Structure

1.1 Introduction

1.2 Present status of Fish Seed production

1.3 Present status of Prawn and Shrimp Seed production

1.1 Introduction

Successful food-fish production is largely dependent on the availability of quality fish seed amongst various other factors associated with ongrowing. Difficulties in accessing adequate fish seed can therefore constrain production, business and food-fish supplies.

Deficiencies in fish seed supply within India were anticipated eleven years ago with the then level of production estimated as being able to satisfy less than half of customer and consumer demands at the time.

In early seventies, riverine spawn accounted for over 92% of total seed availability. But, IN due course of time fish farmers experienced difficulty in obtaining required amount of pure ‘Seed’, as the number and quality seed deteriorated due to various environmental problems playing havoc with the natural aquatic habitats. Moreover, the availability of adequate quantity of ‘Seed’ of cultivable species is the most important prerequisite for the development of ‘fish culture’.
During the last few decades efforts have been made by fishery scientists to tackle the pressing problem of acute shortage of quality of fish seed by evolving suitable methods of breeding carps in Bundhs or in fish farms purely by Induced Breeding Technology.

1.2 Present Status of Fish Seed Production

During the Sixth and Seventh Plan period, the government laid adequate emphasis on production of fish seed (major carps) to meet the growing requirement of fish farmers in the country. In the process, a number of commercial fish seed farms and hatcheries were established in the government sector. These farms and hatcheries along with the private enterprise (mainly restricted to West Bengal and Assam) did bring the desired results and around late eighties the country seemed to be self sufficient in meeting the seed (major carps) requirement of farmers.

From Eighth plan onwards, the government has been encouraging fish seed production in the private sector. In the process, fish seed production has increased from 9691 million fry in 1989-90 to 16589 million fry in 1999-2000 with a growth rate of 4.60% per annum. During Eighth Plan the growth rate for seed production was 5.44% per annum. However, the growth rate during the first three years of the Ninth Plan has been 2.1% per annum. This is likely to be increased by the end of the ninth plan.

India is reckoned to be self sufficient in carp seed production to support aquaculture. However, much still requires to be done in the area of fish seed production and besides production of quality fish and shrimp seed, the deficit areas needs promotion. The carp seed production infrastructure in the country is inadequate and inefficient particularly in public sector and is localized in certain states only. Diseases free and diseases resistant carp seed is to be ensured with strict quarantine measures. Brood stock maintenance is to be encouraged on the seed farms. Further technologies for raising seed of minor carps, cat fishes and cold water fish species, particularly of game fish, indigenous ornamental fishes and species for mariculture programmes are required to fill the gaps and for further promoting aquaculture through diversification. Genetic upgradation of candidate species for aquaculture through genetic selection process is an immediate necessity so that better performing fish seed stock is made available to the aquaculturists. Application of bio-technology should be given emphasis in fisheries sector, particularly in aquaculture.

Seed being the basic input into culture system, its production has been accorded priority in terms of brood stock management, establishment of hatcheries, refinement of induced breeding techniques, rearing and production
of quality seeds across the country. It is estimated that a total of 17,000 million fry (Indian major carps and exotic carps) shall be produced by the end of the Ninth plan.

The target set for fish seed production for the Tenth plan for the Indian major carps and exotic carps are based on an annual (of 8%) growth rate and it is expected that about 25,000 million fry will be produced by the end of the Tenth plan (2006-07). Besides, adequate infrastructure and efforts on priority are required to produce seed of shrimp (about 20,000 million PL) and Finfish (about 150 million fry) such as Sea bass, Grey mullet, Grouper, Snapper, Chanos sp. etc.) for diversifying fisheries activities during the Tenth plan.

India is the second largest in aquaculture production in the world. Fish production has increased from 41.57 lakh tonnes (24.47 lakh tonnes for marine and 17.10 lakh tonnes for inland fisheries) in 1991-92 to 82.90 lakh tonnes (32.20 lakh tonnes for marine and 50.70 lakh tonnes for inland fisheries) in 2010-11.

1.3 Present Status of Prawn and Shrimp of Seed Production

In the context of the ever increasing demand for export of prawns, attention is being focussed on possibilities of large scale commercial culture of marine as well as freshwater prawns. Marine and freshwater species suitable for culture are widely distributed and their young ones occur in natural habitats, during certain parts of the year, in varying abundance. In brackishwater areas, the prawn seed is collected using the traditional method, where tidal water along with its fauna is taken in at the high tide and young ones are trapped. Though plenty of prawn seed are collected every year from its natural sources, these generally meet the seed requirements of small scale culturists only. Large scale collection of seed sometimes may not be possible, and at the same time the population is decreasing due to over exploitation. If seed is available in large quantities, prolonged storage of collected seed often results in heavy mortal. Non-uniform size and mixture of species are also problems in natural collection. Hence, prawn hatcheries are necessary for production of prawn seed in large quantities.

In India about 2.2 million ha. of Brackishwater prawn cultivable land is available. So far only 50,000 ha. of the above land is converted into prawn culture farms which was facing already scarcity of prawn seed from natural sources. For a full fledged extension of Brackishwater aquaculture in the above said total available land, the basic requirement is steady supply of young prawn larvae. The estimated prawn seed required for all the stocking available 50,000 ha. of Brackishwater area in our country (which is under culture at present) is worked out as 600 crores if prawn seed for fours crops (at a stocking density
rate of 30,000/ha). The development of shrimp hatchery has most important role for intensive shrimp farming in India. Since limited numbers of shrimp seed can be obtained directly from natural resources.

As early as half a century ago, Hudinaga successfully shrimp and reared of Penaeus japonicus to the mysis stage (Hudinaga 1955). Unfortunately world war II interrupted further development for more than 10 years. It was not until the late 1950’s, that several Americans became highly interested in Penaeid hatchery work. In India also Marine hatcheris started by mid 1970’s and adopted slowly by different state, central and private organisation, in different parts of the country like Narakkal (Kerala), Regional shrimp hatchery, Azicode (Kerala), Paradeep (Orissa), Okha (Gujarat), Dahanu (Maharastra), Villarpadu (MPEDA) (kerala), Madras (Tamilnadu), CIFE, Bombay and at BWFF Kakinada (A.P.) Mahabalipuram by Hindustan lever (Tamilnadu). But all the above hatcheries are unable to supply the required numbers of seed to the prawn farmers. In 1988 two commercial prawn hatcheries have come up in the east coast

1. OSSPARC (Orissa Shrimp Seed Production And Research Centre) hatchery established at Gopalpur in Orissa State, and

2. TASSPARC (The Andhra Pradesh Shrimp Seed Production and Research Centre) hatchery established at Visakhapatnam in Andhra Pradesh.

These two commercial hatcheries are able to supply about 50 millions of prawn seed per annum, as per the demand of the shrimp culturists.

Short Answer Type Questions

1. Expand TASSPARC.

2. Expand OSSPARC

3. What is present status of India in aquaculture production in the world?

4. What is the target set of the seed feed production of 10th plan for the cultivable carp species?
## Structure

2.1 Introduction  
2.2 Life cycle of Fish  
2.3 Life Cycle of Prawn  
2.4 Life Cycle of Shrimp  
2.5 Life Cycle of Crab

### 2.1 Introduction

Aquaculture has great scope now-a-days. Aquaculturist should mention the good management practices. A person should know that biological aspects of aquatic organisms such as their life cycle, food, feeding, maturation, reproduction etc.

### 2.2 Life Cycle of Fish

Each fish species has a unique reproductive strategy and favors certain habitats for spawning and for early development of their newly hatched young. Many Great Lakes fish can be found in shallow water during part of their life cycle. Many species use shallow waters of lakes or rivers as spawning habitat either in the spring or fall. Some, such as northern pike, prefer wetlands with aquatic vegetation. Others such as lake whitefish prefer shallow reefs, which provide rich areas for food and rocky structure to protect the eggs and later the fry.
Fish life cycles vary among species. In general, however, fish progress through the following life cycle stages:

**Eggs:** Fertilized eggs develop into fish. Most eggs do not survive to maturity even under the best conditions. Threats to eggs include changes in water temperature and oxygen levels, flooding or sedimentation, predators and disease.

The number of eggs produced by a single female differs considerably and depends upon several factors like her age, size, condition and species. The egg is generally surrounded by a shell but when it leaves the ovary, it is enclosed in a vitelline membrane. Generally, the egg is spherical or oval in shape and has some amount of yolk in it. Eggs of bony fishes are of two main types. Pelagic eggs are buoyant and provided with a thin, nonadhesive membrane, while demersal eggs are heavy and sink to the bottom, and are covered by a hard adhesive membrane.

![Fig. 2.1 Developmental stages of a bony fish.](image)

Sticky, demersal eggs become attached to the debris of the bottom and are prevented from being swept away along the current of water at the time of deposition. Marine fishes, produce either pelagic or demersal eggs, but the eggs of fresh water fishes are generally demersal. Pelagic eggs are of
small size and single large oil globule may be present on the surface of its yolk. The eggs of some species (scomberisocidea, belonidae and exocoetide) have sticky threads for attachment with some object or with each other.

**Larval Fish**

Larval fish live off a yolk sac attached to their bodies. When the yolk sac is fully absorbed the young fish are called fry.

**Stage I**: This is called prolarva with fairly large sized yolk sac. The yolk sac is broad anteriorly, tapering towards the posterior end, and has a row of pigments on its upper part. It has a broad head, pigmented eyes, and a median continuous fold. The dorsal fin is demarcated but rays are not present in it. The caudal fin is truncate and 7-8 rudimentary rays are present in it. Anal fin is not demarcated and the pelvic fin is not yet formed. The pectoral fin is represented by a membranous flap without any rays.

Fig. 2.2 Fish larval stages
Stage II: Yolk sac is slightly reduced, and chromatophores are present on the head. Dorsal fin is further demarcated and 7-8 rudimentary rays can be seen in it. Caudal fin consists of 15-16 rays. The anal fin is slightly demarcated but rays are not seen in it. The pectoral fin does not contain rays and is still in the form of a membranous flap. The air bladder is now visible.

Stage III: The yolk sac is considerably reduced. The gape of the mouth extends backwards. The dorsal fin is almost complete with rays but is still connected with the caudal fin which is now deeply forked and contains 19 rays. The anal fin now has three rudimentary rays. A rudimentary pelvic fin can be seen as a minute bud. Pectoral fin is still without rays. Alimentary canal is now visible and chromatophores are present on the head.

Stage IV: Yolk is completely absorbed and it resembles the adult fish. The dorsal fin is fully developed and is not connected with the caudal fin. The anal fin contains 7 rays and is still connected with caudal. Pelvic fin is further developed. Pectoral fin is still without rays and a black spot is present on the caudal peduncle.

Stage V: Larva is almost like the adult fish and all the fins are fully developed. Anal fin contains 9 rays and is separate from the caudal fin. Pectoral fins are well developed and contain 9-10 rays. Black spot on the caudal peduncle and the chromatophores on the back of the larva are more prominent.

Fry

Fry are ready to start eating on their own. Fry undergo several more developmental stages, which vary by species, as they mature into adults. Young fish are generally considered fry during their first few months (during their first few months to less than one year in some species).

Juvenile

The time fish spend developing from fry into reproductively mature adults varies among species. Most fish do not survive to become adults. Threats to survival include fluctuations in water temperature, changes in oxygen levels, competition for habitat, and predators.

Adult: When fish are able to reproduce, they are considered adults. The time it takes to reach maturity varies among species and individual fish. Fish with shorter life spans reach maturity faster. For example, female round gobies mature in approximately one year and live for two to three years. Lake sturgeon can live from 80-150 years, but females don’t reach maturity until they are approximately 25 years old.
Maturation and Spawning

Both male and female gonads undergo marked cyclic morphological and histological changes before reaching full maturity and becoming ripe. This is called maturation of the gonads. Most of the fishes exhibit seasonal cycle in the production of gametes. The expulsion of gametes from the body into the surrounding water is called ‘spawning resulting in fertilization’. Fish spawns during a specified period which depends upon several factors. The period during which the gonads attain full maturity and spawning takes place in the population is called the breeding season of the species. After spawning, a new crop of germ cell is formed, which gradually mature to become ready for the next season.

2.3 Life cycle of Prawn

Although freshwater prawns require brackish water in the initial stages, most of their lifecycle is spent in turbid, riverine systems. They are not cold tolerant so production in northern climates can be limited.

Fig. 2.3 Adult male and female M. rosenbergii

Freshwater prawns have a hard outer shell that must be shed regularly in order to grow. This process is called “molting”. Because of these periodic molts, growth occurs in increments, rather than continuously. This results in four distinct phases in the life cycle; egg, larvae, postlarvae, and adult.
Females become sexually mature before six months of age. Mating occurs only between hard-shelled males and ripe females that have just completed their pre-mating molt and are soft-shelled. Within a few hours after mating, eggs are laid and transferred to the underside of the tail where they are kept aerated and cleaned. Although first spawns are often not more than 5,000 to 20,000 eggs per female, mature females have been reported to lay between 80,000 to 100,000 eggs during one spawning. The eggs remain attached to the abdomen until they hatch. The bright-yellow to orange color of newly spawned eggs gradually changes to orange, then brown, and finally to grey-black. At 82º F, eggs hatch 20 - 21 days after spawning.

Fig. 2.4 Larva stages I - XII of M. rosenbergii
After hatching, larvae are released and swim upside down and tail first. Although larvae can survive for 48 hours in freshwater, they must be transferred to brackish water (9 to 19 parts per thousand) for optimum survival. Larvae undergo 11 molts over a period of 15 to 40 days before transforming into postlarvae. The rate of this transformation depends upon food quantity and quality, temperature, and other water quality variables. Larvae feed primarily on zooplankton and larval stages of aquatic invertebrates. See larger chart of the larvae stages.

At this point, the prawns resemble small adult prawns, about 0.3 to 0.4 inch long and 50,000 to 76,000 per pound. They change to principally bottom dwelling, crawling individuals. Postlarvae can tolerate a range of salinities. The postlarvae prawn’s diet expands considerably and they may become cannibalistic under conditions of food limitation. Although no standard definition exists, the term juvenile is used to describe the freshwater prawn between postlarvae and adult.

### 2.4 Shrimp Life Cycle

1. **Eggs**: Shrimp eggs are thought to sink to the bottom at the time of spawning. Egg diameter is less than 1/64 in. Most spawning is believed to occur in high salinity oceanic waters.

2. **Nauplius**: There are five naupliar stages. The first stage is about the size of the egg and succeeding stages are slightly larger. Nauplii have limited swimming ability and usually are a part of the oceanic plankton. Nauplinds is the first
larval form of shrimp. It hatches out of the egg sheel in about 1-14 hours after spawning, depending upon the temperature and environmental conditions. It is a free swimming larvae and it swims with the help of its biramous appendages. They get the desired nutrition from the yolk in the body. Hence it does not required any feed. The nauplius has six substages and the body length vaires from 0.32 to 0.50 mm. The number of stylets on the second antennae varies from 5 to 11 and caudal stylets vary from 2 to 14. In the late nauplius stage the rudimentary cephalothoracic carapace forms with two groups of 7 spines each. the duration of the nauplius stage lasts for 36-96 hours.6 substages of nauplius are found in P. monodon P. Indica.

3. Protozae: The three protozoal stages range in size from 1/25 to 1/12 in. These planktonic forms are found in oceanic waters. Protozoa have undergone development of their mouth parts and the abdomen has begun to develop. It is the second larval form of shrimp. The nauplius after the sixth moult forms the protozoae. The larvae swim by flexing the joined appendages. Protozoa has three stages. It has large cephalothorax with an anterior rostrum, two prominent stalked compounds eyes, well developed.

Cephlic and anterior thoracic appendages, rudimentary posterior thoracic appendages and a long abdomen with a forked etlson. The first stage, the eyes are simple and sessile, body is distinct as the head and tail. Third ethoracic segment a very long body is found and segmented upto the 9th thoracic segment. In the second stage, the compounds eyes are found and are protruded. At the centre of the anterior maring of the carapace a protrusion appears. Five abdominal segments are prominent. In the third stage, dorso mdian spines and
uropod development appear. The 6th abdominal segment is very long and the caudal segments develop with caudal appendages. Feeding starts from the first stage. During the initial stages it feeds on minute pytoplankton. The duration of protozoea stages I-III is about 38-90 hours, depending upon the temperature and food.

4. Mysis: There are three mysid stages ranging in size from 1/8 to 1/5 in. These are planktonic in the ocean. Mysids have early development of legs and antennae. After the third moult of protozoea, the mini prawn/Mysis larva/schizopod larva is developed. The head and thorax fuse completely to form the cephalothorax. The carapace extends up to the eighth thoracic segment. It has biramous appendages on all the thoracic segments and a long abdomen with five pairs of pleopods and a pair of uropods. It has 3 stages. In Mysis stage-I the pleopods are not developed. Pleopod buds appear in stage-II and fully formed pleopods with segments are seen in stage-III. The body is bent at the junction of thorax and the abdomen and the walking legs move rapidly up and down. The larvae swim backwards. The duration of mysis stage is about 118-207 hours. It develops into the post-larval stage after 3 months of the mysis stage.

Fig. 2.9 Mysis

5. Postlarva: The two postlarval stages for white shrimp are about 1/6 to 1/4 in. Brown shrimp postlarvae are larger, up to 1/2 in. The walking and swimming legs have developed and the postlarvae appear as miniature shrimp. The second postlarval stage rides the flood tides into the estuaries, apparently becoming active during flood tide and settling to the bottom during ebb tides. The postlarvae ultimately settle in the upper parts of tidal creeks.

Fig. 2.10 Postlarva
6. **Juvenile**: Postlarval shrimp develop directly into juvenile shrimp. Growth is rapid, up to 2 1/2 in. per month. Juveniles are similar to adults except they are characterized by a much longer rostrum (horn). Juveniles typically remain in the marsh creeks until reaching about 4 to 4 1/2 in. before moving into the deeper rivers.

![Image of Juvenile Shrimp](image1)

**Fig. 2.11** Juvenile

7. **Sub-adults**: Sub-adults move into the deeper waters of the estuaries and may remain there for a month or more before moving seaward. These shrimp continue to grow but at a slower rate than juveniles. Sub-adults usually do not exhibit any signs of ovarian maturity.

![Image of Sub-adult Shrimp](image2)

**Fig. 2.12** sub-adults

8. **Adults**: Adults may be 5 to 8 inches in length. Adults are usually found in the ocean, but in dry years may delay migration until cold weather occurs. Spawning females are characterized by brightly colored ovaries that can be seen under the shell on the upper side of the body. Adults may be found near the beaches out to 5 or 6 miles from shore. Some species are known to migrate hundreds of miles along the coast.

![Image of Adult Shrimp](image3)

**Fig. 2.13** Adults
Key to identify the zoea, Mysis PL stages

Appearance of appendages in zoes, Mysis and post Larvae stage is as follows

**Zoea Stage**
1. Eyes are sessile, body distinct as head, thorax and tail.
2. Eyes protrude.
3. Appearance of dorsal median spines and uropod development

**Mysis Stage**
1. Pleopods not fully developed.
2. Pleopods buds make appearance.
3. Pleopods segmented.

**Postlarval stage**

Pleopods with serri, in this stage all characters resemble with adult prawn except sexual organs.

2.5  Life Cycle of Crab

The crabs’ breeding timetable is fixed around the phases of the moon. Spawning (the dropping of their eggs into the sea) must occur before sunrise on spring tides during the last quarter of the moon, regardless of any other factor. The timing of spawning is the only certain and predictable part of the whole migration; all other stages of the migration will vary with the prevailing weather.

The crabs will start their migration if there is enough time for them to complete their downward migration, mate and develop eggs before the next suitable spawning date.

The red crab breeding migration comprises a series of separate actions on the crabs’ part that follow on from one to the other in a programmed sequence. These separate actions in combination make up the breeding migration and one action will not occur unless the preceding action is accomplished. If there isn’t enough time for them to do all of these things before the next spawning opportunity, they will delay the start of their migration and attempt to meet the following month’s spawning date.

The first action that occurs is movement of crabs to the sea. The largest mass movement of crabs takes place in this first downward migration. Males farthest inland start this movement and are progressively joined by more and
more crabs (both males and females) as the movement progresses toward the sea.

When the crabs arrive at the shoreline, they dip in the sea to replenish body moisture and salts. The male and female crabs then move back on to the shore terraces where the males dig burrows for mating. Mating takes place and then the males again dip in the sea and then they will start their return migration.

The females remain behind in the mating burrows to brood their eggs. This takes a couple of weeks. A day or two before the spawning date the females emerge from the breeding burrows with ripened eggs and move to the shoreline where they again dip in the sea and then retreat to shade.

Before the turn of the high tide and just before dawn the females will again move to the waterline and around the turn of the tide they will drop their eggs into the sea. After they have jettisoned their eggs the females commence their return migration.

The next phase of the breeding migration takes place in the sea. The eggs that the females drop into the sea hatch immediately into larvae. They grow through several larval stages into tiny prawn-like animals called megalops. After about four weeks the megalops emerge from the sea and they moult into baby crabs. The baby crabs then move inland and settle at suitable localities. The successful emergence of baby crabs is unpredictable but is incredible when large numbers emerge. Some years very few, or none, emerge. After about 4 years growth crabs will take part in the breeding migrations and the life cycle continues.
If the rains stop or peter out, the crabs will delay the start of their migration, or, if they have started migrating, they will stop moving and stay wherever they are until the rains begin again. It is rare that substantial rains will begin early enough in the year for a spawn during the last lunar quarter in October - but it has happened! Spawning in November or December are the more usual, which means that rain must commence in the preceding month and continue.

All phases of the crabs’ breeding migration involve colossal numbers of crabs and usually occur all over the island. If the rains continue, there is usually a second, and sometimes even a third, smaller, downward migration by crabs that did not join in the first migration. When this happens it is possible to see crabs on return journeys mingling with the crabs on their downward migration. It can become confusing for all concerned! We are sorry that we can not be more explicit about the timing of the start of the red crab migrations, but the weather as you know cannot be accurately predicted. The best advice we can give is to be at Christmas Island during the last quarter of the moon in either November or December for the best chance of seeing something interesting happening in the annual red crab migration. If you are able to arrive earlier and to stay longer the more parts of the migration sequence you will be able to experience.

**Short Answer Type Questions**

1. Write the types of eggs found in fishes.
2. Define ‘fry’ and write the approximate size of the fry.
3. Define hatchlings?
4. What is external fertilization.
5. Define spawning in fishes.
6. What is moulting?
7. Name the larval stages present in life cycle of shrimp.
8. What is nauplius?
9. Write the feed of Zoea and Mysis.
10. What is megalopa?
Long Answer Type Questions

1. Describe the life cycle of fish with the help of neat labelled diagram.

2. Explain the different stages present in the life cycle of freshwater prawn.

3. Describe the lifecycle of shrimp with the help of diagram.

4. Explain the different larval stages present in the life cycle of crab.
3.1 Introduction

India is the sixth largest producer of fish in the world (6.41 million tonnes) and second in world aquaculture production (2.22 million tonnes). About 95 percent of India’s aquaculture production comes from inland aquaculture. Of late, inland fish production has surpassed marine fish production. India produces about 17,000 million fry annually.

Among the different states, West Bengal is ranked first in inland fish production as well as fish seed production (8,400 million fry). Indian freshwater aquaculture is based mainly on polyculture of Indian major carps, such as catla, rohu and mrigal and three exotic carps, namely, silver carp, grass carp and common carp. Fish seed destined for aquaculture are obtained from three sources, i.e. rivers, bundhs and hatcheries. During the period from 1964 to 1965, 92 percent of the country’s fish seed were obtained from rivers, while in the 1980s, bundhs contributed to 63 percent of the total seed source. Rivers are traditional sources of fish seed for aquaculture. The Ganga River system is the largest river system and is the home to Indian major carps. Fertilized eggs,
spawn, fry and fingerlings constitute riverine seed. Spawn/fry collection is undertaken in few States. Among coldwater fish seed resources, trouts (exotic) and mahseers are found in the Himalayan region and the Peninsular Indian rivers that originate in the Western Ghats.

Presently, hatcheries account for 95 percent of seed source. A steady increase in fish seed production from the 1980s can be attributed to the use of Chinese type carp hatchery technology and the application of ready-to-use spawning agents. There are more than 420 carp hatcheries, producing about 34292 million spawns (17000 million fry). The Chinese type carp hatchery is most widely used, followed by the jar hatchery.

The traditional method of transportation of fish seed is the open system, which uses earthen/aluminium/galvanized iron or tin containers for seed transportation. The closed method of transportation of fish seed in plastic bags with oxygen and water is more widespread. Broodfish are transported in open FRP tanks/plastic pools/tarpaulins mounted in trucks. Hatchery production of sterile common carp fry is now receiving increased attention.

(i) riverine collection
(ii) bundh breeding and
(iii) hatcheries (through induced breeding).

In addition to these sources, common carp seed produced without hormone injection, was initially included as the fourth source and was accordingly categorized as ‘common carp breeding’ until 1964–1965. Since then, the data of the common carp seed is included with that of the other carps produced through induced breeding.

Over the years, the hypophysation technique has been standardized and refined, new broodstock diet developed, spawning agents (alternative to pituitary) used successfully, new breeding and hatching devices evolved and better larval rearing techniques developed. However, there still remains a big gap between seed production and requirement. At present, the lion’s share of India’s fish seed production comes from hatcheries. India now produces about 17000 million fish fry which is much less than the demand.

### 3.2 Freshwater Fish Seed Resources

#### a. Riverine Fish Seed Resources

The freshwater fish resources of India (Table 7.11.3) are found mainly in five major river systems, i.e. (i) the Ganga, (ii) the Brahmaputra and (iii) the
Indus in the North, (iv) the Peninsular East Coast and (v) the West Coast River in the South (Figure 7.11.3) (Jhingran, 1991).

**The Ganga River System**

The Ganga River system has a total length of about 8,047 km and is among the largest river systems in the world. It harbors the richest freshwater fish fauna of India ranging from the cultivable Gangetic (major) carps to mahseers and other coldwater fishes of the Himalayas, the hilsa (a clupeid) catfishes and a wide array of other fishes of considerable commercial importance.

**The Brahmaputra River system**

The Brahmaputra River system, with a combined length of 4,023 km has a rich fauna in its upper stretches, but without much economic value. However, its middle and lower stretches have several species of carps, catfishes, the anadramous hilsa and other air breathing fish.

**The Indus River system**

The Indus River system, though massive as a whole, covers only a small part of northwest India, harboring the exotic rainbow and brown trouts in the upper reaches and a variety of indigenous carps and catfishes in the lower sections. The trout streams of Kashmir constitute one of the world’s richest sport fishing waters attracting anglers and tourists all over the world.

**The East Coast River system**

The East Coast River system in peninsular India is rather a composite system of rivers, the main constituents of which are the Mahanadi, the Godavari, the Krishna and the Cauvery, with a combined length of about 6,437 km. The Mahanadi has all the Indian major carps common with the Ganga system. The other rivers, besides their own indigenous fish fauna of several carp species, catfishes, murrels, prawns, etc. have had their water enriched by repeated transplantation of the Gangetic carps from the north. The transplants have established themselves and contributed significantly to the current fish fauna of these rivers. The tributaries of the Cauvery from the Nilgris have coldwater fishes like trout and tench.

**The West Coast River system**

The West Coast River system in the south drains the narrow belt of Peninsular India, west of Western Ghats and includes the basins of the Narmada and the Tapti which are rich in fauna. The other rivers that originate in the Western Ghats possess carps, catfishes, mahseers, murrels, perchs, prawns, etc.
b. Reservoir fish seed resources

Information on India’s reservoir fish seed resources is scanty. The reservoirs in Uttar Pradesh and Madhya Pradesh, by virtue of their being connected with the Ganga River system have natural stocks of major carps. But in view of the large volume of water impounded by them, the original stocks are being supplemented through regular stocking with major carp fingerlings. The reservoirs across other basins, however, do not have natural stocks of major carps.

Hence, major carp fingerlings produced elsewhere are brought and released in these reservoirs. Several schemes were formulated for the construction of fish seed farms at reservoir sites to facilitate effective stocking operations. In most cases, where they were constructed, they did not function successfully due to poor soil quality (high porosity).

The population of predatory and weed fishes dominated the catches of many reservoirs, thus reservoir stocking with desirable varieties of fish proved to be not fruitful. However, in many instances fish breed either in the reservoirs or in tributaries or streams which eventually drain into the rivers or reservoirs, leading to natural stocking of reservoirs.

Seed Resources/Supply

Until the late 1970s, riverine seed collection was the main source of seed of IMC for aquaculture contributing to 91.67 percent of the total fish seed production during 1964–1965. Bundhs (a special type of tanks where riverine conditions are simulated during monsoon and carps bred) accounted for a major portion of fish seed from the 1960s through to the 1980s. With the advent of the technique of induced breeding of IMC by Chaudhuri and Alikunhi (1957) and exotic carps by Alikunhi, Sukumaran and Parameshwaran (1963a) through hypophysation, it became possible to obtain quality seed of major carps for aquaculture.

This resulted in an increased reliance on induced breeding for obtaining quality fish seed. During 2002–2003, induced breeding accounted for most of the seed produced in the country (Figure 7.11.6), with bundhs and rivers contributing to nearly 5 percent. In spite of the intensive collection of carp spawn and fry in certain sections of rivers, a regular survey of such resources had not been made prior to 1964–1965, except for a few cases. The Central Inland Fisheries Research Institute (CIFRI) located at Barrackpore, Kolkata (formerly Calcutta), helped in locating new carp seed collection centres from 1949 through to 1957. In 1964, CIFRI initiated, in 1964, a pioneering programme on seed prompting investigations in various river systems with a view to assess the the following:
(i) quality and quantity of fish seed, availability
(ii) gears used for spawn collection
(iii) methods of collection
(iv) measurement of fish seed
(v) factors responsible for fluctuation in seed availability and other aspects on an all-India basis.

The diverse geographical and climatic conditions of India are reflected in the riverine resources of the country. The most significant difference in the rivers of the north and those of peninsular India lies in the greater abundance of the IMC in the former and their poor availability in the latter which naturally has a bearing on the production of quality fish seed and its potential in the two regions. The riverine fish spawning grounds are generally located in the middle reaches of rivers. Of all the river systems, the Ganga is the richest in terms of carp seed resources.

3.3 Shrimp Seed Resources

Shrimp farming has received the greatest attention of all forms of mariculture. Starting in the early 1970s, shrimp farming expanded rapidly and is still expanding with a steady increase in production tonnage. Seed supply is the most important initial requirement of shrimp farming; however, this issue did not receive much attention until severe shortages in wild seed supply were experienced. Most of the world’s wild stock of shrimp is now overexploited, which has led to strong reliance of shrimp farms on the wild shrimp seeds.

Shrimp fry collection has also been reported as a major cause of the steady decline in the coastal fisheries resources and, consequently, shrimp fry fishery has become an important concern too. Hatchery production of shrimp seeds started in 1980s and has been a potential alternative of wild shrimp seed. While precise data do not exist globally, a reasonable estimate would suggest that 65–75% of all post-larvae (PL) used by shrimp farms at present are produced in hatcheries.

However, in the absence of effective effluent treatment facilities, shrimp hatcheries are likely to produce high loads in effluents, discharged ultimately into the coastal waters. The present paper reviews the environmental issues related to wild shrimp seed collection and, given the absence of sufficient data from field observation, discusses the possibility of environmental impacts resulting from mass production of shrimp seeds in hatcheries.
Shrimp seed supply from the wild

Although artificially produced shrimp PL provides the major source of shrimp seeds, shrimp farms still depend on wild source in many areas. However, the target species, the tiger shrimp, P. monodon constitutes only a very small portion of the total catch. Consequently, huge mortality and loss of other species have been reported for every single P. monodon PL collected from the wild. Primavera (1998) reported an estimated loss of 475 juvenile shrimp in Malaysia, 15–330 in Philippines, and 47–999 in India for every single PL.

Artificial seed production

Hatcheries have shown the most rapid growth of any ancillary economic activities related to shrimp farming because hatcheries are believed to be able to develop so-called ‘pathogen-free’, and also because hatchery PL are reported to produce a better growth and survival over wild fry. Hatcheries utilize a combination of live feeds, such as microalgae and brine shrimp nauplii (Artemia). The principal algal species employed are Skeletonema, Chaetoceros, Tetraselmis, Chlorella, Brachionus and Isochrysis.

Along with the addition of supplemental formulated diets, high density (3.5–5 · 10^6 cells/l) pure culture of algae particularly diatoms is a common practice to ensure continuous supply of live foods; artificial diets are used for broodstock. Considerable amounts of wastes accumulate in the tanks because of higher feed loss (30% or higher) and higher FCR (2.0 or higher) (Boyd and Clay, 1998). The excess nutrients stimulate growth of phytoplankton, which eventually die, sink and decompose on the bottom of the ponds, consuming large amounts of oxygen in the process. Graslund et al. (2003) listed as many as 290 chemical and biological substances presently in use in shrimp systems; the major groups are treatment compounds, fertilizers, pesticides and disinfectants, antibiotics, probiotics, immunostimulants, vitamins, and feed additives. All of these groups are in use also in hatcheries (Juarez and Fegan, 2001; DeWalt et al., 2002) despite the fact that many of them have not been scientifically proven to have a positive effect on production. Sara and Erik (2001) reported that a wide variety of chemicals and biological products are used in Asian shrimp farming including hatcheries. They recommended reducing the use of chemicals and biological products because of the risks to the environment, human health and to production.

Some chemicals used in shrimp farming, such as organotin compounds, copper compounds, and other compounds with a high affinity to sediments leave persistent, toxic residues, and are likely to have a negative impact on the environment. The potential impacts of chemical and biological products were
discussed among others by Sara and Erik (2001) and Grøaslund et al. (2003). Hatchery facilities are generally built using cement cisterns or other concrete materials and are engineered to achieve a high degree of water exchange, often as high as 100–200%. Unlike earthen ponds where a major part of the wastes and chemicals are consumed and trapped, many wastes in hatchery systems are discharged with effluent waters through the outlet channels which usually open into nearby drainage systems or rivers. Juarez and Fegan (2001), in a survey of 36 shrimp hatcheries in the Western Hemisphere, reported daily discharge quantities of 50–2000 m3 from hatcheries with shrimp PL production ranging 10–100 million PL/month, depending on the size of the hatchery. Most hatcheries in their report did not have facilities for monitoring chemical composition of their discharges. With no published data on the waste loads produced by shrimp hatcheries throughout the world, the Indian Association of Shrimp Hatcheries (personal communication) reported a high degree of effluent loadings in shrimp hatcheries, Varin et al. (1998) isolated 45 strains of marine bacteria from larval black tiger shrimp, brine shrimp nauplii and rearing seawater in Thailand.

### Short Answer Type Questions

1. Define the term ‘seed’ in aquaculture.
2. Name any three sources of fish seed.
3. Write the different stages of fish seed.
4. Name the riverine fish seed resources present in India.
5. What algal species used as live feed in shrimp hatchery.
6. What is the need of hatchery.
7. What are the disadvantages of wild spawn.
8. What are the advantages of artificial seed production.

### Long Answer Type Questions

1. Describe the Riverine fish seed resources in India.
2. Explain the different shrimp seed resources.
Seed Procurement

Structure

4.1 Introduction

4.2 Seed procurement from Natural Seed Resources

4.3 Collection of Seed from natural resources

4.4 Factors effecting seed collection

4.5 Identification of eggs, spawn, fry and fingerlings of culturable fishes in India

4.1 Introduction to Seed Procurement

Fish seed is the most important component for fish culture. The freshwater resources of our country for fish culture are estimated to be 2.85 million hectares of pond and tanks. In addition to this, another 2.05 million hectares of water area is available in the form of reservoirs or lakes. It has been estimated that nearly 14250 million fry would be required for stocking even the present available cultivable resources of 2.85 million hectares on a conservative stocking rate of 5000 fry/ha. The present production is 15007 million fry. Apart from this, at least an additional quantity of 4100 million fry are required for stocking the available area of lakes and reservoirs with an average stocking rate of 2000 fry/ha. This indicates that there is a necessity to raise the fry to stock the available water resources. The fish seed is obtained from 3 sources - riverine, hatcheries
and bundhs. The collection of seed from riverine source was an age old practice. This method is strenuous and we get the mixture of wanted and unwanted fish seed. Hatcheries are the best way of getting fish seed. Apart from these, the bundh breeding is also a good method to collect the fish seed by creating a natural habitat. The different river systems of India display variations with regard to the distribution and abundance of their fish fauna. This is mainly due to their individual ecological conditions, such as gradient, terrain, flow, depth, temperature, substrata, etc. The northern rivers are perennial and support rich commercial fisheries. Except for the deltaic regions, the fishery of the peninsular rivers is poor both in the upper and middle reaches.

4.2 Seed procurement from Natural Seed Resources

The different river systems of India display variations with regard to the distribution and abundance of their fish fauna. This is mainly due to their individual ecological conditions, such as gradient, terrain, flow, depth, temperature, substrata, etc. The northern rivers are perennial and support rich commercial fisheries. Except for the deltaic regions, the fishery of the peninsular rivers is poor both in the upper and middle reaches. India has five major river systems (Fig. 2.1). These are: Ganga river system, Brahmaputra river system, The Indus river system, East coast river system and West coast river system.

Indian Major Riverine Systems

The Ganga river system

River Ganga covers the states of Haryana, Delhi, Uttar Pradesh, Madhya Pradesh, Bihar and West Bengal. The length of the Ganga river system is 8,047 km. It is the largest river and contains the richest freshwater fish fauna in India. The fish eggs are collected from the breeding grounds and downstream. Eggs are collected from 1-2' deep water by disturbing the bottom and scooping them with a gamcha. The collection of spawn on a commercial scale is prevalent in these states alone contributing 51.9% of the country’s total production. The major carp spawn is available from May to September. The melting snow is responsible for floods and bring the carp spawn. The first appearance of spawn in India occurs in the Kosi followed by the main Ganga, Gomati and its other western tributaries. Billions of carp fry and fingerlings are caught in north Bihar from July to October.

The Brahmaputra river system

It is found in the states of Assam, Nagaland, Tripura and comprises the fast flowing river, which distribute the commercially important major carps. Length of this river system is 4,023 km. The north-bank tributaries of Brahmaputra are
comparatively large with steep shallow-braided channels of coarse sandy beds and carry heavy silt charge, while the south-bank are comparatively deep.

The seed collection is made in this fast-flowing river with steep banks by fixing two long bamboo poles near the banks with a boat tied on to them across the current. The percentage of major carps are poor. The northern Gauhati centre investigated in 1969 revealed only rohu content of 9.58%. The river, being torrential and flashy due to steep gradients of its tributaries, changes its current pattern very rapidly, hence, the carp seed is less and difficult to collect.

The Indus river system

It is rather rich when compared to the Brahmaputra river. The Beas and the Sutlej and their tributaries cover the states of Himachal Pradesh, Punjab and Haryana. There is no commercial fishery for major carps in Himachal Pradesh, with the upper reaches having cold water forms. Punjab is a good source for carp fishery. Length of Indus river system is 6,471 km.

East coast river system

The rivers flow towards the east into the Bay of Bengal. It comprises the Mahanadi, Godavari, Krishna and Cauvery river systems. The length of east coast river system is 6,437 km. Mahanadi is the largest river of Orissa and the state’s only major source of fish seed. The river mainly harbours the hill stream fishes from its origin upto Sambalpur. Large number of spawn collection centres are identified between Sambalpur and Cuttack. Godavari and Krishna river system is the largest of the east coast river system, found in Maharashtra and Andhra Pradesh. No spawn collection centres exist in Godavari river in Maharashtra. The delta regions of these rivers are very abundant in fishes, but the percentage of major carp spawn is only 20.3% in the Godavari at Rajamundry. The upper regions of the Cauvery, being fast-flowing and sufficiently cool, are unsuitable for carp fishery, the middle and lower reaches harbour a fairly good fishery of major carps.

West coast river system.

The major rivers of the west coast are Narmada and Tapati, which are found in Madhya Pradesh, Maharashtra and Gujarat. Length of the river system is 3,380 km. The upper stretches of the rivers being rocky and unproductive, are not suitable for seed collection. The remaining parts are good for seed collection. The major estuarine systems of India are the Hoogly-Matlah estuary of river Ganga, Mahanadi in Orissa, the Godavari-Krishna in Andhra Pradesh, the Cauvery in Tamil Nadu and the Narmada and the Tapati in Gujarat.
The important brackishwater lakes of the country are the Chilka in Orissa, the Pulicat in Tamil Nadu and the Vembanad in Kerala. The common feature in the estuaries is the occurrence of horse shoe shaped sand bars at river mouths. Estuaries receive freshwater during the south-west monsoon months, from July to October. All the estuaries are good sources of freshwater and brackishwater fish and prawns.

**Lakes and Reservoirs**

Naturally formed lakes and man-made reservoirs constitute great potential fishery resources of India. Lakes and reservoirs are estimated to have an area of about 2.05 million ha. in our country. Important lakes in India are Chilka, Pulicat, Ooty, Kodaikanal, Nainital, Logtak lakes, etc. Important large reservoirs in India are Nagarjunasagar, Nizamsagar, Gandhisagar, Shivajisagar, Tungabhadra, Krishanarajasagar, Hirakud, Beas, Govindsagar, Ramapratapsagar, Bhavanisagar, Matatila, Rihand, Kangasabati, etc.

### 4.3 Collection of Seed from Natural Resources

Availability of fish seed in large quantities is a primary requisite to develop fish culture in India. Indian major carps Catla (Catla catla), rohu (Labeo rohita) and mrigal (Cirrhina mrigala) are preferred for cultivation in freshwater ponds and tanks throughout the country. Natural habitat of these Indian major carps is rivers, and their original spawning grounds are the flooded rivers. Since a long time traditional methods of collection of carp spawn and fry from those natural resources were built up, particularly in Bengal, which soon spread to other states of eastern India. Fish seed trade even today depends on this resource in few places. With a view to providing scientific basis, seed prospecting investigations were initiated in various river systems of in India.

Attempts were made to standardise the spawn collection nets, to evolve methods of collection and to ascertain factors responsible for fluctuations in the availability of fish seed in relation to time and place.

**Site Selection for Seed Collection**

A pre-monsoon survey is conducted to ascertain the topography of the terrain and bank features at and in the vicinity of a site to determine the extent of operational area. The topography of dry beds and bank features to gauge the likely current pattern of the river at different stages of flooding. The distribution and composition of the fish fauna in the selected stretch of the river, resident or immigrant, for assessing the abundance of major carps during the monsoon season. The location of tributaries, rivulets and canals along with their main river, as they might constitute important connecting links between the river and
breeding grounds. The identity and accessibility of the site. The bends and curves of various shapes in the river course often show a precipitous, fast eroding bank on one side called erosion zone and a flat, gently sloping bank exactly opposite called shadow zone (Fig. 2.2). These banks are not useful for spawn collection. Best seed collection sites lie on the side of the sloping bank but at the spot the current force the seed to the sides by centrifugal force. These spots are best to operate nets to collect large amounts of spawn.

Methods of Seed Collection

Generally shooting nets are used to collect the seed in the rivers. A shooting net is a funnel-shaped net of finely woven netting, and is fixed with the mouth of the net facing the current. It is operated in the shallow margins of a flooded river. At the tail end of the net, there is a stitched - inning of split bamboo or cane, and to this is attached, during the operation, a receptacle, termed the gamcha. A gamcha is a rectangular open piece of cloth. The seed moving along with the
marginal current collects in the gamcha, and is stored in hapas or containers after removal.

Benchijal is used to collect the seed in Bengal. Midnapur net is also used in Bengal, especially in the south-western parts, to collect the seed. The shooting net (Fig. 4.2) is fixed in line with the water current direction. The bamboo poles are fixed firmly at the selected site and the net is fixed to bamboo poles. Two bamboo poles are fixed near the mouth and other two poles are fixed at tail ring. The anterior end of gamcha is then tied round the tail ring. The gamcha is fixed in position with the help of two more bamboo poles. In order to select the spot of maximum availability of spawn within a specified stretch of the river concerned, a number of trial nets are simultaneously operated at a number of suitable spots. After selecting the spot, the operation is started with full battery of nets. Once it is done, the collection from the tail piece of each net is scooped one after the other in quick succession every 15 minutes or depending upon the intensity of spawn. The contents of the gamcha are then scooped immediately into a container half filled with river water. The collection is then passed through a mosquito netting sieve so that the unwanted organisms and non floating debris can be removed. The spawn are measured and kept in hapas for conditioning, then transported to fish farms and stocked in nurseries.
4.4 Factors Effecting Seed Collection

Floods and water current play an important role in the collection of seed.

**Flood**

Floods show positive correlation with spawn. There may be three or more floods in a season. The pattern of flood is that the water first rises, then recedes. After few days again a second flood is caused and so on. Carps breed during floods in the rivers. In the first flood of the season the spawn of undesirable species is available. The major carp seed is available in subsequent floods. In between the floods the catches of major carp seed are less. The availability of spawn are linked with the floods. In the receding phase of the floods results in the draining of spawn out of the breeding grounds down the river. Spawn is available both during day and night; more seed is found in night catches.

**Water Current**

There is no effect on spawn when the water current is mild (0.086 km/hr). No significant effect is seen on spawn upto 0.4 km/hr water velocity. With increased water velocity all the spawn is carried away down the stream. The slow and gentle current velocity varying from 0.5-3 km/hr is the best to collect the spawn. While faster currents of the mid-stream carry little spawn, low velocities of less than 1 km/hr are unfavourable for spawn catch. In deeper parts of the river, the spawn is not available due to non-generation of floods.

**Other Factors**

There is no effect of turbidity, pH and dissolved oxygen on spawn availability in the rivers. However, turbidity is associated with floods, and determines the efficiency of spawn collection. The turbidity reduces the mesh size of the net, and it is better to clean the nets at regular intervals. Air and water temperatures never show any effect on the spawn availability.

The optimal temperature is 28-310C. Overcast conditions with breeze and with or without drizzle is found ideal for spawn collection. The stormy weather is totally unfavourable for spawn collection due to disorder currents and waves and the uprooting of shooting nets. Light also does not show any effect on spawn collection. The occurrence of plankton have no connection with the availability of spawn or its abundance in rivers. Spawn associations found abundant from the onset of monsoon dwindle thereafter to almost nil at the end of the season.
4.5 Identification of Eggs, Spawn, Fry and Fingerlings of Culturable Fishes in India

In order to avoid wastage of precious rearing space, identification and segregation of different species from a mixed collection of fish seed should be accorded utmost importance. An exhaustive account on the egg and larval (spawn, fry and fingerlings) stages of carps, catfishes, murrels, mullets, cichlids, featherbacks and other fishes has been given by Jhingran (1991).

**Egg**: The eggs of IMC and medium carps are non-adhesive, while those of catfishes (e.g. *Notopterus* and *Mastacembelus*) are adhesive. The eggs of murrels and *Anabas* are identified by their floating nature (Jhingran, 1991). The colour of eggs is used as a reliable criterion for the identification of species.

**Spawn**: It is difficult to identify major carps at spawn stage as the spawn of medium and minor carps also have similarity with the former. However, a mixed collection of fish seed can be categorized as desirable and undesirable spawn. If the length of spawn is more than 5 mm when yolk sac is completely absorbed, it is considered a desirable spawn wherein the IMC account for more than 10 percent of the total spawn.

The spawn is regarded as undesirable if the length is less than 5 mm when yolk sac is completely absorbed. The undesirable spawn have less than 10 percent IMC. On the other hand, it is relatively easy to identify IMC at fry stage based on the number of dorsal fin rays and morphological characters.

**Fry (14-25 mm)**: The carp fry can be distinguished from that of catfishes and murrels by the number of dorsal fin rays as follows:

(a) Major carps: number of undivided dorsal fin rays > 11
(b) Minor carps: number of undivided dorsal fin rays 11 or <11

(c) Catfishes and murrels: pigmented (either black, brown or orange)

Fig. 4.5 Larva of Catla, Rohu and Mrigal

Fig. 4.6 (a) Catla, (b) Rohu (c) Mrigal
Keys to identify Species/Group

Catla: Large head; no distinct spot on caudal peduncle, opercular region brightly reddish

Rohu: A dark spot present on caudal peduncle; a pair of barbels present; lips fringed.

Mrigal: Small head and slender body; a triangular dark spot on caudal peduncle; no barbels, lips thin, not fringed.

Common carp: Eyes prominent; no reddish glow on operculum; deep body; 2 pairs of barbells; no prominent spot on caudal peduncle

Silver carp: Small scales and eyes; lower jaw upturned; fins dark

Grass carp: Body elongated; head broad with short, round snout; no barbells; body dark grey above and silvery on the belly

Catfish fry: Head large; thin body; large barbells; scaleless body and movement wriggling

Murrel fry: Orange/brownish; move in shoals near the surface of water

Short Answer Type Questions

1. Name the major river systems present in India.
2. What rites are suitable for Fish seed collection from the river.
3. Draw the labelled diagram of shooting net.
4. Name any two main factors which effecting natural seed collection.
5. Define spawn and fry.
6. What is gamcha.

Long Answer Type Questions

1. Describe the major riverine system found in India.
2. Write an essay on fish seed collection from natural resources.
3. Describe the factors effecting the fish seed collection from natural resources.
4. Explain the seed identification key characters of Indian Major carps.
Induced Breeding Technology

Structure

5.1 Introduction
5.2 Brook Stock Management
5.3 Induced breeding with different inducing agents
5.4 Stripping
5.5 Influence of factors on breeding
5.6 Breeding of Common carp

5.1 Introduction

Carps breed in flowing waters like rivers. Naturally they never breed in confined waters. The seed collected from natural resources is generally a mixed stock with both desirable and undesirable varieties. Separation of desirable seed from mixed stock is a big problem. Due to the handling, the desirable varieties may die. If any predaceous fish seed is found, they injure desirable fish seed. Another big problem is never get required number in natural collection. Availability of pure seed is very difficult. To overcome all these problems induced breeding is an excellent technique to get pure and required fish seed. It has several advantages.
With induced breeding pure seed of desirable species can be obtained. Suppose rohu seed is necessary, only rohu seed can be produced in a couple of days. Required number of seed can be produced with this technique. Suppose a fish farm needs 1 crore fish seed, this number can be produced very easily in less time. The problems of identification and segregation of seed does not arise. This technique is very simple. Healthy seed can be produced. Fish can be spawn more than one time in one year. Hybridization is possible. In induced breeding techniques, four main types of materials are used to give injections to fish - pituitary gland extractions, HCG, ovaprim and ovatide.

The fish seed is obtained from three sources - riverine, hatcheries and bundhs. The collection of seed from riverine source was an age old practice. This method is strenuous and we get the mixture of wanted and unwanted fish seed. Hatcheries are the best way of getting fish seed. Apart from these, the bundh breeding is also a good method to collect the fish seed by creating a natural habitat. The different river systems of India display variations with regard to the distribution and abundance of their fish fauna. This is mainly due to their individual ecological conditions, such as gradient, terrain, flow, depth, temperature, substrata, etc. The northern rivers are perennial and support rich commercial fisheries. Except for the deltaic regions, the fishery of the peninsular rivers is poor both in the upper and middle reaches.

5.2 Brood stock Management

Broodfish is a prerequisite for all induced breeding programmes. Proper broodstock will lead to better breeding responses, increased fecundity, fertilization, hatching and larval survival rates and more viable fish seed. Hence, the subject of broodfish management has assumed great importance in hatchery management.

Carp broodfish pond. Carp broodstock ponds are generally large (0.2-2.5 ha), 1.5-2.5 m deep, rectangular, seasonal or drainable and earthen in nature. Water inlet and outlet should be such that they simulate riverine/fluviatile conditions, which is the natural habitat for IMCs and Chinese carps.

Source of broodfish. Since selective breeding and hybridization programmes of pedigreed fish are not carried out in fish seed farms, the source of broodfish is stock ponds from the same farm or different farms. In order to avoid inbreeding in a hatchery, it is necessary that fresh fish germplasm from natural sources or other hatcheries is introduced regularly with timed periodicities. If this is not done, inbreeding depression may set in, which has been reported to have occurred in some carp hatcheries in India (Eknath and Doyle, 1985).
Care of broodfish. The recommended stocking density of carp broodfish is 1 000-3 000 kg/ha, depending upon the species. Systematic studies on nutritional requirements of carp broodfish are limited. It is customary to feed carp broodfish with a traditional diet consisting of rice bran and oil cake (1:1 ratio) at a feeding rate of 1-2 percent of their body weight daily. In addition to the artificial feed, the grass carp is also given tender aquatic weeds/terrestrial grass. However, the breeding habits of some species like common carp demand their separation from other carp species due to their natural breeding in ponds with aquatic vegetation. As a result the common carp broodfish is segregated sex-wise and stocked in separate ponds to prevent accidental spawning in pond. However, the rest of the species can be stocked in a communal pond or stocked in separate ponds after species-wise and/or sex-wise segregation. Catla, in particular, needs to be separated from the rest of the species as it shows poor response to hormonal injection when stocked with other species. It is believed that catla broodfish in separate ponds after species-wise and/or sex-wise segregation. Catla, in particular, needs to be separated from the rest of the species as it shows poor response to hormonal injection when stocked with other species. It is believed that catla broodfish management is a pre-requisite for successful spawning. The number and quality of eggs produced is significantly affected by the conditions under which the broodstock is maintained. The quality of broodstock diet, feeding regime, the quality of broodstock and water management are the principal factors that influence the condition of the broodstock. Most seed farms raise broodstock on their own farm and maintain them in ponds at densities of 1 000-2 500 kg/ha. The earthen broodstock ponds vary in area from 0.2 to 1.0 ha, with depth ranging from 1 to 2 m. Most farms use water from perennial reservoirs. The main steps in the preparation of broodstock ponds are: (i) control of aquatic weeds, which is done manually; (ii) eradication of unwanted fish by applying mahua oilcake at 2 000-2 500 kg/ha and pond liming at 100-200 kg/ha depending on the pH of soil and water; (iii) fertilizing the pond with cattle dung, at 15 000-20 000 kg/ha/yr or poultry manure at 5 000-10 000 kg/ha/yr to enhance heterotrophic food production. In addition, 200-400 kg/ha/yr NPK mixture is applied in split doses at fortnightly or monthly intervals. The initial dose of organic manure is reduced by half if mahua oil cake is used for eradicating unwanted animals. After stocking, the pond with carps that are one-yearold or more, are fed with a conventional feed containing a mixture of groundnut oilcake and rice bran (at 1:1 or 1:2 ratio) at 1-2 percent body weight once daily. To ensure better and timely development of gonads, fish breeders use a special broodstock diet (protein: 25-30 percent) prepared using locally available cheap feed ingredients.
This diet is nutritionally superior, advances maturation and spawning by one or two months and results in increased fecundity and better seed quality.

5.3 Induced breeding with different inducing agents

Induced Breeding with Pituitary Gland Extraction

Fish breeding by pituitary gland extraction is an effective and dependable way of obtaining pure seed of cultivable fishes and is practiced today on a fairly extensive scale in India as well as many other countries in the world. It involves injecting mature female and male fishes with extracts of pituitary glands taken from other mature fish.

Fish Pituitary Gland

Fish pituitary gland is a small, soft body and creamish white in colour. It is more or less round in carps. It lies on the ventral side of the brain (Fig. 3.1) behind the optic chiasma in a concavity of the floor of the brain-box, known as Sella turcica and enclosed by a thin membrane called duramater. In few fishes it is attached to the brain by a thin stalk, known as the infundibular stalk. Based on the infundibular stalk, the glands are classified into two types, namely, platybasic - without stalk, have an open infundibular recess and leptobasic - with stalk, have obliterated infundibular recess. Leptobasic type of pituitary glands are found in carps and platybasic type found in channidae and nandidae. The size and weight of the gland varies according to the size and weight of the fish. In Labeo rohita, the average weight of the pituitary gland is 6.6 mg in 1-2 kg fish, 10.3 mg in 2-3 kg fish, 15.2 mg in 3-4 kg fish and 18.6 mg in 4-5 kg fish.

Pituitary gland secretes the gonadotropic hormones, FSH or Follicular Stimulating Hormone, and LH or Luteinizing Hormone. Both hormones are secreted throughout the year, but the proportion in which they are secreted is directly correlated with the cycle of gonadal maturity.

The FSH causes the growth and maturation of ovarian follicles in females and spermatogenesis in the testes of males. LH helps in transforming the ovarian follicles into corpus lutea in females and promoting the production of testosterone in males. These hormones are not species specific, i.e., a hormone obtained from one species is capable of stimulating the gonads of another fish. However, there is great variability in its effectiveness in different species. Experiments conducted on induced breeding of fishes have clearly shown the relative effectiveness of fish pituitary extracts over mammalian pituitary hormones, sex hormones and various steroids. This is the reason why fish pituitary is being extensively used today in fish breeding work all over the world.
Collection of Pituitary Gland

The fish donating the pituitary gland i.e., the fish from which the pituitary gland is collected is called the donor fish. The success in induced breeding of fish depends to a great extent on the proper selection of the donor fish. The gland should preferably be collected from fully ripe gravid fishes, as the gland is most potent at the time of breeding or just before spawning. The potency of the gland decreases after spawning. Glands collected from immature or spent fishes usually do not give satisfactory results. Glands in induced-bred fishes collected immediately after spawning have also been found to be effective and can be used for reeding of other fishes. Most suitable time in India for collection of pituitary glands of major carps is during May to July months, as the majority of carps attain advanced stages of their maturity during this period. Since common carp, Cyprinus carpio is a perennial breeder, its mature individuals can be obtained almost all the year round for the collection of glands. The glands are usually preferred to be collected from freshly killed fishes but those collected from ice-preserved specimens are also used.

Several techniques are adopted for the collection of pituitary glands in different countries. In India, the commonly adopted technique of gland collection is by chopping off the scalp of the fish skull by an oblique stroke of a butcher’s knife. After the scalp is removed, the grey matter and fatty substances lying over the brain are gently cleaned with a piece of cotton. The brain thus exposed is carefully lifted out by detaching it from the nerves. In majority of the cyprinids, when the brain is lifted, the gland is left behind on the floor of the brain box. The duramater covering the gland is then cautiously removed using a fine needle and forceps. The exposed gland is then picked up intact without causing any damage to it because damaged and broken glands result in loss of potency. Glands are also collected through foramen magnum. It is, in fact, a much easier method of gland removal which is commonly practiced by the professionals for mass-scale collection in crowded and noisy fish markets. In this method of gland collection, the fish is required to be essentially beheaded. In markets, glands are collected from fishheads that are already cut by retailers. In the cut fish-heads, the foramen can be clearly seen from behind holding grey matter and fatty substances in it. The brain lies on the ventral sides of the foramen. For taking out the gland, the grey matter and fatty substances are first removed by inserting the blunt end of the forceps into the foramen and pulling out the entire matter without disturbing the brain. The brain is lifted up carefully and pushed forward or is pulled out of the hole. The gland lying at the floor of the brain box is then picked up using a pair of fine tweezers. An experimental worker easily manages to collect about 50-60 glands in one hour by adopting this technique of collection.
Preservation of Pituitary Glands

If the collected glands are not meant for use then and there, they must be preserved. Due to their glyco- or muco- protein nature, they are liable to immediate enzymatic action. The pituitary glands can be preserved by three methods - absolute alcohol, acetone and freezing.

Preservation of fish pituitary gland in absolute alcohol is preferred in India. Moreover, experiments done so far with alcohol preserved glands on Indian major carps have given more positive results than with acetone preserved glands.

The glands after collection are immediately put in absolute alcohol for defatting and dehydration. Each gland is kept in a separate phial marked serially to facilitate identification. After 24 hours, the glands are washed with absolute alcohol and kept again in fresh absolute alcohol contained in dark colour bottles and stored either at room temperature or in a refrigerator. Occasional changing of alcohol helps in keeping the glands in good condition for longer periods. In order to prevent moisture from getting inside the phials, they may be kept inside a dessicator containing some anhydrous calcium chloride. It is preferable to keep the glands in a refrigerator. They can be stored in refrigerator upto 2-3 years and at room temperature upto one year. Acetone also is a good
preservative. In this method, soon after collection, the glands are kept in fresh acetone or in dry ice-chilled acetone inside a refrigerator at 100 C for 36-48 hours. During this period, the acetone is changed 2-3 times at about 8-12 hours intervals for proper defatting and dehydration. The glands are then taken out of acetone, put on a filter paper and allowed to dry at room temperature for one hour. They are then stored in a refrigerator at 100 C, preferably in a dessicator charged with calcium chloride or any other drying agents.

**Preparation of Pituitary Gland Extract**

Preserved glands are then weighed. This is essential for accurate determination of the dose to be given according to the weight of the breeders. The weight of the gland may be taken individually or in a group. To get a more accurate weight, a gland should be weighed exactly after two minutes of its removal from alcohol. The pituitary extract should be prepared just before the time of injection. The quantity of gland required for injection is at first calculated from the weight for the breeder to be injected. The glands are then selected and the required quantity of glands is taken out of the phials. The alcohol is allowed to evaporate, if the glands are alcohol preserved ones. Acetone-dried glands are straight away taken from the phials for maceration.

The glands are then macerated in a tissue homogeniser by adding a measured quantity of distilled water or common salt solution or any physiological solution which is isotonic with the blood of the recipient fish. The most successful results of induced breeding in the Indian major carps have so far been obtained with
distilled water and 0.3% common salt solution. The concentration of the extract is usually kept in the range of 1-4 mg of gland per 0.1 ml of the media i.e., at the rate of 20-30 gm. of the gland in 1.0 ml of the media. After homogenation, the suspension is transferred into a centrifuge tube. While transferring, the homogenate should be shaken well so that settled down gland particles being mixed with the solution come into the centrifuge tube. The extract in the tube is centrifuged and the supernatent fluid is drawn into a hypodermic syringe for injection.

The pituitary extract can also be prepared in bulk and preserved in glycerine (1 part of extract: 2 parts of glycerine) before the fish breeding season so that the botheration of preparing extract every time before injection is avoided. The stock extract should always be stored in a refrigerator or in ice.

Technique of Breeding

The induced breeding operation of major carps is taken up when regular monsoon sets in, the fishes become fully ripe and water temperature goes down. Females having a round, soft and bulging abdomen with swollen reddish vent and males with freely oozing milt are selected for breeding. A male breeder can also be easily distinguished by roughness on the dorsal surface of its pectoral fins.

1. Dosage of pituitary extract

The most important aspect of induced breeding of fish is the assessment of proper dosages of pituitary extract. The potency of the gland varies according to the size and stages of sexual development of the donor, as well as the species of the donor fish, time of collection of glands and their proper preservation. The dose of the pituitary gland is calculated in relation to the weight of the breeders to be injected. It has also been noticed that identical doses to breeders of similar weights may give contradictory results owing to difference in maturity of gonads. Even heavy doses of hormones may not be effective if the gonads are in the resorption stage. By careful selection of breeders and administering a known weight of pituitary gland extract per kg body weight of the breeders, successful breeding can be obtained. Experiments on standardisation of doses indicate that administration of a preliminary low dose in the female breeder followed by a higher effective dose after 6 hours proves more successful than a single knockout dose. A single high dose has been found useful when the breeders are in ideal condition and the weather is favourable. Rohu responds well to two injections while catla and mrigal to both one and two injections.

An initial dose at the rate of 2-3 mg. of pituitary gland per kg body weight of fish is administered to the female breeder only. Male breeders do not require any initial dose, if they ooze milt on slight pressure on their abdomen. Two males
against each female make a breeding set. To make a good matching set, the weight of the males together should be equal to or more than the female. In case the condition of any one of the two males is not found in the freely oozing stage, an initial injection may be administered to the male at the rate of 2-3 mg/kg body weight. After 6 hours, a second dose of 5-8 mg/kg body weight is given to the female, while both the males receive the first or second dose at the rate of 2-3 mg/kg body weight. Slight alterations in doses may be made depending upon the condition of maturity of the breeders and the prevailing environmental factors. In the absence of a chemical balance, 1-3 pituitary glands are effective for a pair of fish.

2. Method of injection

Intra-peritonial injections are usually given through the soft regions of the body, generally at the base of the pelvic fin or sometimes at the base of the pectoral fin. But there is some risk of damaging the internal organs, specially the distended gonads when administering an intra-peritonial injection in fully mature fishes. Injections are usually given at the caudal peduncle or shoulder regions near the base of the dorsal fin. While giving injections to the carps, the needle is inserted under a scale keeping it parallel to the body of the fish at first and then pierced into the muscle at an angle. There is no hard and fast rule regarding the time of injection. Injections can be given at any time of the day and night. But since low temperature is helpful and the night time remains comparatively quieter, the injections are generally given in the late afternoon or evening hours with timings so adjusted that the fish is able to use the quietude of the night for undisturbed spawning. The size of the needle for the syringe depends upon the size of the breeders to be injected.

Fig. 5.4 A brood fish being injected at the caudal region
3. Breeding hapa and spawning

After the injection, the breeders are released immediately inside the breeding hapa. A breeding hapa is generally made of fine cloth in the size of 3.5 x 1.5 x 1.0 m for larger breeders and 2.5 x 1.2 x 1.0 m for breeders weighing less than 3 kg. All the sides of the breeding hapa are stitched and closed excepting a portion at the top for introducing the breeders inside. Generally, one set of breeders is released inside each breeding hapa, but sometimes, in order to save on pituitary material, community breeding is also tried by reducing the number of male breeders. After the release of the fish, the opening of the hapa is securely closed so that breeders may not jump out and escape. Instead of hapas, cement cisterns or plastic pools as big as hapas can also be used for breeding. Spawning normally occurs within 3-6 hours after the second injection. Soon after fertilisation, the eggs swell up considerably owing to absorption of water. Fertilised eggs of major carps appear like shining glass beads of crystal clear transparency while the unfertilised ones look opaque and whitish.

Fig. 5.5 Breeding Hapa

The size of eggs from the same species of different breeders varies considerably. Fully swollen eggs of the Indian major carps measure 2.5 mm in diameter, the largest being that of catla and the smallest of rohu. The carp eggs are non-floating and non-adhesive type. The yolk possesses no oil globule. The Indian major carps have a profuse egg laying capacity. Their fecundity, on an average, is 3.1 lakh in rohu, 1-3 lakh in catla and 1.5 lakh in mrigal. The developing
eggs are retained in the breeding hapa undisturbed for a period of at least 4-5 hours after spawning to allow the eggs to get properly water-hardened. After this, the eggs are collected from the hapa using a mug and transferred into a bucket with a small amount of water. The breeders are then taken out and weighed to find out the difference before and after spawning. This gives an idea of the quantity of the eggs laid. The total volume and number of eggs can be easily calculated from the known volume and the number of eggs of the sample mug. Percentage of fertilised eggs is also assessed accordingly by conducting random sampling before and after spawning. This gives an idea of the quantity of the eggs laid. The total volume and number of eggs can be easily calculated from the known volume and the number of eggs of the sample mug. Percentage of fertilised eggs is also assessed accordingly by carrying out random sampling.

**Induced Breeding with H.C.G.**

Today pituitary gland extraction is a well established technique for induced breeding all over the world. Its large scale use poses the following problems with regard to availability and quality of pituitary gland (P.G). Inadequate supply of P.G, high cost, variability in pituitary gonadotropin potency and cheating by unscrupulous P.G suppliers.

To overcome these problems, Human Chorionic Gonadotropin (H.C.G) has been found as an alternative for pituitary gland. H.C.G was discovered in beginning of 1927 by Aschheim and Zondek. They extracted good quality hormone with luteinising gonadotrophic activity from the urine of pregnant women. Russian workers first used chorionic gonadotropin in 1964 with a trade name as Choriogohin and got good results on Loach. Bratanor (1963) and Gerbilski (1965) used H.C.G on carps and trouts and achieved great success. Tang (1968) stated that when Chinese carps were treated with fish pituitary in combination with C.G, effectiveness on induced breeding increased. A perusal of literature indicates that H.C.G is effective either alone or in combination with P.G extract in inducing various fishes all over the world. H.C.G is a glyco-protein or sialo-protein, because of the carbohydrate molecules attached to the protein molecules. Its primary function is to maintain the production of oestrogen and progesterone by the corpus luteum. It is produced by the placenta and excreted through the urine during early stages of pregnancy (2-4 months). H.C.G comprises of 2 sub-units a and b and has a molecular size of 45,000-50,000 daltons. There are 17 amino acids in it, out of which alanine, proline, serine, cystine and histidine are important. Due to the large number of amino acids, H.C.G has a high protein content. The molecular weight has been reported as 59,000 by gel filtration and 47,000 by sedimentation equilibrium. During early stages of pregnancy H.C.G is rich in the urine of pregnant women. Several
methods are employed for the extraction of H.C.G. Aschheim and Zondek (1927) used ethanol for precipitation.

Katzman and Caina used different absorbents. Commercial crude H.C.G extraction is made with gel filtration. Follicle stimulating hormone (FSH) and luteinising hormone (LH) of the pituitary play an important role in the normal reproduction of fish i.e., in promoting the development of gonads, growth, maturity and spawning. H.C.G is more or less similar in character and function to F.S.H and L.H. As pituitary gland is used for induced fish breeding, H.C.G can also be used for early ripening of gonads. Superiority of H.C.G over P.G can be measured on the following grounds. Fish attains maturity faster with H.C.G, the spawn of the breeding season can be increased with H.C.G, H.C.G ensures better survival of spawn, it reduces the time gap between preparatory and final doses, H.C.G is more economical and has a long shelf life, H.C.G is easily available from a standard source, hence is more reliable, periodical injections of H.C.G throughout the year ensure better health and increase in weight and gonadal development. Potency of H.C.G is known (30 IU/mg), available in neat packets of known weights, no preservation is involved, cannot be spurious, H.C.G treated fishes can be used more than once for induced breeding in the same season, mortality rate of hatchlings is negligible, consumption of the drug is less during induced breedings, H.C.G can be used as growth hormone and absorption of eggs at the end of the breeding season is comparatively less by the administration of H.C.G. The crude H.C.G is in powder form and greyish white or light yellow in colour. It dissolves easily in water.

The calculated quantity of crude H.C.G is taken into a tissue homogeniser and stirred for 5-10 minutes with measured distilled water. It is centrifuged for 3-5 minutes. The clear light yellowish supernatant liquid having the H.C.G hormones is taken and injected immediately. Any delay in use will result in the loss of the potency. In case of silver carp (Hypophthalmichthys molitrix), use of H.C.G is found to be quite successful. The dosage is 4-6 mg/kg body weight of male, and 6-8 mg/kg body weight of first dose and after about 6-7 hours, 10-12 mg/kg body weight of second dose for female which gave good results. Use of only H.C.G in the breeding of Indian major carps has not given successful results so far. A combination of 60-80% H.C.G and 40-20% P.G for Indian major carps and grasscarps (Ctenopharyngodon idella) is successful. Fishes which are induced to breed with H.C.G alone are mullets, Cyprinus carpio, Lctalurus punctatus, Oreochromis nilotica, risticthys nobilis, Misgurnus fossilis, Esox lucius and Epinephelus tauvina. Recent work shows that the combination of H.C.G and P.G is more recommendable than H.C.G or P.G alone. More work needs to be done to standardize the dosage of H.C.G for induced breeding of major carps and Chinese carps.
Induced Breeding with Ovaprim

Due to the problem of varying potency of pituitaries, alternatives were tried. Attempts have been made in various countries to use the analogues of luteinizing hormones - releasing hormones (LH-RH) for induced breeding of fishes with varying degrees of success. However, the success achieved with LH-RH was not always consistent, apart from its higher dose requirement for induction of spawning. This epoch making investigation paved the way for developing simple and effective technology for induced breeding of most of the cultivable fishes. In a joint collaborative project, funded by International Development Research Centre, Canada to Dr. Lin of China and Dr. Peter of Canada, a series of investigations were carried out to develop a reliable technology for breeding fishes. Their investigations led to the development of a new technique called as ‘LNPE’ method, wherein an analogue of LHRH is combined with a dopamine antagonist. Based on the principle, M/s Syndel Laboratories Limited, Canada have manufactured a new drug called as ovaprim. Ovaprim is a ready to use product and the solution is stable at ambient temperature. It contains an analogue of 20 μg of Salmon gonadotropin releasing hormone (sGnPHa) and a dopamine antagonist, domperidone at 10 mg/ml. The potency of ovaprim is uniform and contains sGnRHa which is known to be 17 times more potent than LHRH (Peter, 1987). The dopamine antagonist, domperidone used in ovaprim is also reported to be better than another commonly used antagonist, pimozide. Ovaprim being a ready to use product and one which does not require refrigerated storage, appears to be the most convenient and effective ovulating agent. Ovaprim being administered to both female and male brood fish simultaneously in a single dose, unlike pituitary extract which is given in two split doses. This reduces not only the handling of brood fish but also helps in saving considerable amount of time and labour which will add on to the cost of seed production. The spawning response in treated species is found to be superior to the pituitary extract injected species.

The efficiency of ovaprim for induced breeding of carps have given highly encouraging results in catla, rohu, mrigal, silver carp, grass carp, big head, etc. The effective dose required for various species of carps is found to vary considerably. The common dose for all carps is 0.10-0.20 ml ovaprim/kg body weight of males and 0.25-0.80 ml ovaprim/kg body weight of females. Female catla is found to respond positively for a dose range of between 0.4-0.5 ml/kg, while rohu and mrigal respond to lower doses of 0.35 ml/kg and 0.25 ml/kg respectively. Among exotic carps, silver carp and grass carp are bred at doses ranging between 0.40-0.60 ml/kg. Big head carp bred successfully at 0.50 ml/kg. For males of Indian carps, 0.10-0.15 ml/kg and for exotic male carps 0.15-
0.20 ml/kg of dosages are found to be optimum. The method of injection is the same as pituitary.

In many countries including our country, ovaprim is used on a large scale for induced breeding of all cultivable fishes successfully. In India, initial trials were conducted during 1988 in Karnataka, Andhra Pradesh and Tamil Nadu. Ovaprim has unique advantages over pituitary hormone - ready to use liquid form in 10 ml vial, consistent potency and reliable results, long shelf life, and can be stored at room temperature, formulated to prevent over dosing, male and female can be injected only once simultaneously, reduces handling and post breeding mortality, repeated spawning possible later in the season and high percentage of eggs, fertilization and hatching.

**Induced breeding with ovatide**

Ovatide is an indigenous, cost-effective and new hormonal formulation for induced breeding of fishes. The new formulation is having the base of a synthetic peptide which is structurally related to the naturally occurring hormone, gonadotropin releasing hormone (GnRH). GnRH is not a steroidal hormone and belongs to the class of organic substances called peptides. It is presented as a low viscosity injectable solution which is not only highly active but also cost-effective compared to other commercially available spawning agents. It is also effective in breeding major carps and catfishes. The doses for females are 0.20-0.40 ml/kg for rohu and mrigal, 0.40-0.50 ml/kg for catla, silver carp and grass carp and 0.20-0.30 ml/kg for calbasu. The dosages for males are 0.10-0.20 ml/kg for rohu, mrigal and calbasu, 0.20-0.30 ml/kg for catla and 0.20-0.25 ml/kg for silver carp and grass carp.

The advantages of ovatide are: It is cost-effective hormonal preparation, it gives high fertilisation and hatching percentage (85-95%), it is increases egg production through complete spawning, it produces healthy seed, it is easy to inject due to its low viscosity, it does not cause adverse effects on brood fish after injection, it can be administered in a single dose to brooders, it can be stored at room temperature, it is quite effective even under climatic adversities and ovatide is available in the market as 10 ml vial, which costs Rs. 300. It is cheaper than ovaprim. The selection of brooders and injecting methods are similar to pituitary extract.

**Induced Breeding with Ovopel**

Ovopel, developed by the University of Godollo in Hungary, is a preparation containing mammalian GnRH and the water-soluble dopamine receptor antagonist, metoclopramide. The concentration of D-Ala6, Pro9NEt-mGnRH and metoclopramide are in the form of 18-20 micro gm/pellets and 8-10mg/
pellets respectively. The hormone is thus available in pellet form. Each pellet contains superactive gonadotropin releasing hypothalamic hormone analogue with an equal effect which a 3 mg normal acetone-dried dehydrated carp hypophysis gland has. Induced propagation of fish had been shown to be more effective if the hormone was administered in two doses, prime dose and resolving dose, as reported by Szabo, T., 1996. For cyprinids successful results were reported when 2-2.5 pellets/kg were administered to female brood fish. However, preliminary trial with single injection of Ovopel gave encouraging result on a few species of Indian major carps and Clarias batrachus.

The required amount of ovopel was calculated on the basis of weight and condition of brood fish. The pellets were pulverized in a mortar and dissolved in distilled water. The trails were conducted in July-August of 1999. The new inducing agent, ovopel is easy to store, simple to use and less expensive, as reported by Szabo, T, 1996. However, in India, detailed studies to establish its efficacy and economic viability are required to be undertaken. The hormone has been successfully tested for ovulation in several species of cyprinids, the Common carp, the Silver carp and the tench (Horvath et al, 1997) in Europe. Ovulation was also reported in African Cat fish (Brzuska, E. 1998). In India, Ovopel was used with success in induced breeding of major carps in UP, Haryana and Punjab. In Assam the trials conducted recently on Labeo rohita (Rohu), Cirrihinus mrigala (Mrigal), Labeo gonius (Gonius) and Clarias batrachus (Magur) gave encouraging results. This indicates the possibility of using this new hormone preparation for commercial production of fish seeds if made available to farmers at a competitive price.

Other Substances used for Induced Breeding

Other substances like LH-RH analogues, steroids, and clomiphene are used for induced breeding of fishes.

LH-RH analogue

Various analogues of Luteinizing hormone -releasing hormone (LH-RH) have been used for induced breeding of fishes. Investigations have revealed that the potential action of releasing hormone when dopamine antagonist is simultaneously used with the analogues is (10-100 ig/kg) used successfully in China. An analogue of teleost GNRH is found to be more potent than LH-RH. GNRH (Gonadotropin releasing hormone) stimulates GTH(Gonadotropin hormone) in teleosts (dosage 25-100 ig/kg).

Steroids

Selected steroid hormones are used to induce fish. The effects of steroid hormones on ovulation are seen primarily as germinal vesicle breakdown
(GVBD). Ovulated oocytes require at least 4 hours to become fertilisable in mullets, whereas in most of the fishes oocytes are fertilisable immediately. The action of pituitary gonadotropins on oocyte maturation is known to be mediated through steroid hormones. Deoxycorticosterone acetate (DOCA) and cortisone effectively stimulate (dosage 50 mg/kg of fish) ovulation in Heteropneustes fossilis (Goswamy and Sunderraj, 1971). 17α-hydroxy-20B dihydroprogesterone (17α-20BDP) is useful to induce gold fish, trout and pikes (Jalabert, 1973). Other steroid hormones commonly used for spawning teleosts are cortisone acetate, deoxycortisol, deoxycorticosterone, hydroxycortisone, progesterone, 11 deoxycorticosterone and 20B progesteron. The advantages of steroids are: most compounds are available as pure preparations in synthetic forms, the quality of steroid preparations is uniform and steroid hormones are much cheaper than gonadotropin preparations.

**Clomiphene**

It is an analogue of the synthetic non-steroidal estrogen chlorotrianisene. It is known to have antiestrogenic effects in teleosts. It triggers the release of gonadotropins. The injections of clomiphene (10 ìg/g) induced ovulation within 4 days in gold fish, whereas with same dosage, common carp spawned successfully after 40-64 hours.

**5.4 Stripping**

Chinese carps however do not spawn naturally and when they spawn, the percentage of fertilisation is generally very low. Stripping or artificial insemination is therefore followed.

![Fig. 5.6 Stripping](image_url)
The female fish is held with its head slanting upwards and tail down and belly facing the vessel, and the eggs are collected into an enamel or plastic trough by pressing the body of the female. The male fish is then similarly held and milt is squeezed out into the same trough. The gamets are then mixed as soon as possible by means of a quill feather to allow fertilisation. The fertilised eggs are then washed a few times with clean water to remove excess milt and allowed to stay undisturbed in freshwater for about 30 minutes. The eggs are then ready for release into the hatching tanks.

**Technique of hatching the eggs:**

The eggs collected from breeding hapas are transferred into the hatching hapas. A hatching hapa consists of two separate pieces of hapas, the outer hapa and the inner hapa. The inner hapa is smaller in size and is fitted inside the outer hapa. The outer hapa is made up of a thin cloth in the standard size of 2 x 1 x 1 m while the inner hapa is made of round meshed mosquito net cloth in the dimension of 1.75 x 0.75 x 0.5 m. All the corners of the outer and inner hapas are provided with loops and ropes to facilitate installation. About 75,000 to 1,00,000 eggs are uniformly spread inside each inner hapa. The eggs hatch out in 14-20 hours at a temperature range of 24-310 C. The period of incubation, in fact, is inversely proportional to the temperature. After hatching, the hatchlings escape into the outer hapa through the meshes of the inner hapa. The inner hapa containing the egg shells and the dead eggs which are removed when the hatching is complete. The hatchlings remain in outer hapa undisturbed till the third day after hatching. During this period, they subsist on the food stored up in their yolk sac. By the third day the mouth is formed and the hatchlings begin directive movement and feeding. At this stage they are carefully collected from the outer hatching hapa and stocked into prepared nurseries.

It has been found that Indian major carps could be induced to spawn twice in the same season with an interval of two months. The breeders after the first spawning are fed with groundnut oilcake and rice-bran in the ratio 1:1 at 2.5 percent of the body weight. When favourable climatic conditions occur, they mature and are ready for sp.

### 5.5 Factors Effecting Induced breeding

Environmental factors like temperature, water condition, light, meteorological conditions, etc. are important factors controlling the reproduction of fish.

**Temperature**

There is an optimal temperature range for induced breeding of culturable fishes. Critical temperature limits exist, above and below which fish will not
reproduce. However, certain teleosts can be made to ripen below the critical temperature by using goandotropins. Warm temperature plays a primary role in stimulating the maturation of gonads in many fishes. Temperature has a direct effect on gonads regulating their ability to respond to pituitary stimulation and effects on primary synthesis and release of gonadotropins. Major carps breed within a range of temperature varying from 24-31°C. Some scientists did not find any correlation between water temperature and percentage of spawning success in induced fish breeding. If an effective dose of pituitary, HCG or ovaprim is given to fish, they spawn successfully even if there is a substantial increase or decrease in water temperature.

**Light**

Light is another important factor controlling the reproduction in fishes. Enhanced photoperiodic regimes result in early maturation and spawning of fishes like Fundulus, Oryzias, etc. Some fishes like Salmo, Salvelinus etc., attain delayed maturation and spawning. Cirrhinus reba attains early maturation when subjected to artificial day lengths longer than natural day even at low temperature. The requirement of light for activation of the reproductive cycle vary from species to species and from place to place, as the day length and temperature differ depending on the latitude of the place concerned.

**Water currents and rain**

Rheotaxtic response to water current is well established in fishes. Rain becomes a pre-requisite to spawning of fishes, even when they are subjected to induced breeding. Fresh rain water and flooded condition are the primary factors in triggering the spawning of carps. The sudden drop in the level of the electrolytes in the environment caused by the heavy monsoon rains induces hydration in the fish and stimulates the gonads resulting in its natural spawning. Successful spawning of fishes has been induced on cloudy and rainy days, especially after heavy showers.

**Hormonal influence**

Gonadotropins have been found to increase during spawning and decrease afterwards. Due to the presence of females, there is an increase in gonadotropin level in males. FSH and LH have been reported to influence gonadal maturity in carps. There are other factors that influence the spawning of fishes. Availability of nest building site stimulate fish to spawn. Factors called the repressive factors like accumulation of metabolic eliminates (Ammonia, faecal pellets, etc.) inhibit spawning.
5.6 Breading of common carp

Common carp (Cyprinus carpio) generally breeds in confined water. Spawning takes place in shallow marginal, weed infected areas from January to March and from July to August. Common Carp is also observed to breed round the year. Controlled breeding of common carp is conducted to achieve better spawning and hatching.

A set of selected brooders one female and two males are put together in breeding hapa. In order to ensure successful spawning sometimes the female fish is injected with pituitary gland extract at a low dose 2 to 3 mg per kg. Body weight. Freshly washed aquatic weeds (Hydrilla, Najas, Eichhornia etc) are uniformly distributed inside the hapa. These aquatic weeds act as egg collections. The quantity of weed used is roughly double the weight of the female introduced. Each weed attached with 40,000 to 1,00,000 eggs are distributed into a single hatching hapa. After 4 or 5 days the weeds are taken out carefully.

Fig. 5.7 Sticky fish eggs
Short Answer Type Questions

1. Define Induced breeding technology.

2. What is Brood stock?

3. Why the pituitary gland is used as induced agent in artificial breeding of fish.

4. Where the pituitary gland is located in fish? Write its gonadotrophic hormones.

5. Why the pituitary gland is called as master gland of endocrine system?

6. What are the agents used in preservation of pituitary glands?

7. Draw the diagram of spawning hapa.

8. Expand H.C.G. What its use?

9. What is stripping method?

10. What environmental factors control the reproduction of fish.

Long Answer Type Questions

1. Explain the fish brood stock management.

2. Describe the Induced breeding with pituitary gland extraction.

3. Describe the factors effecting Induced breeding.
6.1 Introduction

Spawners for hatchery production of prawn seeds were always collected from the commercial fishing grounds where they are known to mature and spawn. The collection of these spawners from the sea has been a serious problem as their availability is not only seasonal and uncertain but their procurement and transport expensive. The researches carried out at the NPCL of CMFRI have made it possible to mature and develop the spawners from the farm reared prawns. Adult prawns taken out from the grow-out ponds of the farm are subjected to unilateral eyestalk ablation and treated in special broodstock development pools where they attain full gonadial development and become ready to spawn. Using this technique several generations of the Indian White prawn Penaeus indicus, that have not gone to the sea during any phase of their life cycle, have been grown in the NPCL farm.
6.2 Induced Maturation in Shrimp

The important problem of shrimp farming is the shortage of pure and healthy shrimp seed. Most of the farmers depend on seed collection from natural resources. Obviously the availability of seed collected from natural sources is restricted to some areas and is seasonal. Further, the seed collected thus will be a mixture of economic and uneconomic seed. The separation of which is rather very difficult. Especially in early stages. Therefore, it is important to have shrimps hatcheries for ensuring the supply of adequate quantity of healthy seed to shrimp farmers. A pre-requisite for the effective production of shrimp seed is the availability of spawners in good conditions. The mature spawners are collected from the sea and are made to spawn in the fields and laboratory.

The shrimps are transported to the hatchery in 300 liters containers. These shrimps are acclimatized to the hatchery conditions. After getting, the brooders keep them in ponds or tanks for spawning. If wild spawners are scare, the brood stock can be developed at the hatchery site for eye-stalk ablation technique. The shrimp breeders are most essential for shrimp hatchery unit. The development of the shrimps in hatcheries is mast important to attain self-sufficiency in seed requirement. Now-a-days healthy shrimps are selected from the culture system for breeding with the help of modern techniques. Moreover, breeding of prawn in captivity is that it involves considerable labour and cost. The process is time consuming and highly elaborates. Eye-stalk ablation technique is used for induced maturation in shrimps.

Eye-stalk ablation

Previously the mature spawners collected from the sea were made to spawn in the laboratory by a technique known as eye-stalk ablation. At present, the shrimps are selected from the culture system. With the perfection of the technique of eye-stalk ablation, the production of shrimp seed is increased enormously. No eye-stalk ablation is necessary in case of males. However, predation during moultng is pronounced if normal males are released with female with one or both eyes removed.

The egg production is a cyclic phenomenon. It is supposed to be controlled by hormones produced by the neuro-secretary centres of brain. The centre and thoracic ganglia produce gonado stimulating hormone (GSH), with promotes vitellogenesis. The X organ in the sinus gland complex situated on eye-stalk close to cornea produces a hormone known as gonad inhabitor hormone (GIH), which inhibits vitellogenesis. Based on this phenomenon the eye-stalk ablation technique has been developed to make the shrimps to mature in captivity.
Panonse (1943) was the first scientist to try ablation of the eye-stalk and to get ovarian development in Leander sarratus. Maturation and spawning of Penaeus monodon has been induced first time in India in brackish water ponds at Bakkah fish farm West Bengal.

The culturable varieties of shrimp are generally collected either from sea pr or from brackish water culture system. Usually the shrimp nearing maturity are selected for eye-stalk ablation. They are acclimatized in the laboratory in well aerated sea water prior to the removal of eye-stalk.

**Methods of eye-stalk ablation**

The removal of eye-stalk is done by more than one method. These are as follows.

1. Pinching of the eye-stalk is done with the help of forefinger and thumb nails.
2. Squeezing out the contents.
3. Crushing the eye-stalk.
4. Cutting the eye-stalk with bent scissors.
5. Serving the eye-stalk with a razor.
7. Caterisation with electro-catery apparatus.

Improved techniques of Caterisation followed recently ensure a higher survival rate of the spawners. The electro-catery apparatus which are used for this technique and only removes the eye-stalk but also seals the cut end so that the loss of blood during this process is minimized to obtain cent percent survival. In other methods loss of blood occurs, leading to weakness, and mortality.

Usually only one eye is ablated because bilateral eye-stalk ablation increases the mortality percentage. Single eye-stalk is removed and eye ablated shrimps are kept in the maturation pools along with a few males. Generally for every male four females are kept in the maturation pool. After Caterisation, care is taken to maintain optimum water condition during maturation. The optimum levels are as follows.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salinity</td>
<td>28-35 ppt</td>
</tr>
<tr>
<td>pH</td>
<td>8 - 8.2</td>
</tr>
<tr>
<td>Temperature</td>
<td>28-32 C</td>
</tr>
<tr>
<td>O2</td>
<td>4 – 5.5 ppm</td>
</tr>
</tbody>
</table>
Within a week the females get matured. If the females are impregnated the male shrimps are to be removed from the pool.

6.3 Induced maturation technology

Operational details

Large sized P.indicus (over 140 mm in size) caught from the grow-out ponds are acclimatised in 32-34 ppt settled and filtered seawater kept in one ton capacity plastic pools for a day. After acclimatization the females are selected and one eye stalk of each of them is removed by using an electro-cautery apparatus. Mortality caused by the procedure is negligible. The cauterised females and half the number of acclimatised males are transferred to the maturation facility for gonadal maturation. The facility consists of 10 ton capacity circular seawater tanks fitted with sub-gravel biological filters with air-lift recirculation arrangement for maintaining the quality of the seawater. The biological filter converts the toxic ammonia excreted by the prawns into relatively harmless nitrates and maintains water quality.

The pH of the seawater is adjusted to remain at 8.2. The prawns are fed ad libitum with fresh clam meat. Under these conditions the females mature within 3-5 days after eyestalk removal and then they are transferred to the spawning tanks of the hatchery. About 75% of ablated females develop mature ovaries and spawn viable eggs.

Production

40 females and 20 males of P.indicus are kept in a 10 ton capacity broodstock pool. On an average 30 spawners will be ready for spawning in 3-5 days and each spawner will produce not less than 1,00,000 nauplii i.e. 3 million nauplii from each pool. If daily production is required the number of broodstock pools should be increased to 5 or 6. At present, NPCL has 3 broodstock pools.

Inventory and cost

The maturation facility is to be considered as part of a hatchery meant to produce prawn seeds. The special inventory required for the maturation facility for a daily production of 3 million nauplii consisting of pools, filters, compressors, pumps, chemicals and testing equipments will cost around Rs. 0.5 million; the land and building will cost 25 around Rs. 0.5 million and contingencies including salary component, labour, maintenance, feed, seawater pumping cost, etc. will cost around Rs.0.5 million; totalling to about Rs.1.5 million. However this cost can be considerably reduced when the project is undertaken as part of a hatchery project.
Estimated cost of production

It is difficult to estimate cost of production in view of the fact that the broodstock pools form part of a hatchery utilizing many of its general facilities. However the production cost per spawner may not exceed Rs.5.

Prospects

A maturation facility, as an integral part of the hatchery, ensures a steady supply of spawners and helps efficient planning of hatchery operations to produce prawn seeds on a large scale. In a developed state it may be possible to sell spawners to nearby hatcheries or even sell newly hatched nauplii to those having only rearing facilities.

6.4 Physiological changes after induced maturation

Physiological changes after induced maturation.

1. Sinus gland produces GIH and MIH (moulting inhibiting hormones) which inhibits gonadal maturation and moulting. GIH acts opposite to GSH. When eye-stalk is ablated only GSH remains in the body which promotes vitellogenesis.

2. Declining levels or MIH might have produced conductive conditions for the actions of the moulting hormone (MH). Eye-stalk ablation accelerated moulting. Frequency in both the sexes has resulted in shortening of intermoult period. Destalking also increases the frequency of berried moults.

3. The growth of body also increased in destalking shrimps. Growth of males is faster than females.

4. The egg production also increased in ablated prawns. Sometimes in M. malcolmsonii this increase is almost double.

5. Growth acceleration, frequent moulting and increased egg output are all energy demanding processes. To acquire this extra energy, the ablated shrimps have to be hyperphagic or efficient converters.

6. Glycogen decreases in heptapancease and muscles in ablated shrimp in contrast to control.

7. Ascorbic acid levels are increased in destalked shrimps. Ascorbic acid is involved in oxidation-reduction reactions. Its higher levels may be due to increased demand of the tissues for oxidation-reduction process to meet the increased rate of oxygen uptake. Bilateral extripation of the eye-stalk increases the normal oxygen consumption as much as 60%.
8. Cholesterol levels are also higher in ablated shrimps. The increase may be due to mobilization glycogen to lipid or due to the formation of new tissues when the cholesterol content increases.

The ovary and other organs of Decapoda have been extensively documented (Bell and Lightner, 1988; Zhao et al., 1998; Deng, 2000), while the morphology and function of the shrimp oviduct have not been well studied. The oviduct of penaeid shrimp is considered to play a role not only in carrying the mature eggs from the ovary to the gonopore during spawning but also in the secretion of some molecules (Talbot and Helluy, 1995; Yu and Lu, 2005). The possible substances secreted from the oviduct may play various physiological roles in the female reproductive system, such as lubrication of the oviduct, participation in oocyte maturation, and induction of capacitation of sperm stored in the female seminal receptacle.

Unlike those of vertebrate animals, the oviducts of penaeid shrimp are short, narrow, simple tubes that continuously connect to the lateral lobes of the ovary. Few histological studies of the shrimp oviduct have been reported (e.g., Macrobrachium nipponense [Lu et al., 2006], Jasus frontalis [Elorza and Dupre, 2000], and Penaeus sertiferus [King, 1948]). In the shrimp Penaeus setiferus, the wall of layers (connective tissue, basal lamina, and a layer of columnar epithelial cells) without a muscular layer (King, 1948). The oviductal wall of P. setiferus (King, 1948) is folded in some areas, similar to that of M. nipponense (Lu et al., 2006). In P. monodon, with 2 g body weight (BW), the oviductal epithelium also consists of a layer of tall simple columnar cells with a basal nucleus (Bell and Lightner, 1988), whereas with 80-100 g BW, possessing a mature ovary (stage IV), the oviductal epithelial cells become disorganized. In contrast to the oviducts of penaeid shrimp, the oviductal wall of lobsters Jasus lalandii (Silberbauer, 1971), Homarus americanus (Talbot and Helluy, 1995), and Jasus frontalis (Elorza and Dupre, 2000) consist of criss-crossed muscular fibers, which also cover the ovarian wall, suggesting an active participation in the extrusion of oocytes from the ovarian follicles and the translocation of the oocytes to the oviduct (Elorza and Dupre, 2000). It has been suggested that the oviductal epithelium of lobsters undergoes cyclical changes with ovarian development and spawning (also described in Talbot and Helluy, 1995). It is believed that the tall columnar epithelial cells lining the oviductal wall secrete a lubricating fluid to facilitate the passage of the mature eggs along the oviduct (King, 1948; Talbot and Helluy, 1995; Lu et al., 2006), although lubricating substances have never been characterized. However, it has been proposed that substances secreted from the shrimp oviduct may be involved in fertilization during spawning. Herein, we report the structural changes of the oviduct of the shrimp P. monodon during
ovarian maturation. We also demonstrate the presence of spherical secretion substances in the oviduct before the spawning process.

**Short Answer Type Questions**

1. What is eye stalk ablation.
2. What is thelycum in shrimp.
3. How can you identify the stage of ovarian maturation in shrimp.
4. What is petasma in shrimp.
5. What is the use of biological filters in What is X-organ.
6. What is X-Organ?
7. Write the optimum levels of salinity and temperature of water during maturation of shrimp.
8. Write any two physiological changes after induced maturation in shrimp.

**Long Answer Type Questions**

1. Describe induced maturation technology in shrimp.
2. Explain the methods of eye-stalk ablation.
3. Write the physiological changes after induced maturation in shrimp.
The term ‘hatchery’ or ‘hatchery proper’ is often used for an indoor facility of fish spawning, egg incubation, hatching and rearing of the hatchlings to post larval stage. One of the major requirements in aquaculture is the appropriate technology for the breeding, hatching and rearing of fish through a standardized method which may apply on national level.

There are different types of hatchery facilities in use, depending on the species, localities and investment capabilities of the aquaculturists. However, the basic requirements are almost similar viz., necessary facilities for holding or rearing an adequate brood stock; spawning or stripping and fertilization of Ova, incubation of fertilized ova and rearing of larvae to the required stage for transfer to nurseries or other culture facilities.
7.2 Types of hatcheries

Many types of hatcheries have been established so far for hatching fish eggs. The main aim of the hatcheries is to improve the percentage of the hatching of eggs. The different types of hatcheries are

**Earthen hatching pits**

The earliest hatchery was the earthen hatching pit with a dimension of 3’ x 2’ x 1’. Based on the requirements the size may vary. These pits are prepared in several rows and their inner walls are plastered with mud. After filling them with water, the collected eggs are introduced into them. About 35,000-40,000 eggs per pit are kept for hatching. Hatching takes place within 24 hours. Pits are also interconnected, properly irrigated and have draining facilities. A constant flow of water is useful to ensure proper aeration and to reduce the accumulation of wastes, thereby improving the survival rate. The percentage of hatching in hatching pits is 30-40%.

![Earthen hatching pits](image)

**The advantages of earthen hatching pits are**

1. These are best suited for hatching eggs from dry bunds. Wide areas near dry bunds can be used for digging earthen pits, so as to use a less quantity of eggs in each pit.

2. Fresh accumulated rain water from the bunds enters into the pits for hatching.

3. Expenditure is very low and the technology is inexpensive.
These pits have some disadvantages also. Huge mortality often occurs due to fluctuations in temperature, because the eggs are hatched in open areas. Depletion of oxygen often occurs which causes heavy mortality of spawn. Continuous water flow has to be maintained in the pits till the spawn are collected. If sufficient water is not available, mortality of spawn occurs.

The Chittagong type of hatching pits are similar to earthen hatching pits, but in each pit a piece of cloth and mosquito nets are used additionally. The cloth is kept just above the bottom of the pits. The mosquito net is arranged above the cloth. The spawn, after the hatching, pass through the net and are collected on the cloth. The net containing the egg shells and the dead eggs is removed after 3 days of hatching. When the yolk sac is fully absorbed, the spawn are taken out.

**Earthen pot hatcheries**

This is the oldest method adopted for hatching. Locally made earthen pots are used for hatching. The collected eggs are kept in pots and hatching takes place inside the pot. The fluctuations of temperature and pH are moderate. This method is not very popular. The percentage of hatching is about 40%.

**Cement hatching pits**

The hatching pits are lined with cement. The eggs are kept in these pits for hatching. The main advantages of these pits are that the recurring expenses are less, they are easy to operate, and regular flow of water is maintained. But capital investment is high and the mortality is mainly due to depletion of oxygen and increase in water temperature. The percentage of hatching is 30-50%.

**Hatching hapas**

Double cloth hatching hapas are most extensively used. The hapa is fixed in the water with the help of bamboo poles in shallow waters. This hapa is double walled, with an outer wall made of either thin or coarse muslin cloth, and an inner wall made of round mesh mosquito netting cloth. The most frequently used cloth for a hatching hapa is 2 x 1 x 1 m in size for the outer one, and the inner wall size is 1.75 x 0.75 x 0.9 m. The water depth is maintained around 30 cm. These hapas are arranged in a series. 75,000-1,00,000 eggs are kept in one hapa inside the inner wall for hatching. After hatching, the hatchlings enter into outer hapa through the mosquito netting cloth, leaving the egg shells, the spoiled eggs and the dead eggs. After hatching, the inner hapa is removed. The hatchlings in the outer hapa are kept for a period of 40 hours till the yolk sac is absorbed. The percentage of hatching is 40-50%.
The main advantages are that the cost is very less and the eggs are away from earth which will not pollute and cause mortality. The disadvantages are the pores of hapas get clogged due to silt deposition which causes heavy mortality, crabs cut the hapas easily, they have a short life period of about 2 years, weather fluctuations result in mortality and they need more water.

Garfil hatching hapas can also be used in place of cloth hapas. The design, construction and arrangement are similar to cloth hapas. The hatching percentage is 50-60%. The advantages are suitable mesh size can be selectively used for inner and

**Floating hapas**

Floating hapas are an improvement over the conventional hapas. These are designed to cope with the rise and fall in the water level. These can be easily fixed even in rock)’ areas without bamboo poles. They can also be fixed in deeper areas so that a mild water current passes through the hapa: this helps in better exchange of water and aeration. It is similar to a conventional hapa, but it is mounted on frames which are made up of polythene or aluminum pipes. Floats are fixed to the hapa for floating. It is tied to fixed objects with long ropes so that it will not be carried away by the current. It is collapsible and can be assembled very easily. The size of outer hapa is 2 x 1 x 1 m and that of the inner one is 1.75
x 0.75 x 0.5 m. The hatching percentage is 50-70%. Silt may get deposited in the hapa which causes mortality of the spawn. It may be dispositioned due to the movement of water and rearranging is time consuming. The hatching rate is not high.

**Tub hatchery**

This hatchery was introduced in Madhya Pradesh. It is an improvement over fixed hapas and provides for hatching in running water. It has a continuous flow of water by gravity and siphons. This system has a series of 8-12 galvanized iron hatching tubs connected to each other with a regular flow of water. Each series consists of an overhead drum. Each tub is 2.5' x 2.5' x 1.5' in dimension and has two nets, an outer and inner one. The fertilised eggs are transferred into the tubs for hatching. The percentage of hatching is 50-70%. Vigilance round the clock is necessary in this system.

![Fig. 7.3 Plastic made nursery, rearing, hatching pool](image)

**Cemented cisternae hatchery**

Tub hatchery has been replaced by cement cisternae hatchery. Cement cisternae are built below the dams of the dry bundh. Pond water is supplied to these cisternae. Each cistern is 2.4 x 1.6 x 0.45 m in dimension and they are connected in two rows. These are not interconnected and each has separate inlets and outlets. About 3,00,000 eggs are kept in each cistern for hatching. The percentage of hatching is 50-70%.
Vertical jar hatchery

This technique is an improved method over the hapa technique and ensures 90% survival of fish hatchlings. The hatchery consists of a continuous water supply, breeding tank, incubation and hatchery apparatus and a spawnery. The vertical jars are made up of glass, polythene and iron.

1. The greatest advantage of the jar hatchery is its very low water requirement. One unit of 40 jars can handle 20 lakh fertilized eggs in a day, and it would need just 20,000 litres of water.

2. It can be operated in a compact area. The space needed to accommodate the 40 jars unit would be around 10 square metres or at the most 20 sq. metres, and such a unit is sufficient for hatching out 20 lakh eggs. Compared to this, the hatching hapa in ponds requires 150 square meters of space.

3. In summer, with the water temperature shooting up over 320°C, hatching will be adversely affected in hapas. But in jar hatcheries, it is possible to overcome this by air-conditioning the room.

4. Developing embryos can be seen with naked eyes and so rectification can be attempted depending on exigencies.

5. A set of 40 jars would cost Rs. 10,000 with accessories. These jars last for 10 years. Hence, the cost per year for 20 lakh hatchlings would be Rs. 1000. But in the case of hapas, to handle 20 lakh hatchlings costs Rs. 9000. The hapas last only for two years and involve more labour. This indicates that jar hatchery is more convenient and also more economical cost-wise.

6. In a day, in a space of about 20 square metres, one can hatch out 20 lakh eggs with a survival rate of about 90%. During the monsoon period about 200 million eggs can be handled in this hatchery.

7. An added advantage of the jar hatchery is that in the same airconditioned room even breeding can be carried out successfully. Breeders respond well at temperatures of 26–28°C.

8. Adverse water conditions can be changed in ajar hatchery. In summer the hydrogen sulphide content is increased, especially in reservoirs, and this affects the hatching in hapas in the ponds fed with the above water. This could be treated in overhead tanks before supply to the hatchery jars.
Fig. 7.4 Vertical Jar Hatchery

Central collection tank with filter bag, hapa & filter media tank cap. 1000 liters
The main disadvantages are as it is made of glass, it is prone to easy damage; difficult to shift to different places and subject to breakage during transport; temperature control system is not provided; metabolites are not removed from the circulating water, and additional air circulation is not provided. In the transparent polythene sheet hatchery, glass jars are replaced by transparent polythene containers. Each polythene jar is 27 cm in height, 10 cm diameter and has a capacity of 2 litres.

In the giron jar hatchery, glass jars are replaced by galvanized jars. This unit is durable, cheaper and has more capacity. It is also more suited for local village conditions. The jars are conical and have a short spout at the top to serve as an outlet. The height of the jar is 75 cm and its diameter is 23 cm. The jars are fixed in an angular iron framework. The rate of the water flow is maintained at about 1 lit/min.

**Plastic bin hatchery**

This unit consists of eight hatchery cum spawnery units (HCS units) and a 5,000 litres water tank. The tank receives water from a natural resource by pumping. The tank is connected to the inlet pipelines of each unit. The HCS units can be arranged in a series to facilitate inlet connections. In this hatchery 2 crore eggs are kept for hatching. The percentage of hatching is 70-80%. Each unit consists of an outer container and the inner common egg vessel. The outer hatchery container is a rectangular aluminium sheet tub of 54" x 18" x 22" dimension and 243 litres capacity. It is unequally divided into three chambers. At a time 8 litres of eggs are placed for hatching in each hatchery unit. It also consists of an inlet outlet and drain pipe. The common egg vessel is made of a 14 gauge aluminium sheet which has 2.5mm diameter perforations. Three egg vessels are placed in each outer container. It is cylindrical in shape with a 12" diameter and 12" height. There is an arrangement of a plunger-lid which can slide and can be fixed at any desirable height on a vertical aluminium rod having a series of holes at 1 cm distance. The lid is useful to cover the eggs placed in the vessel closely so as to prevent any overflow and at the same time to enable efficient circulation of water. Each egg vessel can hold about 2 lakhs of eggs. The advantages are that the cost is less as it is primarily made of plastic, and is easy to operate. The disadvantages are that it has no temperature control device, no additional air circulation, metabolites may not be removed from circulating water and rhegaplankton may come from the overhead tank, which are injurious to the spawn.
**Plastic bucket hatchery**

It consists of an outer plastic bucket with a perforated aluminium bin egg vessel and a galvanised iron sheet spawnery. The plastic bucket height is 47 cm, 30 cm diameter and the capacity is 45 litres. It has 3 inlets at the bottom and 2 outlets at the top. The eggs are kept in the egg vessel for hatching. The survival rate is 70-80%.

**Hanging dipnet hatchery**

This hatchery unit has a spawning tank, two hatching tanks, two breeding tanks and an overhead tank. The spawning tank is 2.36 x 3.23 x 0.9 m, hatching tanks are 3.3 x 1 x 1 m and breeding tanks are 1.2 x 0.7 x 1.06 m in size. The water is supplied from an overhead tank, which is fixed at 3.2 m height over the roof. All the tanks are with inlet and outlet pipes. Sprayers are fixed over all the tanks. Air coolers are used for cooling the water. Hatching dipnets are fixed in the hatching tanks. These nets are barrel shaped with steel rings. The size of the net at the top is 65 cm and at the bottom 46 cm. Dipnets are covered with 1/16 inch mesh cloth. A 50 mm brass spray head is fixed at the bottom of each net. About 1 lakh eggs are kept in each net. During hatching, 1-1.5 lit/min water flow is maintained. The hatchlings enter into spawning tanks. The percentage of hatching is about 80%.

**Circular cisternae hatchery**

It has a drum which is made up of a galvanised iron sheet with one metre diameter and one metre height. At 5 cm above the bottom of the drum an inlet pipe is fixed at an angle of 45°. The inlet pipe is connected with the main water supply. Near the inlet a check valve is fixed to regulate the incoming water flow into the drum. The inlet pipe creates water circulation inside the drum. The surplus water goes out through the outlet, which is fixed at the top of the drum. The eggs are kept in the drum, and due to the water circulation the eggs are also circulated. A monofilament cloth with 60 mesh per inch at the outlet prevents the escape of eggs. After the hatching the egg shells get disintegrated and escape along with the surplus water. The hatchlings are found inside the drum and these are collected later. Due to the circulation of water plenty of dissolved oxygen is available to eggs and hatchlings. The percentage of hatching is about 90%.

**7.3 D-variety Hatcheries**

The seed production is dependent on nature, but the problem has now been solved with the evolving of a modern hatchery model CIFED- 81. It is now possible to breed fish without rains in this modern hatchery. Thus, we have become independent of the monsoons and natural environment. The brooders
are kept in the breeding unit, while hatching is done in jars having control over silt, oxygen, temperature and metabolites. This hatchery system consists of breeding and hatchery units.

**Breeding Unit:** This unit consists of air conditioners, breeding tanks, sprayers, water current system, aeration system, water pumps, overhead tanks and a filter unit. The breeding unit is installed in an airconditioned room. An air conditioner of 1.5 ton capacity is used. The air-conditioned room may have an area of 22.5 sq.m. and two breeding tanks of 440 x 115 x 80 cm size each, for breeding 240 kg females in 30 operations in four months of breeding season. The breeding tanks are either plastic pools, LDPE tanks, cement tanks or fibreglass tanks. The breeding tanks are provided with fine 75 mm diameter showers and spray channels arranged around the upper edge of the tanks. The spray and showers have independent operating systems, but can be used simultaneously if required. The water in the breeding tank is recirculated by a 1/16 HP pump and oxygenated through spray and showers. In each of the breeding tanks two floating hapas 180 x 90 x 90 cm in size are arranged. In each floating hapa a close net hapa of 170 x 80 x 80 cm size with a mesh of 20 mm and an opening for the introduction of injected brooders is fixed. In this system, 2.4 million eggs can be obtained in one operation.

Reservoir, pond or tube well water is directly pumped through the filter unit to remove silt and suspended solids into overhead tanks. Water is supplied to the breeding tanks through spray and showers from overhead tanks. The spray and showers increase the dissolved oxygen, keep the water cool and simulates natural conditions. Besides, aeration is also arranged by means of an oil free air compressor or blower.

**Hatching unit:** This unit consists of overhead tanks, vertical hatchery jars, oil free air compressor and blower, spawneries, spray and floating hapas. The
Fisheries

hatchery is installed in a shed or building, where temperature can be maintained at 27-29° C. Aeration is arranged to increase the dissolved oxygen of water between 7-9 ppm. The hatchery jars are made up of low density polythene. The height of the jar is 62.5 cm, the upper part is 44 cm and the capacity is 40 litres. A 37 cm diameter pipe with a control valve is fitted below the jar. Each jar has an independent control valve. The outlet is found at the top of the jar. The jars are arranged in a series. An inner egg vessel of 20 litres capacity is used inside the hatchery jars for removing the egg shells after hatching. Every three jars are provided with a spawn receiving low density polyethylene tank of 1450 litres capacity, 6’ diameter and 3’ height. Water spray is arranged around the upper edge of each tank.

**Spawn receiving tanks**: The spawn receiving tanks are provided with 50 mm diameter overflow pipes, which are connected to the storage tank, from which the water is again pumped back to the overhead tank through a filter for recirculation. A fine meshed nylon floating hapa is arranged in the spawn receiving tank to accommodate the spawn. The spawn is received from the hatchery jars to this hapa through a 32 mm diameter flexible PVC pipe to avoid any injury to the spawn. Showers and spray are provided to cool and aerate the water. Aeration is arranged in the hatchery jars and also in the spawn receiving hapa to increase the dissolved oxygen level, and the eggs are kept in floating condition in the egg vessel.

**Operation of D-81 hatchery unit**: Selected breeders are subjected to induced breeding and introduced in the breeding hapas. In case the water temperature is too high, the fishes are acclimatized gradually by lowering the temperature to 26-27° in the breeding unit. Then the spray and showers are started. The air-conditioner is put off when temperature reaches 26° C, but the spray and showers are kept in operation. After breeding takes place, the big meshed hapa is removed along with the spent brooders. The eggs remain in the breeding compartment of the hapa. After 5 hours the eggs are transferred to the hatching unit. After 4 hours of spawning the eggs are transferred to the egg vessel which is fixed in the hatchery jar. About 2 to 2.25 lakh eggs can be accommodated in each hatchery jar depending on the species. Continuous mild aeration and water flow are maintained in the jars for free floating of eggs. The rate of water flow is maintained at 1-2 litres/59 min.

The eggs hatch within 14 hours. When the hatching is complete, the egg container with the shells is removed. Then the flow rate of water in the jars is slightly increased for speedy transfer of the hatchlings into the spawn receiving tank. The remaining hatchlings if any are transferred into the hapa by siphoning with a 25 mm diameter pipe. Once the jar is emptied, water flow in the hatchery
jars is stopped. The spray is arranged around the upper edge of the spawn receiving tank and is kept in operation to ensure high level of dissolved oxygen and low temperature. The aeration and spray are kept in operation continuously until the yolk sacs of the hatchlings are absorbed, which normally takes 2 days. The percentage of hatching is 93-98%.

**The advantages are**

1. Material used is low density polyethylene, hence difficult to break.
2. Easy to pack and transport to different interior places.
3. Controlled temperature system is introduced.
4. Metabolites are removed from the circulating water by filtration.
5. Due to the additional aeration, oxygen in water is raised to 7-9 ppm.
6. Even when fertilization of eggs is low, the hatching rate is high.
7. The system ensures breeding and hatching without rains and monsoon.
8. Due to the filtration, the water is free from sediments and silt.
9. Each jar has a provision for independent regulation of aeration and water flow. In case of mortality, pollution or disease in any of the jars, it can be isolated from the rest of the system.
10. The common carp eggs normally hatch in 72 hours, but in this system these hatch out within 42 hours.

This system has no disadvantages at all. During 1984, large size HDPE D-84 jars were used in place of polythene jars. HDPE D-84 jars of 160 litres water capacity and a loading capacity of 0.75 million have been designed and successfully operated with a 92-95% survival rate.

### 7.4 Chinese Hatchery

The Chinese spawning and hatching systems are based on continuous flow of water by gravity to breed carps and hatch the eggs. The cost of construction and operation of a Chinese hatchery is less when compared to any other design for the same production capacity. In India also, the Chinese hatchery system is now considered to be highly suitable for the production of quality fish seed. Chinese type of Hatchery consists of four main components, viz., overhead water storage tank, the spawning/breeding pond, incubation hatching pond and hatchling receiving pond. This system is designed for fish breeding and incubation. The water required for the hatchery system is regulated through the pipe supply
from an overhead tank. The duration of one operation for hatching is 4 days. It can be repeated after a period of 4 days.

**Overhead water storage tank**: The floor of the tank should be 2.6m. above ground level. The inside dimension should be 5.5 x 2.7 x 2.2m and it should have a 30,000 liters capacity. Water supply to the overhead tank should be arranged by pumping water from an open well or a deep tube-well. The overhead tank is used to supply sufficient water for the spawning, incubation and storage tanks. A smaller overhead tank with a 5,000 litres capacity is also useful for this type of an operation. Spawning pond: It is a circular masonry/concrete pond with an inside diameter of 8 m. It has 50 cubic metres of water holding capacity. The inside depth at the periphery is 1.20 m. which slopes down to the centre at 1.50m. A water supply line is laid along the outside of the wall, and the inlet to the pond is provided at 14-16 places equally spaced and fixed at an angle of 45° to the radius of the tank using a 20 mm diameter pipe with a nozzle mouth, all arranged in one direction.

These are fixed to the vertical wall and the nozzle mouth is flush with cement plaster face and near the bottom along the periphery of the pond. In the fitted through which, on opening the valve, fertilized eggs along with water are transferred into incubation pond for hatching. The water flow in the spawning pool create an artificial riverine condition for the fish to breed. The shower and a perforated galvanised iron pipe are useful to increase the dissolved oxygen.
About 70 kg. of males and 70 kg. of females can be kept in the spanning tank which can yield 10 millions of eggs in one breeding operation. Incubation ponds: There are two circular incubation ponds each of 3.6 m. internal diameter. There are 2 chambers in each pond. The dimension of the outer chamber is 4 m. having an outer masonry/concrete wall. Another circular wall with a fixed nylon screen is provided at 0.76 m. clear distance from the outer wall. These tanks are about one metre in depth with 9-12 cubic metres of water holding capacity. They hold 70,000 million eggs/cubic metre. The inner chamber is provided with 10 cm diameter vertical outlets with holes at different heights for taking out excess of water of the incubation pond. The spawn along with water flows from these ponds to spawn collection pond.

**Fig. 7.7 Circular spawning pool**

From the overhead tank, the initial 7.5 cm. diameter pipe line is reduced to a 5 cm. diameter pipe line, and then to a 1.2 cm. diameter pipe line. 8 number of outlets are fitted in the floor of the incubation pond, with each outlet having duck mouth opening fixed at an angle of 45° towards inner wall. All the outlets are fixed in one direction only. Water supply pipes are fitted from the circular spawning tank by a 10 cm. pipe line which is then bifurcated into 2 pipelines of 0.7 cm. diameter each, one for each of the incubation tanks which are further connected to duck mouth outlets in the floor of incubation ponds. There is an outlet of 7.5 cm. diameter through which the hatchlings pass into the hatchling receiving pond. This opening is also used for complete dewatering of the outer chamber of the incubation pool. Desired water movement is about 0.2-0.3 m/sec.

**Hatchling receiving pond** : This is a rectangular masonry concrete tank. The inside dimensions are 4 x 2.5 x 1.2 m. This is located at a lower elevation than the incubation pond. So as to drain out the water from it by gravity, lift ground levels may permit. Fresh water supply from the overhead tank is provided
by a 7.5 cm. diameter pipe line, bifurcated into 3 numbers of 3 cm. diameter pipelines. These pipelines are arranged so as to provide the spray for aeration. From each of the incubation ponds 7.5 cm. diameter pipes are provided for transferring and regulating spawn intake into the spawn receiving pond. Hooks are fixed in two opposite side walls of the pond for fixing the net for the collection of spawn. Steps are also provided for getting into the pond for the collection of spawn. The overflow from this pond is discharged into an open drain and suitably utilised in the earthen ponds, if possible.

**Operation of the Chinese hatchery:** Brooders are kept in the spawning pond for about 4-8 hours for conditioning. Then between 4-6 PM, the first injection is given to the females. After 6 hours a second dose of injection is given to the female and one dose to the male. After 4 hours of the injection, the water jets are started so as to get the circular motion in the water. After 4-8 hours of the second injection, breeding takes place. One crore of eggs can be treated at a time in one operation. The eggs are collected from the bottom and are transferred into the incubation pools through pipes by opening the valves. Arrangements are made to chum the water again in the incubation pools. In 4 days time, the spawn is about 6 mm in size and then it is taken into the hatching' spawn receiving pool. From there it is lifted and stocked in separate water ponds until they reach the fry stage. If oxygen is less, aeration can be given through a compressor in the incubation pool at the rate of 6 kg/cm² run by a 1 HP motor. For aeration water showers, water jets, etc can also be provided depending upon the requirement. During the breeding season lasting about 120 days in a year, the breeding and hatching operations can be carried out in about 30 batches, each batch of 4 days. About one crore eggs can be hatched in one batch, and with a 95% hatching success, 285 million spawn of about 6 mm size can be produced. The main advantages are that the structures are of permanent nature, the hatchery is easy to operate and it needs less manpower.

### 7.5 Artemia Culture

The brine shrimp (Artemia) is in the phylum Arthropoda, class Crustacea. Artemia are zooplankton, like copepods and Daphnia, which are used as live food in the aquarium trade and for marine finfish and crustacean larval culture. There are more than 50 geographical strains of Artemia. Many commercial harvesters and distributors sell brands of various qualities. Approximately 90 percent of the world’s commercial harvest of brine shrimp cysts (the dormant stage) comes from the Great Salt Lake in Utah. However, the lake’s cyst production is heavily influenced by freshwater inflow, and the supply varies dramatically. The cost of good quality cysts fluctuates with supply and demand; buyers might expect to pay $12 to $40 or more per pound (1/2 kg). Normally
200,000 to 300,000 nauplii might hatch from each gram of high quality cysts. This publication describes the process of hatching Artemia cysts for use as larval food for cultured species, and the benefits of Artemia as a food source.

**Background**

Artemia are extremely euryhaline, withstanding salinities from 3 ppt to 300 ppt. They can even survive short periods of time in freshwater, but cannot reproduce in it. Artemia survive temperatures ranging from 15 to 55 oC (59 to 131 oF). They have two modes of reproduction. Sometimes nauplii (first Artemia swimming stage) hatch in the ovisac of the mother and are born live. However, when the body of water where adult Artemia are living begins to dry up and salinities rise, embryos are encased in a hard capsule, or cyst, so that they are protected and can hatch later when conditions are better. The cyst is 200 to 300 micrometers in diameter, depending upon the strain. Its external layer is a hard, dark brown shell. Dry conditions cause the encysted embryo to enter a dormant state, which allows it to withstand complete drying, temperatures over 100 oC (212 oF) or near absolute zero, high energy radiation, and a variety of organic solvents. The dehydrated cyst can be stored for months or years without loss of hatchability. Only water and oxygen are required to initiate the normal development of the Artemia embryo, but it does help the hatch rate to maintain the temperature above 25 oC (77 oF) and place a light near the eggs. The durable, easily hatched cyst makes Artemia a convenient, constantly accessible source of live feed for the finfish hatchery operator. Artemia cysts are best stored in a tightly sealed container in a cool, dry environment and, if possible, vacuum packed.

Within 15 to 20 hours after being placed in seawater at 28 oC (82 oF), the shell breaks and the prenauplius in E-1 stage appears (Fig. 1a). For the first few hours, the embryo hangs beneath the cyst shell in what is called the umbrella stage. The newly hatched Artemia relies on its yolk sac for nutrients because its mouth and anus are not fully developed. The pre-nauplius E-2 stage (Fig. 1b) is then released as a free-swimming nauplius (Fig. 1c) called an Instar 1 nauplius. In this stage it is brownish orange because of its yolk reserves. It uses specially modified antennae for locomotion and later for food filtering. Approximately 12 hours after hatch it molts into the second larval stage (Instar II) and starts filter feeding on microalgae, bacteria and detritus. The Artemia nauplius can live on yolk and stored re-serves for up to 5 days or through the Instar V stage (Fig. 1d), but its caloric and protein content diminish during this time. The nauplius progresses through 15 molts before reaching adulthood in approximately 8 days.

The goal of the hatchery manager is to use the Artemia as feed as soon as possible after they hatch because that is when they are most nutritious. However, the lipid level and fatty acid composition of newly hatched Artemia nauplii can
be highly variable, depending upon the strain and year class. Many researchers have studied the levels of highly unsaturated fatty acids (HUFA) in Artemia. Most of these studies indicate that the performance of larval fish is directly related to the level of HUFA in Artemia being fed and that essential fatty acids are the principal food value of Artemia. When Artemia contain low levels of HUFA, the survival of larval fish declines.

The type of food consumed by the parent Artemia greatly influences the fatty acid content of the cysts. Artemia composition is generally in the range of 51 to 55 percent protein, 14 to 15 percent carbohydrate, 13 to 19 percent fat, and 3 to 15 percent n-3 HUFA. When analyzed on a dry weight basis, cysts of one well-known brand of Artemia contained 28 percent crude protein, 10 percent crude fiber and 10 percent crude fat. To compensate for a poor HUFA level in Artemia, they can be enriched with omega yeast, vitamins (E, D, C and B12), marine oils, vitamin B12-producing bacteria, and commercial enrichment media (Super Selio®, Algamac®, etc.).

It is important to feed Artemia nauplii to fish larvae as soon as possible after hatching to take full advantage of the yolk and stored reserves found in freshly hatched Instar I nauplii (Fig. 1c). If there is a delay in feeding Artemia, they may also become too fast and too large for the fish larvae to catch and eat. Also, freshly hatched nauplii are dark orange and much easier to see than older nauplii, which are transparent.

Some strains of Artemia may be too large for the fish being cultured, so it would be wise to ask other hatchery managers for their suggestions about which strains to use. Figure 2 shows the size of a freshly hatched Artemia nauplius relative to a 12- to 13-day post-hatch red drum larva. Feeding an oversized Artemia strain can cause fish larvae to grow poorly or even starve.

**Optimum conditions for hatching Artemia cysts**

The optimal conditions for hatching Artemia are: 1) temperature above 25 oC (77 oF), with 28 oC (82 oF) being optimum; 2) salinity of 5 ppt (1.030 density); 3) heavy, continuous aeration; 4) constant illumination (example: two 40- watt fluorescent bulbs for a series of four 1-liter hatching cones); and 5) a pH of about 8. Stocking density is set by adding no more than 5 grams of cysts per liter of water. Good circulation is needed to keep the cysts in suspension. A container that is V-shaped or cone-shaped is best (2-liter bottles work well; glue a valve on the bottle cap and invert it). The best container is a separation column, found in any lab supply, although it is more expensive. Unhatched cysts, empty shells and hatched nauplii can be easily removed separately. The hatching percentage and density are usually a function of water quality, circulation, and the origin of the cysts.
Preparation and use of Artemia

There are seven tasks involved in feeding Artemia to larvae.

1. Determine the weight of Artemia cysts required to feed the larvae in a tank of known volume.

2. Hydrate and decapsulate cysts (decapsulation is optional, but recommended).

3. Incubate cysts.

4. Separate cysts from shells and debris (not necessary if cysts were decapsulated).

5. Count the hatched Artemia.

6. Calculate the number of Artemia remaining in the rearing tank from the previous feeding.

7. Calculate the number of Artemia nauplii required by the larvae and transfer them to the rearing tank.

Be careful with step number 6, as remaining nauplii may have little nutritional value and may need to be flushed out of the system.

Details of each of the tasks will be discussed in the following smallscale example. Materials and equipment needed are:

- Artemia cysts
- two 250-ml (8.5-fluid ounce) beakers
- distilled water
- household bleach
- sodium hydroxide (NaOH)
- 1-liter Imhoff cone or settling column
- low-pressure air supply (aquarium pump)
- seawater or equivalent (salinity of 5 to 32 ppt)
- siphon tube (approximately 4 feet long) or a valve at the bottom of the cone.
- 1-ml pipet
- 10-ml pipet
In India about 2.2 million ha. of Brackish water fish and prawn cultivable land is available. So far only 50,000 ha. of the above land is concerted into fish and prawn culture farms, which was facing already scarcity of prawn seed from natural sources. For a full fledged extension of Brackish water aquaculture in the above said total available land, the basic requirement is steady supply of young prawn larvae. The estimated prawn seed required for all the stocking available 50,000 ha. of Brackish water area in our country (which is under culture at present) is worked out as 600 crores if prawn seed for four crops (at a stocking density rate of 30,000/ha.) The development of prawn hatchery has most important role for intensive prawn farming in India, since limited numbers of prawn seed can be obtained directly from natural resources.

A person should know the following aspects.


Site Selection: Selection of site plays very important role for running a hatchery successfully, for selecting a suitable site, consider the following aspects. A. Brood stock source B. Location C. Climate D. Sea water quality and supply E. Power Supply F. freshwater supply G. Transportation facilities.

Brood stock supply: It is ideal for hatcheries to be near the source of wild spawners and brood stock. Wild spawners (mother Shrimps) is usually caught with a shrimp trawl, trawling time is usually kept limited, so as to avoid stress on mother prawns. Only spawners with late maturing or mature ovaries are selected for hatchery. If wild spawners are scarce, the brood stock can be developed at the hatchery site by eye-stalk ablation techniques.

Location: the penaeid hatchery should be located near the sea shore where clean water can be pumped easily and economically. The site must be free from pollution that is away sources of Agricultural. Biological and Industrial wastes.

Climate: The prospective hatchery must be located in areas relatively dry from November to April and wet during rest of the year. This type of climate will help in providing optimum temperature (28 – 30 C)

Sea water quality: Sea water for hatchery must have salinity range from 30 ppt to 35 ppt, which must be free from any type of pollution.

Power supply: Continuous power supply is essential during the entire larval period for running Air blower/aerator, pumps, lights and other domestic
equipment used in the hatchery. Better to have a stand by generator in case of power failure. According to CMFRI (1985) report a 10 KVA 3 phase generator operated by 16 H.P. diesel motor is necessary tor in a 35 million of PL 5 per year.

**Fresh water supply:** Continuous freshwater supply is necessary in the hatchery for lowering salinity when acclimating post larvae, to reduce the salinity from 35 ppt to 30 ppt, for washing and for the uses in the hatchery.

**Transportation facilities:** The hatchery should be connected with food transportation facilities with railway or road for seed lifting and to transport of materials and other required things for hatchery.

**Hatchery facilities and equipment:** Prawn hatchery should have complete facilities and necessary equipment for successful operation. It should have suitable tanks for larval and post larval rearing, Algal or phytoplankton and Zooplankton culture, air and sea water supply systems.

**Tanks for rearing of larvae and post larvae:** Larval tank capacity varies from 1 to 20 tones. For economical operation, a larval rearing tank should have a water capacity of 3-5 tons, while a postlarval (nursery) rearing tank should hold 6-10 tons, both at 1 m depth, one 3 ton larval tank can hold from 1,50,000 to 3,00,000 nauplii obtained from a single spawner.

**Algal culture (or) phytoplankton tanks:** Small and shallow tanks of not more than 1 ton capacity and about 0.5 m deep are in use for algal or phytoplankton culture. This is because adequate light is necessary for faster algal growth the tanks may also be mad of bamboo and plastic materials.

**Aeration supply:** Aeration is most essential in a hatchery to provide oxygen in the culture water and to keep larvae and food in suspension. It is may be commonly supplied by an electric blower/a compressor, or a portable aerator.

According to CMFRI (1985) report to run a 35 million PL5 capacity per year, which requires a 5 H.P. Air blower capable of delivering 160 cu.m of air/hour. At a pressure of 0.3 kg/cm.

**Sea Water Supply:** Using a single suction line laid a few feet above the sea bed. The intake pipe opening should be fitted with screen to prevent fish and other unwanted organisms from being sucked in. Pumped water directed to the hatchery where it may be thoroughly filtered before use. This filtered sea water should be free from turbidity, debris and other undesirable marine organism. This filtered water should pumped to the overhead tank. These overhead tanks serve as a desiltation tank PVC or brass pipes used for the distribution of sea water from the overhead storage tank.
Building: A concrete building is advised for hatchery. Building (shed) can be constructed by using inexpensive and locally available materials such as Nipa, Coconut and palmirah lumbs can be used to instruct building to house larval rearing tanks. Nursery tanks may be placed outdoors and covered individually with plastic sheet or canvas provide areas for monitoring, storage and for technicians quarters, for round the clock availability.

Hatchery equipment: The basic equipment needed in a hatchery are:

Refractometer/Hydrometer: Required for monitoring the salinity from time to time in larval tanks and in the water storage tanks.

Thermometer: Thermometer is required for monitoring the temperature of the water in the larval tanks.

Heamocytometer: Heamocytometer is required for counting algal cells.

Refrigerator: For storing stock cultures of Algal and other feeds for larval and post larval stages.

Microscope: Required for monitoring the conditions of larval and feed density

Air Diffusers: Air diffuser stones are used for serration in the larval tanks.

Scoopnets: Used for scooping larval of fry from tanks or from harvesting box.

Harvest box: to use for harvest of fry (post larvae).

Drainers: Drainers various types and mesh sizes for draining the water, during the water exchange.

Glass beaker: Beaker or any other transparent container of 200 ml to 1 lt. for counting, feeding and checking of the condition of larvae.

Method of brood stock selection: In the selection marine prawn brood stock, only gravid female (female prawn carrying full of riped eggs) will be selected, since mating already take place in the sea. The brood stock selected by technicians from the wild catch, for which the following desirable characteristics. The prawn should have a clear outline of the ovary when observed from the back. The matured ovary can be seen as three knobs in the anterior part of the abdomen. The ovary should extend until distal part of the abdomen. An ovary which does not reach the distal part of the abdomen is considered to have spawned partially. The colour of the ovary is in dark green/light yellow/light green, which differs from prawn to prawn. The spawning success of the middle
size group (20 cm in length and 80 Gms in weight) is very good. 70 prawns of brood stock are put in 200 m tank for spawning.

**Egg collection and cleaning:** After spawning the eggs have to be taken out from the spawning tank. At the same time the eggs also cleaned by washing thoroughly, to remove the rose colour substance. This rose cleaning material comes along with eggs during spawning. If proper cleaning is not attended very soon the larvae get infection. The broodstock may be checked after spawning, dead females and spawners should be removed. The aeration in the spawner tank should be adjusted so as to weakly bubble the water. The egg collection time usually occurred in nights though it depends on the spawning condition of the brood stock. The number estimation after sucking up the eggs using an air hose, put this method needs judgement by experience.

**Hatching & identification of larvae:** fertilized eggs are hatched into oval shape free swimming larvae known as Nauplius. One middle size female releases 3,00,000 eggs and percentage of hatching is estimated 80%.

**Identification of larvae stages:** Prawn larvae moults repeatedly and metamorphose in the following manner. The first larval stage, Nauplius stage undergo five moultings to reach Nauplius VI Stage (NI to B VI) of course in some species it is different.

Zoea stage which second larval stage after completing Nauplius, has three sub stages, Zoea I to Zoea III, third stage Mysis also has three substages, Mysis I to III, and the last stage postlarvae stage in which there is no substages. For the cycle from hatching to reach postlarvae stage, it takes about 12 to 20 days.

### Short Answer Type Questions

1. What is hatchery?
2. Name any two types of hatcheries.
3. Write any two advantages of D.variety hatchery.
4. Draw the diagram of floating hapas.
5. Write main components of chinese hatchery.
6. Why the chinese hatchery more advantageous than the vertical jar hatchery.
7. What is artemia?
8. Write any two examples of live feed.
9. Write the scientific name of brine shrimp.

10. Mention the phylum and class of Artemia.

**Long Answer Type Questions**

1. Describe the different types of fish seed hatcheries.

2. Explain unit components and operating of D-81 hatchery.

3. Describe main components and operation of the chinese hatchery.

4. Describe the culture of Artemia.
8.1 Introduction

In various countries, pond breeding species are generally preferred for fish culture as they do not involve the difficulties in the collection and transportation of young fish. But the widely cultured species of carps reputed for their very fast growth and culture conditions do not ordinarily breed in ponds and as such their young ones have necessarily to be collected mainly from the flooded rivers where these carps spawn annually during the short monsoon season. Indian major carps ordinarily breed in flooded rivers during the south-west monsoon months of June to August. They also breed in reservoirs, tanks and irrigation dams. In the confined waters of ponds they do mature but do not breed. If these matured breeders are transferred from confined waters to semi-confined rain-fed ponds, where the pond bottom is of muddy nature, the fish breeds whenever there is a good rainfall and a drop in temperature of water. This indicates that the few
factors which are responsible for breeding may not be found in the ponds. The semiconfined rain-fed seasonal water bodies have more dissolved oxygen, light, waves, water current and turbidity, and less temperature, which stimulate ovulation. Based on the above factors, the places where excess of rain water is used in creating riverine conditions, which stimulate ovulation in fishes, are known as bundhs. The bundhs are suitable places in producing fish seed.

8.2 Types of bundhs

The bundhs are of two types viz. wet and dry bundhs.

Wet bundhs

These are also known as perennial bundhs. The wet bundh is a perennial pond located on the slope of a vast catchment area of undulating terrain with proper embankments having an inlet facing towards the upland and an outlet towards the opposite lower ends. During summer, only the deeper portion of the pond retains water containing breeders. The remaining portion is dry and is used for agriculture. After a heavy rain a major portion of the bundh gets submerged with water flowing in the form of streamlets from the catchment area and excess water flows out through the outlet. The fish starts spawning in such a stimulated natural condition in the shallow areas of a bundh.

Fig. 8.1 Wet bundh
The outlet is protected by fencing to prevent the escape of breeders. The wet bundhs are comparatively much bigger in size than the dry bundhs. These are also known as perennial bundhs.

**Dry bundhs**

A dry bundh is a shallow depression enclosed by an earthen wall, which is locally known as a bundh, on three sides, and an extensive catchment area on the fourth. Bundhs get flooded during the monsoon, but remain completely dry for a considerable period during the remaining part of the year. These are seasonal rainfed water bodies, and are also known as seasonal bundhs. The topography of the land has a great role to play in the location and distribution of the dry bundhs. It is preferred to have undulated land because it provides a large catchment area and facilitates quick filling of the bundh even with a less rain, at the same time quick and easy drainage due to gravitation. In West Bengal, a catchment area of more than five times the bundh area is considered most suitable (Saha, 1977), whereas in Madhya Pradesh a ratio of 1:2.5 is considered essential (Dubey and Tuli, 1961). In Bankura district of West Bengal, most of the dry bundhs are fed with water from storage tanks, constructed in the upland area.

![Fig. 8.2 Dry bundh](image_url)
Bundh breeding being practiced since a century, has been given a greater importance. Since last three decades particularly after it has been reviewed in Madhya Pradesh, it has gained importance to such an extent that in some of the states like West Bengal, Rajasthan and Andhra Pradesh, besides rivers, the contribution of spawn production from bundhs is quite significant, particularly the spawn from dry bundhs as this source yields 100% pure spawn. It is known for its simplicity and mass production at one time.

8.3 Management of Bundh breeding

Site selection

The efficiency of the bundhs depends on many factors. The following criteria may be kept in mind when designing bundhs for fish breeding.

1. Extensive upland area from where, with heavy rains, considerable amount of rain water carrying soil and detritus enters the main pond.

2. The pond should have extensive shallow marginal areas which serve as ideal spawning grounds.

3. The soil should be of gritty nature which is considered to be the most suitable for the breeding of fishes.

4. Increase in oxygen contents of water which is due to the vast and shallow area of the pond.

The land should provide a place where a good sized pond can be made with a small dam. The place with a flat area surrounded on three sides by steep slopes should be selected. The fourth side, where the area drains out, should be as narrow as possible. The side slopes should constrict to shorten this up the construction area or axis of the dam.

Catchment area

A water shed with more than fifteen hectares of hard land for every hectare of water surface in the pond is considered essential. If the soil is retentive in nature, then forty hectares of watershed for each hectare of surface water is a better proposition. The fields must not erode. If the water shed is found either too big or too small even then it may be possible to correct the situation by using diversion terraces. If water is more, excess watershed may often be cut off and the water disposed off elsewhere. If more water is needed, a diversion terrace will increase the effective water shed.
Embankment

The embankment must be constructed at the low level side. The slopes must be built on each side of the dam. On the lower side the slope should be 20%, i.e., two feet on horizontal distance for each foot of vertical rise. The upper or pond side slope requires more attention. If the fill material has a very high proportion of clay, it may safely be built to the 2 to 1 dimension. If it is loamy or silty or with any sand or gravel in it, this slope should be broadened out to 3 to 1. For one hectare pond, a minimum of 4 feet width is desired at the top and a free board of 2 feet is essential.

A spillway and sluice are a must in the bundhs also. The spillway or flood outlet is a surface drainage way that will carry surplus water during heavy rains. Without this, the whole dam may be lost by overlapping in some sudden monsoon cloudburst. It must be placed around one end of the dam in hard ground. When required the pond can be emptied completely with the help of sluice gates. Spillway and sluice should be provided with strong iron netting, so that the fishes may not escape from the breeding bundh.

Factors responsible for spawning

Hora (1945) stated that heavy monsoon and flood are the primary factors responsible for spawning of Indian major carps. The strong current is necessary to influence the breeding intensity of carps. Mookherjee (1945a) observed that a low depth of water is quite sufficient for fish breeding. Das and Dasgupta (1945) believed that the molecular pressure of water particles and silt on the body of natural breeders has a stimulating effect for spawning in conjunction with rising temperature. Dasan (1945) reported that monsoon floods from the hills, having a peculiar smell, specific chemicals and physical properties, were responsible for breeding of fishes in the bundhs. The availability of shallow ground was also considered to be a factor for spawning (Khan, 1947). According to Saha (1957), temperature has no specific influence on spawning, but cloudy days accompanied by thunder storm and rain seems to influence the spawning. Mookherji (1945) stated that pH and oxygen content of water do not influence spawning in fishes. Bundhs having highly turbid waters with a distinct red colour, low pH between 6.2-7.6, 5-8 ppm of dissolved oxygen, low total alkalinity and 27-290 C temperature provide favourable conditions for spawning in bundhs.

Fish breeding techniques

Rohu, catla, mrigal, common carp, silver carp and grass carps are used to breed in bundhs. 100% pure seed can be produced in bundhs. Besides, more seed can be produced at a time. Once the bundhs are constructed, they can be used for many years to get more profits.
The brooders are collected in May and stocked in storage tanks where they are kept sex wise till the first monsoon showers. As soon as water accumulates in the bundhs, a selected number of these breeders are introduced into these bundhs and a constant vigil is maintained. In the olden days no importance was given to maturity, sex ratio, etc. The techniques were improved later and the breeding was done with a better understanding of sex, ratio and number of breeders. Fully ripe females and males 1:2 in number and of 1:1 weight were introduced into the bundhs on rainy days. Successive spawning could also be achieved as many as 5 times in one season.

In the modern techniques few pairs of females and males are being injected with either pituitary, or HCG or ovaprim extract and are released in the bundhs. This process, “sympathetic breeding in dry bundhs” has been used in West Bengal. By this method of partial hypophysation all the limiting factors for spawning like rain, thunder, storm and current of water can be bypassed. It is reported that about 160-200 million spawn of major carps has been produced. Recently at Mogra, the farmers have created a cement pond of about 75* x 25'. The bottom of the pond is pucca, but divided into two portions possessing a gradual slope. When water is filled into the pond, the first part possesses about one meter depth of water an4 lower one has about 2 meters depth. The owners called it as West Bengal bundhs. The bottom is filled with 6" of fine river sand. Before releasing them into the pond, the male and female breeders are partially hypophysed. It is reported that 160-200 million spawn of major carps has been produced here.

Fish in bundhs generally commence to breed during the early hours of the morning and continue to breed throughout the day. Catla prefer deeper waters, when compared to rohu or mrigal, which breed in shallow waters varying in depth from 0.5-1 metre. In wet bundhs, the brooder stock may be maintained throughout the year or replenished prior to the monsoons. The brooders are generally not injected with pituitary extracts but are stimulated to breed due to the current of rainwater from the catchment area, like in the case of dry bundh breeding.

Collection and handling of eggs

As soon as breeding commences, arrangements for collection and hatching of eggs are made. The eggs are collected by pieces of nylon net or mosquito netting, cloth or gamcha after lowering the water level and hatched in the double walled hatching hapas, ordinarily fixed in the bundhs. Collection of all the eggs is impossible, especially in case of wet bundhs, due to its larger areas. About 70% of eggs can be collected from the bundhs. In Madhya Pradesh, the hatching of eggs is carried out either in double-walled hatching hapas fixed in the bundh
itself or in rectangular cement hatcheries measuring 2.4 x 1.2 x 0.3 m. However, in West Bengal, the eggs are kept for hatching in specially dug out small earthen pits with mud plastered walls. The hatchlings are lifted from the pits by dragging muslin cloth pieces after 12 hours of hatching and are transferred to similarly prepared bigger earthen pits. The survival rate is about 35-40% in the hapas. It can be increased to 97% by using modern hatcheries.

Fig. 8.3 A double hatching hapa

**Improved features of dry bundhs**

The dry bundhs can be improved keeping in view the following points:

1. Selecting shallow sloping depressions and undulating terrain of sandy soils with maximum catchment areas.

2. Constructing a small earthen bundh at the far end of the depression opposite to the catchment area so that water could be retained for a certain period. A maximum depth of 2 meters of water is maintained in the bundhs and a fine meshed wire netting protects any overflow water.

3. Constructing a battery of 10-20 rectangular cement hatcheries measuring 2.4 x 1.2 x 0.3m.

4. Constructing a small double storied building which could serve as an observation tower cum store cum shelter.
8.4 Advantages and Disadvantages of Bundh

Advantages

1. Since major carps generally breed almost at any place in the shallow bundhs, it may be advantageous to prepare spawning grounds at different levels so as to get them flooded at different water levels in the bundh. But, it is necessary to have the spawning ground away from the direction of the current.

2. A few storage tanks, cement cisternae or earthen ponds can also be provided adjacent to the bundhs to store the breeders temporarily prior to their introduction in the bundh.

Disadvantages

The problems encountered in bundh breeding are:

1. Sometimes it is difficult to coordinate the collection and hatching of large quantities of eggs at a time, particularly in the case of wet bundh breeding.

2. During egg collection from wet bundh, often unwanted fish spawn, and predatory insect larvae, etc. are also collected.

3. In most cases, the hatching rate of eggs and survival of hatchlings up to the spawn stage have been poor, even when the fertilization rate of eggs was high. This could be improved by using modern hatchery techniques.

4. Presence of fairy shrimps (Streptocephalus sp. and Branchinella sp.) is in large numbers in dry bundhs particularly when breeding is late, i.e., three weeks of water accumulation during the collection of eggs. They can be controlled by supplying bleaching powder at the rate of 1 ppm on the first day of water accumulation.

5. Most of the dry bundhs primarily belong to the government. These are typically meant for drinking water and irrigation purposes. Fish breeding in these bundhs is, therefore, a secondary activity. No control on the inflow and outflow of waters for fishery activities is possible.

6. The brood fish are mainly collected from the wild habitats for dry bundh breeding. Gillnets or cast nets are used for catching the brood fish thereby causing injuries to the brood fish.

7. Brood fish may carry some infection or injury.

8. When the rains are heavy after spawning is over the influx of water is so strong that much of the gonadal products are destroyed by mechanical injury.
9. Before the release of brood fish or at the time of spawning and development of the spawn, adequate attention is not paid to monitoring the water quality as regards dissolved gases, toxic substances and predatory organisms.

10. In the late monsoon with accumulation of more waters, some dry bundhs start overflowing, thus increasing the risk of loss of seed from the bundh.

11. In the post-monsoon months with receding water level, the fingerlings are exposed to the risk of predation by the birds.

12. In some dry bundhs having a uniformly flat basin, when the water is reduced to critical level, seed collection becomes difficult and there may be mortality due to rise in temperature and turbidity in shallow sheets of water caused by repeated netting operations.

13. Late harvest of fish seed with decreased amount of water further aggravates the problem of poaching.

14. The early major carps are voracious in their feeding habits. If adequate food is not made available to them they become cannibalistic, especially if there is a noticeable difference in the size groups. This is especially true when brood fish are released in batches.

15. Often, when the dry bundh is supporting a good number of fish seed, water is drained out for irrigation purposes. This may also cause loss of sizeable stock from the dry bundh.

16. In most cases the spawn is allowed to stay uncared for in the dry bundh under natural conditions. If in excess, the silt, predatory insects and copepodes cause heavy damage to the developing eggs and subsequently to the juvenile fishes.

17. When spawning occurs the water may recede to critical levels thereby exposing a large amount of eggs in the peripheral areas of dry bundh thus causing large scale mortality of spawn.

**Economics**

In an experiment in Nain Thallia, about 20 million eggs were produced per hectare. In Midnapore and Bankura, 75 lakhs of spawn was produced at a time, and 160-220 million spawn produced in a season. With the increasing pace in the creation of a large number of bundhs, it is necessary to mention that spawn production through dry bundhs, is quite economical. Many crops of seed can be easily obtained from one bundh in a season of 4 months. By utilising the
rain water which would otherwise have been waste water, we can produce carp seed and reap good profits.

The bundhs are not only useful for fish breeding but also useful to culture fish after breeding. If the water is available for at least 6 months, those bundhs can be utilised to culture the fish. The fish seed of cultivable fishes can be introduced in the seasonal rain-fed bundhs and can be cultured for six months. Without providing supplementary feed and inorganic manures the yield can be about 1000 kg/ha/6 months. By providing supplementary feed and inorganic manure the yield can be increased to about 2500 kg/ha/6 months. It indicates that the bundhs are useful for both breeding and culture, and are highly profitable.

8.5 Seed Transportation

Transportation of breeders, fry and fingerling is a common phenomenon in fish culture systems. The fish seed are transported from hatchery units to the fish farm to rear them in culture systems. The breeders are usually transported from culture system to hatchery units for breeding either by induced breeding or naturally. The fish seed is also transported from natural collection centres to the fish farm. Hence, transportation of fish seed is an important step in the fish culture practices. Now-a-days, there is an awareness for taking up fish culture almost throughout the country, whether it is freshwater or brackish water, due to non-availability of fish seed at the place where it is required.

Reasons for Fish Mortality during Transportation

Effect of CO₂ and Dissolved Oxygen

Mortality of fish seed may be expected during transportation. It is mainly due to the depletion of dissolved oxygen and accumulation of gases like ammonia and carbon dioxide in the medium of fish seed carriers. These gases are lethal as they may reduce the oxygen carrying capacity of fish blood. However, the lethal limits owing to carbon dioxide in fish depends on the level of dissolved oxygen. It has been reported that fry of more than 40 mm in size may die at 15 ppm of carbon dioxide at a dissolved oxygen level of less than 1 ppm. Such fry may die only at 200 ppm, if the dissolved oxygen is around 2 ppm. Carbon dioxide given out during respiration dissolves in water and renders it more and more acidic which is injurious to fish. In transport of fish the shortage of oxygen has to be tackled either by replenishing the oxygen which is used up or by economising its use by regulating the number of fish seed and by reducing its oxygen demand. The oxygen utilisation of fish in transport is dependent upon a number of factors like the condition of the fish - normal, active and excited condition of fish, temperature, size and species. The oxygen consumption of different species of the same size or weight varies considerably. For example, 400 common carp
fingerlings of 40-50 mm size can be transported for two days in seven litres of water under oxygen packing. Only half of the number of other major carps and 1/8 of number of milk fish fingerlings of the same size can be transported under same conditions. Low to moderate temperatures are preferred for fish transport, since the amount of oxygen in water increases with the decrease of temperature and keeps the fish less active. Increase of CO2 depresses the active metabolic rate. Further increase proves fatal. In an oxygen packed closed system CO2 forms a limiting factor. Mortality of seed in such a system is mainly due to bacterial load in the medium. With the death of a few seed, bacteria increase enormously and utilise more oxygen. Bacteria increase from 250/ml in the beginning to over 110 million/ml in 24 hours. CO2 is found toxic to seed at 2.5-5 ppm concentration.

**Effect of Ammonia**

A large amount of NH3 is excreted by fishes. If ammonia concentration is 20 ppm, total mortality of fish occurs in oxygen packed packets. As NH3 increases in water, the oxygen content of blood decreases and its CO2 content increases. NH3 interferes with O2-CO2 exchange capacity of blood with the outside medium. The rate of NH3 excretion increases 10 times with a rise in water temperature from 8-150°C. Increase in water temperature and decrease of dissolved oxygen reduce the tolerance of fish to NH3.

**Effect of temperature**

Temperature has a distinct effect on oxygen utilised by the fish. Metabolism increases continuously with increased temperature till the attainment of lethal temperature limit. Each species displays its own characteristic rate of increase at a given range of temperature.

Fish, prawn and their seed face hyperactivity during transportation. As a result, lactic acid tends to accumulate in their tissues and severe oxygen debts are created. Fish take a long time to overcome this oxygen debt even in their natural life in ponds and other habitats. This may be due to the death of fish after few hours after handling, transport and liberation even in oxygen-rich water. Hence, the use of sedatives is most important in modern live-fish transport technology. Due to hyperactivity the bigger fish often suffer injuries which may cause death or severe external infection. If the fish and their seed are of different sizes, the smaller ones are very much affected and die. This risk may be avoided by selecting for transport fish of uniform size, and by sedating the fish.

By taking the above factors in to account, suitable steps are to be taken in tackling these problems and deciding the number of individuals to be put in the containers depending upon the time and duration of transport. The fish seed to
be transported is kept under conditioning so that their bellies are empty and excretion during transport is limited. Further, the conditioning will help in acclimatizing the fish to limited space in the containers. If the fish is brought directly from the pond into the container it is very active and hits to the sides of the container thus getting injured. The transport medium, water, should be filtered through a plankton net so as to make it free from phytoplankton and zooplankton which are present in the water and consume some oxygen themselves.

**Techniques of Transport**

Several types of containers are used in the transport of fish seed. These are mud pots, round tin carriers, double tin carriers, oxygen tin carriers and tanks fitted on lorries. The containers are transported by bicycles, carts, rickshaws, boats, lorries, trains and aeroplanes.

**Mudpots**

Mudpots are commonly used in Assam, West Bengal and Orissa for transporting spawn, fry and fingerlings. This is a traditional method. Mud pots of about 15 litres capacity are used for transportation of fish seed. The pots are filled with water of spawning ground to about two thirds of their capacity. After filling the pot with water, about 50,000 spawn are introduced. It is better to condition the spawn in the hapas for about three days without feeding prior to transportation. Otherwise, due to feeding more excreta is produced which pollutes the water in the pot, leading to the death of fish seed. To avoid the mortality of fish seed due to asphyxiation, water is changed once in every five hours. The temperature of water in mudpots is not affected easily, which is an advantage in transport. This method, however, has several drawbacks, such as, the mudpots are liable to break in transit, which may result in the loss of the seed. Fish seed may be injured due to the shaking of pots.

Possible for transportation only for short distances and short durations. Frequent changes of water may result in mortality of fish seed due to difference in water quality. Considering these factors modern methods of transportation have now been propounded.

**Round Tin Carriers**

Round tin carriers are used for transport of fish seed from several years. The tin is made up of galvanised iron sheet. It is a round container having a diameter of 18" and height 8". The lid has a number of small holes, which are useful to get oxygen. This container has a capacity of gallons of water, but is filled up only with 8 gallons of water. The seed is introduced into it and transported to various places.
Double tin carriers

Double tin carriers are made up of galvanised iron and have two parts - outer and inner tins. The outer tin is 13" x 13" x 8" and the inner one is slightly smaller than outer one and can be easily kept inside the outer tin. The outer tin is open and with a handle. The inner tin is closed with a lid and entire tin has small openings. The inner tin is filled with water after keeping it in the outer tin, then fish seed is introduced into it. It holds about 6 gallons of water and is generally used for carrying a small number of fish seed by hand.

Oxygen tin carriers

Tins of 18" x 28" size and big polythene bags of 17" x 15" size are used in this method. In this technique, fish seed are transported by road, train and air. The polythene bags are filled with water, seed and oxygen and packed in the tin, then transported. This is the most common method of fish seed transportation and the latest in technique of transporting the fish seed. After checking the damage, the good polythene bags are kept in a tin container and about 1/3 of its capacity is filled with aerated pond water. The fish seed, starved for one day and acclimatized are then carefully introduced into the bag. 20,000 fry can withstand packing in one bag for a journey of 12 hours. Similarly 200 fingerlings in one bag can withstand a journey of 12 hours. The number of fish seed to be packed in a bag has to be decided depending on the distance and size of the seed. A tube from the oxygen cylinder is then allowed into the bag and the portion of the bag, about 10 cm from the top is twisted and a string is kept ready for tying. The oxygen is then drawn in from the cylinder through the tube until 2/3 of the bag is inflated or the top of the inflated bag is slightly below the top of the tin. The string is tied round and the tin is closed. The packed tins are kept in a cool place. To ensure better survival rate, the tins should be transported during the morning or evening. Card board containers are used in place of tin containers.

Tanks Fitted on Lorries

For road transport lorries with one or two large tanks of suitable dimensions fitted at the rear can be advantageously used. This will facilitate seed transport problem to a large extent.

Use of Anesthetics in Transportation

Recent investigations have shown that the fish seed could be anesthetised for transportation for ensuring better survival rate. The purpose of this is to ensure that the fish seed survives for a longer period of time, and also to minimise the concentration of toxic gases like ammonia and carbon dioxide in the medium by lowering the metabolic rate of the fish seed. Anesthetised fish seed have been
found to survive for double the time of unanesthetised seed, besides ensuring a better survival rate, which is about 90%. Carbonic acid has been found to be the best anesthetic compared to others such as quinaldine, sodium amytal, urathane, veronal chloroabutanal and TMS-222 (Tricaine Methan Sulphonate). Carbonic acid is not only cheap but also safe and easy to use. To about 8 litres of water in bag containing fry, 8 ml of 7%, sodium bicarbonate solution and 8 ml of 4% sulphuric acid are added so as to produce 500 ppm concentration of carbonic acid. This anesthetised bag should be immediately filled with oxygen.

Absorbants are added to the medium during transportation to eliminate toxic ammonia from the medium and safeguard the fish seed from mortality. These absorbants are permutit, synthetic amerlite resin, pulverised earth and clinoptilolite. Addition of sodium phosphate, which acts as a buffer, at a rate of 2 gm/lit. of the medium may bring about a favourable pH of the medium for fish seed during transit. Due to the non-availability of some anesthetics and the risk involved in the improper use by laymen, the method has remained at the level of a scientist only.

**Estimation of Quantity of Fish Seed for Transportation**

The number of fish seed to be transported in closed and oxygen packed containers may vary according to the type and size of the fish seed, mode of transport, duration of transport and the environmental temperature, etc. The number of fish seed for transportation in containers can be calculated using the following formula

\[
N = (D - 2) \times V \\
R \times H
\]

Where : D is dissolved oxygen in ambient water in ppm.
V is volume of water in litres.
R is the rate of oxygen consumption by individual fish seed in mg/kg/hr.
H is period of transportation in hours.

N is number of seed to be introduced.

**Short Answer Type Questions**

1. What is bundh breeding?

2. Mention the types of bundhs in bundh breeding.
3. What is wet bundhs?
4. Write any two advantages of bundh breeding.
5. Mention any two disadvantages of bundh breeding.
6. Write any two reasons for fish seed mortality during transportation.
7. Write the formula estimation of quantity of fish seed for transportation.
8. What is the use of anesthetia in fish seed transportation?
9. Write the effect of temperature during the fish seed transportation.
10. Define the term ‘Conditioning’ used during transportation of fish seed.

**Long Answer Type Questions**

1. Describe the wet and dry bundh breeding.
2. Explain the fish breeding techniques and factors responsible for spawning in bundh breeding.
3. Describe the reasons for fish seed mortality during transportation.
4. Describe the techniques of fish seed transportation.