lime needed depends the soil pH. Lime helps by maintaining pond culture environment increases hardness and alkalinity of water, helping in better productivity (plank blooming).

4. Water culture: Appropriate water culture methods help in better survival of the seed. Water culture starts from liming. Since natural food in culture ponds is in the form of plankton and benthos, it is influenced not only by fertilization but also by soil-water interaction, pH, alkalinity, hardness etc

Stocking: Seed should be transported carefully from hatchery to the pond site to avoid stress. At the time of stocking bright sunny hours have to be avoided. Stocking density depends on the method of culture

	Extensive	Semi-intensive	Intensive
PL per hectare:	10,000-15,000	50,000-2,50,000	above 2,50,000

Acclimatisation: Shrimp is a euryhaline animal it can survive over a wide range of salinity variations, if enough time is given to adjust. This process of adaptation of post larvae to the pond environment is called acclimatisation.

Post larvae are produced in the hatcheries at 29-33 ppt salinity. Hence the water (contained in seed bags) salinity brought from hatcheries must be slowly changed to required salinity (pH and temperature also). The seed should be slowly released into pond water from the seed bags after acclimatisation. The salinity, pH and temperature of water in seed bags have to be adjusted to that of pond water before releasing the seed into the pond

6. Feeding: Shrimp in traditional and extensive culture ponds depend mostly on natural food produced in the pond. As the stocking densities increase, the importance of artificial/formulated feeds also increases proportionately.

Natural food of shrimp consists of plankton, a micro benthic complex (lab lab) of algae, diatoms and other smaller invertebrates.

Formulated feeds: Shrimp requires 35 -42 % protein in the feed, the remaining

Percentages are made up of carbohydrate, fat, minerals, vitamins, fibre, moisture etc. The

precooked and processed feeds are available in the form of pellets of different diameter.

Crumbled feed of juveniles contain more protein than grower and finisher feeds.

7. Water quality Management: Water quality variables to be measured on daily basis are water temperature, salinity, pH and dissolved oxygen. Shrimp growth retards if the pond water oxygen levels drop below 2 ppm.

Dissolved oxygen levels in a 24 hrs cycle reach its maximum in the early afternoon

and reach its lowest critical levels during early hours i.e. before day break.

While under2feeding invites drop in survival and cannibalism, excess feeding

deteriorates water quality and pond bottom, resulting some times in mass mortality. So optimum feeding to the demand makes successful and profitable culture. Excess feeding or bad water quality management results in accumulation of

ammonia, H,S etc., gases and alter pH levels also. This situation creates physiological

stress to the pond grown shrimp.

Water exchange Water exchange has several advantages. It optimises and helps in reduction of nutrient concentrations and good plankton blooms. It lowers the concentration. of toxic metabolites and prevents rise of salinity during summer. Following table shows the average monthly water exchanges required in shrimp ponds.

1 month	5% every time	4 times
2 month	10% every time	5 times
3rd month	20% every time	6-8 times
4th month	30% every time	8-10 times

Removal of bottom water and application of lime (Ca CO, or CaO) in shrimp ponds has added advantage.

8. Aeration: As the intensity of shrimp production increases beyond 1.5 tonnes/hectare/ crop (stocking density above 50,000) mechanical aeration becomes inevitable to maintain enough dissolved oxygen levels, to eliminate toxic gases and for maintenance of homogenous pond water environment (destratification). A minimum number of 4 paddle wheel aerators are needed per hectare pond area and the number increases with an increase in stocking density

9. Harvest: Shrimp quality is directly related to harvest time, harvest techniques and post harvest handling methods. Usually drain harvest method is most suited in well planned farms. Bag nets are tied to the outer rim of drain pipe during draining the pond. For partial harvest traps or cast nets can also be used

10. Effluent treatment: Dead and decaying plankton, faecal matter, unconsumed decaying feed and eroded soil increases concentrations of ammonia, nitrogen phosphorous, H_2S and suspended solids in the drained water during water exchange and also during harvest of ponds.

UNIT-I

SHORT ANSWER QUESTIONS:

Scope of Aquaculture

The freshwater aquaculture systems in the country has primarily confined to three Indian major carps, viz., rohu, catla and mrigala, with exotic species: silver carp, grass carp, and common carp forming the second important group. Among the catfishes, magur (*Clarias batrachus*) has been the single species that has received certain level of attention both from the researchers and from farmers due to its high consumer preference, high market value and most importantly itsuitability for farming in shallow and derelict water bodies with adverse ecological conditions. Recent years, however witnessed increasing interest for farming of *Pangasius* spp., especially in Koleru lake region of Andhra Pradesh due to its higher growth potential and ready market. Other potential species include *Labeo calbasu*, *Labeo gonius Labeo bata*, *Labeo dussumeri*, *Labeo fimbriatus*, *Barbodes carnaticus*, *Puntius pulchellus*, *Puntius kolus*, *Puntius sarana*, and *Cirrhinus cirrhosa*. Some of these species are being cultured at a very low level in different parts of the country, mostly based on wild seed collection. The freshwater air-breathing and non air-breathing species, *Channa marulius*, *Channa striatus*, *Channa punctatus*, *Channa gachua*, *Channa stewartii* have not been taken up for the aquaculture activities in serious way. With the technology available for seed production and culture of air breathing (*Clarias batrachus*, *Heteropneustes fossilis*) and non air breathing catfish like (*Wallago attu*, *Mystus seenghala*, *Mystus aor*, *Horabagrus brachysoma*, *Pangasius pangasius*), scientific organized catfish farming can be taken up in extensive and semi intensive way (Ponniah and Sundaray, 2008). The giant freshwater prawn, *Macrobrachium rosenbergii* has been the principal species, adopted both under monoculture and under mixed farming of freshwater prawn production of about 43,000 tonnes in the country at present. However, *M.malcomsonii* and *M. gangeticum* have not been taken up in a big way

In the brackishwater sector, the aquaculture development is mostly contributed by shrimp, *Penaeus monodon* culture only. The other shrimp species like *Fenneropenaeus indicus*, *Fenneropenaeus merguiensis*, *Penaeus pencillatus*, *Marsupenaeus japonicus* and *Penaeus semisulcatus* are not cultured on a commercial level large-scale culture. Recently *Fenneropenaeus vannamie* culture is developing in India. The finfish species like the seabass (*Lates calcarifer*) and grouper (*Epinephelus* spp.), grey mullet (*Mugil cephalus*), pearl-spot (*Etroplus suratensis*), milk fish (*Chanos chanos*) which are promising and ideal for aquaculture has not been exploited. The potential marine finfish species are *Epinephelus malabaricus*, *Epinephelus coioides*, *Epinephelus tauvina*, *Epinephelus fuscoguttatus*, *Epinephelus polyphekadion*, *Cromileptis altivelis*, *Rachycentron canadum*, *Seriola quinqueradiata*, *Trachinotus blochii*, *Coryphaena hippurus*, *Psettodes erumei*, *Lutjanus argentimaculatus*, and *Pampus argenteus*. Mariculture is expected to be a major activity in the Indian coastal areas in the years to come. Given the wide spectrum of cultivable species and technologies available, the long coastline and favorable climate, mariculture is likely to generate considerable interest among the coastal population and entrepreneurs.

In the present era of food insecurity, aquaculture shows enormous potential to feed not only the ever increasing human population but also the aquaculture products can be utilized as a feed ingredient in the diets of different domesticated animals of high commercial value. The aquaculture sector has become a modern, dynamic industry that produces safe, high valuable and high quality products, and has developed the means to be environmentally sustainable Sustainable aquaculture is currently the need in India as elsewhere. Eco-friendly aquaculture in harmony with environmental and socioeconomic needs of the society has to be evolved.

Water re circulating system

A Recirculating Aquaculture System (RAS) can be defined as an aquaculture system that incorporates the treatment and reuse of water with less than 10% of total water volume replaced per day. The concept of RAS is to reuse a volume of water through continual treatment and delivery to the organisms being cultured. Water treatment components used in RAS need to accommodate the input of high amounts of feed required to sustain high rates of growth and stocking densities typically required to meet financial outcomes. Generally, RAS consist of mechanical and biological filtration components, pumps and holding tanks and may include a number of additional water treatment elements that improve water quality and provide disease control within the system

Recirculating systems are usually characterized by minimal connection with the ambient environment and the original water source. These systems have minimal exchange of water during a production cycle, hence the description as 'closed' systems. Water is added to offset the effects of evaporation or incidental losses or, more frequently, to maintain water quality. Some water is dis-charged and replaced each day in most recirculating tank systems with intensive culture. This arises from aspects of the regular maintenance system, such as removing accumulated solids from filters. Water quality in completely closed tank systems with intensive culture is much more difficult to maintain than in systems in which there is a regular 5% or more replacement per day. Even with some limited water exchange each day, water quality within a recirculating tank system will only be maintained by artificial manipulation.

The cost of construction and production in intensive recirculating tank systems has limited the commercial development of these systems for grow-out production. However, the possibility of high yields with year-round production close to markets drives their development.

The artificial means of waste processing and some typical components used in recirculating systems are shown in Fig. (2) Feed input, animal metabolism, wasted feed and feces production all impact upon water quality.

Parameters that require regulating in an intensive recirculating tank system are:

- particulate matter (settleable, suspended and fine waste solids) in the system resulting from feed and feces;
- nitrogenous wastes (un-ionised ammonia, ionized ammonia, nitrite and nitrate, which are often expressed as NH_3-N, NH_4-N, NO_2-N and NO_3-N, respectively);
- dissolved gases (O_2, CO_2 and N_2);
- pathogens;
- pH and alkalinity.

At high stocking densities without recirculation technology, a water exchange in excess of 100% per hour would be required to maintain water quality during maximal production. In recirculating tank systems, water quality is maintained by pumping the culture water through specialized filtration and aeration equipment. Advantages of closed systems

1. Easily harvesting.
2. High stocking density.
3. Require minimal water
4. Food and drugs can be added efficiently into the system
6

5. Complete control of water condition

Disadvantages of closed systems
1. High capital coast
2. Require very careful management
3. Rapid spread of disease.

Types of fish cages

Fixed Cage • Consists of net bag supported by posts driven and fixed into the bottom of a lake or river

- Limited in size and shape

• Restricted to sheltered shallow sites with suitable substrates

Floating Cage

• Most widely used cage type

• A frame supports the cage bag

• Floats are attached to the frame for buoyancy

• Can be designed in a variety of shapes and sizes according to choice of the culturists

Submersible Cage

• Relies on the frame or rigging to maintain shape

• Position in the water column can be adjusted to take advantage of prevailing environmental condition

Submerged Cage

Structure is similar to floating type but does not have floats

Anchored to the substrate by stones or posts

* Minor carps*

The minor carps are commercially important fishes of the Cyprinidae family.

The carps that are used in aquaculture include Reba (*Cirrhinus reba*), Bata (*Labeo bata*), Fringe-lipped carp (*Labeo finbriatus*), Calbasu (*Labeo calbasu*), white carp (*Cirrhinus cirrhosus*) and Cauvery carp (*Labeo kontius*).

The commercially important barbs are the Silver barb (*Barbonymus gonionotus*) and Olive barb (*Systomus sarana*) and they belong to the family of Cyprinidae.

The minor carp and barbs, except Cauvery carp, are normally distributed throughout India.

Adults inhabit large streams and rivers They also exist in tanks, canals, ponds and beels.

They primarily feed on plankton and detritus, but may also feed on mud, vegetables, crustaceans and insect larvae.

The brood fishes are reared in the earthen ponds. Before 2 – 3 months of the monsoon season, the brood fishes are separated from the commercial culture condition.

The fishes that are more than two years old are separated into the broodstock tank at a stocking rate about 500 – 600 kg/ha.

The local food such the mixture of Groundnut oil cake and rice at 1:1 ratio or commercial feed is provided at the rate of 2 – 3 percent of body weight of fish

Tilapia

Tilapia are a hardy, fast growing fish, that can live up to ten years and reach ten pounds in weight. Tilapia are shaped like a sunfish or crappie and are easily identifiable by the interrupted lateral line characteristic of the Chiclid family of fishes. They are laterally compressed with deep bodies and have long dorsal fins. The foremost portion of the dorsal fin is heavily spined. Spines are also found in the pelvic and anal fins. They are usually wide vertical bars of dark coloration found along the sides of fry, fingerlings, and sometimes adults.

Biology and Life History: In the wild, tilapia are found in turbid rives and lakes. They are herbivores who feed mainly on plankton, algae, and other vegetable matter. As a result of their feeding patterns they do not accumulate toxins in their bodies. Wild tilapia can spawn throughout the year, with females producing as many as 1,200 eggs per spawn. Some species deposit eggs into nests while other species are mouth brooders carrying fry in the mouths of the males for protection from predators. Most widely farmed are the mouth brooding species because even though they lay fewer eggs the fry have a much higher survival rate. Tilapia are farmed in both intensive and extensive aquaculture systems. Most farmers prefer open air earthen ponds. Under ideal farming conditions females spawn every 17 days. If water quality and temperatures are manipulated to a favorable environment market sized fish can be obtained in seven to ten months. In areas of the southern United States, tilapia production is strictly regulated to reduce unwanted introductions of the species into native waters, for fear that they might damage sport fish populations.

Stocking: To produce one pound fish, the common practice is to stock 5,000 to 8,000 fish per acre. In static water ponds with aeration 20,000 to 28,000 males per acre with a 20% water exchange. According to Texas Parks and Wildlife an exotic species permit is required to stock and transport tilapia.

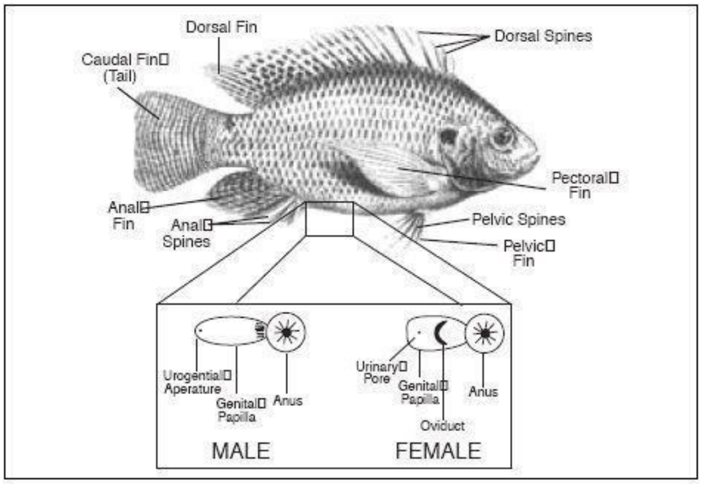


Figure 1. Fins and genital papilla of the Nile Tilapia.

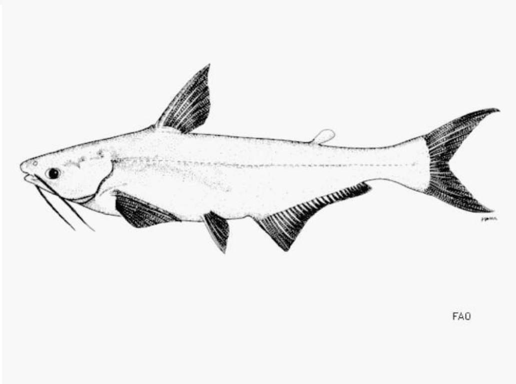
Pangassius

Although Pangasius is mostly found in freshwater, it can live in salt concentrations of around 0.7 percent - 1 percent and alum water (PH >5) which can be tolerated at temperatures of around 30°C.

With a streamlined body, dark grey coloured back, silver belly, wide mouth and long twin beard, Pangasius has more red blood cells than other fish, an additional respiratory organ and can breathe through bubbles and skin. This means it is able to tolerate environments with little dissolved oxygen.

Its growth rate is rapid and it can live in the wild for as long as 20 years. After around 2 months during breeding, it reaches about 10-12cm long and 14-15 grams in weight.

By the age of 10, it can reach around 25kg in farming ponds, and those weighing between 800 - 1,100 grams after 6 - 8 months (not including the breeding stage) are best for harvesting

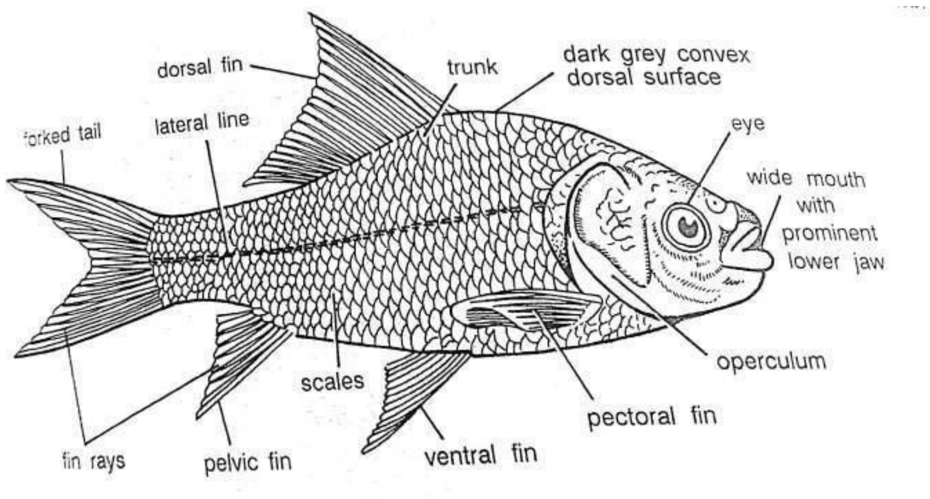


*** Catla catla***

CATLA CATLA

- Generally called krishna Bocche.

- Body broad, specific head, mouth on dorsal side at the tip, clear lips with folding Dorsal fin with 17-19 rays are identification characters.
- This live on Surface waters and take planktons, algae, plants etc.
- Development rate is very fast, attain maturity at 2 years age.
- Generally Cultured in India, Pakistan, Barma, Bangladesh.
- In ponds attain weight 6-l4 kg while in reservoir attain 57-66 Kgs.

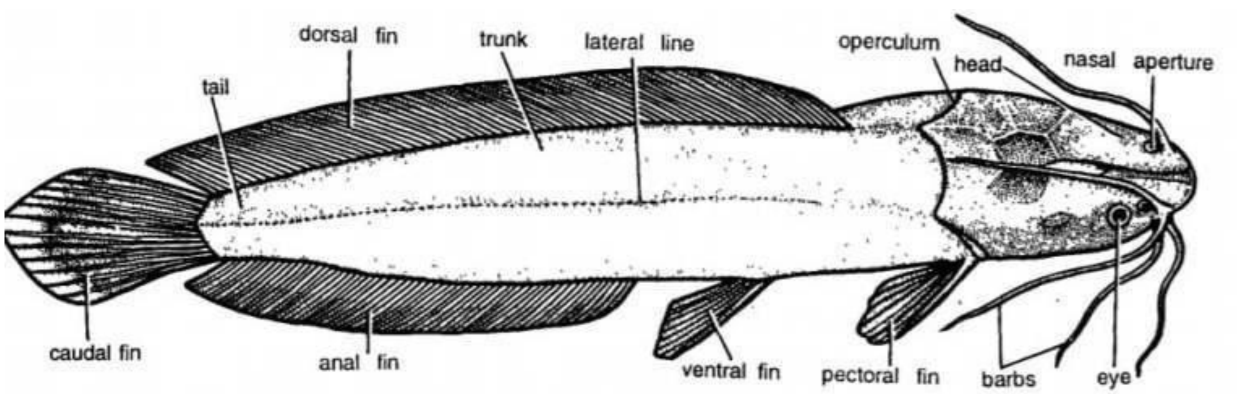


Clarius batrachus

1. 1. Magur fish English name:Walking Catfish,Clarias Catfish,Freshwater Catfish. Local name:Magur, Mosgur,Mojgor. Scientific name:Clarias batrachus.
2. Biological distribution • This is air breathing fish.Here accessory respiratory organ is branched and placed near the gills. • The head of this fish is larger then singhi and mouth is preasent on the ventral side. • Of the eight barbels ,two are much stouter and longer,while the other are similar.
3. 4. • Following paired and impaired fins are present,which differ from the Singhi. • Paired Fins • Pectoral Fin: • Present near the opercular opening,first fin ray is modified into a sharp defensive structure. • Pelvic Fin: • Present on the ventral side and close to the pectoral fin.Supported by soft fin rays.
4. 5. • Unpaired Fins: • Dorsal Fin: • Very large, extends along the mid-dorsal line of entire trunk and tail region.Supported by innumerable soft fin rays. • Anal Fin: • Present along the mid-ventral line of the tail region.Numerable soft fin rays are present. • Caudal Fin: • Semicircular and present on the terminal end of the tail region.
5. 6. Habits and Habitats • Walking Catfish are benthic,omnivorous.Consume a wide variety of prey, including eggs or larvae of others fish, small fishes and a number of invertebrates. • Found in a wide variety of habitats including lakes, rivers, ponds, canals.
6. 7. Advantages of culture of magur fish • There are more demand of magur in the market and that's why more profit can be obtained by their culture. • Method of cultured is easy.

They can be cultured any types of water body. • They can survive in adverse in environment such as less oxygen high temperature of water, even polluted water.

7. 8. • They can be cultured in less water and with more density. • Less affected by disease and high tolerant. • They can be marked as live condition as they can survive in less water and even in without water. • If earing properly, fishes can be marketed early (6-8 months) • Along earing individual culture, they can also be cultured with carp fish, tilapia fish etc. as mixed cultured.
8. 9. Distribution • The Walking Catfish is a widely distributed speices, known from pakistan, eastern India, Sri Lanka, Bangladesh, Myanmar, Singapore, Indonesia, and the Philippines.
9. 10. Economic importance • Clarias batrachus is a commercially important catfish species of Bangladesh. The fish is delicious and nutritious. Owing to its ability to survive for some time out of water. • Commercial large-scale production of Clarias batrachus can play a vital role in the country's economy. The fish is important as an ornamental fish and cultured in aquariums. It is a high priced fish because of its exceptional nutritional value.
10. 11. Status and conservation • Not considered as threatened in the Red List of IUCN Bangladesh (2000). Because of its ability to withstand marginalized and poor quality water, the fish still exists as a common species. • The Walking Catfish can be sold and traded fresh fish product. The fish has a great reputation for their wholesome qualities.
11. 12. • It is cultured in shallow ponds, and the stocking density ranged from 25,000-1,00,000/ha. Maximum production of 5,043kg/ha obtained from a farm pond of 0.1ha has been reported. • The fish can also be cultured in case, cemented cisterns, paddy fields and sewage waters.



Composite fish culture

COMPOSITE FISH CULTURE SYSTEMS

Selection of Pond

The main criteria to be kept in mind while selecting the pond is that the soil should be water retentive, adequate supply of water is assured and that the pond is not in a flood prone area.

Derelict, semi derelict or swampy ponds can be renovated for fish culture by dewatering, desilting, repair of the embankments and provision of inlet and outlet.

The pond may be owned by the individual or taken on lease in which case the lease period should be more or coterminous with the repayment period.

Pond Management

Pond Management plays a very important role in fish farming before and after the stocking of fish seed. Various measures that are required to be undertaken in pre and post stocking practices are tabulated below:

1. Pre-stocking In case of new ponds, pre stocking operations starts with liming and filling of the pond with water. However, the first step for existing pond requiring development deals with clearing the pond of unwanted weeds and fishes either by manual, mechanical or chemical means. Different methods are employed for this.

i) Removal of weeds by Manual/Mechanical or through Chemical means.

ii) Removal of unwanted and predatory fishes and other animals by repeated netting or using mahua oil cake @ 2500 kg/ha metre or by sun drying the pond bed.

iii) Liming: The soils/ tanks which are acidic in nature are less productive than alkaline ponds. Lime is used to bring the pH to the desired level. In addition, lime also has the following effects –

The normal doses of the lime desired ranges from 200 to 250 Kg/ha. However, the actual dose has tobe calculated based on pH of the soil and water as follows:

Soil pH Lime (kg/ha) 4.5-5.0 2,000

5.1-6.5 1,000

6.6-7.5 500

7.6-8.5 200

8.6-9.5 Nil

The pond is required to be filled with rain water or water from other sources after liming in case it is a new pond.

iv) **Fertilisation/ Manuring**:

- Fertilization of the pond is an important means for intensifying fish culture by increasing the natural productivity of the pond.
- The fertilisation schedule has to be prepared after studying the quality of the pond soil.
  a) Organic Organic manure to be applied after a gap of 3 days from the date of liming. Cow dung @ 5000 kg/ha or any other organic manure in equivalent manurial value.

  b) Inorganic Inorganic fertilisation to be undertaken after 15 days of organic manuring. Requirement of nitrogenous and phosphate fertilisers

  2. **Stocking** The pond will be ready for stocking after 15 days of application of fertilizers.
     - Fish fingerlings of 50- 100 gm size (approx) should be used for stocking @ 5000 nos. per hectare.

3. Post stocking

i .Supplementary feeding

- Fishes need much more food than what is available naturally in the pond. Fishes can be fed with a mixture of rice bran and oilcakes in the ratio 4:1. Due to the high cost of Groundnut Oil Cake (GOC) farmers have tried using alternate sources like Cotton seed oil cake which is comparatively cheaper than GOC.

ii. Manuring

i) Organic manuring may be done in monthly instalments @ 1000 kg/ha.

ii) Inorganic fertilization may be done at monthly intervals alternating with organic manuring.

iii. Harvesting

- Harvesting is generally done at the end of 1st year, when the fishes attain average weight of 800 gm to 1.25 kg

UNIT-III

* Anabas*

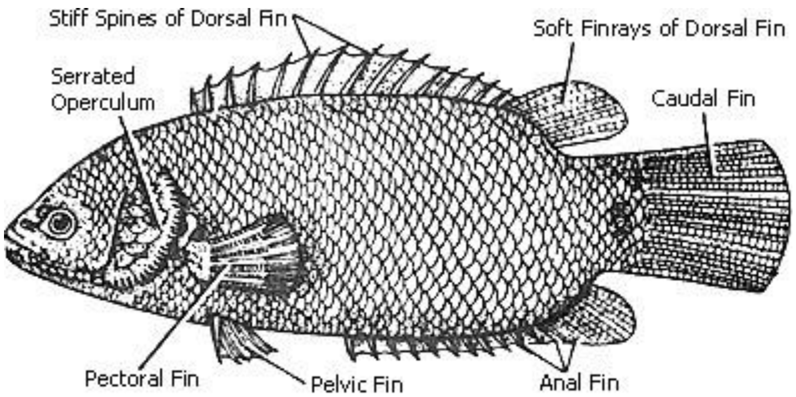
Body laterally compressed. Mouth is anterior and lower jaw slightly longer. Villiform teeth are present on jaw.

Long dorsal and anal fin is found. Body colour is dark to pale greenish, fading to pale yellow on belly where as dorsal and caudal fin dark grey, anal and pectoral fins pale yellow, pelvic fin pale orange colour.

Pectorals and caudal fin rounded. Dorsal, pelvic and anal fin rays are modified to spin. Scales are ctenoid, lateral line interrupted

Inhabits fresh and brackish water; mostly in canals, lakes, ponds, ditches, floodplains ,bottom dweller and insectivorous fish.

Breeding starts in the month of April with the onset of monsoon and continues till July. Eggs are pelagic, floating over surface. At a temperature of 28.5°C hatching takes place in 18 hours.



Climbing perch, Anabas testudineus

Cold water fishes

Introduction to Cold Water Fisheries:

Cold water Fisheries occupy an important place amongst the freshwater fishes of India. The cold water fisheries deal with fisheries activity in water where temperature of water ranges from 5 to 25 degrees centigrade. The water temperature under cold water fisheries should not be more than 25°C even in summer.

- **Species of Cold Water Fisheries:**
    - **Mahaseer:**
- There are 4 species of mahaseer. It has a big head hence it is known as Mahaseer. It is a migratory fish running in the main rivers for spawning. Two of them are edible fishes and are of commercial use, they are Tor putitora and Tor tor. They exist from Kashmir to Assam.

- They are about 1.5m in length and breed from July to September. Tor mosal is available in Kashmir, Sikkim and in rivers of Assam. Tor khudree (Deccan Mahseer) are found in the rivers of southern part of India. It is found at an elevation of 875 below.

- Normally they are found between pitted rocks and stone with filamentous algae. It requires DO(ppm) 7.8-8.4 and temperature of water should be between 18.5-27.6. (Figs. 29.1a-c).

Labeo:

- The fishes which are present in mountain rivers are minor carp and have no significance as commercial fisheries. The fishes are L. dera, L. dyocheilus and Crossocheilus latius (Fig. 29.4a,

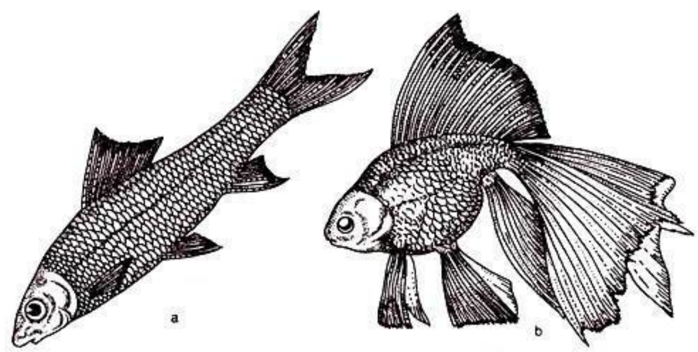


Fig. 29.4a, b : Fishes present in mountain rivers : (a) *Labeo dora*, (b) *Carassius auratus*

Exotic Fishes:

Trouts:

- The following trouts are now acclimatized in the streams, lakes and reservoirs in Indian waters, particularly in Nilgiri, Kodai Kanal, Kashmir and Himachal Pradesh. The fishes are now available for food and farming.

- The management practice is important for myskii promoting angling tourism of brown trout, Salmo trutta fabrio and Oncorhynchus are two main genera. They constitute trout fisheries in Indian uplands. Salmon has three main species while Oncorhynchus has two.

- **They are mentioned as follows:**
- Salmo trutta fabrio, Salmo eredius, Salmo gairdinarii

- Oncorhynchus mykiss (rainbow trout), Oncohrynchus nakrii

Cyprinus Carpio:

- This fish has been well cultured in Kashmir and in the northeastern region. The culture is being successfully done by induced breeding methods. The methods are described in carp breeding.

- The culture of indigenous snow-trouts endemic to Kashmir inhabiting lakes, river/ streams has declined but conserved by artificial propagation in this part of India.

Seed resources of clarius

The matured male of magur possesses a pointed anal papilla. while that in female is oval in shape. Though cat-fishes breed throughout the year, the peak season for the collection of seed is pre-winter period when paddy is harvested and the low lying fields get exposed. Spawning generally takes place in fairly deep waters. The female makes a hole of 20 em diameter and 25 cm deep on the bottom.

The fertilised eggs measuring 1-1.5 mm (diameter) are yellowish-brown in colour and adhere to grasses. The males guard the eggs till it hatches within 20 hours at a temperature of about 25-30°C. About 2000 to 15,000 fries per hole can be collected from natural areas with the help of a small fine- meshed hand-net. They are then reared in nurseries till they reach a length of 5 cm.

I case of pond breeding, comportments or enclosures of 1m x 1m are made of wire screen in the pond having water depth about 25 cm. At the center of each compartment a hole of 30 cm diameter is dug up to a depth of 25 cm.

The holes are provided with some aquatic plants. The matured male and female fishes suitable for breeding are put into each compartment and they spawn within a period of 10 days. A maximum of 5,000 fry are collected from each compartment.

Seeds of catfishes can also be collected through induced breeding. The effective dosage of pituitary extract for different sized fishes is as follows: (1) For catfishes weighing less than 100 gm is 10 mg extract.

(2) For catfishes weighing 100-150 gm is 25 mg extract.

(3) For catfishes weighing 150-200 gm is 35 mg extract

Feeding and Feed Schedule:

To maintain an abundant food supply for the growing fingerlings of the air-breathing fishes, it is essential that the stocking pond be rich in animal food source such as tadpoles and trash fishes. In case these food sources are found to be inadequate, tilapia may also be grown, so that the young of tilapia (which is a fast breeder) may serve as a regular and staple food source for the fingerlings of cat fishes and murrels.

In case of maritime states (West Bengal, Orissa, Kerala, Andhra Pradesh, etc.), abundant availability of dried marine trash fish would make the culture of air-breathing fishes more economical. However, in ponds where the above facilities are not available, then one has to resort to supplementary feeding.

Artificial feeding for singhi and magur is undertaken using fish offal or slaughter house waste or dried silkworm pupae mixed with rice bran and oil cake in the ratio of 1:1:1.

A mixture of rice bran, mustard oil cake and trash fish meal in the ratio 2:1:1; rice bran and poultry feed in 3:1; biogas slurry and rice bran in 1:2 or poultry dropping and rice bran in 1:2 ratio may also be given daily at the rate of 5-8 per cent of body weight of the fish fingerlings stocked.

Murrels

Murrels or snakeheads belonging to the family Channidae (= Ophiocephalidae)
are highly regarded food fish in the South and Southeast Asian countries.
Their ability to breathe atmospheric oxygen makes it possible to keep them alive for long periods out of water and to sell them alive at high prices in the market. Besides the high-quality flavour and texture of their flesh, murrels are especially regarded as diet for invalids and recuperating patients. Though cultivated in many countries of Asia, murrel culture has not yet developed to major commercial importance.
Among these, the species of aquacultural importance are *Channa* (= *Ophicephalus*) *striatus* , *C. marulius*, *C. punctatus*, *C. maculatus* and *C. micropeltes*. *Channa striatus*, *C. marulius* and *C. micropeltes* grow to sizes of 1–1.2 m, whereas the other two species are smaller in size, reaching 22–30 cm. Though adult murrels of any size have a market in Asian countries, the preferred size is between 600 and 1000 g.

els are very hardy and can tolerate unfavourable conditions. If kept moist, they can live out of water for long periods, and are known to survive droughts by aestivating for months in moist mud. The preferred temperature is in the range of 20–35°C, and the upper and lower lethal limits are reported to be 40 and 15°C respectively. Though sensitive to sudden changes in pH, they can survive in both acidic and alkaline waters. They are essentially fresh-water species, but can withstand low salinity brackish-water conditions.

The most common system of murrel culture is in earthen ponds ranging in size from 800 to 1600 m^3 and in depth from about 0.5 to 2 m. Often the ponds have fine-meshed wire fencing to prevent escape of the fish. In Kampuchea and Vietnam, murrels are usually growth in cages moored near the shore or trailed behind fishermen’s boats. The cages vary in size from 40 to 625 m^3.

Sewage- fed fish culture

- As stated earlier, West Bengal is the only state in India where raw sewage is used for fish culture.
- The sewage fed fish culture is carried out in Bheries where raw sewage from Kolkata city is let into the Berries in small quantities at monthly intervals.
- In small Bheries fish and paddy are grown alternately while in bigger Bheries only fish is grown. The sewage is let into the ponds to a depth of 90 cm along with tidal water in a ratio of 1:4, sewage to water. The water is allowed to settle for 15-20 days after which it becomes clear and odourless. Subsequently plankton will grow in the Bheries. The ponds are then stocked with fingerlings of Indian major carps of size 7.5 – 15 cm in the month of April. Some farmers also stock silver carp and common carp. Harvesting begins in September and ends in February. The weight of the stocked fish is about 500-550 kg/ha and the final yield from this system is about 3000 kg/ha/year.
- Tilapia can also be grown in sewage fed ponds since they are capable of tolerating poor water quality prevalent in sewage fed ponds and production of up to 9000 kg/ha/yr of 70-200 mm Tilapia can be obtained.
- Raw sewage has the potential to cause human health hazard. Therefore only treated sewage should be used for fish culture.
- Other countries such as Far East, Middle East, Germany, Hungary and Israel use treated sewage for fish

Pen culture

Pen culture is defined as raising of fish in a volume of water enclosed on all sides except bottom, permitting the free circulation of water at least from one side. This system can be considered a hybrid between pond culture and cage culture. Mostly shallow regions along shores and banks of the lakes and reservoirs are used in making pen/enclosure using net/wooden materials where fish can be raised. In a fish pen, the bottom of the lake forms the bottom of the pen. Pen has the advantage of containing a benthic fauna which serves as food for the fish and polycultue can be practiced in pens as it is in ponds. The environment in fish pen is characterized by a free exchange of water with the enclosing water body and high dissolved oxygen concentrations.

Advantages:

a. Intensive utilization of available space : Stocking density can be increased compared to that of a pond culture system

b. Safety from predators: Within the enclosure the predators can be excluded. In the larger pens this would be more difficult, but in smaller pens this can be done as efficiently.

c. Suitability for culturing many varied species : Due availability of more space and the natural water system

d. Ease of harvest : In the large pens the harvest may not be as easy as in cage rearing but it more controllable and easier than in the natural waters.

e. The flexibility of size and economy : When compared with the cage, pens can be made much larger and construction costs will be cheaper than that of the cages.

f. Availability of natural food and exchange of materials with the bottom : Since, the bottom of the pen is the natural bottom, the pen cultured organisms are at an advantage that they can procure food/exchange materials from the natural bottom.

Disadvantages:

a. High demand for oxygen and water flow

b. Dependence on artificial feed

c. Food losses : Part of the feed is likely to be lost uneaten, and drifted away in the current, but the loss here would be less than in floating cages.

d. Pollution : Since a large biomass of fish are cultured intensively a large quantity of excrements accumulate in the area and cause a high BOD - also substances such as ammonia and other excreted materials, if not immediately removed/ recycled. They pollute the water and cause damages.

e. Rapid spread of diseases : For the same reason of high stocking density in an enclosed area, any disease beginning will spread very quickly and can cause immense mortality of stock and production decline.

f. Risk of theft : Since the fish are kept in an enclosed area, 'poaching' and thefts can take place more frequently than in natural waters, but perhaps less than those from cages.

g. Conflict with multiple use of natural waters : In locations where a pen is constructed, if the water is used for multipurpose like irrigation and recreational activities, such as swimming, boating etc. may lead to conflicts.

UNIT-IV

* Commercial value of prawns*

1. Palaemon Styliferus (Rushna Chingri):

Distribution – Pakistan to Malay Archipelago. In India, present along the northern regions of both coasts.

Maximum size – 90 mm

Fishery importance in India – One of the most important fisheries of the Gangetic Delta.

2. Macrobrachium Malcomsonii:

Distribution – India and Myanmar. Present in the peninsular rivers of India and migrates into brackish waters during breeding season.

Maximum size – Male-230 mm Female-200 mm

Fishery importance in India – Fairly good fishery during monsoon in North-East Coast.

3.Macrobrachium Rosenbergii (Golda Chingri):
Distribution – Wide distribution, it extends from the Indo-Pacific zone up to Indo- China. In India common in lakes and estuaries.

Maximum size – 320 mm

Fishery importance in India – Very good fishery during the monsoon and post-monsoon months, particularly in Kerala.

4. Macrobrachium Rude:
Distribution – India (South-West Coast and East Coast), East Africa, Madagascar and Sri Lanka.

Maximum size – 130 mm

Fishery importance in India – Good seasonal fishery in Orissa. Bengal and Andhra Pradesh.

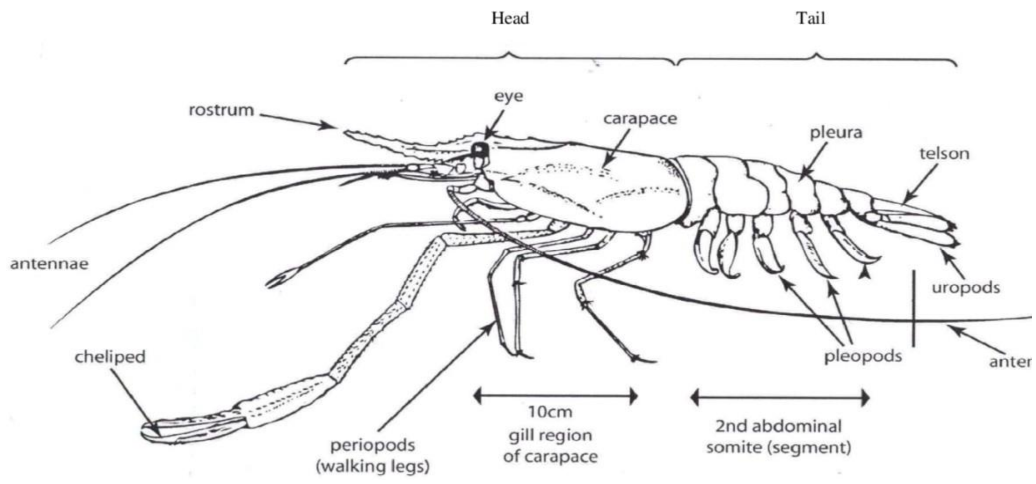
5. Metapenaeus Affinis:
Distribution – Found along the coasts of India. Indian seas to Malaysia, parts of Indonesia to Hong Kong and Japan.

Maximum size – 180 mm

Fishery importance in India – Very important fisheries along both the coasts. Juveniles are caught from estuaries.

Machrobrachium rsenbergii

- This species is suitable for culture in confined waters.
- Rostrum long, sword shaped 13-14 dorsal spines dorsally and 11 rostral spines ventarally.
- -the second pals of working legs of male develop abnormally with well developed chela and thus sexual dimorphism exhibitied.
- It occurs in rivers, estuaries and coastal areas migrates to estuaries during breeding season.
- lorgest among fresh water prawns, attains a maximum length of 32 cm (male) 25cm female.
- 3 It is an omnivorous, bottom, feeder, feeding on molluscs, worms, insects small crustaceans, vegetable matter, tender leaves, aquatic weeds etc
- The breeding season to east coast is from Dec-July with peak in march- may whereas in west coast it is from AUG-Dec. the sizee at first maturity 14 cm. fecundity 7000-5,00,000



Pond preparation

Pond Management:

Pond Preparation: Before a pond can be stocked for a new crop, the excessive wastes, which accumulate in the pond during the previous crop, must be removed and the soil and water conditioned.

Pond Cleaning: The cleaning of a pond or removal of the wastes, especially the organic and phosphatic wastes that have accumulated in the pond bottom could be, accomplished by drying, liming and ploughing.

Liming: Once the pond is cleaned, it is then filled with water and left overnight before flushing out to remove debris and elevate the pH. This process should be repeated until the pH of the water remains above 7, and only then the lime is applied. The types of lime to be used depend on the water pH. It is recommended that agricultural lime (CaCO3) or dolomite [CaMg(CO3)2] should be used in a pond with water pH near neutral and the hydrated lime [$Ca(OH)_2$] should be used in a pond with water pH below 5.

Eradication of Predators: After liming, the pond should be filled to the maximum depth through a screen with fine mesh to prevent the predators and competitors from entering the pond. These animals, including fish, crustaceans and some invertebrates, may compete for food, prey on the shrimp or carry diseases and parasites.Some chemicals should be used to eradicate these animals in the pond before stocking. Fish can be killed by the application of tea seed powder at the rate of 20-30 ppm.

Fertilization: The pond must be fertilized with either organic or inorganic fertilizer to stimulate the plankton bloom in order to provide shade to the pond bottom. The shade will also prevent the growth of harmful benthic algae. The sun dried chicken manure is the most common organic fertilizer to be used in the amount of 200-300 kg/ha.

Inorganic fertilizers, such as urea and compound fertilizers like, ammonium phosphate or those with N:P:K combination of (16:16:16) can be used at 20-30 kg./ha. The fertilizer must be dissolved in water before it is spread over the water surface which will enrich the soil and accelerate the growth of benthic algae.

Stocking:

The most suitable species for culture in India are the Indian white prawn Penaeus indicus and tiger prawn P. monodon. The stocking density varies with the type of system adopted and the species selected for the culture. As per the directives of Supreme Court only traditional and improved traditional shrimp farming can be undertaken within the Coastal Regulation Zone (CRZ) with a production range of 1 to 1.5 t/ha/crop with stocking density of 40,000 to 60,000/ha/crop. Outside CRZ extensive shrimp farming with a production range of 2.5 to 3 t/ha/crop with stocking density of 1,00,000/ha/crop may be allowed.

*** Biology of M.malcomsonii***

- commonly called Riven prawn
- -The rostrum is shost and straight. It bears 11 -12 dorsal spines and 4-5 ventral spines.
- the second pair of walking legs of male develop chela and thus sexual dimorphism is exhibited the second pots of legs are longer than the body and stout.
- They migrate in rivers to estuaries during breeding season.
- It occurs in rivers and attain a maximum length ao 23 cm (male) 20 cm (female)
- It is a benthophgic omnivores and feeds on worms, insects, molluscans, crustaceans. algae, vegetable matter and weeds
- It breeds during April - November with a peak period of June-July.

- -The size at first maturity is 4cm. The fecundity 4000-60,000

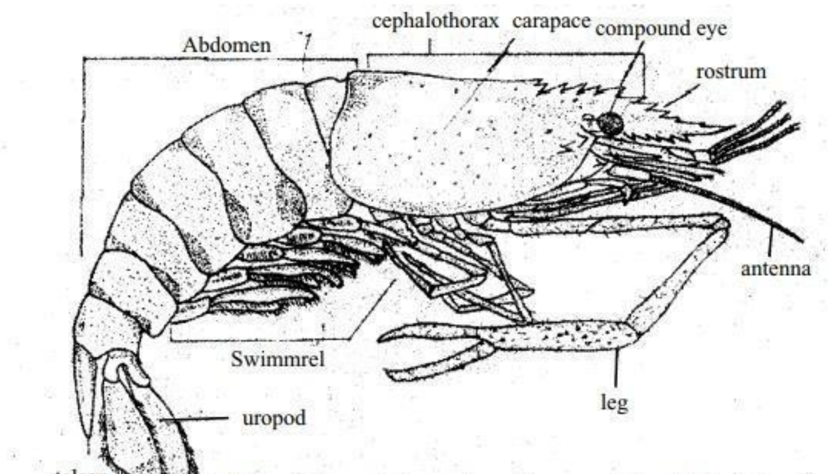


Fig : External characters of prawn (lateral view)

Macrobrachium malcomsni

*** SEED PRODUCTION***

- The berried female bearing dark grey coloured eggs are sourced from the brood stock pond or natural waters and is held in PVC pipes or cylinders capped on both sides with netting to prevent puncturing of the bag.
- The rostrum and telson are capped with protective rubber tubes. Temperature is controlled using ice bags in the container during transportation.
- Starving of prawn for a few hours before packing reduces accumulation of metabolites during transport. Immediately after arrival at the hatchery, the berried prawn is given a bath in 100 ppm formalin for 10 minutes followed by rinsing in freshwater to eliminate the epifauna, if any.
- The berried female is kept individually in separate FRP tanks of 500 l capacity with 300 l filtered water at 6 ppt salinity and fed with oyster or clam meat. Mild aeration is provided continuously. Left over feed and metabolic wastes are removed from the tank and half of the water is replaced during every morning hours.
- *Maturity stages*

- Initially, the colour of the egg is yellow, then it changes to bright orange to pale grey, and further it darkens to slate grey by the time of hatching.
- Once, the egg colour turns dark grey, hatching will be started within 48-72 hours at 26-31^{0}C.
  The larvae are collected in the early morning using a scoop net. Soon after hatching, female is carefully shifted back to stock tank.

Nursery pond

Nursery pond is a small water body which may be seasonal or perennial, but having sufficient fertility, of the soil and water for the natural production of planktonic organisms.

This pond is used only for rearing in a restricted period(3 -4 days old spawn to 15 -20 days till they grow to fry stage) of fish life cycle.

Earthen pond : area- 0. 02 -0. 1 ha, depth- 1. 0 -1. 5 m(tropical) 0. 5 to 1. 0 m(temperate)
Concrete tank: area-50 -100 m 2 provide with soil base of 15 -20 cm

Nursery management Principle of nursery management:

Nursery management is based on the principle of bringing about suitable and proper ecological, physico-chemical and biological conditions in pond, where by protection from harmful external agencies and promotion of optimum growth of fish young, will be ensured in natural conditions or through human manipulation.

The various operations involved in nursery managements are directed to meet the above principle.

UNIT-V

PEANAEUS MONODON

- The Giant Tiger prawn is a marine crustacean which is cultivated widely for food. It is also known as **Asian tiger shrimp**, **Penaeus monodon** and many other different names in different part of the world.
- It is native to Southeast Asia, the Philippines and Australia. It was also introduced into the United States for mariculture.
- Giant Tiger prawn is also found in the Indian Ocean and western Pacific and is distributed from east and southeast Africa to northern and eastern Australia, Japan, Pakistan and the Malay Archipelago.
- The Giant Tiger prawn is cultivated commercially in much of it's range. It is an invasive species in the northern waters of the Gulf of Mexico and the Atlantic Ocean of the southern United States. However, read some more information about Giant Tiger prawn below.
- The Giant Tiger prawn are the largest commercially available shrimp. They are generally dark colored, with the carapace and abdomen transversely banded with black and white.
- The rest of their body color is variable, ranging from light brown to blue or red. But some smaller specimens show a dull red dorsal strip from the rostrum to the sixth abdominal segment.
- The thorax has a spine called the rostrum, one pair of eyes, two pairs of antennae, three pairs of maxillipeds for feeding and five pairs of walking legs.
- The female Giant Tiger prawn can reach about 33 cm body length, but their average body length is between 25 and 30 cm. The males are slightly smaller than the females.
- The males can reach about 20-25 cm body length. The males can gain between 100 and 170 grams body weight.
- And average live body weight of the mature females is between 200 and 320 grams.

Feeding

- The Giant Tiger prawn are generally fed on commercial feeds. Each major producing country has developed it's own commercial feed factories, as shrimp feed technology has been readily available.
- This system has reduced feed production costs, instead of relying on expensive imported feeds.
- Prolonged storage of imported feed caused by sea transport or because of the necessity to import economically large volumes in each order, tends to reduce feed quality due to the rancidity.
- Under natural conditions, the giant tiger prawn is more of a predator than an omnivorous scavenger or detritus feeder than other penaeid shrimp.

- **Breeding**
- Wild male Giant Tiger prawn produce spermatozoa from around 35 grams body weight, and the females become gravid from their 70 grams body weight.
- Their mating generally occurs at night, shortly after moulting, while the cuticle is still soft, and sperm are subsequently kept in a spermatophore (sac) inserted inside the closed thelycum of the female.

- The females of the Giant Tiger prawn are highly fecund. The gravid females can produce as many as 0.5 million to 0.75 million eggs. Spawning generally occurs at night and fertilization is external.
- The females release sperm from the thelycum as eggs are released in offshore waters. Hatching occurs after 12-15 hours of fertilization.

Uses

- The Giant Tiger prawn is mainly used for food. It has a very important role in the economy of many south Asian countries.
- The Giant Tiger prawn is the second-most widely farmed prawn species in the world, after only whiteleg shrimp. They are generally inhabitants and found at depths from 0 to 110 meters.
- They inhabit bottom mud and sand. They can live in brakish, estuarine and marine environments. They prefer and do well in water temperatures of 18-34.5 °C, and salinities of 5-45 ppt.
- Although this shrimp has grown commercially at salinities of 1-5 ppt. It appears to select muddy mangrove channels and often associates with marginal or floating vegetation.
- Bamboo traps are traditionally used for harvesting selected large shrimp in extensive culture.
- In semi-intensive system, the Giant Tiger prawn are harvested by draining the pond by tide through a bag net installed at the outlet sluice gate.
- The shrimp are sold directly after harvesting, or kept in iced water. However, review full breed profile of the Giant Tiger prawn in the following chart.

Check tray

To assess the feeding and save feeding from wastage and further deterioxation and to increase profitability in culture feed trays are kept along the periphery of the ponds.

- Feed trays are generally 2×2 feet nets with frame with a float for identification location.
- A pond of 1 hec size would need 4_6 feeding trays about 1_4% daily ration is kept in these feeding trays/ check trays.
- Every day after each feeding the feed in the feeding tray is checked to know whether feed is fully consumed.
- Depending on the quantity consumed the adjustment of feed is made
- Since, shrimps are under water and always in dynamic movement it is very difficult to assess the exact number of shrimps available in the pond during stock assessment.Hence survival can be checked based on the actual quantity of feed consumed per day.
- Survival rate= Actual feed consumed/ calculated feed requirement
- Feed requirement is estimated based on the calculated survival rate.
- If pond is well prepared without any predators the calculated quantity of feed should be consumed.
- If calculated feed is not consumed due to decrease or reduction in survival rate feeding ration should be adjusted.

- Average amount of unconsumed feeding remaining in trays adjustment to feeding rate.

Mixed culture

The rapid expansion of shrimp culture over the last decade and its contribution to foreign exchange earnings has been quite remarkable. Shrimp culture covered an area of 1.4 lakh ha in 1995-'96 in contrast to 0.87 ha in 1985-'86 (DoF 1998). The biology of these two species are mostly associated with the salinity of the environment. The former is regarded as the marine or brackishwater species and the latter as freshwater species depending on their environment. In most cases, monoculture of both the species are being practiced and recently, polyculture with fin fish has been started (Hoq et al. 1996). However, as the market price of fin fish is much lower than that of shrimp, farmers could not show interest to practice polyculture with fin fish rather than mixed culture of both marine and freshwater shrimp species in the same ghers or ponds. There are a vast area of semi-saline waters in wide-spread coastal belt of Bangladesh in which salinity M.E. Azim eta/. fluctuate from about 0 to 20 ppt. This type of waterbodies could be used for culturing of both golda and bagda. However, farmers in this region is practicing mixed culture of golda and bagda round the year without comprehensive study on their biological characteristics, inter-species relationship, stocking ratios and production performance. Under the Aquaculture Research for Sustainable Development Project, Bangladesh Fisheries Research Institute (BFRI) undertook this study to determine growth, survival, yield and economics of golda and bagda in polyculture system.

Materials and methods Experimental site and gher preparation The experiment was conducted for a period of 10 months from April'97 to January '98 in four farmer's ghers at Dumuria Thana of Khulna district. All ghers were newly constructed and equal in size and depth with an area of 0.5 ha and an average depth of 1.0 m. The experimental area was low-land floodplain area beside the river Hamkura which is a dead one, flowing only in the rainy season. Lands of gher were leased from land owner for a period of 10 years except gher 4. In December-January, embankments of the ghers were constructed. Each gher was made in such a way that a deep drain (about 2.5 m) at the two border side of the ghers were made and the soil was used to make the embankment. Embankments were made wider (1 m) for escaping break down during the rainy season. Different types of vegetables were cultured on to the embankment. The ghers were ploughed and treated with lime (80 kg/gher) and cowdung (500 kg/gher) in February. In March, the ghers were filled up with water by low-lift pump and afterwards ghers were received rain water.
Stocking of slnimp and fish Stocking of shrimp and fish seeds started from April and continued up to June, 1997 on an irregular basis in all of the experimental ghers. As practiced, farmers did not agree to stock fin fish alongside the shrimp, but they were motivated to stock few fin fish in the experimental ghers except gher 4. However, farmers had the freedom to maintain all aspects of stocking and management practices with a little suggestion from the respective scientist. Fry

Macrobrachium rossenbergii (locally called golda) and Penaeus monodon (locally called bagda), and fingerlings of fin fish were procured from natural sources through local traders.
Detailed species combinations and stocking densities in different ghers are presented in Table 1.
Table 1. Species combinations and stocking densities in different experimental ghers

Table 1. Species combinations and stocking densities in different experimental ghers

Species	Gher 1	Gher 2	Gher 3	Gher 4
Macrobrachium rossenbergii	27,600	9,250	8,500	16,500
Penaeus monodon	6,900	9,250	8,500	1,000
Fin fish	500	1500	500	--
Total	35,000	20,000	17,500	17,500

Gher management
A feeding programme was maintained to each pond on more or less regular and daily basis as appeared in Table 2. A mixture of rice bran and fish meal with or without mustard oil cake was supplied in the morning and snail meat in the evening to the experimental ghers. No fertilizer was applied to the ghers during the culture period. Some shelters made of coconut branches and plastic pipe were kept on the bottom of ghers so that the shrimps could take shelter during their molting. Shrimp and fish samples were collected monthly with a cast net to check up their health condition

Table 2. Summary of the feeding programme applied to the experimental ghers

Food Item	Gher 1	Gher 2	Gher 3	Gher 4
Rice/wheat bran (kg)	1.0	2.0	3.5	1.0
Mustard oil cake (kg)	1.0	Nil	Nil	Nil
Fish meal (kg)	0.5	1.0	1.0	1.0
Snail meat (kg)	2.5	3.5	4.0	4.0
Total	5.0	6.5	8.5	6.0

Study of water quality parameters Some water quality observations - temperature, pH, salinity, Dissolved Oxygen (DO) and total hardness were recorded during 1000-llOO h at monthly intervals using a HACH kit (FF-2).
Harvesting The farmers started harvesting of farmed animals in irregular basis from August 1997 to January 1998 with a seine net and sold the products to the local depot. The grade (size) of shrimp, quantity, respective price and total cost were recorded regularly. In January, all the ghers were de-watered and all the marketable animals were harvested.

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