Package of Practices for Breeding and Culture of Commercially Important Freshwater Fish Species






NFDB

National Fisheries Development Board

Department of Animal Husbandry, Dairying & Fisheries

Ministry of Agriculture & Farmers Welfare, Govt. of India

Hyderabad – 500 052

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FOREWORD

India with an annual fish production of about 11.41 million tonnes stands second among the top ten fish producing countries in the world. Quite significantly, nearly 50% of this production is from Aquaculture, especially from freshwater fish farming. Bulk of the Inland Aquaculture production comes from farming of the three Indian Major Carps – Catla, Rohu and Mrigal - also known as Gangetic Carps that inhabit the major river systems in the country, and a few exotic species.

Owing to the varied habitats and rich biodiversity in the country, there are a number of other species of freshwater fishes that are distributed in different geographical and climatic zones. Out of the 838 freshwater fish species occurring in India, 450 fish are categorized under ***Small Indigenous Species (SIS)***, which grow to a maximum length of 25-30 cm. They are in great demand because of their superior nutritional value and consumer preference. Some of them command a very high price in the domestic market, especially in the North-East States. However, these species owing to their biological characteristics and environmental preferences are difficult to breed and propagate. Over the years Scientists from different Fisheries Research Institutes of the Indian Council of Agricultural Research, Govt. of India, have strived hard to overcome the limitations and developed technologies for breeding and farming of these species under confined conditions. Results of these studies are presented in the Handbook – *'Package of Practices for Breeding and Culture of Commercially Important Freshwater Fish Species'.*

The authors have presented Package of Practices for breeding, seed production and culture of a group of fishes, some being '***SIS Fish***', some declared as '***State Fish***', vij., (i) Striped Murrel (*Channa striatus*), (ii) Magur (*Clarias batrachus*), (iii) Singhi (*Heteropneustes fossilis*), (iv) Indigenous Minor Carps (*Labeo fimbriatus, L. gonius, L. bata, Cirrhinus reba*), Pengba

(*Osteobrama belangeri*) and Barbs (*Puntius sarana, P. pulchellus, P. gonionotus*), (v) Golden Mahseer (*Tor putitora*), (vi) Rainbow Trout (*Oncorhynchus mykiss*), (vii) Pabda (*Opmak bimaculatus*) and (viii) Giant Freshwater Prawn Scampi (*Macrobrachium rosenbergii*).

This Handbook would be of immense help to field functionaries of the Dept. of Fisheries, progressive fish farmers and entrepreneurs, to domesticate, propagate and culture these fishes in the States where they occur naturally and are in great demand as food fishes, especially in the North and North Eastern States of India. Enhancing their production would certainly meet the protein requirement of those people living in far flung and remote areas across the country. Also, there is renewed interest in the Giant Freshwater Prawn, Scampi, for not only stocking reservoirs to augment its culture-based capture fishery, but also to revive its culture in farm ponds owing to demand in the domestic as well as export markets.

I compliment the Directors and Scientists of the Central Institute of Freshwater Aquaculture (ICAR-CIFA), Bhubaneswar, and the Directorate of Coldwater Fisheries Research (ICAR-DCFR), Bhimtal, for contributing the articles on package of practices pertaining to some of the indigenous and valuable species.

I would also like to place on record my sincere appreciation to Dr. K. Ravindranath, Senior Consultant (Technical), NFDB, for the meticulous and excellent editing.

Hyderabad
27 September 2018

(I. Rani Kumudini)

Contents

Induced Breeding and Seed Production of Striped Murrel, *Channa striatus*

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1. Introduction

Murrels are very important air-breathing indigenous freshwater fishes of India. They are commonly known as snakehead or serpent-headed fish due to the elongated and cylindrical body, flattened head and presence of eyes on the anterior part of head. The commercially important Murrel species in India are *Channa striatus* (Bloch, 1793), *C. marulius* (Hamilton, 1822) and *C. punctatus* (Bloch, 1793); they fetch high price (Rs. 250-500/kg) in many States like Madhya Pradesh, Bihar, Uttar Pradesh, Haryana, Andhra Pradesh, Karnataka, Tamil Nadu and all North-East States. They have high consumer preference because of nice flavour, meaty flesh with few intra-muscular bones and medicinal value. These fishes are considered as high-value food fishes and marketed in live condition, as they can be kept alive for several hours outside water. The good growth rate, high consumer preferences, lucrative market value and their ability to withstand adverse water conditions make them suitable candidate species for freshwater aquaculture. The demand for Striped Murrel seed is presently being met from wild collections. However, commercial culture of Striped Murrel is still not common due to inadequate availability of seed. Therefore, to meet the challenge of seed scarcity, ICAR-CIFA developed induced breeding technology of Striped Murrel in hatchery condition.

2. Captive Broodstock Development

The collection of Striped Murrel brooders, for induced breeding, from earthen pond, is quite difficult as fish undergo stress which results in poor breeding response. Therefore, protocol has been standardized for growing brood-stock in cement concrete cisterns/ tanks by providing habitat conditions, feed and manipulating hormonal levels for better breeding response in hatchery condition.

Fish weighing 200-250 g each are stocked at a density of 2/m^2 in concrete cisterns/tanks during winter months (November-January). A brief description of the protocol is provided below.

Fig.1. Striped Murrel, *Channa striatus*

2.1 Habitat and Feed Management

The cement tank bottom is provided with 15 cm thick layer of soil. Floating aquatic macrophytes are added and maintained in about 20% water-spread area to simulate natural environment. Fish are fed 3% of their biomass, 1% comprising of live insects/prawn/ small fish and 2% of trash fish & rice bran (3:1). Recently, ICAR-CIFA has formulated and developed pellet feed with good acceptability for brood fishes. Total replacement of water is done at weekly interval to maintain the water quality.

2.2 Preparing and Implanting Sustained-release Hormone Pellet

Pellets containing hormones are implanted in the fish for sustained-release of hormone to advance and synchronize maturation of gonads. Twenty parts of cholesterol and one part of binder (Gelatin: Gum Acacia - 1:1) are mixed well with the help of mortar and pestle. The required quantity of HCG hormone is added and mixed thoroughly. Ethyl alcohol (50%) is added and continuously mixed to get a gel-like consistency. The HCG Hormone Pellets of 2 mm x 4 mm size (oval/rice-grain shaped) and weighing 15-20 mg are made by hand. The hormone concentration of the pellets is adjusted according to the requirements and it may range from 200-1000 IU of HCG. The GnRHa Pellet is also made similarly except that the mixture is kept at 35 °C for drying to get a gel-like consistency.

The pellet is implanted intramuscularly on the dorsal side of the female and male fish. Small incision is made on the skin and the Sustained-release Hormone Pellet is pushed into the muscle manually. After proper implantation of pellet, antibiotic cream is applied on the incision. It has been observed that the wound gets healed completely in a week and only a tiny black scar could be seen after two weeks. The oval/ rice-grain shaped pellets are easy to implant and also it requires very small incision in the fish muscle*. Therefore, fish are less stressed and the chance of rejection is also minimized. Brooder fish are implanted hormone pellet at the rate of 500-1000 IU HCG/ kg body weight in the month of February. By the end of April gonads matured fully and remained mature till September. The gonad development was good and about 80-90% of brood fishes showed gonadal maturity. These brooders showed better spawning performance upon induced breeding under hatchery condition.

3. Induced Breeding in Hatchery

In India Murrels spawn naturally during southwest monsoon (June-August) and also in northeast monsoon (October-December) in flooded rivers. The spawning season is different in different regions depending upon the pattern of rainfall. The males and females can be easily distinguished during the spawning season by their secondary sexual characters. Females exhibit slightly bulged abdomen, round and reddish vent, anal papilla is broad and blunt with reddish dots, whereas

*Hormone pellets can also be made using a Pellet Mould and implanted by means of an Implanter. Branded hormone pellets are implanted using a Pellet-gun. – Editor

Fig. 3. Female Striped Murrel

Fig. 2. Male Striped Murrel

males exhibit pale vent, and the anal papilla is prominent with a pointed tip. *Channa striatus* female weighing 300-600 g and male weighing 400-800 g gives better breeding performance under hatchery condition. Striped Murrel does not require water circulation in breeding pool and spawns successfully in stagnant freshwater. Breeding pool is filled with water (26-30 °C) and one-fifth of the water surface area is covered with floating aquatic macrophyte (waterhyacinth). It is important to keep at least two feet of free board in breeding pool, which has a net covering, to avoid fish jumping out during spawning. The floating aquatic macrophyte is not essential but it probably helps in simulating a natural environment and this fish usually prefers to lay eggs in a nest made of aquatic vegetation. Any of the inducing agents can be injected intramuscularly to the female and male fish at the following doses: HCG @ 2000 IU/ kg and 1500 IU/ kg body weight; Carp pituitary gland extract (PGE) @ 10-15 mg/kg body weight and 7.5-10 mg/kg body weight; Ovatide/ Ovaprim @ 0.6 ml/kg body weight and 0.4 ml/kg body weight, respectively. Injection is given at the base of pectoral fins. Before spawning they move in pair and chase each other. Spawning occurs after 16-18 hours. Eggs are spherical, non-adhesive, free floating and straw yellow in colour. Fertilized eggs are transparent and unfertilized eggs are opaque/white. The size of the fertilized eggs range between 1.1-1.4 mm. Eggs are collected with the help of plankton net and kept in FRP tanks for hatching. The average fecundity is in the range of 10,000-15,000 eggs/ kg body weight.

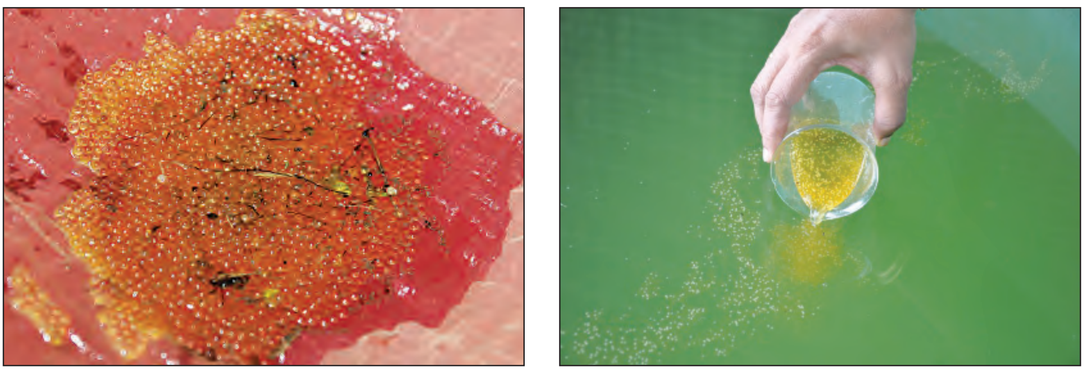

Fig. 4. Striped Murrel Fertilized Eggs

Incubation time is 16-18 hours. The fertilization and hatching rate range between 75-98% and 70-95%, respectively; the success rate was better with Carp pituitary gland extract. Size of the newly hatched larvae is 3.0-3.5 mm. Feeding starts 72 hours after hatching. Micro-zooplankton, especially rotifers are preferred food of hatchlings.

Fig. 5. Striped Murrel Spawn

Fig. 6. Striped Murrel Fry

4. Nursing Spawn to Fry

It is recommended to rear the larvae in indoor concrete or fiber reinforced plastic (FRP) tanks. Larval feeding starts after 72 hours of hatching because yolk sac in larvae serves as stored food during this period. After yolk sac absorption, the larvae are fed *ad libitum* with either zooplankton or *Artemia* nauplii. A stocking density of 2,500 nos/ m^3 of water is optimum for better growth and survival. Optimum water quality is to be maintained by exchanging water daily during the nursery phase. They attain 25-30 mm size in 20-25 days. Survival in nursery rearing (spawn to fry) ranges between 50-60%. After three weeks of indoor nursing, fry should be transferred to outdoor tanks.

5. Rearing Fry to Fingerlings

Striped Murrel fry are further reared in outdoor concrete tanks of 5-15 m^2 for fingerlings production. Stocking density of 200-250 nos/m^2 is considered optimum for good growth and survival. Fry should be fed with small crustaceans, mainly aquatic insects, tubifex, chopped earthworms, etc. They prefer aquatic insects because of their habit to chase the prey. Powdered fish meal and soya flour (3:1) @ 5-10% of their body weight should be sprinkled twice a day in addition to live-feed. The fingerlings of *C. striatus* prefer live-feed but its availability in bulk is a constraint in rearing

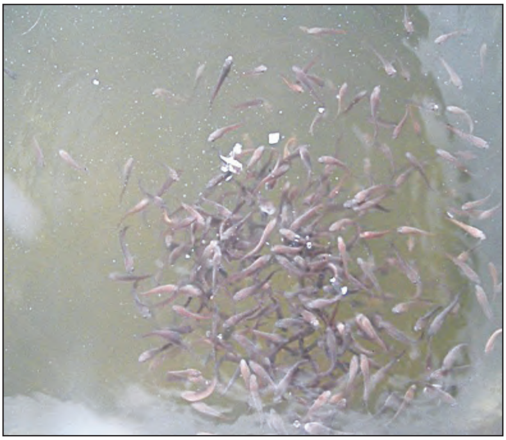

Fig. 7. Striped Murrel Fingerlings

them. To overcome this problem boiled trash fish/poultry offal and oil cake and rice bran (3:1) is given in moist condition. Trash fish after proper mincing along with rice bran is well accepted by fingerlings, but in the absence of trash fish, boiled and minced poultry offal in combination with rice bran and vitamin-mineral mix can also be given. A pellet feed for the Striped Murrel fingerling has been formulated and evaluated and has given good growth and survival. Protein requirement for fingerlings is about 44%. Average survival from fry to fingerlings is 30-40%.

Size heterogeneity and cannibalism is a major concern which leads to poor survival during rearing fry to fingerlings. It has been observed that 2-3% of fry turned into shoot-fry during rearing, which takes heavy toll on smaller size fry. It is therefore necessary to net the rearing tank at weekly interval and check for shoot-fry/fingerling and rear them separately. Periodic segregation and separate rearing of shooters is essential to achieve higher survival and returns.

* * *

Breeding and Grow-out Culture of Magur, *Clarias batrachus**

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1. Introduction

Clarias batrachus (Linnaeus, 1758), popularly known as "Magur" in India, has good consumer preference in various parts of the country especially in States such as Odisha, West Bengal, Bihar and North Eastern States due to its good taste, flavour and therapeutic values. It fetches high market price and is sold at Rs.200-400/kg. Magur is generally stocked at higher densities i.e., 5-10 times higher than the carps because of its hardy and air-breathing nature. The availability of magur seed is inadequate to meet the demand of the fish farmers and entrepreneurs, as there are very few Magur Hatcheries in the country. Breeding failure, early larval mortality, lack of suitable feed, infrastructure necessary for rearing or degree of involvement, etc. are some of the bottlenecks for its seed production. ICAR-Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar, has developed breeding, seed production and grow-out culture technology of this species and is involved in disseminating the technology through trainings and demonstrations. A brief account of hatchery and grow-out technology developed by ICAR-CIFA is provided below.

2. Broodstock Management

- Brooders of 100-200 g are maintained in small ponds (100-200 m^2) or tanks at a stocking density of 3-4 fish per m^3.
- Brooders require good water quality and proper feed to attain maturity under captive condition.
- Cement or concrete tanks, with 4-6 cm thick soil provided on the bottom, are recommended for raising brooders.
- Brood fish are stocked in the cisterns at least two to three months prior to breeding season to avoid problem of collecting from ponds during rainy season.

Fig. 1. Feeding Magur brooders in pond

******Clarias batrachus* (Linnaeus, 1758) distribution is now restricted to Java Island of Indonesia; the populations of 'Magur' occurring in India and Bangladesh belong to *Clarias magur* (Hamilton, 1822). – Editor

- Brooders are fed twice daily with fishmeal based feed containing 30-35% protein @ 3-5% of the body weight.
- Water quality in brooder tanks should be maintained at optimum level by exchanging 20-30% water at fortnightly intervals.

3. Selection of Brooders

- Magur attains sexual maturity at the age of one year; it is considered a monsoon breeder and usually breeds during June to August.
- Brood fish of 100-150 g are considered ideal size for induced breeding operation during June-August.
- Male has elongated and pointed genital papilla near anus whereas female has round and button shaped genital papilla and in case of fully mature female, bulging abdomen and reddish vent indicate readiness to spawn.

Fig. 2. Sex differentiation in Magur

- Female maturity stages can be examined by gently inserting a soft-flexible catheter into the vent. The female is suitable for breeding when egg size is 1.2 to 1.4 mm.
- The selected brooders are separated sex wise and kept in the indoor tanks for induced breeding operation.

4. Induced Breeding

- Synthetic hormones such as Ovaprim/ Ovatide/ WOVA-FH/ Gonopro and Carp pituitary gland extract have been successfully used as inducing agent in Magur.
- Successful induced breeding requires 1-1.5 ml/kg body weight synthetic hormone (Ovaprim/ Ovatide/ WOVA-FH/ Gonopro).
- The optimum dose of Carp pituitary gland extract is 30-40 mg/kg body weight.
- The females are stripped 17 h after injecting hormone to get ovulated eggs.


Fig. 3. Administering synthetic hormone to Magur

4.1 Sperm Suspension Preparation

Fig. 4. Collection of testis in Magur

- Male brooder of 100-150 g should be selected for breeding operation.
- As the male brooders do not respond to stripping, the males are sacrificed for collection of testis.
- The male with creamy white testis is selected for preparing sperm suspension.
- The sperm suspension can be prepared by macerating testis in normal saline solution (0.9% Sodium chloride, NaCl: 9 g in 1 litre of water).
- The ideal sex ratio for higher fertilization rate is 1 male and 2-3 females.

Fig. 5. Preparation of Magur sperm suspension

4.2 Fertilization

- Eggs stripped into a plastic tray are fertilized with the sperm suspension.
- Eggs are mixed thoroughly with the help of a bird feather and a little quantity of water is added to egg mass for activation of sperms and successful fertilization.
- After 2-3 min of mixing, the eggs are washed thoroughly in running water and shifted to the flow-through incubation tubs.

Fig. 6. Adding sperm suspension on Magur egg mass

- Fertilized eggs of Magur are adhesive in nature and the light brown coloured eggs are considered good whereas white coloured eggs are unfertilized.

4.3 Flow-through Hatchery

- The indoor flow through hatchery consists of a metallic stand or concrete platform on which plastic tubs of at least 30 cm diameter and 15 cm height are placed in a row, each under a water tap (see figure). Each tub usually accommodates 1000 to 1500 eggs.
- Each plastic tub has provision for an outlet at about 4-5 cm below the edge.
- The fertilized eggs are uniformly distributed in the incubation tubs and a feeble water flow is provided to maintain optimum oxygen level.

Fig. 7. Flow-through Hatchery System: Incubation for 25-26 h @ 27-30 °C

- After hatching, the larvae and egg shells are separated by washing the hatching tubs.
- Hatching of incubated eggs takes about 24-27 h at 27-30 °C
- The newly hatched larvae measure about 4-6 mm in length and weigh 2-3 mg and possess yolk sac, which gets absorbed at the end of 3rd day.

Fig. 8. Spreading fertilized Magur eggs in incubation tubs

5. Nursery Phase (Larva to Fry)

5.1 Water Management

- Larvae being small and delicate require good aquatic environment for survival. Therefore, the quality and depth of water in indoor rearing system play a major role in their survival.
- Aerial respiration commences after 10-11 days and hence, the larval rearing tubs/tanks are provided with aeration for optimum dissolved oxygen.
- Accumulation of metabolites and unconsumed feed are common in rearing tubs/tanks and may pollute the environment, which ultimately cause oxygen depletion leading to incidence of disease and morality.
- Therefore, it is advised to replenish 50-60% of water twice daily and maintain water depth of 10-15 cm.
- The larvae should be reared in the indoor tanks for about 15-20 days at the stocking density of 1000-1500/m^2. Care should be taken to minimise disturbance during cleaning or refilling the tank.

Optimum water quality parameters for larval and fry rearing of *Clarias batrachus*

Water Quality Parameters	Optimum Range
Water temperature (°C)	27-30
Dissolved Oxygen (ppm)	> 3
Carbon Dioxide (ppm)	< 15
pH	7.0 - 8.5
Alkalinity (ppm)	90 -160
Hardness (ppm)	80-150
Ammonia (ppm)	< 0.05
Nitrite (ppm)	< 0.25

5.2 Larval Feed Management

- Zooplankton such as Copepod, Daphnia, Moina, *Artemia* nauplii, molluscan meat, tubifex and egg custard are often served as larval feed after yolk sac absorption (from 4th day onwards).
- Mixed zooplankton serves as good larval food during its early life and gradual withdrawal of live feed by compound feed (Starter-M: A product of ICAR-CIFA) from eight days onwards resulted in higher growth and survival of the larvae.
- Larvae should be fed at the rate of 8-10% of body weight and twice/thrice a day.
- Removal of leftover feed and bottom debris, continuous aeration, water management and optimum stocking density (1000-1500/m^2) are some of the practices usually followed during larval rearing.

Fig. 9. Live-feed (Copepods, Daphnia, Artemia nauplii) for Magur larvae

Fig. 10. Advanced Magur fry (15-20 days old)

- The larvae grow to 10-20 mm and 30-40 mg during 15-20 days of rearing. This is the ideal size for transferring to outdoor tanks for fingerling production.

5.3 Larval Health Management

Sustainable aquaculture production can be achieved only when fish are healthy and free from disease. Prevention of diseases is an essential step for the successful operation of any hatchery system. Magur larvae are very delicate and susceptible to various diseases and stress. Because of the complexity of the environment, larvae are susceptible to viral, bacterial, fungal, and parasitic infections. Provision of optimum rearing condition will result in increased survival of Magur larvae. Therefore, identifying and controlling disease are vital tasks during the hatchery operation.

5.3.1 Common Diseases

- Skin fluke, *Gyrodactylus* sp
- Ulcerative diseases cause by *Aeromonas caviae*
- Aeromoniasis bacterial disease
- Fungal infection

Treatment and Control of diseases common in larvae and fry of *Clarias batrachus*

Disease	Treatment and Control
Aeromoniasis	Oxytaetracycline 50-70 mg/kg feed for 10 days
Columnaris disease	Copper sulphate at a concentration of 1:2,000 for 15 minutes, followed by a bath in running water
Fungal disease	A mixture of malachite green (0.05 ppm) and formaldehyde (20 ppm); Also, 1-2 min dip in 2-3% salt solution may be useful

6. Economics of Magur Hatchery (production capacity of 1.5 lakh fry)

Sl.No.	Item	Amount (Rs)
A	**Fixed/ Capital Cost**	
1	Pond construction(0.01 ha)	10000
2	Hatchery shed (20x10m)	30000
3	Flow-through hatchery	15000
4	Electrical connection and fittings	5000
5	Round rearing tanks (1x0.3m)	50000
6	Aerators	2500
7	Operational equipment	1000
8	Overhead tank	5000
9	Electric pump and pipe fittings in hatchery	15000
	Sub-total	**1,33,500**
B	**Variable Cost**	
1	Brood stock (15 kg @ Rs. 250/kg)	3750
2	Feed (800 kg)	16000
3	Inducing agent (synthetic)	2000
4	Wage (one labour @ Rs. 3000 for 3 months)	9000
5	Miscellaneous expenditure	5000
	Sub-total	**40,750**
C	**Total Cost**	
1	Variable Cost	40750
2	Interest on fixed capital @ 13% per annum	17355
3	Depreciation on fixed capital @ 10% per annum	13350
	Grand Total	**71,455**
D	**Gross Income**	
	Sale of seed (1,50,000 fry) @ Rs. 750/1000 fry	1,12,500
E	**Net Income** (Gross Income-Total Cost: D-C)	**41,045**

7. Rearing Phase (Fry to Fingerling)

- Magur fry (about 15-20 mm length and 30-40 mg weight) are stocked @ 150-200/m^2 in concrete cisterns to raise fingerlings.
- The concrete nursery tanks (10-20 m^2) are provided with 2-3 cm soil bed and initial water level of 25-30 cm. Manuring the tanks is done like in carp nursery for plankton development, which serves as initial food for early-fry.

Fig.11. Rearing tanks (Fry to fingerling production)

- Floating weeds such as waterhyacinth and duck weed *Lemna* are placed in tanks for shade and shelter of fry.
- Magur fry are fed at the rate of 6-8% of body weight and twice/thrice a day.
- It is necessary to net-out filamentous algae developed due to nutrient leach from the compound feed or uneaten feed or faeces.

Fig. 12. Periodical removal of filamentous algae

- The fry reach about 3-5 g, in 3 months, the ideal size to stock grow-out culture ponds.

8. Grow-out Culture

- Small (0.02-0.1 ha) and shallow (0.75-1.0 m water depth) earthen ponds/stone pitched ponds/ concrete tanks are suitable for grow-out culture of Magur.
- Generally, a high density of 50,000-70,000/ha is recommended for culture of Magur, but lower stocking density can be adopted for higher growth of fish.

Fig. 13. Stocking of Magur fingerlings

- Stocking bigger sized seed (3-5 g) shows good survival and growth during grow-out culture.
- Magur is an air breather; they normally come up to the water surface for atmospheric oxygen. This behaviour attracts predatory birds. Therefore, it is required to cover the ponds with bird net to protect fish from bird predation.

8.1 Pre-stocking management

8.1.1 Site Selection

- Pond should not be dug in low lying area because it is always prone to inundation during rainy season.
- Soil should be tested for seepage loss of water.
- Clayey bottom is suitable for pond construction and sandy soil should be avoided.
- Pond construction should be in warm climate region where atmospheric temperature is 25-30 °C.
- Water should be free from any pollution.

8.1.2 Pond Construction

- For effective management, grow-out culture ponds should be 0.02 – 0.1 ha.
- Pond bund should have a suitable slope of 1:2-1:3.
- Pond with clay-loam soil is preferable.
- Pond sides must be stone pitched.
- Water depth may be maintained up to 1 m.

Fig. 14. Pond preparation

8.1.3 Pond Preparation

- Drying and exposing the pond bottom or application of mahua oil cake or bleaching powder are the best means of eradicating predatory and weed fishes as a pre-stocking management.
- Mahua oil cake can be applied @ 2500 kg/ha/m depth or bleaching powder @ 350 kg/ha, as recommended for carp culture.
- Liming depends on the pH of soil and water, where 200-250 kg/ha of agricultural lime is applied when the soil pH is above 6.0.

8.2 Culture Management

8.2.1 Water Quality Management

- Water quality management is an important aspect in successful farming operation. Accumulation of metabolites and leftover feed are common in culture ponds and may pollute the environment, which ultimately cause oxygen depletion leading to incidence of disease and morality.
- Therefore, it is advisable to replenish 20-30% of water as and when required to maintain water quality parameters at optimum level as shown below:

Optimum water quality parameters for grow-out culture of Magur

Water Quality Parameters	Optimum Range
Water Temperature (°C)	26-31
Dissolved Oxygen (ppm)	> 3
Carbon Dioxide (ppm)	< 15
pH	7.3 - 8.5
Alkalinity (ppm)	60-200
Hardness (ppm)	70-180
Ammonia (ppm)	< 0.1
Nitrite (ppm)	< 0.05

8.2.2 Feed Management

- Fishmeal based compound feed (30-32% protein) provides optimum nutrition for Magur growth.
- Magur fingerlings are fed twice a day at the rate of 3-5% of body weight in the feeding basket placed in different places of the pond to avoid competition between individuals while feeding.
- The feeding rate is adjusted based on the monthly sampling and feed consumption rate to avoid feed loss.
- Feeds like Starter-M, CIFA-Ma were developed at ICAR-CIFA for different life stages of Magur.
- The fishmeal based commercial feeds are available in the market and can also be used for grow-out culture of Magur.

8.2.3 Health Management

- Bacteria are among the most important pathogens of Magur, which may cause extensive losses.

Fig. 15. Diseased Magur with ulcerative lesions

- Mortality due to bacterial pathogens is often associated with environmental stress.
- Pond water with high levels of organic material may cause bacterial/fungal diseases in Magur.

Diseases and Control Measures

Disease	Causative Agent	Symptoms	Control Measures
Aeromoniasis	*Aeromonas hydrophila*; *Aeromonas punctata*	Erythema (redness) at the base of the fins, in and around the mouth; pinpoint haemorrhages	Oxytaetracycline @ 50-70 mg/kg body weight in feed for 10 days
Abdominal Dropsy	*Aeromonas hydrophila*	Accumulation of fluid in the body cavity; haemorrhages on internal organs	Potassium permanganate @ 5-10 ppm
Edwardsiellosis	*Edwardsiella tarda*	Extreme emaciation, anaemia, loss of skin, peeling off and dropping of skin and gas filled abscesses with foul smell	Oxytetracycline in the feed @ 50-60 mg/kg body weight/day for 10 days.
Fin Rot and Tail Rot	*Aeromonas liquifaciens, Aeromonas formicans; Pseudomonas fluorescens*	Progressive erosion and disintegration of fins and tail; whitening of the outer margin of the fins	Dip treatment in a 1:1 mixture of formalin and malachite green (1:40); Formaldehyde @ 20 ppm
Epizootic Ulcerative Syndrome (EUS)	*Aphanomyces invadans; Aeromonas hydrophila*	Ulcerative lesions throughout the body; severe haemorrhagic and necrotic lesions – secondarily infected with bacteria and/or fungi	CIFAX @ 500 ml/ha^{-m} controls the disease within 3-7 days

8.2.4 Production and Harvesting

- Magur attains marketable size of 100-150 g in a culture period of 10-12 months.
- Harvesting is done by complete dewatering and picking them manually from the culture ponds.
- Production of up to 2-3 tonnes/ha can be achieved in 10-12 months of culture period.

Fig. 16. A haul of Magur from farm pond

9. Market Potential

Clarias batrachus seed is in great demand in different parts of the country. A few hatcheries are established in private and Govt. sector in Odisha, West Bengal, Bihar, Chhattisgarh, Assam, Manipur and Tripura. Magur seed are usually sold at Rs. 1.0 per fry (20-day old).

10. Economics of Magur Culture (one hectare, leased-pond, per year)

Sl. No.	Item	Amount (Rs)
A	**Variable Costs**	
1	Pond lease value	10000
2	Seed cost (Rs. 5 per piece)	250000
3	Manuring	5000
4	Feed (5 tonnes @ Rs. 20/kg)	100000
5	Wages (Rs. 3000/month/labour)	36000
6	Harvesting expenses	5000
7	Miscellaneous expenditure	5000
	Sub-total	**4,11,000**
B	**Total Costs**	
1	Variable Costs	411000
2	Interest on Variable Costs @ 13%	53430
	Grand Total	**4,64,430**
C	**Gross Income**	
	Sale of Magur @ 250/kg for 2 tonnes	5,00,000
D	**Net Income** (Gross Income - Total Costs: C-B=D)	**35,570**

* * *

Breeding and Seed Production of Singhi, *Heteropneustes fossilis*

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1. Introduction

Heteropneustes fossilis (Bloch, 1794), commonly known as 'Singhi' or 'stinging catfish' belongs to the sub-order Siluroidei and family Sacchobranchidae; it is an excellent candidate species for fish culture. *H. fossilis* has good consumer preference in the Indian sub-continent because of its nutritional and medicinal value and commands high price. This species constitutes bulk of the production of air breathing fishes in India, which at present comes mainly from capture fisheries. The non-availability of seed is a constraint for its culture. In order to provide simpler technology for breeding and seed rearing, the ICAR-Central Institute of Freshwater Aquaculture has standardized the technique of seed production of *H. fossilis* in order to meet the growing seed demands from farmers.

2. Broodstock Management

Breeding season of *H. fossilisis* is normally between July to August. Broodstock can be collected from natural waters and reared under laboratory conditions in cement cisterns, providing mussel (bivalve mollusk) meat as feed. Also, male and female fish can be stocked in small ponds (100-200 m^2) at a density of 10-20 fish per m^3 and fed rice bran, fishmeal, soybean meal and oil cake. Ponds should be periodically manured for availability of natural food.

3. Hormone Administration

Singhi can be induce-bred by administering hormones through intramuscular injection. The following hormones and doses are effective for breeding female *H. fossilis*; male fish are administered half the dose given to female:

Fig. 1. Administering hormone to Singhi

- Pituitary Gland extract: 15-20 mg/kg body weight
- Ovaprim: 0.6-0.9 ml/kg body weight
- LHRHa and Pimozide: LHRHa 50 μg + 50 mg/kg body weight
- 17α-hydroxy-progesterone: 8 mg/kg body weight
- 17α-hydroxy-20β dihydro progesterone: 2 mg/kg body weight.

The muscle beneath the anterior dorsal fin and above the lateral line of the fish is the best spot for injecting inducing hormone. Hypodermic syringe needle of 19 or 21 gauge may be used, inserting at an angle of 30 degrees to the body and to a depth of 2-3 cm; care should be taken such that needle does not touch the vertebral column, otherwise fish may die. The hormone is injected slowly allowing it to disperse properly into the body, otherwise, when the needle is withdrawn, the solution may be ejected out. After injecting, the fish is left in a plastic tub having water circulating/ aeration.

4. Egg Stripping and Fertilization

The best way to fertilize catfish eggs is semi-wet method. The mature female fish releases eggs 11-14 hours after administering hormone injection. Females with ripe ovaries when given gentle pressure on the abdomen begin to release a few eggs. Such mature females are cleaned and dried from the abdomen to the tail region and stripped into a clean dry enamel or plastic tray with gentle pressure on the abdomen. If the fish is perfectly ready to spawn, then eggs are released smoothly like a jet.

Stripping of male for obtaining sperm is often not successful. Therefore, the testis from male fish is dissected out and homogenized by squeezing it with the help of muslin cloth using 0.8% saline solution (8 g table salt in 1 litre of water) and the sperm suspension is spread over the stripped eggs in the tray. The sperm suspension can also be prepared prior to stripping of the female, using 2-4% of saline solution and stored in the freezer.

The sperms and egg mass are mixed gently for 2-3 minutes using a bird feather, and then freshwater is poured and mixed well for 3-5 minutes in the enamel or plastic tray. The eggs are washed repeatedly in freshwater. The fertilized and unfertilized eggs are distinguished after 10 minutes by observing the colour of the eggs. The fertilized eggs are generally greenish-blue in colour and tend to settle at the bottom, whereas, the unfertilized eggs are whitish in colour and float above the fertilized eggs.

Fig. 2. Stripping female Singhi brooder

Fig. 3. A haul of Singhi from grow-out pond

5. Incubation and Hatching of Eggs

Fertilized eggs are incubated in stagnant or running water in plastic/fibre glass containers or cement tubs. Fine mesh nylon net is spread horizontally in the incubation container 5-10 cm below the water surface, and fertilized eggs are spread evenly in a single layer over the nylon net. The eggs maintained under flowing and well-aerated water result in better survival. The embryos hatch out in 16-19 hours after fertilization at 28-30 ^{o}C ambient temperature. The hatchlings wriggle out from the eggs and move to the bottom of the container through the meshes, leaving the dead egg shell over the nylon net.

The newly hatched larvae possess a large yolk sac which gets absorbed in 3-4 days. The unfertilized and dead egg shells must be removed immediately by lifting the mesh to avoid fouling of water. Prior to incubation, treating fertilized eggs with fungicide and bactericide bath i.e. malachite green (5 ppm for 10 minutes) considerably prevents the fungal and bacterial infection.

6. Larval Rearing

Nursing of *Heteropneustes fossilis* larvae is an important stage before moving them to grow-out ponds or cisterns. The larvae are about 2.7 mm having a large yolk sac. After 48 hours, the healthy ones will swim towards the corner of the tank and remain in a group. The yolk sac is completely absorbed within 3-4 days and the larvae are fed minute rotifers and boiled egg yolk for 1-2 days. Continuous supply of zooplankton (rotifers and ciliates) as food from 3-12 days ensures better survival and growth of larvae. From 13-day onwards, the larvae can be fed chopped molluscan meat in addition to zooplankton. After 19-20 days, larvae transform into fry.

7. Rearing Early-fry

The laboratory-reared early-fry are stocked in specially prepared outdoor fiberglass rearing tanks or cement cisterns. These containers are provided with 2-3 cm thick layer of soil on the bottom and water depth of 25 to 30 cm is maintained. Superphosphate (about 100 g) and filtered cow dung suspension (about 2 kg) are added to these containers that are kept in shade allowing partial exposure to sunlight to promote green algal growth. Plankton collected from ponds is inoculated into these tanks/cisterns at periodic intervals. Singhi fry are stocked in such cisterns at 200/ m^2 and fed a diet of finely ground trash fish and rice bran and chopped molluscan meat *ad libitum*. They attain a size of about 4-5 cm in one month and can be stocked in grow-out ponds.

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Induced Breeding, Seed Production and Grow-out Culture of some Minor Carps and Barbs*

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1. Introduction

Natural water resources of our country harbour rich biodiversity of fish fauna many of which have the potential for aquaculture. However, increased anthropogenic activity in these waters has significantly impacted on their biodiversity and ecology, pushing many of these species to vulnerable or even extinct stage. While there is an urgent need for conservation and protection of these natural fish fauna, freshwater aquaculture offers scope for an assured conservation through culture and propagation. With emphasis in recent years on diversification of species in freshwater aquaculture sector, many of these potential species have been successfully brought under the cultured species umbrella. Many of the indigenous Minor Carps, viz., *Labeo fimbriatus* (Fringed lipped carp), *L. gonius* (Kuria labeo), *L. bata* (Bata), *Cirrhinus reba* (Reba), *Osteobrama belangeri* (Pengba), indigenous Barbs viz., *Puntius sarana* (Olive barb) and *P. pulchellus* and Exotic Barb such as *P. gonionotus* (Silver barb), having regional importance, growth potential and consumers acceptability, have been brought to the mainstream of culture and tried for their wider domestication across the country.

Silver Barb *Puntius gonionotus*

Olive Barb *Puntius sarana*

Bringing these small and indigenous species into the culture system needs an understanding of their habitat preference, food and feeding habit, compatibility with other Indian Major Carps and their proportion while incorporating in a polyculture system. Over the years, the ICAR-CIFA has undertaken these studied. Species like Kuria Labeo is observed to be typical bottom dweller and competes with Mrigal for food in the culture system. The Fringed Lipped Carp is a column-bottom dweller showing some degree of competition with both Rohu and Mrigal. The Olive Barb despite being a bottom omnivore shows competition with Rohu. It prefers to stay in the marginal area of

*Some Minor Carps and Barbs, their valid scientific names and synonyms are given in an Appendix on page 28. – Editor the pond preferably in the submerged marginal weed cover. The Silver Barb utilizes surface and column niches in the pond. It is an omnivore and also feeds on the tender leaves of submerged aquatic macrophyte and floating duck weed species. Similarly, tender leaves of submerged macrophyte have been observed in the gut of Pengba which mostly occupies the water column. The study has revealed its compatibility with Rohu. In culture system all the above species have shown minimum competition with Catla. Despite varied degree of competition of these Minor Carps and Barbs with the Major Carps for food and space in the culture system, incorporation of most of these species at 15-25% of the stock composition in multi-species farming has shown similar or higher biomass yield as compared to the Major Carp poly-culture system.

2. Seed Production

Efforts were made at ICAR-CIFA and elsewhere in the country to develop/standardise seed production technologies of these Minor Carps and Barbs. At present, seed are being produced in commercial scale for species such as, *Labeo calbasu, L. fimbriatus, L. gonius, L. bata, Cirrhinus reba, Puntius sarana, P. gonionotus* and *Osteobrama belangeri*. Almost all these species respond well to induced breeding using synthetic hormone formulations like Ovaprim, Ovatide and Ova-FH. The FRP Carp Hatchery model has also been used for induced breeding on a small scale while Eco-hatchery Model is being used for large scale breeding of these species.

2.1 Broodstock Development

Sexual maturity in male and female of all the above Minor Carp and Barb species is attained in the 1st year. In all cases, size of mature males is generally less than that of their female counterpart of the same age group. However, mature individuals of 2+ year age-group are preferred for induced breeding. Mature fishes are collected and kept in the broodstock pond at 1.2-1.5 t/ha at least three months prior to the breeding season. It is always advisable to maintain the brooders of Minor Carp and Barb groups separately from the Major Carp brooder which facilitates proper feeding of the former group. Since these brooders are maintained with supplementary feed, all the species may be kept in the same pond at equal species ratio. Use of only floating pellets in the broodstock pond does not yield good broodstock development in some typical bottom dwelling species such as Kalbasu, Kuria Labeo, Olive Barb, etc. and necessitates provision of dough feeding of groundnut oil cake and rice bran/polish mixture. Supplementary feed should be provided at minimum 3% of the biomass during the three months of broodstock development.

2.2 Induced Breeding

Breeding of the Minor Carps starts with the onset of monsoon and continues during the rainy season. Silver Barb (*P. gonionotus*) breeds naturally under favorable condition in pond with a good water depth. However, despite being a high fecund species, the tiny size of its hatchlings (3 mm) limits the fry survival in pond condition. Release of mature males and females into large concrete tank or pond leads to spawning even without hormone induction, while brood fish injected with hormone exhibit better breeding performance. Olive Barb (*Puntius sarana*) is a batch spawner releasing eggs among weed masses. While provision of aquatic weed in bunches in the breeding tank facilitates its spawning, the stem and leaf surface of weed such as *Hydrilla* also act as a substratum for the eggs of Olive Barb which typically bear a stalk for attachment. Breeding protocol for Fringed Lipped Carp, Kuria Labeo, Bata and Reba is almost similar to that of the Indian Major Carps.

Matured males at oozing condition and females with bulging abdomen are collected from the broodstock pond and transported to the hatchery carefully in thick canvas bags filled with water. Minimum stress should be ensured for the brooders during handling. The males and females are kept separately in two breeding hapas that have been previously fixed in the circular breeding pool under a shower. The male:female sex ratio followed is usually 1:1. Though female are larger than the male in these species, care should be taken to select the best fit pair, i.e. having minimum weight difference between the two sexes, for better breeding result. In case of male being too small compared to female, the male sex ratio may be increased accordingly. A single injection of Ovaprim/ Ovatide at 0.3 and 0.15 ml/kg body weight of female and male brooder, respectively, is being used for successful spawning of all the above mentioned Minor Carp and Barb species. The selected best fit pairs of a given species are administered hormone injection and kept in one hapa for breeding.

2.3 Hatching

The spawning response time in all these species varied between 8-11 hours at water temperature 27-28 °C. Fertilized eggs collected from the breeding hapa are incubated in the circular incubation tank/pool. Larvae hatch out after an incubation period of 15 hours at 27-30 °C temperature. The hatched larva called hatchlings are retained in the incubation tank/pool for another 60-62 hours during which yolk absorption is completed and the larvae develop to tiny fish called spawn. The spawn measure 4-5 mm in all the Minor Carp and Barb species except in Silver Barb (*Puntius gonionotus*) in which they measures about 3 mm in length. Spawn recovery is in the range of 72,000-77,000 per kg female body weight.

3. Seed Rearing

Seed of Minor Carps and Barbs are generally reared in small earthen ponds of 0.02-0.10 ha with depth of 1.0-1.5 m, though ponds up to 0.5 ha can also be used for large-scale production. However, large concrete tanks of 50-100 m^2 and 1.0 m water depth are preferred as nurseries for high density seed rearing. Preparation of the nursery pond for rearing the spawn of Minor Carps to fry stage is similar to that followed for Major Carps. Essentially, the pond management practices involves environmental and biological manipulations for obtaining higher levels of seed or grow-out fish production, which can be broadly classified as pre-stocking, stocking and post-stocking operations.

3.1 Nursery Pond Preparation

Nursery pond preparation begins with making them free of weeds and predators and generating adequate natural food to ensure high rate of survival and good growth and thereby yields. Ponds that dry up in summer or could be easily and economically drained have no problems, but perennial ponds generally harbour weeds, predators and competitors which should be eradicated prior to undertaking the seed rearing activity. Although a wide range of manual, mechanical, chemical and biological methods are available for weed control, generally manual method is advocated to ensure seed rearing activity over a longer duration in the season.

Eradication of predatory and weed fishes in perennial nursery ponds is another important step of pond preparation. Dewatering followed by sun drying the pond is the most effective method adopted for eradication of these fishes. The other methods include:

(i) Application of Mahua oilcake @ 2,500 kg/ha-m three weeks before stocking, which besides acting as piscicide, serves as organic manure after its decomposition.

(ii) Application of commercial bleaching powder (30% chlorine) @ 350 kg/ha-m of water (approximately 10 mg/l chlorine).

(iii) Alternatively, application of urea @ 100 kg/ha-m followed by commercial bleaching powder @ 175 kg/ha-m after 18-24 hours effectively controls these fishes.

Generally soil with slightly acidic to neutral pH (6.5-7.0) is considered productive, while low pH is always associated with low productivity. Acidic soils are treated with lime for increasing the soil pH. High dose of organic manure (3.0-5.0 t/ha) is applied to reduce pH of moderately alkaline soil, while alum is used in the case of highly alkaline soil. Soil pH in most parts of the country falls in the range of 6.5-7.0; soil of ponds with such a pH is amended by application of agriculture lime @ 200 kg/ha. Liming is also done at the same dose for every meter water depth as a disinfecting agent during culture operation to maintain the water pH in alkaline range (7.5-8.5).

Nursery pond needs to have adequate quantity of desired kind of natural food for the spawn. Over the years, several phased manuring practices advocated for nursery rearing have shown encouraging results, but could not be adopted on large scale due to their complex application schedule. Phased manuring with a mixture of groundnut oil cake at 750 kg, cow dung 200 kg and single super phosphate (SSP) 50 kg (total quantity 1000 kg) per ha is used for production of desired plankton on a sustained basis during the nursery phase and in the seed rearing ponds of Indian Major Carps. This method has also been found to be equally effective in seed rearing of the Minor Carps. A thick paste of one third to half the total dose of the three inputs is prepared and applied as basal dose 2-3 days prior to spawn stocking. The remaining amount is applied later in 2-3 split doses depending on the plankton levels of the pond or tank during the nursery phase.

3.2 Nursery Pond Stocking

The spawn are transferred from the hatchery and stocked in nurseries during cool hours, preferably in the morning, after due acclimatization to the new environment. For earthen nursery ponds the ideal range of spawn stocking density recommended for different Minor Carps and Barbs is 3-5 million/ha (300-500/m^2), with an outcome of 30-40% survival. For large cement nursery tanks, the ideal density recommended for different species are presented in the following Table:

Recommended Stocking Density for Minor Carp and Barb Seed in Cement Nurseries

Species	Stocking Density*	Nursery Phase	Feed	Survival (%)
L. fimbriatus	1600 spawn/m^3	25-30 days	GNOC + rice polish	31-51
L. gonius	800 spawn/m^3	25-30 days	GNOC + rice polish	50-60
L. calbasu	1000 spawn/m^3	25-30 days	GNOC + rice polish	50
P. sarana	1000 spawn/m^3	25-30 days	GNOC + rice polish + 20% dry fish meal	71
P. gonionotus	---	45 days	Soya milk + egg custard	**

*For practical purpose, while stocking, spawn can be measured as wet volume; 1 ml contains about 380 - 400 spawn of Minor Carps and Barbs.

**An intermediate-nursing period of 10-15 days is recommended prior to the nursing phase as it is difficult to count the tiny spawn.

3.3 Supplementary Feed

The most commonly used supplementary feed during nursery phase has been the powdered mixture of groundnut oil cake and rice bran (rice polish) in 1:1 ratio by weight. The dry feed mixture is added in nurseries normally at 0.4 kg/lakh/day, from the second day of release of spawn in a prepared nursery pond/tank. Daily feed quantity is increased roughly by 50-75 g/ lakh/ day depending on the consumption pattern. Daily ration may preferably be provided in two splits for better utilization of supplementary feed. The nursery period usually extends up to 25-30 days in Minor Carps during which they grow to a size of 15-20 mm.

3.4 Rearing Fry to Fingerlings

Like nursery ponds, the rearing ponds also need specialized management for good survival and production of healthy fingerlings. Some of the basic operation such as clearing aquatic weeds, soil pH correction, and control of predatory and weed fishes are done as in nursery pond preparation. Pond fertilization is carried out with application of raw cow dung @ 12-15 tonnes/ha depending on the organic carbon load of the soil. While one third of this amount is applied 10-12 days before stocking, the remaining amount is applied in equal split doses at fortnightly intervals. In case poultry droppings are applied, the dose may be reduced from one third to half of the amount of cow dung. In addition to the organic manures, inorganic fertilizers such as urea and single super phosphate are applied depending on the nutrient status.

Stocking is preferably done in rearing pond during morning or evening hours after proper acclimatization of the seed to the new environment. The usual stocking density followed varies from 2.0 to 3.0 lakh fry/ha. In ponds with facilities for water circulation/exchange or aeration, the fry density can be further increased to a considerably higher level. Fry rearing of Minor Carps and Barbs can be undertaken either alone or along with the Indian major carps under a polyculture system.

Since all carps at their fry stage are planktophagic with preference for zooplankton, the normal method of pond fertilization is applicable in the rearing pond for supporting the natural productivity. Feed requirements of the growing fingerlings are met through the available natural fish food and provision of supplementary feed commonly in the form of mixture of groundnut/mustard oil cake and rice bran/wheat bran at 1:1 ratio by weight. Other ingredients such as fish meal, soybean flour, vitamin-mineral mixture, etc. are also suggested to be incorporated for improving the feed quality. Periodical samplings of the fry at fortnightly interval are done to assess the growth and biomass. Feed is provided at the rate of 8-10% of biomass of fry stocked per day during the first month, which is reduced to 6-8% and 4-6% of the standing biomass during the subsequent two months. While the fingerlings show better acceptability to powdered feed floating on the water surface, bag feeding or moist dough form is also recommended. Crumbled pellets of preferably 1-2 mm diameter may also be used for reducing the feed wastage. The fish fingerlings are harvested after 3 months of the rearing phase.

4. Grow-out Culture

The grow-out fish farming in our country is mostly carried out for one year period depending on the water availability. Ponds are usually stocked with 7,500-10,000 carp fingerlings/ha. But in the process, initial fish biomass in pond remains much below its carrying capacity leading to underutilization of productivity potential. There is a scope to utilize the pond productivity effectively during this initial phase of culture through increasing the initial stocking density followed by periodical removal of juvenile fish. Such method has proven to increase the overall fish production

Olive Barb *Puntius sarana*

Fringed Liped Carp *Labeo fimbriatus*

in the pond. While such additional/increased stocking density with the same Major Carp species increases both inter- and intra-specific competition, incorporation of compatible Minor Carps for the additional stocking minimizes the inter-specific competition. Such intercropping of these species in the conventional carp polyculture and their culture in seasonal ponds of certain States has proved to be more rewarding.

Pengba *Osteobrama belangeri*

Minor Carps & Barbs and Indian Major Carps from a polyculture grow-out system

Species compatibility of Minor Carps and Barbs with Indian Major Carps in Fingerling Rearing and Grow-out Culture Ponds

Minor Carp / Barb	Catla	Rohu	Mrigal	Remarks
Fringed Lipped Carp (*Labeo fimbriatus*)	Compatible	Compatible	Competition	Can partially replace Mrigal
Kuria Labeo (*Labeo gonius*)	Compatible	Compatible	Strong Competition	At 33% incorporation, can be alternative species to Mrigal
Olive Barb (*Puntius sarana*)	Compatible	Competition	Competition	At 33% incorporation, can replace Mrigal in carp polyculture
Silver Barb (*Puntius gonionotus*)	Compatible	Strong Competition	Compatible	Strong competition with Rohu. But, no influence on survival or biomass production of any species

Over the years, incorporation levels of the various species of Minor Carps and Barbs in the Indian Major Carp based grow-out polyculture system has been standardized. *Labeo calbasu* is recommended at 15% incorporation level substituting Mrigal in the bottom dwelling component. Providing substrate for periphyton growth significantly increased growth of Rohu and Kalbasu by 33% and 28%, respectively, which together registered 13% increase in net biomass. Monoculture of Silver Barb (*Puntius gonionotus*) at 5,000-15,000 fingerling/ha resulted in 77.3 - 94.3% survival and production of 1.56 - 2.13 t/ ha/ 8 month, suggesting 10,000/ha density to be ideal. Though it shows certain degree of competition with Rohu, its inclusion at 33% of stock density in Major Carp system neither affected the survival of any carps nor yielded any significant changes in biomass production. In a polyculture study, Olive Barb (*Puntius sarana*) along with Catla, Silver Carp and Rohu combination showed lower FCR and higher biomass yield compared to that species combination with Mrigal in place of Rohu. This indicated feasibility and advantage of culturing Rohu with Olive Barb rather than Mrigal. The study further suggested feasibility of replacing Mrigal with Olive Barb in the grow-out carp polyculture system. Similarly inclusion of Kuria Labeo (*Labeo gonius*) as the bottom component along with Catla, Silver Carp and Rohu combination has shown higher growth of Rohu and similar biomass yield as that species combination with Mrigal as the bottom component, proving the former (Kuria Labeo) to be an alternative to Mrigal in the Major Carp polyculture system. *Labeo fimbriatus* (Fringed Lipped Carp) incorporated at 33% in the IMC based polyculture revealed its inter-specific competition with Mrigal up to certain degree, though it also suggested feasibility of using the former in place of the latter for higher biomass yield in the grow-out carp culture system.

5. Conclusion

During the years of development, aquaculture sector has been posed with several major challenges that include need to (i) produce more fish to cater to the ever increasing demand, (ii) increase farm income in the face of low market value of carps which forms the main stay of Indian aquaculture, (iii) preserve the species diversity in the face of their dwindling stock in the nature due to anthropological activity, (iv) produce varied fish protein to provide more choices to consumer with increased per capita income and, (v) increase fish production per unit use of land and water, (vi) produce fish in a sustainable and environment friendly manner, and the most important one (vii) take the technology to the field. Incorporating the Minor Carps, Barbs and other potential species (available in our natural waters) into our culture system is the answer to all these challenges in the coming years. However, it needs a coordinated effort of the fish farmers, State functionaries, researchers and the planners to preserve our natural resources and comply with utilizing them sustainably for our living.

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Editor's Note:

Appendix

Minor Carps and Barbs, their common names, valid scientific names and synonyms*

Common Name	Valid Scientific Name & Author	Synonym
Fringed Lipped Carp	*Labeo fimbriatus* (Bloch, 1795)	---
Orangefin Labeo, Calabasu	*Labeo calbasu* (Hamilton, 1822)	---
Bata	*Labeo bata* (Hamilton, 1822)	---
Kuria Labeo	*Labeo gonius* (Hamilton, 1822)	---
Reba Carp	*Cirrhinus reba* (Hamilton, 1822)	---
Olive Barb	*Systomus sarana sarana* (Hamilton, 1822)	*Puntius sarana* (Hamilton, 1822)
Chameen, Haragi, Saymeen	*Hypselobarbus pulchellus* (Day, 1870)	*Puntius pulchellus* (Day, 1870)
Silver Barb	*Barbonymus gonionotus* (Bleeker, 1849)	*Puntius gonionotus* (Bleeker, 1849)
Pengba	*Osteobrama belangeri* (Valenciennes, 1844)	*Rohtee belangeri* (Day 1878)

*Source: http://www.fishbase.org/search.php

Hatchery Management and Seed Production of Golden Mahseer, *Tor putitora*

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1. Introduction

The Golden Mahseer, *Tor putitora* (Hamilton, 1822), are large cyprinid fish, inhabiting clear, pristine and fast flowing waters of Asia, from the cool waters of Himalayan streams to the tropical rivers of South East Asian jungles. They are highly sought-after fish, valued for their excellent taste, ornamental beauty and fighting skills as a game fish. Mahseer, the big-scaled carp attracts the anglers as well as naturalists from all over the world.

The species is distributed in many rivers, streams and lakes in India all along the Mid Himalayan belt – Jammu & Kashmir, Sikkim, Assam; broadly it occurs in Afghanistan, Pakistan, Nepal, Bangladesh, China, Myanmar, Thailand, Cambodia, Laos, Vietnam, Malaysia and Indonesia. Mahseer is one of the potential fish species of Trans-Himalayan countries for development of its fishery, including aquaculture.

Mahseer has an elongated and slightly compressed body. The snout is pointed while the jaws are of equal length; they have two pairs of short barbells. The dorsal fin arises opposite the ventral fin while the caudal fin is deeply forked; they have large scales covering the whole of their body. The body colour is golden along the lateral portion with the dorsal side being a dark grey shade; the fins are reddish-yellow in colour.

In natural aquatic systems, especially large rivers, the fish is known to reach 45 kg body weight. Their habitat is characterized by rapids and fast flowing currents and this fish is a fast swimmer; it swims upstream and can go through rapids of 20-25 knots (37-46 kmph). Not much is known about the lifespan of this fish but experts guess that they live up to an age of 20-25 years; the largest specimen ever caught weighed 55 kg.

2. Food and Feeding

Mahseer is an omnivore in its adult stage; it is found to feed on green filamentous algae, insect larvae, small molluscs, and algal growth on rocks. In natural habitat, food of Mahseer fingerlings consisted of insect matter (81.4%), plant matter (15.9%) and other items including fish (1.6%).

Diatoms formed the most preferred food component followed by green algae, blue-green algae and micro- and macro-benthic animals. Various species found in the gut include *Navicula, Amphora, Cymbella, Synedra, Fragillaria, Oscillatoria, Zygnema, Spirogyra, Tribonema, Arcella, Keratella* and *Chironomus.*

3. Inherent Constraints of Natural Breeding

The following inherent constraints have been identified in the natural breeding of Golden Mahseer:

- Extremely low fecundity
- Demersal eggs - may sink in mud and perish
- Long hatching duration - 80 to 90 hours
- Hatchling to free-swimming stage prolonged – 10 days.
- High vulnerability from egg to free-swimming stage (up to 15 days).

Therefore, artificial propagation is recommended and ICAR-DCFR, Bhimtal has taken the lead in this direction.

4. Spawning

Golden Mahseer is an intermittent breeder, the fish lay eggs at intervals throughout the year, but main spawning occurs in monsoon. The Mahseer prefers clean water for breeding and its migratory habits for this purpose are well known. During the floods, Mahseer ascends to upper reaches of rivers, traversing long distances in search of fresh breeding grounds to spawn. There they lay eggs in sheltered rock pools, one batch of eggs at a time, repeating the process several times in a season. It was observed that Mahseer most certainly breeds at the commencement of rains. Breeding season and spawning among hill-stream fishes is the result of a combination of temperature, pH, velocity, turbidity and rains, which collectively induce the fish to spawn and Golden Mahseer also follows the same pattern. Mahseer breeds several times a year. Five distinct stages were observed in breeding females – Stage I (immature virgins), Stage II (maturing virgins), Stage III (ripening), Stage IV (ripe) and Stage V (fully ripe).

5. Hatchery Operation

5.1 Water Supply

Selection of a suitable site for a Mahseer hatchery is the most important aspect of a successful aquaculture programme. Quantity of water available for the capacity and type of hatchery to be developed is also to be taken into consideration.

The ideal quantity of water required at various stages of Mahseer breeding and rearing is as follows:

Water Flow Rate	Hatching / Rearing Capacity
1 litre / minute	Incubating 2000 Eggs at 20-28°C
3-4 litres / minute	Rearing 2000 Fry (0-3 months) at 20-27°C
4-6 litres / minute	Rearing 1500 Fingerlings (4-9 months old)

5.2 Flow-through Hatchery

Overhead tank – 1000 litre capacity, installed at a height of 5 m above ground. Hatchery tanks – of galvanized iron (GI) sheet or fiber glass (FRP) of 200 cm x 60 cm x 30 cm size. Hatching trays – dimensions 50 cm x 30 cm x 10 cm, with synthetic netting cloth of 1 mm mesh size forming the bottom.

5.3 Artificial Breeding

As spawning season approaches, brood fish leave their safe haunts in deep pools of rivers, lakes and reservoirs and ascend to shallow areas for breeding. The brood stock is obtained from natural breeding grounds in rivers, lakes and reservoirs. Ripe fish usually congregate at the breeding grounds in the streams and at the outfall of the streams in the lakes/ reservoirs, and are carefully collected either by cast net or gill net.

The selected female and male brood fish are stripped of their eggs and milt, respectively, by exerting pressure on the caudal portion of the fish in a particular manner. The stripped eggs are collected in a plastic tub/bowl and the milt is spread over the eggs. The eggs and milt are thoroughly mixed with the help of a bird's feather and allowed to stand for 5 min. After that, the eggs are washed thoroughly with clean oxygenated water 3-4 times to remove the excess milt. The tub/ bowl containing fertilized eggs is then filled with freshwater and allowed to stand for 15-20 min in shade for the eggs to swell and harden.

5.4 Hatching and Rearing

The water-hardened eggs are released into hatching trays in which 5000 - 6000 eggs can be stocked/tray. The fertilized eggs are demersal (sink), lemon yellow or brownish golden in colour. The percentage of fertilization is about 90-100%. Hatching period of Mahseer (*Tor putitora*) is 80-96 hours at water temperature 22-24 °C. The empty egg shells are removed by lifting the meshed hatching tray from the hatching tank while the hatchlings pass through. Once the yolk-sac is completely absorbed the swim-up fry start moving freely.

The swim-up fry are then stocked in nursery tanks at 8,000 - 10,000/tank in which water flow rate is 2-3 litres per minute. The fry are fed artificial feed and reared to fingerlings. For raising table size fish or brood stock, natural seed or hatchery-reared fingerlings can be stocked in earthen ponds, cement ponds, running water ponds or cages.

Mahseer Brooder: Male

Mahseer Brooder: Female

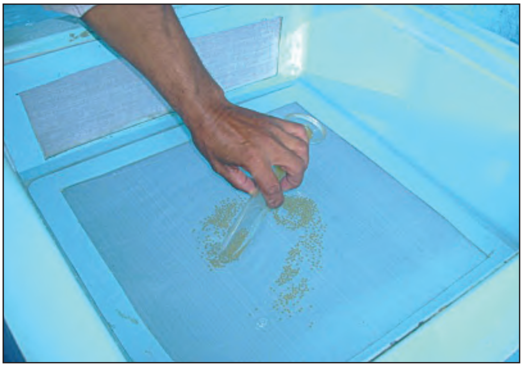
Brood stock development and breeding activities at Jasingfaa Aqua Farm, Assam

Mahseer female brooder

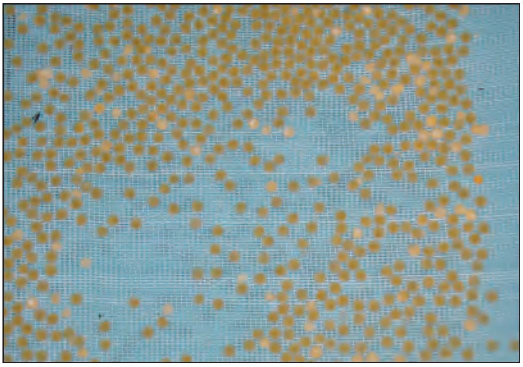
Stripping female brooder

Stripping male brooder

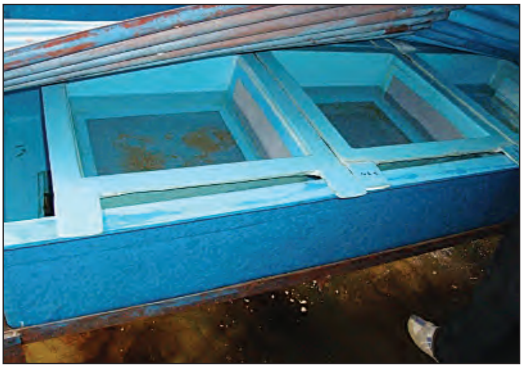
Fertilization of eggs



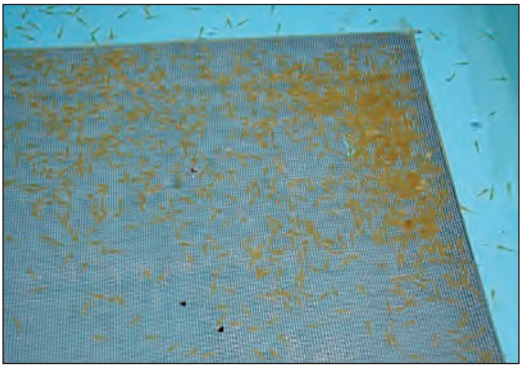
Egg Incubation in Hatching Tray



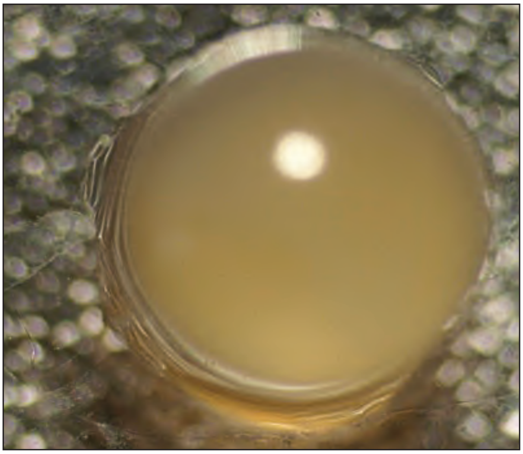
Eggs in a Hatching Tray having mesh bottom



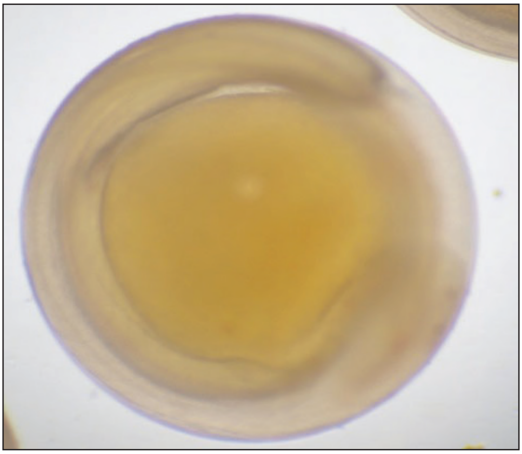
Hatching Tanks with Hatching Trays



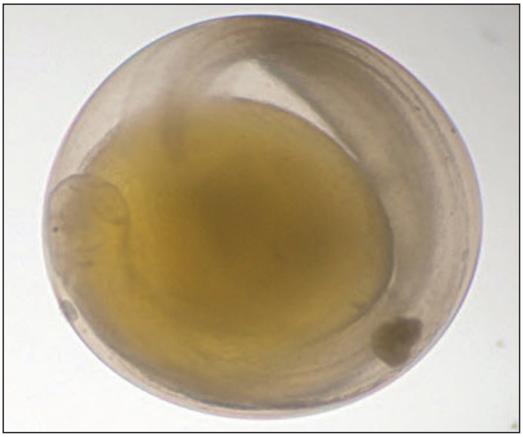
Hatchlings/Swim-up Fry in Hatching Tank



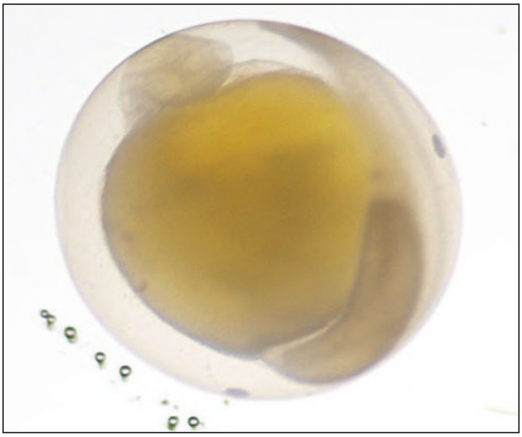
Blastula



Gastrula



Formation of Pigmented Eye



Formation of Muscle Structure

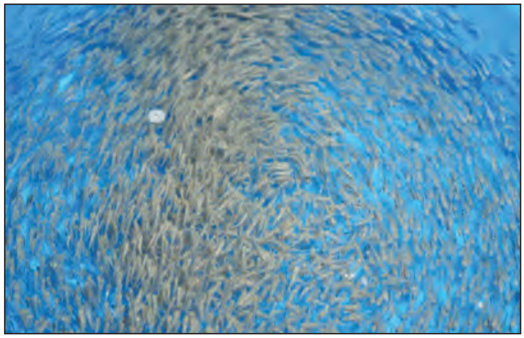
1-day Larva

7-day Larva

1-month old Fry

3-month old Fry

Feeding the Fry



Haul of Mahseer Fry

Mahseer Seed Counting

Mahseer Seed Packing for Transportation

Mahseer Ranching in Mehao Lake, Arunachal Pradesh

Mahseer Ranching in Nainital Lake

HRD - Training

HRD - Demonstration

Breeding and Culture of Rainbow Trout, *Oncorhynchus mykiss*

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1. Introduction

Among the freshwater salmonids, *Oncorhynchus mykiss* (Walbaum, 1792)**,** popularly known as Rainbow Trout is one of the promising cultivable fish species in cold waters that offers considerable scope for expansion of aquaculture in upland areas. Being a high valued fish, Trout has good potential for domestic marketing as well as export. Despite several positive traits such as ease of domestication, fast growth, less bones, nutritious and tasty flesh and high market price, development of Trout Farming on a large scale is yet to be taken up. Primarily native to the Pacific drainages of North America, Rainbow Trout is a carnivorous fish, introduced in India by Europeans in the beginning of 19th century mainly for sport fishing. The species is presently farmed commercially in over 100 countries in the world. In India, Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh are the potential Hill States for large-scale Trout Farming, in both private and public sectors. The ICAR-DCFR, Bhimtal has standardized the techniques of breeding, seed rearing and culture practices of this high-valued fish for the benefit of fish farmers in hilly regions.

2. Breeding and Hatchery Management

Rainbow Trout requires cold, clean and highly oxygenated water for ripening of brooder, successful breeding and hatchery activities. It breeds during November to February and attains maturity after 3 years age. The whole process of breeding includes brood stock rearing, stripping of females and males, mixing of eggs and milt, incubation of eggs in trays fitted in the troughs with continuous flowing water, and rearing sac-fry and swim-up fry in FRP tanks. A Trout Hatchery with flowing water system is known as ***Ova House***, where incubation and hatching of eggs takes place. An Ova House comprises of indoor structures such as hatching trays, troughs, nursery tanks and rearing tanks, with continuous water flow and following dimensions:

(i) Hatching Tray – 50 x 40 x 20 cm (to hold 10,000 fertilized eggs)

(ii) Rectangular Trough – 220 x 50 x 30 cm (with 4 trays to hold 40,000 fertilized eggs)

(iii) Nursery Tank – 2.0 x 0.5 x 0.60 m (to raise 40,000 fry)

(iv) Rearing Tank – 2.0 x 1.5 x 0.75 m (to raise fingerlings)

2.1 Brood Stock

Males and females are segregated 2 months prior to spawning and held in separate raceways at a density of 5-10 kg/ m^3. Trout will not spawn naturally in aquaculture systems. Generally, two males to one female are deemed a satisfactory sex ratio for brood stock. During breeding season, female has round body appearance, bloated and soft belly with swollen and reddened vent, while male has dark and dull appearance, large pointed snout with hooked lower jaw and oozing milt (seminal fluid). Food and feeding significantly influences fecundity. Healthy and large sized brooders are preferred for quality seed production.

Fig.1. Trout Raceway

Fig.2. Brood Stock

Fig.3. Stripping of male

2.2 Spawning and Egg Incubation

Dry stripping method is practiced for spawning Rainbow Trout. Fertilized eggs are lemon yellow or light green in colour and measure 4-5 mm. A mature female Trout of 1 kg body weight can produce 1500 – 1800 mature eggs. In dry stripping method of induced breeding, the following steps are taken:

1. Weigh selected brooder
2. Wipe with soft and dry cloth
3. Strip female fish with the right hand thumb and index finger to release eggs into a tub
4. Release stripped fish immediately into aerated water
5. Fecundity check – may be done by counting number of eggs in a 5 g mass
6. Strip male fishes and spread milt over the eggs in the tub
7. Stir/ mix eggs and sperms with the help of a bird feather
8. Keep for 1-2 minutes for fertilization to take place
9. Add 100 ml of Normal Saline Solution (0.9% NaCl) to fertilized eggs; keep for 5 minutes
10. Wash eggs with clean freshwater

11. Transfer eggs to meshed hatching trays
12. Place hatching trays in the troughs
13. Fix water flow rate at 2 litres per minute (LPM) for 10,000 eggs
14. Unfertilized/ dead eggs are segregated and removed
15. Eggs hatch in 40-60 days at 9-14 ^{0}C.

Fertilized eggs are incubated undisturbed, until the Eyed-ova stage, in hatching troughs with meshed trays or in vertical flow incubators or hatching jars. When hatching troughs are used, eggs are placed in meshed hatching trays (mesh size 1.5-2.5 mm); each tray can hold a layer of 2000-3000 fertilized eggs. Mesh of the tray is made up of stainless steel or aluminum. The meshed trays are placed 10 cm above the bottom of hatching troughs, and water passes through the meshes of trays from bottom of troughs to the top across the trays. The hatching trays are covered with lids as hatching always takes place in the dark. Unlike carps and catfishes, Trout have prolonged incubation period lasting several days (40-60 days). Duration of incubation depends on the water temperature. There are four distinct stages during incubation, namely:

1. Green-eggs (fertilized eggs)
2. Eyed-eggs
3. Alevin or Sac-fry
4. Swim-up Fry

Transportation of eggs can be done only at Eyed-egg stage, 5 days prior to hatching. As the eggs hatch (95% hatching rate), the Sac-fry drop through mesh of the hatching tray to the bottom of rectangular trough. Sac-fry can remain in hatching trough for 10 to 14 days after hatching, until swim-up stage. Initially hatchlings of Trout, called Alevin or Sac-fry (size 1.5 -1.8 cm, weight 45-50 mg), feed on reserve food in the yolk sac (which lasts for 2-4 weeks). Hatching of a batch of eggs usually takes 2-3 days, during which time all egg shells as well as dead and deformed Sac-fry should be removed regularly.

Fig.4. Egg incubation in Hatching Trays

Fig.5. Alevin or Sac-fry in Nursery Tank

Fig.6. Fry of Rainbow Trout in Rearing Tank

Upon hatching, Alevin/ Sac-fry are carefully removed from the meshed trays and put into the mesh cage arranged in the rectangular troughs wherein running water flow is maintained @ 0.3-0.5 litre per minute per 1000 larvae. The Sac-fry are protected from bright light and retained in the trough until absorption of the yolk sac and attain the Swim-up Fry stage. Free-swimming fry are fed 10 times a day @ 5-10% of biomass with Starter-feed I. After one week, feeding frequency is reduced to 3-4 times a day and fry are transferred into rearing tanks.

3. Fry and Fingerlings Rearing

Fry are reared in fiberglass or concrete nursery and rearing tanks, preferably circular in shape to maintain a regular water current and uniform distribution of the fry. Fry are stocked at density of 1000 numbers/m^2 and provided Starter-feed II. Fry attain the Fingerling stage (2-5 g) at the end of 3 months rearing. These 3-month old fingerlings can be stocked in raceways. For production of 1 lakh fingerlings, 400 kg brooders are required, which produce 2 lakh fertilized eggs, 1.5 lakh fry with a cumulative survival of 50% from eggs to fingerlings.

4. Rainbow Trout Culture

4.1 Site Selection

The site should have a perennial water source free from pollution and silt and a proper approach road. Water should have higher dissolved oxygen preferably above 7 mg/l, pH 6.5-8.0 and temperature range of 0-20 ^{0}C round the year. However, thermal regime of 13-18 ^{0}C is optimum for better survival and growth. Water temperature above 18 ^{0}C for longer duration creates environmental stress and mortality in the growing-stock. Rectangular concrete raceway (RCC) with an area of 30 m^2 (length-width ratio 15:2) and water depth of 80-90 cm having 3% bottom slope is mostly preferred. Single or a battery of parallel raceways may be constructed in a Trout Farm, each with separate inlet and outlet facility.

4.2 Stocking Seed in Raceways

Stocking density depends on quality and quantity of water. Trout fingerlings (size 5-6 cm, wt. 2-5 g) are stocked @ 50-100 fingerlings/ m^3, and 15-20 kg/ m^3 fish can be harvested in 12 months. Based on size attained in the culture facility, segregation of smaller and bigger ones is essential at regular intervals to avoid cannibalism and to achieve uniform growth. Trout attains 300-400 gm in 12 months when water conditions are suitable and adequate good quality feed is provided, but the same weight is gained in 10 months when 10-20 g fingerlings are stocked.

4.3 Feed and Feeding

Dietary protein requirement of Trout is in the range of 30-50% on dry matter basis. Trout has an exclusive requirement of n-3 or w-3 PUFA in their diet; 10-14% lipid is included in the diet. Fish meal (> 60% protein), solvent extracted soybean meal, mustard oil cake, wheat flour, starch, fish oil, Brewer's yeast powder, linseed oil cake and vitamin & mineral mixture may be used for formulating Trout diet. In general, 50% protein and 14 % lipid in starter-feed, 45% protein and 16% lipid in rearing-feed and 35% protein and 14 % lipid in grow-out feed is required for proper growth. Requirement of Arginine (6.427%) is comparatively higher than the other essential amino acids. Solvent extracted soybean meal (SESM) contains 48% protein and has the best amino acid profile, is highly palatable and digestible to Trout (Digestion Coefficient 80%). It also contains Arginine (3.91% on dry basis), an important amino acid for Trout. Dry floating pelleted feed is used for feeding grow-out stock. Trout feed-formulation involves grinding, mixing, agglomerating, heating, drying, screening, pelleting and crumbling of feed.

Ingredients and Inclusion Level of Feed in Trout Grow-out

Ingredients	Inclusion Level (g kg^{-1})
Fish meal	400
Poultry/Fish by-products	80
Blood meal	0-50
Soybean meal	50-100
Wheat grain by-product	150-250
Vitamin premix	10
Trace mineral premix	1
Choline chloride (60%)	4
Ascorbic acid	1
Fish oil	120-250 ml

Feeding Different Growth Stages of Trout

Weight of Fish (g)	Protein Content (%)	Lipid (%)	Feeding Rate (%)	Feeding Frequency
< 10	40-50	14	5-10	7-8
< 50	35-45	16	5-6	3-4
> 50	35	14	2-3	2-3

4.4 Water Supply & Water Quality Management

The success of Trout culture mainly depends on the quality and quantity of water supplied to the farm. Year round supply of cool, clean, oxygen-rich, pollutant-free and suspended matter-free water is one of the most important prerequisites for successful Trout farming. Optimal or near-optimal conditions of water supply depend on the age of fish and its biomass. Critical water quality parameters are temperature, dissolved oxygen, ammonia and pH. However, water temperature is the most important parameter requiring regular monitoring during Trout farming. The preferable source of water is snow-melt water of stream, creek, river, lake or spring which can be obtained through a feeder channel, storage tank or pipeline, by gravity.

The ideal water temperature for production of Trout is one that does not rise too high nor fall too low in winter; the best possible water supply is one in which the temperature remains in the range of 13-18 ^{0}C for as long as possible. The temperature of water supply should never exceed 20 ^{0}C. There are cumulative effects of synergistic interactions between and among different variables, which influence the growth and survival of Trout at any moment in rearing practice. For example, increasing water temperature directly affects Trout as well as reduces the dissolved oxygen in pond water and feed intake.

Preferably flow-through system is required for Trout farming. An abundant and continuous water supply is needed to sustain the flow-through system. In a conventional flow-through system, the oxygen requirement of the fish biomass is met by the inflow water. Water flow is expressed by the quantity of water needed for 1000 specimens of eggs, fry or fish. It is expressed either in litres per second (LPS) or litres per minute (LPM). Water supply may also be expressed by the exchange rate of water per hour or day. To hold one tonne of fish nearly 3-5 LPS (190-300 LPM) of water flow is required at the thermal regime of 13-18 ^{0}C. In general, estimated water requirement for Trout culture is 0.3 LPM for 1 kg of Trout, with aeration. The water supply in concrete raceways remains higher than in earthen ponds, hence the density of fish can also be higher in concrete raceways. In earthen ponds, water can be exchanged a minimum of 4-6 times/day for maintaining optimal dissolved oxygen.

Water Requirement for Different Life Stages of Trout

Stage and Age in Months	Stocking Density Nos. / m^3	Water Flow* Per m^3		Water Flow in Raceway (30 m^3)
		At 5 ^{0}C	At 18 ^{0}C	At 12-18 ^{0}C
Egg Incubation/ Swim-up Fry	1000	0.2 LPM	0.5 LPM	–
Fry (1-5 g), 0.5-2 months	1000-2500	3-6 LPM	4-8 LPM	110-180 LPM
Fingerlings (5-25 g), 2-4 months	100-250	3-8 LPM	5-11 LPM	120-270 LPM
Growing Fish (25-250 g), 4-10 months	60-100	3-6 LPM	5-8 LPM	150-240 LPM
Table Fish (300-350 g), 10-12 months	60-100	4-6 LPM	6-10 LPM	190-300 LPM
Adult Fish (> 350 g)	30-50	2-3 LPM	3-5 LPM	90-150 LPM

*LPM - Litres per minute.

4.5 Health Monitoring

Regular monitoring of growing stock is essential to recognize clinical signs of both infectious and non-infectious diseases and to prevent and control them. Commonly occurring health problems of Rainbow Trout are eye infection, fungal infestation, dermal head necrosis, sun burning and mortality of un-stripped brooders. Generally, mass mortality occurs due to sudden change in water temperature, low dissolved oxygen or increase in ammonia (> 0.5 mg/l). Most of the health disorders originate from poor feed management and unhygienic conditions in raceway. Regular cleaning of raceway, proper feeding, stocking disease free seed, disinfecting Trout stock and tank, ensuring sufficient oxygen and quick treatment at the time of disease outbreak are some of the measures highly beneficial for maintaining a healthy stock and for achieving optimum Trout yield.

4.6 Harvesting and Yield

In general, the production levels of Rainbow Trout in India are 500 - 700 kg per raceway (30 m^2) in 12 months. However, productivity up to 1 tonne/ raceway has been achieved in Himachal Pradesh by some progressive Trout growers. Fish can be partially harvested by drag netting or complete harvesting can be done by draining off water from the raceway. Before harvesting, fish should be starved for 24 - 48 hrs. Harvested fish is degutted, washed with fresh water and packed with ice and salt. Grading by size before packing is also done as per market requirement. Fish can be sold in fresh condition in local market, while ice-packed fish can be sent to fish markets and restaurants in metropolitan cities; however, bulk of the produce can also be exported. A net profit of Rs. 1.25 lakh may be earned from a Trout Raceway of 30 m^2. Value addition and branding of the produce, as for example "Himalayan Trout", may help fetch better market price.

Fig.7. Trout Raceways of a private farmer in Sikkim

Fig.8. Trout Growth in 12 months

5. Conclusion

Rainbow Trout Farming in India has been developing over the last few decades with a present production of more than 842 tonnes per year. Many aspects of culture practices are highly efficient and are being used as a well-established system. Indeed, current research and development is aimed at improving production efficiency and sales by increasing rearing densities, improving recirculation technology, developing genetically superior strains of fish for improved growth, controlling maturation and gender, improving diets, reducing phosphorous concentrations of effluents and developing better marketing.

Fig.9. Rainbow Trout, *Oncorhynchus mykiss* grown in a Raceway

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Breeding, Seed Production and Grow-out Culture Technology of Indian Butter Catfish, *Ompok bimaculatus*

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1. Introduction

Ompok bimaculatus (Bloch, 1794) is a non-air breathing cat-fish, popularly known as 'Indian Butter Catfish'. This species is endemic to Asia and is widely distributed in the plains and sub-mountain regions of eastern and north-eastern States of India where it is known as '***Pabda***'. It is commonly found in streams, rivers, canals, *jheels*, reservoirs, and tanks. This fish also occurs in other countries such as Pakistan, Bangladesh, Myanmar, Thailand, Malaysia, Vietnam, Laos, Sumatra, Java and Borneo. It breeds in large water bodies particularly in rivers and *beels* but does not generally spawn under captive condition. During the last 5 decades population of this species has declined alarmingly to 50% or even less and has been listed under "near threatened" species according to IUCN-based CAMP report. Other reasons for decline may be attributed to indiscriminate fishing of brood fishes during breeding season, shrinkage as well as siltation of breeding ground, and discharge of widely used pesticides and insecticides from agricultural fields causing pollution. Considering its rich nutrients content, commercial value and need for conservation, seed production and grow-out technology has been developed at Kalyani Field Station of ICAR-CIFA.

2. General Description

Systematic Position

Kingdom - Animalia

Phylum - Chordata

Class - Actinopterygii

Order - Siluriformes

Family - Siluridae

Genus - *Ompok*

Species - *O. bimaculatus* (Bloch, 1794)

Common/Local Names of Indian Butter Catfish, *Ompok bimaculatus*

English: Indian Butter Catfish **Hindi:** Puffta, Papta, Jalkapoor, Chechera, Gugli	**Tamil Nadu:** Chaithavelai, Chetahwahlah, Chotah walai, Chotah-wahlah, Chotawahla, Silaivalai
Meghalaya: Khababia	**Kerala:** Chotra valay, Mangeewalah, Manjivala, Mungeewahlah
West Bengal & Tripura: Pabda	**Karnataka:** Godalae, Godla, Kembari
Assam: Pabho, Pabo, Pahboh, Pava	**Maharashtra:** Mounee, Goongware, Moon, Valanj, Wanz
Odisha: Pabtah, Pob-tah	**Gujarat:** Gungwari
Andhra Pradesh: Duka-damu, Dukaduma, Theenuva	**Punjab:** Googwah, Goongwah, Pallu, Pallus, Pubta, Pufta

Source: www.fishbase.org

2.1 Physical Characteristics

It has two pairs of barbels; the maxillary pair is longer reaching the anal fin while the mandibular pair is short, sometimes rudimentary. The rayed dorsal fin is shorter while the pectoral fin is long and surpasses the pelvic fin reaching to the anal fin. The caudal fin is deeply forked with pointed lobes (the upper lobe conspicuously longer than the lower). The skin is smooth and silvery with a purplish tinge. The dorsal portion has faint shade of a dark green with a yellow tinge. The fins are pale gold in colour. There is a small triangular black spot on the caudal peduncle, just above the lateral line. The maximum reported size is 45.7 cm.

2.2 Habit and Habitat

This fish is found in open *beels* and flood-plain wetlands like *mauns* that connect to the river during monsoon. These water bodies are rich in submerged and floating aquatic vegetations that serve as shelter and hiding place for the fish. They also harbour many insects that form the natural food of the fish.

3. Reproductive Biology

3.1 Breeding Season and Maturity

Ompok bimaculatus attains maturity during first year. Males mature by late April while females attain full growth from late May to end of July. The breeding season of the fish extends from early June to late July. However, in places where the monsoon comes early such as in North-eastern part of India, breeding period ranges from April to July.

3.2 Sexual Dimorphism

Sex can be identified externally by the pectoral fin serration which is prominent in male but absent in female. Males are smaller in size, slender, more translucent and less pigmented as compared to females. The genital papilla is elongated and pointed or somewhat conical in shape in male. Females are bigger in size with soft, round and bulged abdomen, fleshy, round and large genital papilla with reddish vent. The sex ratio male : female is 1:1.338.

Fig.1. Indian Butter Catfish *Ompok bimaculatus:* Male (above) and female (below)

3.3 Fecundity

Fecundity ranges from 2,000 to 30,000 per female; number of mature ova per gm weight of ovary varied from 950 to 1090 and the number of ova per gram body weight of fish from 80 to 200. In the mature-stage ovary, different size eggs are seen; fully developed fresh ova are dull brown in colour and measure 0.858-1.365 mm in diameter.

3.4 Scope

The Pabda has high consumer preference in the country owing to its soft flesh, absence of intramuscular bones and rich nutrients (protein - 19.2 g; fat - 2.1 g; minerals - 1.1 g; carbohydrates - 4.6 g; calcium - 310 mg; phosphorus - 210 mg, and iron - 1.3 mg per 100 g fish). Therefore, it fetches a very high market price and has been prioritised as a candidate species for freshwater aquaculture (both monoculture and polyculture). The fish is hardy, easy to handle and transport in live condition and hence can be sold as live-fish in the market at higher price. Its culture can be expanded in various agro-climatic regions of the country.

4. Breeding and Seed Production Techniques

4.1 Brood Stock Culture and Management

Ripe brooders weighing around 40 g and above (male and female) are most suitable for induced breeding and seed production. Brood fishes can be stocked in 0.1 ha earthen pond @ 50,000 nos./ ha, with regular application of cow-dung as manure @ 10 tonnes/ha and lime @ 250 kg/ha per year. Water Hyacinth should be introduced in the pond to simulate natural habitat conditions, serve both as hideout and source of food (periphyton). The water depth to be maintained is 1.0–1.5 m. The brood fishes are fed daily with boiled chopped chicken viscera/ trash fish @ 5% body weight.

4.2 Induced Breeding

Induced breeding is done by administering synthetic hormone (Ovatide/ Gonadoprim/ Ovasis/ Wova-FH) @ 1.5 – 2.0 ml/ kg body weight of female and 0.5 – 1.0 ml/ kg male. The hormone is injected (intramuscular) at the base of the pectoral fin or in between base of the dorsal fin and lateral line. After hormone administration (preferably morning), the brood fishes should be transferred to a breeding hapa/ pool.

The females are stripped for spawning by applying gentle pressure on the abdomen after 8 - 12 hours of hormone injection. The eggs are collected in a dry enamel/ plastic tray. Males are cut open and sacrificed to remove testes. The dissected testes are kept in normal-saline, cut into pieces and macerated to prepare sperm-suspension. The sperm-suspension is spread over the collected eggs in the tray and mixed thoroughly using a bird feather, to facilitate fertilization. A little distilled water can be added to activate the sperms. The fertilized eggs are then washed thoroughly with freshwater, cleaned and transferred to a specially designed Pabda (*O. bimaculatus*) hatchery or into a simple flow-through system.

Fig.2. *Ompok bimaculatus*: Administering hormone to a gravid female

Fig.3. *Ompok bimaculatus*: Stripping of female

Fig.4. *Ompok bimaculatus*: Artificial fertilization – mixing milt with eggs using a bird feather

4.3 Egg Incubation and Hatching

The flow-through system comprises of a stand or platform on which a row of plastic tubs (30 cm diameter and 15 cm depth) are placed. Water is supplied to all the tubs from individual control taps. Each tub is provided with an outlet at a height of about 4 cm. The fertilised eggs are distributed uniformly in the plastic tubs and a gentle/feeble current of water is provided. Instead of plastic tubs, circular FRP tanks can also be used for hatching purpose. Hatching takes place within 22-24 hours of fertilization. Water temperature between 27-30 ^{0}C is ideal for hatching. Soft water with less alkalinity is conducive for a better embryonic development and better hatching rate. The newly hatched larvae are cylindrical in shape, transparent, devoid of mouth, and have pectoral fins and body pigments. Yolk sac is pale greenish in colour and gets absorbed in three days.

4.4 Larval Rearing and Management

The mouth of the larvae starts opening by the second day. A little amount of live feed is provided from that day onwards. During rearing period, cannibalism is observed from the second day onwards wherein the healthy larvae prey upon the weaker ones. Therefore, thinning the density of stocked spawn and subsequent segregation based on their size is essential; this is done using nets of different mesh size. Fish larvae are fed *ad libitum* with a heterogeneous mixture of live zooplankton alone up to 7th day. Later, mixed zooplankton (@ 8-10 cc/ l) along with tubifex worms and egg custard may be provided as larval feed twice a day @ 25% of the body weight of the spawn up to 15th day to obtain better survival and growth of fry. However, chopped tubifex worms along with finely sieved zooplankton is the best food to control their cannibalistic nature. The larvae prefer darker places and hence it is necessary to provide hideouts and shelters for better survival.

After two weeks they are provided with nutritious and balanced formulated diets comprising of egg custard and fish meal. In addition, they are also fed with boiled and finely chopped chicken viscera and/or any kinds of animal protein, particularly low cost fish like Bombay Duck, trash fish, etc. The fry are fed daily 2-3 times, in feeding tray, @ 3-5% of the body weight. Fry attain fingerling size (5-6 cm and 3-4 g) within a rearing period of 40–45 days with 80% survival. These fingerlings are ready for stocking in well prepared stocking pond (0.1-0.5 ha) for grow-out culture.

Fig.5. Pabda fingerlings

4.5 Water Quality Management during Larval Rearing

Spawn rearing can be carried out in FRP tank and cement cistern. Under better management practices, stocking density may be as high as 15-20 larvae/ l of water. The water temperature and dissolved oxygen level are to be maintained between 28-32 ^{0}C and > 5 mg/ l respectively. Initially, the water depth in the container should be 7–10 cm, which can be gradually raised up to 15–20 cm after a period of one week. The water level is adjusted in accordance with different stages of larval development so as to minimize stress. The larval rearing tanks should be provided with a 5-6 cm thick layer of soil. For larval rearing, it is always better to use filtered pond water. Non-chlorinated water with less alkalinity and hardness, with an organic carbon-rich base is conducive for better spawn growth. Periodical water exchange should be done.

5. Grow-out Culture Techniques

5.1 Pre-stocking Management of Culture Ponds

Earthen ponds of 0.05 to 0.2 ha size with water depth of at least 0.75 – 1.0 metre for a period of 8 – 9 months is generally considered suitable for *Ompok bimaculatus* culture. Predatory and weed or unwanted fishes should be removed by repeated netting. After 3-4 days of lime application (200 kg/ha), raw cow dung is broadcasted @ 5000 kg/ha. Inorganic fertilizers may be applied if needed. To simulate their natural habitat, after 4-5 days of manure application, pond surface is covered with submerged and floating aquatic macrophytes up to least 25% of water-spread area in monoculture and up to 10-15% in polyculture.

5.2 Stocking

After about a week, post-manuring, stocking is done early morning @ 60,000 – 80,000 nos./ ha for monoculture and @ 20,000 – 25,000 nos./ ha for polyculture with Carps. The minimum length of Butter Catfish seed considered for stocking in earthen ponds is 6 cm which weigh about 1 g. Suitable seed for stocking ranges from 1 – 5 g for better survival. Polyculture of *O. bimaculatus* with 2–5 species of Carp is found to yield better return than monoculture of the species alone. For balancing the system and maintenance of water quality in monoculture system, carp species namely IMCs, Silver Carp and Grass Carp may be introduced at very low density (@ 500-600 nos./ ha).

Fig.6. Stocking Pabda fingerlings

5.3 Post-stocking Management

Supplementary feed can be locally prepared using cheap feed ingredients comprising at least 30% protein. Commercial feed with protein content above 30% can be used particularly for monoculture. The feed can be broadcasted 2 - 3 times a day early morning and evening @ 8 - 9% initially and gradually reduced to 3 - 5% of the body weight. Feeding rate of Pabda should be adjusted frequently depending on its consumption rate, size and season. In polyculture system, low protein content feed (25% protein) is broadcasted for Carps during day time. Monthly fertilization is done with raw cow dung @ 2500 kg/ha. Stop application of feed or reduce feeding rate and exchange pond water if transparency is less than 20 cm. The fish grow to a marketable size of 50 – 60 g in 8 – 9 months of culture. Multiple harvesting is done by drag netting.

Fig. 7. *Ompok bimaculatus:* Fingerling (left) and a haul of grownup fish (right)

6. Constraints, Pitfalls & Precautions

Since Pabda is cannibalistic in nature at larval stages, survival is low during that stage. Thus, it is very important to feed the larvae sufficiently and take extra precaution. Hideouts or shade should be provided (25% of the total area) using submerged/ semi-submerged aquatic vegetation such as *Eichhornia*, *Hydrilla*, etc. in rearing tanks. Maintenance of water quality such as water hardness, dissolve oxygen and alkalinity are critical, failing which mass mortality can occur. Periodical water exchange and siphoning of faecal matters and excess food in rearing tanks is required to prevent rise in ammonia content.

7. DOs and DONTs

7.1 Breeding and Seed Production

DOs

- ✓ Maintain proper density of brood fish in brooders' pond (5 nos./m^2).
- ✓ Provide proper shelter to the brood fish using aquatic macrophytes.
- ✓ Use supplementary feed having high protein for the brood fish.

- ✓ Use soft water for maintenance of larvae, fry and fingerlings.
- ✓ Harvest rain water and pond water for egg incubation and larval rearing.
- ✓ Provide mixed zooplankton / chopped Tubifex soon after 42-48 hours after hatching.
- ✓ Constantly remove faecal matters and unutilized food particles from the rearing tank at every 2-3 days interval.
- ✓ Up to fingerling size, rearing should be done under controlled conditions in cemented or FRP tank.

DONTs

- ✓ Removal of submerged aquatic weeds in brooders' pond.
- ✓ Use of direct ground water during egg incubation and larval rearing.
- ✓ Use of very hard and highly alkalinity water in hatchery.
- ✓ Constant feeding to the fishes without exchange of water.
- ✓ Rearing of spawn in large water bodies.
- ✓ Removal of shade/hiding place in rearing tank till fry attain fingerling size.
- ✓ Application of only formulated feed without adding live feed.

7.2 Grow-out Culture

DOs

- ✓ Maintain proper density of fish (60,000 – 80,000/ ha).
- ✓ Feed regularly in time in required amount (3-4% of body weight).
- ✓ Monthly sampling, periodical health check up and bottom racking.
- ✓ Remove vegetative hideouts before they started decaying.
- ✓ Stop application of fertilizer and reduce feeding rate if water transparency is less than 20 cm.
- ✓ Pump water from outside if pond water level reduces during winter and summer.

DONTs

- ✓ Constant feeding to the fishes without water quality monitoring.
- ✓ Removal of shade during grow-out culture period.
- ✓ Excessive application of feed and fertilization.

8. Economics

8.1 Breeding and Seed Production of Pabda, *Ompok bimaculatus* (1.50 lakh fry)

Sl.No.		Item	Amount (Rs.)
A	**Fixed Cost**		
	1	Pond construction (0.02 ha)	30,000.00
	2	FRP circular hatching-cum-rearing tank (20 nos.)	1,60,000.00
	3	FRP circular breeding tank (one)	20,000.00
	4	Hatchery shed (25 × 8 m)	50,000.00
	5	Overhead tank (Poly. made, capacity-2000 litres)	20,000.00
	6	Installation cost of overhead tank	25,000.00
	7	Electric pumpset (1 HP) with fittings like suction and delivery pipe, valves, etc.	10,000.00
	8	Aerators	3,000.00
	9	Operational equipment	2,000.00
	10	Electrical connections and fittings	6,000
	11	Spring balance (1 no.)	1000.00
		Sub Total	**3,27,000.00**
B	**Variable Cost**		
	1	Pond preparation and maintenance (0.02 ha)	2,000.00
	2	Brood fish-16 kg @ Rs.500/kg.	8,000.00
	3	Fish feed (for brood fish and raising advanced fry)	15,000.00
	4	Tubifex worms / Chicken eggs / Chicken liver	5,000.00
	5	Synthetic hormone	700.00
	6	Wages for one person (@ Rs. 6000/month for 2 months)	12,000.00
	7	Electrical expenses	10,000.00
	8	Additional labour cost	2,000.00
	9	Miscellaneous	3,000.00
		Sub Total	**57,700.00**
C	Interest on fixed capital @15% per annum		59,000.00
D	Depreciation on fixed capital@10% per year		32,700.00
E	**Total Cost (B+C+D)**		**1,39,400.00**

Sl.No.	Item	Amount (Rs.)
F	Sale of advanced fry: 0.50 lakh @ Rs. 3.00 each (45 days old)	**1,50,000.00**
	Sale of fry: 1.00 lakh @ Rs. 1.00 each (20-day old)	**1,00,000.00**
	Gross Income (from sale of two sizes of seed)	**2,50,000.00**
G	**Net profit (F- E)**	**1,10,600.00**

8.2 Polyculture of Pabda, *Ompok bimaculatus* (for 0.1 ha leased pond)

Sl. No.		Item	Amount (Rs.)
A	**Fixed Capital**		
	1	Pond lease value – 0.10 ha (1 year)	5,000.00
	2	Fencing net and cover net	3,000.00
	3	Water pump and other accessories	30,000.00
		Sub-total	**38,000.00**
B	**Variable Cost**		
	1	Pond preparation and maintenance (0.10 ha)	3,000.00
	2	IMC seed – 500 nos. @ Rs.5/no.	2,500.00
	3	*O. bimaculatus* seed – 2000 nos. @ Rs.4.0/no.	8,000.00
	4	Fish feed	20,000.00
	5	Miscellaneous	2,500.00
		Sub-total	**36,000.00**
C	Interest on fixed capital @ 15% per annum		5,700.00
D	Depreciation on fixed capital @ 10% per year		3,800.00
E	**Total Expenditure (B+C+D)**		**45,500.00**
F	Sale of *O. bimaculatus* - 100 kg @ Rs. 400.00/kg		40,000.00
	Sale of IMC – 350 kg @ Rs. 130.00 /kg		45,000.00
	Gross Income		**95,000.00**
G	**Net Profit (F-E)**		**49,500.00**

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Breeding and Culture of Giant Freshwater Prawn (Scampi), *Macrobrachium rosenbergii*

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1. Introduction

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

2. Field Identification Key

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

Fig. 1. Giant Freshwater Prawn (Scampi) *Macrobrachium rosenbergii:* An adult male weighing 375 g

3. Life Cycle

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

4. Distribution

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

5. Habit and Habitat

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

6. Hatchery Production of Seed

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

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

7. Steps Involved in Establishing a Hatchery

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

7.1 Site Selection

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

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

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

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

7.1.4 Availability of adequate freshwater and seawater: The hatchery site should preferably be near the coastal areas. Seawater used in the hatchery should be free from pollutants. Seawater can be pumped from surface of the sea or estuary during high tide phases through an *in situ* filter bed. Saltwater also can be drawn from underground source by sinking deep tube-well fitted with suitable pumps. Freshwater can be drawn from a river/ canal/ shallow groundwater source.

Un-contaminated freshwater is essential for hatchery operations, mainly for broodstock management, for diluting seawater (larval medium) and for general use.

7.1.5 Good physical access to the site: Site should have good all-weather approach-road for facilitating easy and low-cost transportation of construction material, pond and hatchery inputs and for marketing seed.

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

7.2 Hatchery Facilities

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

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

7.2.2 Water storage tanks: Separate cement tanks for storing seawater, freshwater and mixed water (larval rearing water) are required. The tanks for the first two types of water may be constructed outside the hatchery shed, whereas the tank(s) for larval rearing water (salinity 12 ppt) are better located either under a temporary shed or even inside the hatchery proper (in small hatchery) to get water of ambient temperature in the larval rearing tanks. The size and capacity of above three types of tanks will depend on the overall production capacity of the hatchery.

Huge quantity of larval rearing water is normally required in a flow through hatchery. Larval rearing medium of about 12-times the total volume of rearing tanks are required for each seed production cycle. The hatchery should have water storage facility of at least 3-times the volume of its larval rearing tanks to allow for adequate water storage, treatment and mixing time for preparation of larval medium. To minimize the costs, tanks are better constructed at ground-level and provision for pumping the water at required place should be made.

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

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

Fig. 2. Scampi Hatchery Interior: Larval Rearing Tanks (LRTs), water pipelines, aeration pipes, etc.

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

Fig. 3. Scampi Hatchery: Post-Larval Rearing Tanks (PLRTs)

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

7.2.7 Aeration system: A reliable 24-hour oil-free aeration system is essential for hatchery in order to maintain dissolved oxygen levels in excess of 5 ppm in various units of the hatchery. The air supply is essential in all the tanks used for broodstock holding, hatching, larval rearing, post-larval rearing and *Artemia* hatching. Although majority of the units require mild aeration, it should be vigorous or rather bumping particularly in larval rearing and *Artemia* hatching tanks. Three-phase electrically operated air-blowers both roots-type and fan-type can be used but fan-type provide better aeration and create relatively less noise. Diesel operated air-blowers could also be used where power supply is either not available or there is frequent failure. The capacity of air-blower should depend on the overall requirement of air in different units or the size of the hatchery. A 200 CFM (5.66 m^3/ minute) air-blower is sufficient to supply air for a hatchery capable of producing 20 million post-larvae/ year.

The air-blower or a set of air-blowers should be used at a stretch for a maximum period of 8 hours and switched off, followed by supply from a second set of similar blowers. This practice reduces losses from early wear and tear and avoids sudden aeration failure in the hatchery. The aeration pipeline grid should be installed in such a way and place that it cannot breakdown due to movement of people and other hatchery items. It is better to arrange pipelines overhead and each tank may be provided separate pipeline of smaller diameter pipe of 0.5 to 1.0 inch PVC pipe (dropping from the main pipeline). Each dropping pipeline in turn ought to be provided with small holes for fixing plastic joints and fixing aeration tubings of 1/8 inch diameter, which are provided with air-stones and dropped into the tanks for aeration.

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

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

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

7.3 Broodstock Management

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

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

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

7.4 Hatchery Operation

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

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

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

Hatching tanks should be provided aeration round the clock. Hatching generally takes place in the night and hence freshly hatched larvae (length about 2 mm) are to be harvested as soon as possible through siphoning as the female may consume them if kept for prolong period. Fresh or low salinity water (salinity 3-4 ppt) having pH below 8.3 and temperature 28-3 ^{0}C should be used in these tanks. The larvae should be disinfected with 15 ppm formalin for 5-10 minutes before shifting to larval rearing tanks.

Larval rearing tanks (LRTs) should be thoroughly cleaned and disinfected with bleaching powder at least two days prior to larvae stocking. The tanks are filled with filtered larval water (salinity 12-13 ppt) prepared at least 48 hours before use preferably in indoor conditions of the hatchery. The tanks should be provided with vigorous aeration throughout the tank area and care should be taken to minimize dead ends. This practice helps in uniform circulation of food particles in the tank for easy feeding by the larvae as well as to reduce larval cannibalism due to continuous movement. The stocking density of larvae in the tanks will depend on the rearing methodology adopted. In single stocking method in which zoea larvae are reared to post-larvae, they are stocked at 50-60/ litre; in two-phase stocking method, initial larval stocking density is 100 larvae/ litre, which is reduced to 50-60/ litre, by thinning/shifting, when they reach Stage-V Zoea. Freshly hatched *Artemia* nauplii (AN) should be fed all the time to all the eleven Zoea Stages (I-XI); however, feeding exclusively nauplii may be cut down after Stage-V Zoea, when egg custard is incorporated in the diet. The quantity of *Artemia* nauplii and egg custard should be given according to the area of the tank and not by the number of larvae being reared. This is essential because the larvae prey on the food by touching and not by seeing.

The larval tanks should be cleaned daily to remove accumulated debris, left over feed and faecal matter through siphoning. Around 50% of the tank water should be replaced with fresh larval water after cleaning. The larval tanks may be provided with 5-10 g of EDTA (Ethylene diamine tetra acetic acid) per tonne of water for chelation of heavy metals after every 3-5 days. Antibiotics should not be used in the larval tanks and instead use of probiotics is considered ideal.

Both live and formulated diets are used in the hatchery for feeding larvae and post-larvae. The live feed used in prawn hatchery are *Artemia* nauplii and *Moina macrura*. The later is used only in few hatcheries, where it is cultured in the pure form separately. The formulated diet comprises of egg custard.

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

Artemia cysts are usually contaminated with bacteria, fungal spores, other micro-organisms and organic impurities that may infect the water of larval rearing tanks if not treated properly. Hence, cysts need to be disinfected before stocking for hatching. The disinfection eliminates the chances of infection. The number of *Artemia* per unit weight depends on the type of artemia. On an average, *Artemia* of Great Salt Lake may yield 2.7 lakh and that of San Francisco Bay 3.2 lakh nauplii per gram weight. Find out the hatching rate of *Artemia* from instructions written on the tin for the first time and subsequently after observing the hatching percentage by manual counting.

The *Artemia* cysts are stocked in the hatching tanks @ 2 g/ l seawater, where they hatch out between 12-24 hours. After harvesting, nauplii need to be acclimatized to the salinity of larval rearing water by gradually mixing freshwater. The nauplii should also be treated with 15 ppm formalin for disinfection. Freshly hatched nauplii are to be fed to the prawn larvae as they are rich in nutritional contents in the beginning which gradually reduces with time.

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

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

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

7.5 Collection of Post-larvae from Larval Tanks

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

Post larvae (PLs) should be reared in freshwater tanks (PLRTs) till they attain the desired size/age. They may be fed on commercial prawn starter diet specially prepared for them. Around 50% tank water is to be changed daily and all leftover feed, faecal matter and debris to be removed at the same time. The growth of post-larvae may be checked by observing their moulting on a regular basis.

Harvesting of post-larvae should be done when they attain the desired size in terms of length. The post-larvae of size above 10 mm is considered ideal for harvesting and stocking in the nursery ponds. The seed of more or less same size should be supplied for stocking in the nursery pond. Post-larvae can be packed in polythene bags containing 4-5 litre water and oxygen and kept in cardboard cartons for transport. For long distance transportation of >12 hours, a sachet of cooling gel is placed in each seed pack container for maintaining temperature.

7.6 Hatchery Hygiene and Prophylactics

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

8. Grow-out Culture

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

8.1 Nursery Phase

Nursery is the intermediate phase between hatchery and grow-out of freshwater prawn. It involves rearing of the delicate 25-day or older post-larvae (10-20 mm), obtained from hatcheries, in well prepared earthen ponds (0.01 to 0.1 ha) or concrete tanks for a period ranging from 45-60 days till they grow to juveniles (1-2 g). Stocking density ranges from 20 to 50/ m^2. Higher stocking densities would require aeration or water exchange. Stocking nursery reared larger juvenile prawns in grow-out ponds gives better yield and predictable production than direct stocking of post-larvae. Hence nursery rearing phase is always recommended prior to grow-out culture. Pond preparation and management are similar to that of grow-out ponds except that hide-outs are not provided in nursery ponds. Floating aquatic plants such as *Eichhornia* sp. may be introduced in a floating bamboo or PVC frame to cover 5-10% of pond surface area. The dense root system of these plants provides shade, shelter and food to growing post-larvae. Good quality commercial pellet feed (Starter-I) is recommended for feeding the post- larvae twice daily. If it is not available, then powdered oilcake and ricebran mixture can also be fed to post-larvae at 100% biomass per day for the first 10 days and slowly reducing the quantity as the prawns grow. Survival rates of 75 to 80% can be achieved during nursery phase under good management practices.

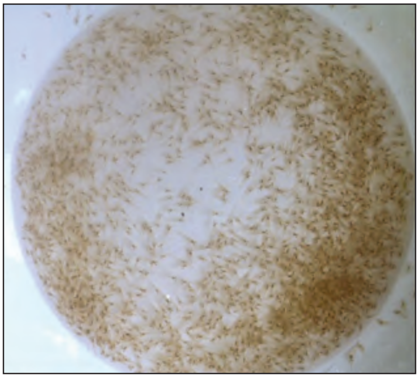

Fig. 4. Post-larvae of Giant Freshwater Prawn (Scampi)

Fig. 5. Juveniles of Giant Freshwater Prawn (Scampi)

8.2 Grow-out Phase

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

8.2.1 Site selection: The selected site should have warm climate for nearly 6-8 months (temperature >20 ^{0}C). It should have a supply of good quality, pollution free freshwater or brackish water (<7 ppt) for at least 6 months. It should have soil with good water retention capacity.

8.2.2 Pond construction:

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

8.2.3 Eradication of competitors and predators:

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

Different Plant-based Fish-poisons and their Dose

Name of Poison	Quantity/ha^{-m}	Toxicity Retention
Mahua oil cake	2500 kg	Three weeks
Derris root powder	150-200 kg	Three weeks
Bleaching powder	350 kg	One week
Bleaching powder and urea	175 kg and 100 kg	One week

8.2.4 Liming:

- Liming is an important step in pond preparation and is done after drying the pond by spreading the lime uniformly on the pond bottom.

- The rate of application varies with soil pH; to a pond having soil pH above 6 agricultural lime (Calcium carbonate) is applied @ 200-250 kg/ha.
- Application of lime helps to correct pH; increases the buffering capacity of water; disinfects the pond bottom as well as acts as a source of calcium which is important for exoskeleton formation in prawns.

Fig. 6. Liming the pond

8.2.5 Fertilization:

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

8.2.6 Provision of hideout and bird netting:

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

Fig. 7. Hideouts for Scampi in grow-out ponds

8.2.7 Stocking the pond:

Fig. 8. Stocking Scampi Post-larvae in grow-out ponds

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

8.2.8 Water quality management:

- Visibility/ transparency and colour of the pond is an important indicator of the health of pond ecosystem. In unproductive ponds the visibility can be up to the bottom which will lead to growth of bottom algae that adversely affect the growth and survival of prawns. Low visibility (<10 cm) indicate high blooming or turbidity that could cause problem of oxygen depletion and mortality of stocks. Ideally, the visibility should be maintained in the range of 30-40 cm to avoid water quality deterioration.

Fig. 9. Long Arm Paddle Wheel Aerator

- Daily monitoring of water quality parameters such as dissolved oxygen, pH and temperature is recommended to prevent loss of stock due to poor water quality. Loss of prawn is usually associated with low dissolved oxygen level in the pond. Therefore it is essential to maintain dissolved oxygen at optimum level of >4 ppm at all times. Provision of aerators (paddle wheel or any other such devices) is recommended especially during the final 2-3 months when the biomass in the pond is high. When the oxygen level in the pond is critically low, the prawns come to the surface along the periphery which indicates the need for taking immediate remedial measures such as water exchange or operation of aerators to avoid mortality of stock.

- Water should be free of pollutants and toxic chemicals and the optimum ranges for a few most important water quality parameters for freshwater prawn culture are as follows:

Optimum Water Quality Parameters for Scampi Farming

Water Parameter	Optimum Range
Temperature (^{0}C)	28 - 31
Salinity (ppt)	Freshwater/ low-saline (<7 ppt)
pH	7.0-8.5
Dissolved Oxygen (ppm)	>4.0
Total Hardness (ppm)	40-100
Calcium (ppm)	50-100

8.2.9 Feed management:

- Freshwater prawns are omnivorous and feed on both animal and plant materials, found on the pond bottom, such as algae, aquatic insects and their larvae, worms, crustaceans, small mollusks, etc.
- Farmers may use commercial pellet feed having good water stability or farm made feed. Most commonly used ingredients for farm made feed includes ricebran, broken rice, groundnut oil cake, tapioca powder, fishmeal, apple-snail meat, etc.
- Prawns are fed daily at 25% of the biomass during the first two months which is gradually reduced to 3% of the biomass at the end of culture period.
- Although feed is usually broadcasted around the periphery of the pond in shallow area, providing of feed in check-trays kept in different areas of the pond will help in determining the quantum of feed required per day.
- Feeding should be done during late evening or early morning since prawns are more active during night time.

Fig. 10. Formulated Pellet Feed

- Feed rate should be revised once every three weeks depending on the average body weight obtained during monthly sampling. Weight dependent feeding rates is given in table as follows:

Optimum Feeding Rate for Scampi in Grow-out Pond

Body Weight of Prawns (g)	Feeding Rate (% Prawn Biomass)
< 2	> 25
2-5	10
5-10	8
10-15	6
15-20	4
20-25	2.5
25-30	2.0
> 30	1.0

- Regular sampling of prawns using cast net or small mesh seine net at 3-4 week interval is essential to assess the growth of prawns. Feed rate is revised after every sampling based on the body weight and estimated biomass in the pond.

8.2.10 Health management:

- Diseases in freshwater prawn grow-out culture are usually found to be associated with poor rearing conditions (over-feeding, water shortage, silting etc).
- Bacteria and fungus are the most common disease causing organisms. Loss of appendages, brown or black colouration of exoskeleton, fouling on the body are some of the symptoms seen in diseased prawns.
- If disease symptoms are noted, water should be replaced, water quality should be tested and necessary steps should be taken. Immediate consultation of experts will help in avoiding loss of stock due to diseases. Following good rearing practices mentioned below will help avoid diseases to a great extent:
    - Use good quality seed and avoid high density stocking.
    - Use good quality pellet feed, monitor the feeding using check-tray and avoid over-feeding.
    - Dry out the ponds between production cycles so that the pond bed can be re-oxidized.
    - Water exchange (30-50%) helps in rinsing the pond and induces moulting.
    - Regular monitoring of water quality especially dissolved oxygen is essential.

8.2.11 Yield and Production Cost:

- Good quality post-larvae stocked at moderate density 3/m^2 and fed with good quality pellet diet will grow to an average size of 50-60 g in 6-8 months.
- Periodic harvesting of prawn is always suggested due to heterogeneous growth among prawns. Large prawns (>40 g) may be harvested using seine net of suitable mesh size after four months of culture, which should continue once every 3-4 weeks thereafter for the next 3-4 months.
- Final harvesting of the prawns may be done after 8 months of culture by complete dewatering and the pond should be freshly prepared for the next production cycle.
- A survival rate of 65 to 70% is expected and prawn yield may range from 800 to 1000 kg/ha (320 to 400 kg/acre).
- The cost of production per kg of prawn may range from Rs.150 to Rs.175/-. Major components of cost of production include cost of seed, pellet feed, energy and labour.

Fig. 11. Giant Freshwater Prawn (Scampi) Harvested Crop

8.2.12 Post-harvest handling:

- Processing yield (tail weight percentage) of freshwater prawns (< 50%) is less than that of marine shrimps (> 60%) and decreases with the increase in size of the prawn and is better for females than males.
- Prawns are sold either head-on or head-less. Sometimes they are sold live also. Ice-chilled uncooked prawns have a short shelf life (3 days) before they become mushy. 'Kill chilling' by dipping prawns in iced water prior to blanching at 65 ^{0}C for 15-20 sec before icing for transport to market, significantly improves quality.
- Usually harvested prawns are washed and iced immediately to prevent quality deterioration. In the processing plants they are removed from ice and washed again. The washed and drained prawns are weighed and sent for de-heading.
- The iced headless prawns are then size-graded by weight.
- After size-grading the product then goes for further value addition according to the requirement of the buyer, such as 'peeled and deveined' (PD) and 'peeled deveined tail-on' (PDTO). Most of the Giant Freshwater Prawn farmed in India is exported in a headless tail-on style.
- Prawns are either bulk frozen or individually quick frozen at -40 ^{0}C. Packed material is finally stored at -20 ^{0}C.
- Removal of head and intensive washing decreases initial microbial load and improves the post-storage quality of prawns which can be stored frozen for up to six months without any deterioration of flavour.

8.2.13 Constraints – pitfalls and precautions:

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

8.3 Polyculture

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

Farming of Giant Freshwater Prawn Scampi – DOs and DONTs

DOs	DONTs
1. Prepare the pond well before stocking following recommended pond preparation protocols.	1. Don't stock prawns without preparing the pond.
2. Remove all predatory and weed fishes and if possible dry the pond or use mahua oil cake for removing predatory and weed fishes	2. Don't stock prawns without removing predatory and weed fishes
3. Apply lime after checking soil pH. Normal dose is 200 kg/ ha if the soil pH is more than 6.0	3. Don't stock prawns without liming the pond.
4. Fertilize the pond 2-3 weeks prior to stocking with organic/ inorganic fertilizers.	4. Don't stock prawns without fertilizing the ponds
5. Use hide-outs. Prawn needs shelter/ hide-out during moulting to avoid predation by other prawns. Hence cut branches of trees, nylon screen, earthen pipes, etc can be provided as hide-out.	5. Don't stock prawns without placing hide-outs in the ponds.
6. Use pollution free, good quality water for culture. Use small mesh screen cover for the inlet to prevent the entry of eggs and larvae of predatory fishes	6. Don't add water from contaminated sources. Don't add water into the pond without mesh screen.
7. Check pH, hardness and transparency prior to stocking.	7. Don't stock ponds without checking pH, hardness and transparency.
8. Correct the pH (optimum 7.0 - 8.5) and hardness (optimum 40-100 ppm) levels if found very low or very high prior to stocking.	8. Don't stock ponds without correcting pH, hardness and transparency levels.
9. Use good quality seed (PLs) of >10 mm for stocking in nursery pond and >1-2 g juveniles for stocking grow-out ponds.	9. Don't stock ponds with poor quality seed or those that are not active.
10. Use well prepared nurseries to rear post-larvae up to juveniles.	10. Don't stock post-larvae in unprepared nurseries.
11. Follow recommended stocking density of 20/sq m for nursery and 3/sq m for grow-out phase.	11. Don't use high stocking densities
12. Always maintain a water depth of 3-4 feet in the pond.	12. Don't allow the water level to be very low < 3 feet in the pond
13. Transparency of the pond should be maintained at 30-35 cm by application of manures (fermented oil cakes or animal manure)	13. Don't allow the water to become very transparent (>35 cm)

DOs	DONTs
14. Prevent bird predation by covering the pond using large mesh gill-net or using poly-amide threads.	14. Don't leave the ponds without any protection to prevent bird predation
15. Feed the prawns twice daily with good quality pellet feed or farm made feed at recommended rates	15. Don't use poor quality feed and do not over feed or under feed.
16. Use check-trays for feeding to have a better estimation of feed consumption by prawns.	16. Don't feed without check-trays.
17. Visit the pond site daily early in the morning. If any prawns are seen on the sides it indicates low oxygen levels in pond. Immediately pump water to the pond or operate aerator to increase DO levels	17. Don't forget to visit the ponds daily early in the morning.
18. Fertilize the ponds frequently to maintain optimum plankton production.	18. Don't forget to frequently fertilize the ponds (once every two weeks) to maintain optimum plankton production.
19. Sample netting the ponds once every 3 weeks using cast net is necessary to monitor growth and health of prawns and adjust the feed quantity.	19. Don't forget sample netting to check the growth and health of stocked prawns.
20. Start partial harvesting using a seine net with pockets when the average weight of prawns is 30 g to remove larger prawns.	20. Don't forget to start partial harvesting using a seine net with pockets when the average weight of prawns is 30 g.
21. Complete harvesting of the ponds can be done after 6-8 months of culture by dewatering the pond.	21. Don't forget to completely drain the pond for final harvest.
22. Contact and arrange prospective buyers prior to harvesting.	22. Don't forget to contact and arrange prospective buyers prior to harvesting.
23. Prawns may be kept in ice only for short duration.	23. Don't forget to deep freeze the harvested prawns as quickly as possible.

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Notes

A Portable FRP Carp Hatchery Demo Unit on display at ICAR-CIFA, Bhubaneswar, Odisha (Photo Courtesy: ICAR-CIFA)

An FRP Hatchery Unit established in a rural setting, comprising of an Overhead Tank, one Breeding Pool, three Hatching Pools, adjacent to an earthen pond (Photo Courtesy: ICAR-CIFA)

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