B.F.Sc IV Sem. Class Notes

Subject

Finfish Hatchery Management

Dr V.P.Saini

Dean, CoF, Kishanganj

Part 1: CARP SEED ROCUREMENT

Part 2: TECHNIQUES OF POND MANAGEMENT

Part 1: CARP SEED ROCUREMENT

The availability of quality seed in adequate quantities is basic and foremost for sustainable aquaculture. The Indian major carps and Chinese carps breed naturally only in the flowing waters of their natural habitat during the rainy season. Prior to the introduction of induced breeding, the required quantity of seed was collected from natural waters which were frequently contaminated with undesirable species. Introduction of artificial breeding techniques and construction of modern hatcheries has helped to meet the demands of the fish farmers. Induced breeding produces seed of much greater consistency and fish can be spawned on demand when it matures. It also provides ample opportunities for stock improvement by selective breeding.

REPRODUCTIVE BIOLOGY

Although there are rare cases of parthenogenesis, such as in the Amazon molly (*Poecilia formosa*), the large majority of teleosts reproduce through sexual reproduction.

1. Number of Breeding Opportunity

Synchronous: Synchronous fish reproduce only once each year, or once in their lifetime. In such species, all oocytes develop simultaneously and are at the same developmental stage at a given time. This is the case for salmonids, for example. Eggs are spawned and the fish dies -Pacific salmon

Group synchronous: Group synchronous fish have two or more distinct populations of oocytes present at the same time and ovulate once in a season, or undergo multiple ovulations over a few days or weeks within the spawning season.-Most species of fish

Asynchronous: Asynchronous fish, such as the zebrafish, are capable of ovulating on a regular basis, sometimes every day, over a prolonged period.

2. Size and Age at First Maturation

Under different geographical and ecological conditions, the maturity age of the same species is widely different. The maturity age of common carp is one year, for gross carp and silver carp 2+ years and in case of Indian major carps such as Mrigal and Rohu the maturity age is 1+ years while for catla 2+ years. However, in the same region maturity age varies somehow rather with ecological conditions and other intrinsic factor. The induced breed species reared in pond culture practice gets early maturity than the natural riverine stock. Generally males mature little earlier than the female, in cultivable carps.

3. Time of Spawning and Duration/Season of Reproduction

The regular monsoon season (July-August) is the breeding season for the 5 cultivable carps viz., Catla, Rohu, mrigal, silver carp and grass carp, in most part of India. However, the season may begin a few months earlier or last longer depending upon the setting in of the monsoon season, early or late in respective regions of the country, e.g. the breeding season for carp's starts earlier in Assam than in Orissa or Bengal. All the above carp species are more difficult to spawn than common carp. The common carp breeds in ponds and has two breeding seasons on the plains of India viz. monsoon and post-winter period i.e. Feb. - March. The major Indian and Chinese carps breed naturally in flooded river conditions during monsoon in their native countries and this is also the suitable season for taking up the induced breeding operation.

- CARPS (IMC): April to Sept. – During monsoon
- Common carp: 1-Feb-March; 2-August-sept

- Grass & Silver carp: April to Sept. – During monsoon
- Catfish(s) : During monsoon period

4. Type of Spawning

Open substrate spawner

Pelagic spawner: A species that sheds pelagic eggs into the water column .The eggs, embryos and larvae of pelagic spawners contain oil globules or have a high water content. They are usually pelagic fish such as tuna and sardines. Some demersal fish leave the bottom to spawn pelagically, particularly coral reef fish such as parrotfish .

Benthic spawner: Benthic spawners deposit their spawn on or near the bottom. They are usually demersal fish such as cod and flatfish.

Brood hider

Brood hiders hide their eggs but do not give parental care after they have hidden them. Brood hiders are mostly benthic spawners that bury the fertilized eggs. For example, among salmon and trout the female digs a nest with her tail in gravel. These nests are called redds. The female then lays her eggs while the male fertilizes them, while both fish defend the redd if necessary from other members of the same species. Then the female buries the nest, and the nest site is abandoned. Annual killifish known as egg buriers lay their eggs in mud. The parents mature quickly and lay their eggs before dying when the water dries up. The eggs remain in a dormant stage until rains stimulate hatching.

Bearers

Bearers are fish that carry their embryos around with them, either externally or internally.

External bearers: Mouth brooders - carry eggs or larvae in their mouth. Mouth brooders can be ovophiles or larvophiles. Ovophile or egg-loving mouth-brooders lay their eggs in a pit, which are sucked up into the mouth of the female. The small number of large eggs hatch in the mother's mouth, and the fry remain there for a period of time. Fertilization often occurs with the help of egg-spots, which are colourful spots on the anal fin of the male. When the female sees these spots, she tries to pick up the egg-spots, but instead gets sperm that fertilizes the eggs in her mouth. Many cichlids and some labyrinth fish are ovophile mouthbrooders. Larvophile or larvae-loving mouth-brooders lay their eggs on a substrate and guard them until the eggs hatch. After hatching, the female picks up the fry and keeps them in her mouth. When the fry can fend for themselves, they are released. Some eartheaters are larvophile mouthbrooders.

Internal bearers: The beginning of the evolutionary process of livebearing starts with *facultative* (optional) internal bearing. The process occurs in several species of oviparous (egg-laying) killifishes which spawn in the normal way on the substrate, but in the process accidentally fertilize eggs which the female retains and does not spawn. These eggs are spawned later, usually without allowing much time for embryonic development.

The next step in the evolution of livebearing is *obligate* (by necessity) internal bearing, where the female retains all the embryos. "The only source of nutrition for these embryos, however, is the egg yolk, as in externally spawned eggs. This situation, also referred to as ovoviviparity, is characteristic of marine rock fishes and the Lake Baikal sculpins. This strategy allows these fish to have fecundities approaching those of pelagic fish with external fertilization, but it also enables them to protect the young during their most vulnerable stage of development. By contrast, sharks and rays using this strategy produce a relatively small number of embryos and retain them for a few weeks to 16 months or longer. The shorter times spans are characteristic of species that eventually deposit their embryos in the environment, surrounded by a horny capsule; whereas the longer periods are characteristic of sharks that retain the embryos until they are ready to emerge as actively swimming young.

Fishes can be classified in to 5 groups on the basis of spawning.

- Lithophils: Fishes which spawn on hard stony surface eg. Salmon.
- Phytophils: Fishes which lag eggs among aquatic plants e.g. carp (Common carp)
- Psammophils: Fishes which deposit eggs in sandy surface e.g. Loach.

- Ostracophils: Fishes which deposit eggs inside a bivalve e.g. Chilogolsio.
- Pelagophils: Fishes which spawn freely in column of water and the eggs float (cod fish)

5. Mating System

Promiscuous: Promiscuous is a mating system where both sexes have multiple partners during the breeding system (e.g. Herring, Cod). In fishes, this is the most common mating system. Breeders make little or no mate choice and spawn with multiple partners, either sequentially or at the same time.

Polygamous: Polygamous is a mating system in which an individual of one sex has multiple partners during the breeding system but individuals of the opposite sex have only one partner (e.g. Sunfish, tilapia, catfish). Evolutionarily, these systems are purported to have an increased chance of passing on “good genes” from individuals that compete for the ability to mate with multiple partners. This mating system can occur with one male and many females (*polygyny*) or one female and multiple males (*polyandry*).

6.Gender System

Gonochoristic: In biology, gonochorism or unisexualism or gonochory describes the state of having just one of at least two distinct sexes in any one individual organism. The term is most often used with fish, in which the individual are often gonochorous.

Hermaphroditic: Fish that, when mature, possess both male (testes) and female (ovary) sex glands at the same time. In such species cross-fertilization can occur during spawning. Most Serranidae (sea perches) are females first or have both sets of glands equally developed. Sex may change after maturation (e.g. Sea bream)

7.Spawning Site Preparation

- No preparation; most spp. of broadcast spawners
- Site preparation and defended; Tilapia, salmons

8. Place of Fertilization

External: External fertilization usually occurs in aquatic environments where both eggs and sperm are released into the water. After the sperm reaches the egg, fertilization can then take place. Most external fertilization happens during the process of spawning where one or several females release their eggs and the male(s) release sperm in the same area, at the same time.

Internal: Internal fertilization occurs most often in land-based animals, although some fishes also have internal fertilization. There are three ways that offspring are produced following internal fertilization: oviparity, ovoviparity, and viviparity.

Oviparity: Ovuliparity means the female lays unfertilized eggs (ova), which are externally fertilized.Examples of ovuliparous fish include salmon, goldfish, cichlids, tuna and eels. In the majority of these species, fertilisation takes place outside the mother's body, with the male and female fish shedding their gametes into the surrounding water.

Ovoviviparity: In ovoviviparous fish the eggs develop inside the mother's body after internal fertilisation but receive little or no nourishment directly from the mother, depending instead on a food reserve inside the egg, the yolk. Each embryo develops in its own egg. Familiar examples of ovoviviparous fish include guppies, angel sharks, and coelacanths.

Viviparity: Viviparity occurs in some Sharks and Surf - perches. Similar to ovoviviparous fish, internal fertilization and development occurs. However, the embryos receive direct nourishment from the mother, similar to the development of an embryo in mammals. Like ovoviviparous fish, the viviparous fish give birth to live young, however viviparous fish are fully advanced at birth allowing for a greater chance of survival.

9. Types of Fish Eggs

Pelagic eggs: The pelagic eggs of most species are small in size, measuring about 0.7 mm to 1.5 mm in diameter. A few species have larger eggs between 1.6 mm and 2.6 mm in diameter. All pelagic eggs are transparent and are practically spherical, except for those of anchovies which are oblong (longer than broad). Occasionally eggs are found to be slightly ovoid. Pelagic eggs are floating type, smaller in size compared to demersal eggs. These eggs do not have adhesive membrane. They are buoyant; the buoyancy is maintained by single oil globule. If the oil globule is not there, high percentage of water is present which helps in floating. During floating stage, dispersion of eggs takes place. The pelagic eggs are subjected to high mortality mainly due to two factors. i. Predation, ii. Eggs are exposed (carrying) to unfavourable conditions. But this is compensated by increased fecundity, protracted spawning season.

Demersal eggs: The demersal eggs sink to the bottom (i.e. carps eggs) and are basically of two types (i.e. adhesive and non-adhesive eggs).The demersal eggs are generally larger than pelagic eggs which may be laid in masses or singly. These eggs are heavy or dense. Since they are heavy, they sink to the bottom. The eggs are provided with adhesive membrane. They stick on to other objects with filamentous structure. Normally there is no relation between habitat and type of eggs produced. i.e. pelagic fishes can produce demersal eggs and demersal fishes can produce pelagic eggs. (Generally most common pelagic food fish have pelagic eggs)

The pelagic sardine produces pelagic eggs, whereas herring is a pelagic fish but the eggs are demersal. Similarly angler fish which is a demersal fish but produce pelagic eggs. Deep sea wolf herring is a demersal fish and produces demersal eggs.

9. Mechanism of Hatching

There are two mechanisms involved in hatching such as: (a) mechanical hatching and (b) enzymatic hatching

A. **Mechanical Hatching**: The mechanical hatching is a process in which egg envelopes are broken down primarily by mechanical action such as pressure exerted from within or mastication by the embryo itself.

B. **Enzymatic Hatching**: In enzymatic hatching emergence of young occurs after dissolution or softening of egg envelope by the enzymes secreted by the embryo. This enzyme is called hatching enzyme. These enzymes are secreted into the perivilelline fluid at the time of hatching from the hatching gland cell located in the epidermis of the embryo. Hatching gland cells are unicellular gland cells developed on the surface of the embryo as they reach the hatching stage. Location of these cells differs in different species. The hatching enzyme has a chariolytic activity and also proteolytic activity. Because of its chriolytic activity it is called chronionase.

The thick layer of chorion that protects the embryo against mechanical, chemical or biological stress effects is also the barrier to the embryo for hatching. Hatching enzymes secreted one hour before hatching, break down the peptide bonds of this layer so that embryo by its movement can break the weakened layer and hatch out. The hatching with the yolk sac attached to its belly is called SAC FRY.

10. Parental Care

Parental care is a very important adaptation among fishes for ensuring the survival of their offspring. The parent fish stock look after their offspring during their most critical stage of life when they are defenseless and very sensitive parental care is of two types: (i) Passive care (ii) Active care.

(i) Passive care: This is actually the hereditary foresight of the female to provide more yolk for embryo to sustain life for a long time or to place the eggs on such sites where the optimum environmental conditions are met and beyond the reach of enemies. Some fish have in their eggs a poisonous substance which keeps predators away e.g. all major carps. Fish with passive care have high number of eggs

(ii) Active care: In active parental care either one or both of the parents take an active part in carrying for and defending their eggs, larvae and sometimes the fry as well. This includes the selection and preparation of a suitable place for depositing the eggs, selection of a good substrate to which the eggs can adhere, collection of nest making material and preparation of the nest e.g. Tilapia, fighter etc. Fish with active care have normally less no. of eggs.

11. STAGES OF MATURITY OF CARPS

Based on the development, maturity in carps can be categorized into 7 steps (Table 6.1 & Fig.6.1). Up to stage III, the development is not very fast, after which the ovary will develop at a very fast rate with increasing temperature. By the time stage V is reached, ovarian weight will be about 20-30% of the total body weight and the gonado- somatic index in case male and female will be around 5-10 and 20-30% of the total body weight respectively. Gonado-somatic index of common carp is relatively higher than IMC and other Chinese carps. With the advancement of maturity, fishes develop few morphological differences. However, the sexual dimorphism they exhibit externally is only relative and not infallibility distinct.

At immature and maturing stages, sexes cannot be differentiated externally. One of the most common differences between sexes is the roughness in the pectoral fin – the males develop relatively long pectoral fin and roughness while that of females are smaller and smooth. On

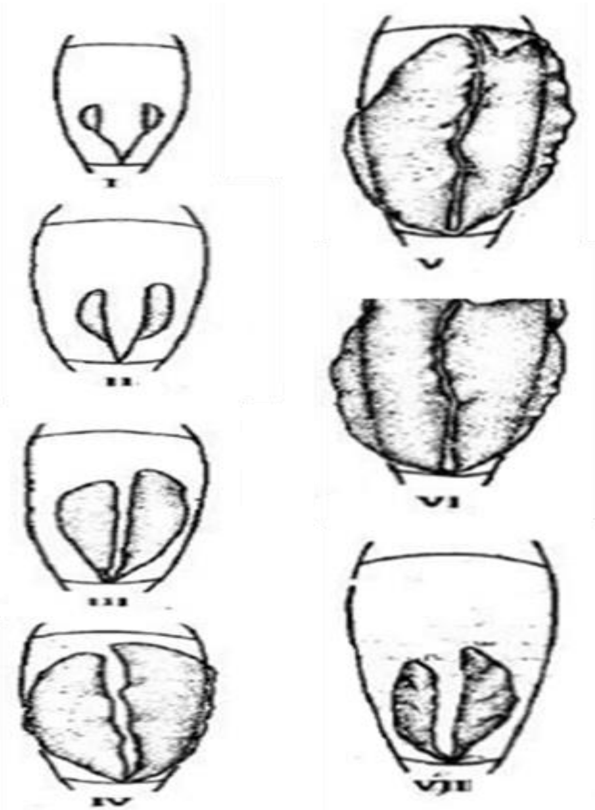


Fig.6.1: Maturation stages of fish

slight pressure, whitish milt oozes out of male while the female develops pinkish and swollen vent. IMC and Chinese carps generally mature in 2nd year onwards. If proper management (especially in the brood stock pond) practice is adopted by providing nutritious food, optimum water quality, optimum stocking density and pollution free water, very good success can be achieved in fish breeding operation. At present fish seed production is a viable and highly profitable business. In India lot of scope exists for the development of seed production. Hence, a basic knowledge of maturation of fish and the factors affecting maturation will help the farmer to develop better understanding in fish breeding operation.

Table.6.1: Maturation stages of fish

Stage of Maturation	Female	Male
I Immature	Transparent, long and narrow strip	Thread like and transparent
II Immature	Thickened strip, translucent	Translucent and thread like
III Maturing	Opaque, granular and sometime grayish, occupy 1/3 of body cavity	Opaque, pinkish white, thin stripe like
IV Maturing	Dull grayish in colour; occupy about 1/3 of body cavity	Thick strips, milky, oozing whitish fluid on applying pressure on the belly
V Mature	Dull grey to greenish; occupy almost the entire body cavity; ovadistinct in shape	Thickened band like; oozing whitish fluid on applying pressure on the belly
VI Spawning	Having loose eggs in the ovarian wall; eggs oozing through genital opening on applying pressure on belly	Oozing milt freely on applying slight pressure on the belly
VII Spent	Ovary- blood- shot, pinkish brown mass but gently shrunk	Oozing milt freely on applying slight pressure on belly

GONADO – SOMATIC INDEX (GSI OR GSR)

Gonadol weight gives an easily measured quantitative record of changes in gonad condition. Thus the gonado somatic ratio (GSR) or index (GSI) is an indirect method for estimation of spawning season and maturity stage of a species. The seasonal change in good weight is more in female than in males. The reason being the discharged weight of sexual products in much more in the farmer. The GSR as proposed by Nikolsky (1963) has to be calculated month-wise and sex-wise for a minimum period of one year.For estimation of gonado-somalic ratio samples are to be processed fresh specimens are weighted whole to the nearest 0.5g and gonad are then weighted separately to the nearest 0.1 mg. the ratios are calculated as follows:

$$GSI = \frac{Weight\ of\ Gonads}{Total\ Weight\ of\ Fish} x100$$

The GSR values ofabout 20 for female and 10 for male are considered good for carps.

SEX RATIO

Sex ratio may be defined as the number of male and females in a group of fish population for calculating sex ratio the no of males and females are separately calculated or counted.

$$Sex\ Ratio = \frac{Female\ (Nos.)}{Male\ (Nos.)} x100$$

$$Ratio\ of\ female\ in\ Population = \frac{No.of\ Females}{Total\ No.of\ Fish} x100$$

$$Ratio\ of\ Male\ in\ Population = \frac{No.of\ Male}{Total\ No.of\ Fish} x100$$

In a group of fish or fish population, the number of females fish are generally high than male fish.For breeding purposes male and female are used in a ratio of 2:1 i.e. two male and one female by number and in a ratio of 1:1 by weight.

FECUNDITY

Fecundity expresses the capacity of fish in term of egg production per year. It (individual or absolute fecundity) is defined as the number of eggs in the ovaries of an individual that are ripening for the coming spawning period. Fecundity is also expressed as the number of eggs per unit length or weight of fish (relative fecundity)

Eggs

Fertilized ova with sperm are known as egg. The eggs soon after fertilization start swelling-up. Within 45 minutes the blastodisc is formed and rapid division starts. On the other hand, fertilized egg maintain regular shape, remain transparent and the development of the embryo proceeds properly.

Condition of Eggs: Healthy and fertilized eggs attain the average diameter of egg for the species, look transparent, while dead eggs or unfertilized eggs appear opaque, smaller in diameter and irregular in shape.

Larval Stages of Finfishes

The different developmental stages of carps are as follows:

Eggs: Unfertilized IMC and exotic carp eggs are 1.25 - 1.5 mm in diameter. Fertilized eggs are 3.5 - 5.0 mm in

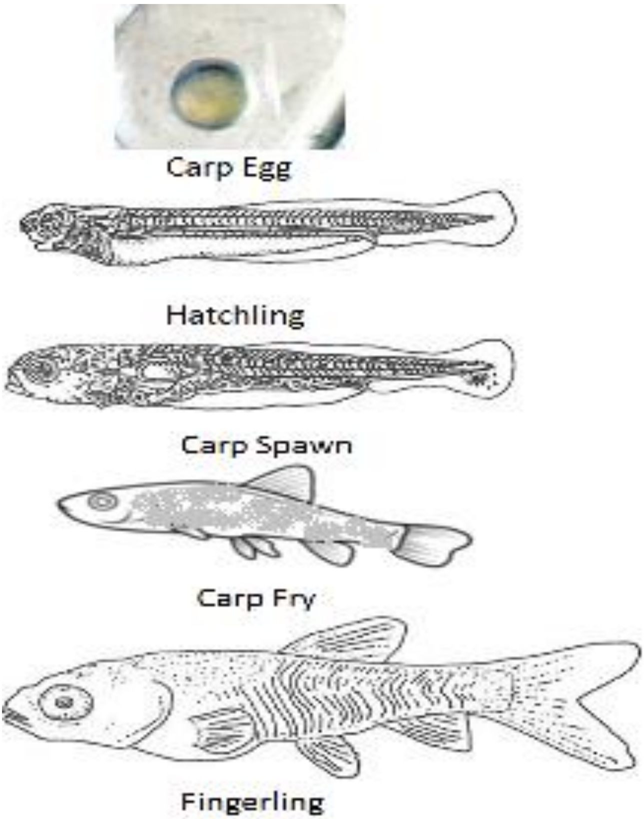


Fig.6.2: Carp larval stages

diameter, and the yolk is separated from the membrane by water that is absorbed

Hatchlings: Post-larvae

/Hatchling hatch from the eggs at 5.0 - 5.5 mm in length. At this stage, they are transparent and completely without pigment. Within three days, they grow to 7 - 8 mm and develop useable gills. At this stage, the eyes become pigmented. During this time, post-larvae also begin to swim. Although post-larvae still are feeding mainly from the yolk sac.

Spawn: By day 4, the larvae are 7.5 - 8.0 mm with a functional swim bladder and gills. The larvae become more motile and more pigmented every day. The larvae are highly pigmented and start to feed from the environment on algae and zooplankton, and by day 5 feed almost exclusively on zooplankton.

Fry: Fry are 1.5 - 2.3 cm with well-developed fins and scales .The swim bladder and the intestine resemble those of an adult. Fry feed on zooplankton and aquatic insect larvae.

Fingerlings: Fingerlings are 4-10 cm in length and resemble small adults. By day 50, the scales are complete, and at approximately day 60 and 7.0 cm in length, the fingerling is identical to an adult.

Yearling: A stage at age group 1 i.e. in the second year of life.

INDIAN MAJOR CARPS BREEDING

The Indian major carps viz. Catla, Rohu and Mrigal generally breed in riverine conditions. Though they show gonadal maturation upto a point in captivity in ponds, yet the final phase of maturation and ovulation do not normally take place in pond ecosystem. However, they breed in bundh type of tanks. The country thus had been primarily depending on riverine carp seed resources till the CICFRI evolved a technique of Induced breeding through hypophysation for IMC in 1957 (on 10.07.1957).

In the traditional system of carp seed production, survival rate of carp fry in nursery ponds hardly emceed 5% while fingerling rearing does not exist at all. Since production of fry and fingerlings are crucial inputs in modern farming, the ICAR Institute conducted experiments extended over a number of years that finally resulted in the standardized technology with high survival rates of fry and fingerlings.

Reproductive Biology of IMC's

Sexuality:All the major carps species are bisexual (hetro-sexual) and sex can be distinguished only during the breeding season. The identifying features between sexes are related to the length and texture of pectoral fin, condition of genital aperture and size of the belly.

a) **Pectoral Fin**: The pectoral fin of male has rough dorsal surface and the same is longer than that of female. In female dorsal side of pectoral fin is smooth.
b) **Genital Aperture**: In female it is radish and swollen whereas in male the same is not prominent. Further on applying gentle pressure, milt oozes out through the genial aperture in male, but in female eggs ooze out.
c) **Shape of the Belly**: Belly of the female is soft swollen and bulging which is not found is male.

Age and Size at First Sexual Maturity: Age and size at first sexual maturity of a given species may vary depending on the temperature and other environmental factors. Generally, all the 3 major carps attain sexual maturity in the second year and the males mature earlier than female. The females grow faster than male and hence usually, the males are smaller than female in a given population of the same age group. Hence carps of 2+ years and upto 5 years are preferred for breeding. After 5 years fecundity sets in and hence is not advised to use for breeding.

Spawning Season: All the 3 major carps are seasonal riverine spawners, spawning during the southwest monsoon months (June to August). They spawn in inundated shallow areas adjacent to the river during floods. They do not breed usually in the first flood but breeding during middle and later parts of monsoon. They do not spawn in confined waters.

Fecundity: Fecundity in Catla has been reported to vary from 1.66 to 2.03 lacs per kg body weight, in rohu it is reported to vary from 3.45 to 3.82 lacs per kg body weight and in mrigal it is in range of 1.39 to 1.87 lacs per kg body wt. Thus out of 3 carps, rohu has greater fecundity than the other two carps. The size of the water hardened eggs also varies in three carps – largest size being in mrigal (20,000 Nos/ lit of water) and smallest being that of rohu (30,000 Nos/lit of water). In catla 25000 eggs are usually found in one liter of water hardened egg.

Artificial Breeding or Induced Breeding

The successful development of the technique of induced breeding through hypophysation, evolved at CICFRI ensures breeding of both Indian and Chinese major carps in captivity. The technique involves injection of fish pituitary gland extract to sexually mature fish of prime condition under favourable water and climatic conditions during monsoon season. The conducive water temperature range is 22 to 32°C with cool and drizzling weather. Rain water is helpful is spawning and also ensures high rate of fertilization. Water temperature between 27-31°C results in better hatching. Various steps involved in the artificial propagation/ Induced breeding technique are outlined below:

- Maintenance of Brood Stock
- Hypophysation
- Egg Incubation

Brood Stock Raising & Rearing: It is a very important aspect of induced breeding operation. Care taken in raising a brood stock help in the recruitment of healthy brood fish that prevents inbreeding depression and genetic drift in the offspring. For this purpose healthy yearlings of desired spp. are collected from natural grounds or from farm reared stock from different hatcheries. This prevents breeding between offspring of the same parents. Care is also taken to avoid the collection of fingerlings from waste water, industrial effluent, and sewage culture system. The size of pond for brood fish raising range from 0.2 to 0.5 ha with a depth of 1.5 meter. Stocking can be 1500-2000 kg/ha to avoid crowding. The pond is kept free from aquatic weeds, predatory and weed fishes. After removal of aquatic weeds, liming (@ 250 ppm), manure @ 5000 kg/ha/yr. and feeding at 2-3% of body weight is done.

In order to develop potential brood stock for hatchery use usually carps that is of 2 to 3 years. Overage fishes (above 5 yr^{-1}) are not advisable to recruit. Usually fish that have bred at least once in the earlier year have been proved better for breeding. Prospective spawners are selected and reared at least for 5-6 months before the breeding season. The stocking pattern is as professional brood stock 60% and the rest four spp. 10% each. For example if Catla in the main brood stock it will be catla 60%, rohu 10%, Mrigal 10%, Silver carp 10% and grass carp 10%. The fishes are feed an artificial diet containing 30% protein.

Induction of Spawning: The technique of breeding by administration of PG extracts is called Hypophysation technique. The different steps in the hypophysation technique are as follows:

- Collection of Pituitary Gland
- Preparation of PG extract (Injection material)
- Selection of mature fish for breeding
- Dosage of Injection
- Injection to brood fish
- Spawning and Hatching

Collection of Fish Pituitary Gland: The hormone exercising a decisive control over maturation of gonads and breeding in fishes is secreted by the PG. In fish, the PG is situated ventrally to the brain immediately behind the optic chiasma in a concavity on the floor of the cranium. PG is collected from fresh as well as properly preserved fishes of 2 kg of both the sexes of same (homoplastic) or allied species (Heteroplastic). Glands from induced bred fish, soon after spawning are also potent. Since mature specimens of common carp are available during most part of the year in farm ponds, they also serve as good source of gland.

The glands are conveniently collected during the pre-monsoon April-June. The glands are preserved in absolute alcohol and preferably kept in refrigeration. The collection methods are as follows.

a) Using a sharp butcher's knife a portion of the scalp is removed and the brain is exposed. The entire brain is lifted with a pair of forceps. The PG is then seen covered by a membrane which is also removed by forceps. The gland is then taken out very carefully avoiding rupture.

b) In fish markets where several heads of fish are usually separately sold, PG can be collected by adopting a simple technique. The posterior part of the brain case is cut by using a bone cutter and a bigger opening is made in the region of the foremen magnum they reposing the posterior region of the brain. Through the opening thus made, the gland can be recovered.

Fig.6.3: Showing position of PG

Preparation of Injection Material: The required quantity of the gland is taken out; the excess alcohol is allowed to evaporate in about a minute and weighed. The glands are then macerated in a tissue homogenizer with small quantity of distilled water or 0.3% saline solution and further diluted by the same liquid to a desired volume. The extract is thereafter centrifuged and only the supernatant solution is utilized for injection.

The extract can also be prepared in bulk, preserved in glycerin (1 part of extract: 2 parts of glycerin) and kept in refrigerator or ICE for later use. It can even be ampoule and transplanted to other places.

Synthetic Compounds Used For IB

Though hypophysation techniques have revolutionized the aquaculture practices, ever since its adoption on commercial scale, aquaculturists faced several problems in course of time:

- Good quality pituitary gland is not available in sufficient quality in time.
- The procedures of preparation of crude pituitary gland extract and administration to fish in field conditions is not farmer friendly.

- Crude PG being a mixture of hormones may have adverse side effects on gametogenesis and other functions.
- The PG extract is variable in potency and has short storage life.

Crude PG extract has less percentage of successful spawning, less no of eggs and less fertilization and hatching rate.

In view of the above, use of pituitary has been replaced in the recent past with synthetic hormones which contain LHRH-a and domperidone, a dopamine inhibitor.

Synthetic Compounds: Synthetic compounds used for IB of fishes under captive conditions are:

- Gonadotropins
- Gonadotropins releasing hormones (GnRH) & Lutenizing releasing hormone (LHRH) & their analogues (GnRH-A or LHRH-A)
- Steroids
- Other drugs

Gonadotropins: Gonadotropins are hormones secreted by the gonadotrops of PG. Two gonadotrops such as FSM (Follicle Stimulating Hormone) and LH (Luteinizing Hormone) are reported in higher animals. However, in fishes only one hormone is reported which performing function of both FSM and LH.

Partially purified or purified form of gonadotrops has been prepared from the PG of teleosts. But these have been produced in limited quantities and hence were used only on an experimental scale.

Gonadotropin Releasing Hormone: Gonadotropin releasing hormone (GnRH) and LHRH was first isolated from porcine hypothalamus. It has been shown to be a decapeptide P glu-His-Tryp-Ser-Tyr-Gly-Len-Arg-Pro-Gly-NH_2. This neuro hormone secreted by the GnRH/LRF neurons of hypophysiotropic area of hypothalamus is regulating the secretion of gonadotropins from the PG.Out of the nine numbers of GnRH molecules synthesized so far, 4 are from fish.

GnRH Analogs: Scientists were successful in synthesizing analogs of GnRH substituting amino acid at position 6, 7, or10. If glycine at position 6 is replaced by D-Alanine the molecule becomes 4 fold more potent. Comparative advantages of analogs are:

- It has longer stability
- It is effective in various spp
- The time from injection to spawning is predictable
- Less stress on brood fish

A few GnRH analogs available in market are as follows:

Ovaprim:It is a synthetic compound manufactured by Syndel Laboratories, Canada and marketed by Agri. Vet. Farma of Glaxo India Ltd., Mumbai. It consists of Salman Gonadotropin releasing hormone analoge and domperidone which is known dopamine antagonist. Recommended single dose of Ovaprim is 0.2-0.5 ml per kg body weight of fish. Ovaprim has been shown to be highly successful and advantageous when compared to PG. It results in higher % of spawning success, high number of eggs, high % of fertilization and hatching. It's mode of action is shown in Fig. 6.3.

Ovatide:It is a synthetic compound launched by Hemmopharma Mumbai. It is also a combination of GnRH analogue with dopamine. Recommended dose of ovatide for major carps are 0.2 to 0.5 Catla, 0.1 to 0.4 Rohu and 0.1 to 0.4 ml for mrigal. Its mode of action is shown is Fig6.3.

Ovapel:It is developed in Hungary. It is combination of mammalian GnRH analog and water soluble dopamine. It is prepared in pellet form, each pellet contains 18-20 mg of mGnRH-A and 8-10 mg metaclopramide Recommended dose is 1-2 pellet / kg of fish. Pellet can be dissolved in water and injection.

Steroid Hormones

Both corticoid steroids such as 11-deoxycortico sterone acetate (DOCA) and progestins such as 17a-hydroxy-20b0dihydro progesterone have been used by same workers to induce the fish for spawning. It was found that these compounds induce final maturation. However, ovulation occurs only when the endogenous gonadotropin concentration is sufficient or when a minimum dose of gonadotropin is supplied exogenously. At present neither corticosteroids nor progestins are utilized commercially for inducing spawning in fish.

Selection of Mature Fish forBreeding: At the advent of monsoon brood fishes of 2 kg and above are netted out and selected for induced breeding. A male is easily distinguished by roughness on the dorsal surface of the pectoral fish. When it is ripe milt oozes out freely on gentle pressing at the belly near the vent. The females possess soft, round, bulging belly and swollen, pinkish genital opening.

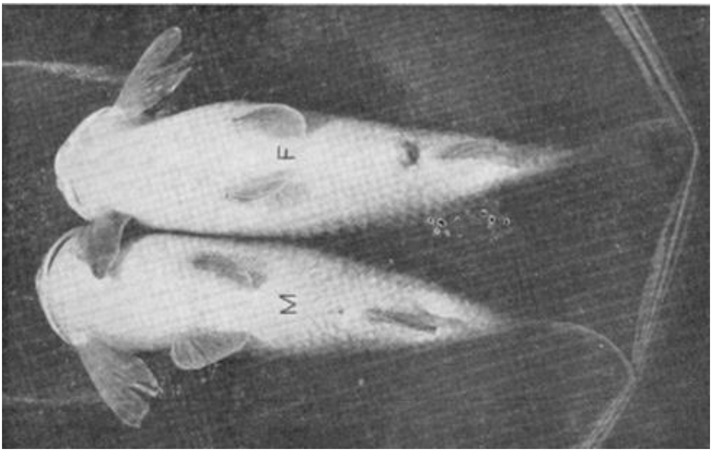


Fig.6.4:1Mature male (M) and female (F) of IMC

While the IMC's are easy to select with the help of the above symptoms alone, a catheter may be useful in confirming the stage of maturity of female carps. Inserting the catheter through the genital opening some of oocytes are taken out and examined by keeping them in a Petridis. Eggs of uniform size and acentric position of nucleus shows proper maturity. Females with such eggs are selected for IB, individually weighed and kept in hapa.

Dosage of Injection:The dosage of injection is calculated in term of milligram of PG per kg of body weight of the recipient fish. IMC females are given two injections at an interval of 6 hrs. Depending on the maturity of fish and climatic conditions etc., the two split up doses vary from 2-4 mg per kg body wt. for first and 5-10 mg per kg body weight at the time of second injection to female. The males receive only one injection of 3-4 mg per kg body wt. at the time of second injection to female.

Injection to Brood Fish: Usually a breeding set consists of one female and two makes, the combined weight of males being equal to that of the female. Keeping the spawner inside the hand net and placing it on a soft cushion, intramuscular injection is given in the caudal peduncle region, avoiding the lateral line. The volume of gland extract normally injected in one dose varies from 0.5 – 2.0 ml/fish depending on the size of the spawner. The first injection to female is preferably administered in the late afternoon hours and second after 4-6 hrs after first injection. Whereas, the male fish is given only one injection at the time of second injection to female. The injected fish set are then released in breeding hapa or breeding pools. A feeble flow of water current is preferable.

Fig.6.5: Intramuscular injection to fish

LINPE METHOD OF INDUCED BREEDING/ **Synthetic Hormone**

Injecting a fish with GnRHa and dopamine antagonist (in combination or GnRH alone followed by dopamine) has been called the Linpe method. This technique was developed by Canadian and Chinese researchers "Lin, Hao-Ren; Peter, R.E. in 1988".and the name of this technique is given after their names. Most of the work resulting in the Linpe method was done on cyprinids, and there is convincing evidence for these fish that the method is effective where injection of GnRH alone is not. Linpe method — induces ovulation in female fish by injecting them with a combination of a synthetic gonadotropin-releasing hormone analogue (LHRN-

A) and the drug domperidone. The hormone stimulates the sex organs of the fish, while the drug inhibits the action of dopamine, a substance produced by the fish that inhibits ovulation.

With traditional fish spawning methods, carp, for example, are raised and killed to produce a pituitary extract used to induce spawning. Many fish are sacrificed in the process and the extract has a poor shelf life. The technique also requires that fish are injected at two separate intervals to induce ovulation. The new method reduces the cost of production, increases the supply of seed fish, and is more convenient. Rates of spawning, fertilization, hatching, and survival were significantly higher in research trials than could be achieved with pituitary injections. The hormone and drug can be introduced together, which means that brood fish stocks are handled only once, reducing the risk of disease or damage to the fish. This method does not alter the reproductive cycle of the fish, and the fertility and viability of offspring are normal. The solution does not require refrigeration and has a long shelf life. It has been tested on a wide range of fresh, salt, and brackish water species, including carp, bream, salmon, catfish, loach, and others.

Linpe method (domperidone/sGnRH-A) of induced spawning of cultured freshwater fish are used in many countries, for leading to commercialization of the method; to determine the effectiveness of sGnRH-A and domperidone in induced ovulation and spawning of marine teleosts; to determine the effects of aging on reproductive function of key species in the Chinese freshwater polyculture system; to determine means of increasing growth rates of cultured fish and; to continue the training of young Chinese scientists in relevant disciplines.

Doses of GnRH and Domperidone

Although there will never be a standard method for spawning all species, culturists working with a single species can standardize methods by systematically eliminating sources of variability and using the lowest effective dose. Effective doses of GnRHa and domperidone vary widely and are not comparable because of differences in species, temperature, state of maturity, and GnRHa.

Following Linpe method, a number of synthetic hormones (i.e. Ovaprim, Ovatide, Gonopro-FH, *etc.*) have been developed, which revolutionized the process of induced breeding of Indian major carps and Chinese carps. It can be used in a single dose of 0.2-0.5 ml/kg body weight in case of female fish and 0.1-0.3 ml/kg body weight for male fish. Other procedures such as selection of brood fish, injection techniques, spawning and hatching remain same as for hypophysation

Spawning and Hatching:Spawning takes place generally inside the breeding pool usually within 4-6 has after final/second injection. Ovulated eggs swell up in water. Fertilized eggs are transparent while unfertilized ones appear opaque and whitish. Eggs are usually collected from breeding tank after 4-6 hrs of spawning with a mug of known capacity and kept for hatching in incubation devices.

Incubation of Eggs

In a commercial hatchery, facilities are built-up for incubating the fertilized eggs so that requirement of developing fish eggs are fully met under controlled condition. The requirement for developing fish eggs are:

- Optimum temperature
- Constant water flow
- Disturbance free environment
- Clean, plankton & pollutant free water
- Prophylaetic measures
- Maintenance of optimum water quality

Optimum temperature: for carps, optimum temperature is 25°C and incubation period is 14-24 hrs.

Constant flow of water: The metabolic wastes from the developing embryo such as ammonia and carbon dioxide are liberate into the water and the accumulation of same is highly toxic to developing embryo. Hence in a carp hatchery provision for maintaining constant flow of water is ensured so that developing eggs are not exposed to lethal dose of metabolic toxicants.

Disturbance free environment: The fishes exhibit better courtship behavior in the absence of human interference and hence a stress free environment is essential for better spawning efficiency.

Clean, Plankton & Pollution free water: As running water from rivers or canals or reservoirs is utilized generally for hatchery, it is necessary that the water should be made free of silt and plankton. The water may be allowed to stand for 24 hrs to allow the setting of silt & debris and then can be passed through fitters before use in the incubator and hatchery unit.

Prophylactic measures: *Saprolegnia* is a common fungus that affects the eggs. This affects the dead eggs first and later causes heavy mortality of the developing eggs. Hence, as a prophylactic measure eggs are dipped in 0.1 – 0.2 ppm malachite green. In case of diseases occurrence, eggs are to be treated in 5ppm malachite green by dip treatment. Growth of bacteria may be due to use of water which is dirty and containing heavy organic load. Plankton like Cyclops hurt eggs shell. Chironomid bite the eggs and damage.

Maintenance of Optimum water quality: Optimum water quality as Turbidity- 20 cm, pH-7.0-7.5, Total alkalinity- 40-60 ppm, P_2O-5 0.01 ppm, NH_4 N- 0.02 ppm, No_3-N- 0.01 ppm, Iron- 0.4 ppm and Manganese -0.1 ppm (All maximum limits) are to be maintained for the spawning & incubation pools. If total alkalinity is above 100 ppm, it is harmful. In such cases water has to be treated with alum to reduce alkalinity. To generalize 1 ppm alum reduce 1ppm alkalinity.

Incubation Devises

Hatching Hapas: Two enclosures or hapas are used, one inside the other (outer & inner hapa) for incubation. The hapa are made of nylon net the outer hapa has a mesh size of 0.5 mm and inner hapa has mesh size of 2-2.5 mm. The hapa are fixed in the pond by means of bamboo poles. The eggs after prophylactic treatment are placed at the bottom of inner

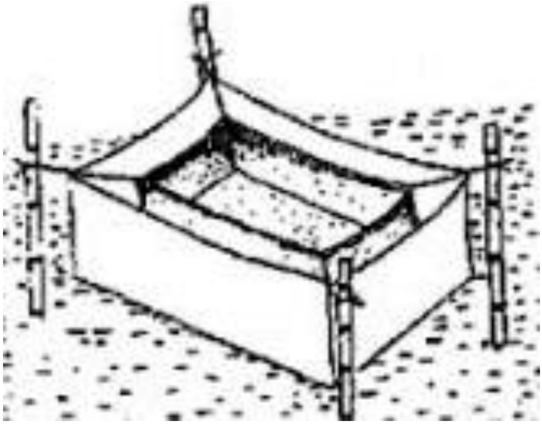


Fig.6.6: Showing hatching hapa

hapa. After hatching, the hatchings move out of the inner hapa and are collected in the outer hapa. The egg shells are left in the inner hapa which are removed along with the inner hapa after the hatching is completed.

Funnel Type Incubators: Funnel type incubator was first time used in Switzerland. It was originally made of glass each having 6 to 16 liters capacity. At present such jars are made up of fibre glass of 40-80 liters capacity and of even 200 liters capacity. If jars of metal are used, it is to be coated with neutral paint. The broad end of the funnel may be closed with rubber head or plastic head and the same is provided with an outlet. The eggs are placed in the funnel after the water is let in through the inlet to funnel connected below. The upward moving water causes the egg to move and roll and in this process the eggs get sufficient oxygen and in turn the CO_2 diffuses out. The metabolic wastes and carbon dioxide are removed along with outlet water in the constant flowing systems. A few important examples of funnel type incubators are:

(i) Glass jar incubator : Egg holding capacity 2-5 thousand
(ii) D-82 type incubator : Egg holding capacity 2-4 lacs
(iii) D-85 type incubator : Egg holding capacity 8-12 lacs

Fig.6.8: D-85 type hatchery

Incubation Pool (Hatching Pool) of Chinese Circular Hatchery: The hatching pool or incubation pool is circular in shape having two chambers, outer chamber and inner chamber. The outer chamber may be of 3 m to 6 m diameter and the inner chamber of 0.8 – 1.5 m and depth of 1 to 1.5 m. the diameter of chambers may also be 3.4 m & 0.8 to 1.5 m for outer and inner chamber respectively. The circular wall separating the outer chamber from the inner chamber is provided with windows which are fitted with fine meshed net (mesh size 1/60" or 1/80"). The water inlet pipe is fixed at the bottom of the outer chamber. These are "duck month" inlets and are placed at an angle so that inlet water moves in a circle in the outer chamber. The vertically erected pipe at the centre maintains the water move in a circle in the outer chamber.

Fig.6.7: Glass jar hatchery

The vertically erected pipe at the centre maintains the water depth in the incubator chamber at the desired level. The eggs are collected from the egg collection chamber and released into the outer chamber of hatching pool after prophylactic treatments. As a constant flow of water is maintained in the pool, eggs released in to the outer chamber gets sufficient oxygen as they are drifted along with water current in a circular motion. Duck month inlets are arranged in a row, 6-12 nos, equidistant from each other and from both inner and outer walls of the chamber. This causes a unidirectional water flow during operation which results in movement of eggs without touching the screen or walls of the chamber. The pool can hold about 7 lacs egg per m^3.The speed of the water flow is maintained at 0.4 to 0.5 m

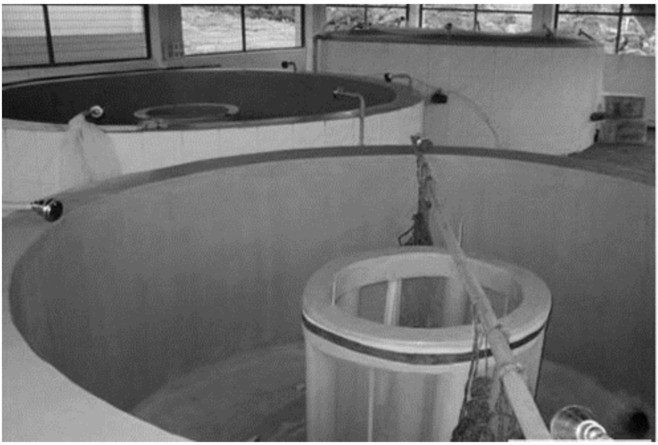


Fig.6.9: Circular carp hatchery incubation pool

per second in first 12 hrs and at 0.1 to 0.2 m per second in the next 6 hrs, which is then increased to 0.3 to 0.4 m per second. Good water circulation inside the pool is very important for the success of the hatching pool. If the circulation is not proper egg settle at the bottom which results in decomposition. This causes growth of pathogenic organisms and saprophytes which is turn cause mortality of developing eggs. Following are the points to be considered while operating egg incubator unit:

- A wooden or bamboo stick of 2 cm diameter is kept in between out wall and screen in outer chamber. This help in accumulating the foam, debris and insects efficiently from surface of incubator water.
- A perforated wooden plank of 4-5 cm^3 width is fixed to surface half submerged. It helps in cleaning the subsurface debris of water.
- 5 to 6 pieces of coir rope with smooth bristles are tied to a stick of 2 cm dia. Column debris containing dead spawn and egg shall stock to rope. Remove coir rope periodically and wash with $KMNO_4$.
- From 2^{nd} day of operation dead spawn, eggshell, etc are siphoned out by means of 2 cm stiff polythene pipe from bottom.
- Inner surface of screen is cleaned using a brush from the inner chamber.

Cause of Egg and Spawn Mortality

Large scale mortality may take place at any stage from spawning to the fry stage. A few causes of mortality of eggs and hatchlings are as below:

- Pollution of water from temperature to above 32°C.
- Pollution of water from an unexpected source such as washing of petrol or containers containing poisonous chemicals.
- Heavy algal bloom: In water with heavy algal bloom oxygen bubbles are generated due to photosynthesis. These bubble stick to the eggs which are buoyed up to surface and they start disintegrating. Due to high surface temp, the embryos get bent and ultimately die.
- Mortality due to oxygen, deficiency & supersaturation.

- Loss of eggs and hatchlings due to attack by copepods.
- Egg mortality due to sudden change in water quality.
- The metabolic wastes from the developing embryo such as ammonia and CO_2 are liberate into the water, the same is highly toxic and cause heavy mortality of eggs and developing embryo.
- Improper flow of water sometimes causes heavy damage to eggs.
- Excess dose of PG (hormones) is also responsible for egg and hatching mortality.
- Genetic components and state of ripeness of the eggs may be an important factor causing spawn and egg mortality.
- Saprolegnia is a common fungus that effects eggs.
- Growth of bacteria due to dirty & organically loaded water may also cause heavy mortality of egg and hatchlings.

Eggs Treatment: Before replacing eggs in hatching hapa or incubator/ hatching pool, status of water should be examined carefully, there should not be any organic pollutant as well inorganic polluter. The water used for incubator should be completely free from planktonic organisms especially copepods.

After ensuring the good water quality the eggs should be replaced in hatching system. Before it, the eggs are given dip treatment with malachite green @ 0.1 to 0.2%.

Bundh Breeding

The Indian carps though mature in ponds fail to reproduce there. This is because some of the important factors which are responsible for spawning are not found in ponds. Carps breed in running water in rivers during floods. Some of the important factors reported to influence spawning of carps are: - Dissolved oxygen, flow of water, light, turbidity and temperature. Flooded rivers during the monsoons provide the necessary stimulus to the carps to breed. In bundh almost all the natural riverine conditions develop during rainy season which ultimately provide good breeding conditions for carps.

What is a Bundh? Bundhs are nothing but specialized type of ponds where riverine conditions are stimulated. They are constructed in the middle of a vast low laying area, with proper embankments and receive large quantities of rain water after heavy shower. Bundhs are provided with an outlet for the overflow of excess water and shallow areas which serve as spawning grounds for the fish. Bundhs are generally of two types.

- Perennial Bundh also called "Wet Bundh"
- Seasonal Bundh also called "Dry Bundh"

What is a Wet Bundh? Perennial tanks or minor irrigation reservoirs where breeding takes place are called wet bundhs(Fig.6.10). The bundhs are filled with run-off water

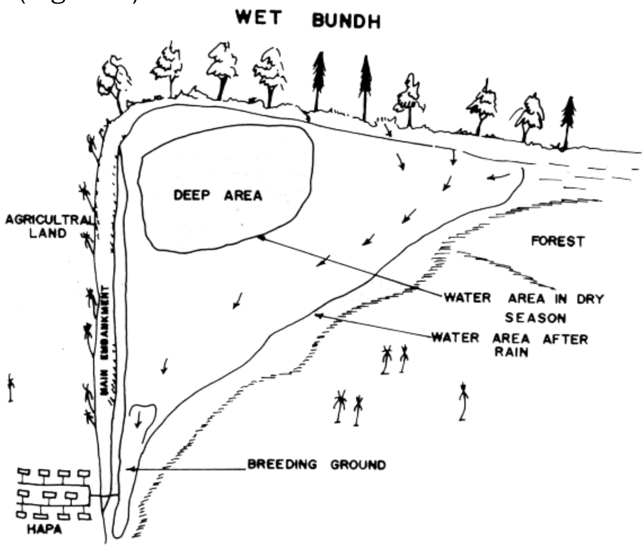


Fig.6.10: Wet bundh

from extensive catchment areas during monsoon rain and create large shallow marginal area which serves as spawning grounds for the fish present in the bundh.

Features of a Wet Bundh

The main features of a wet bundh are as follows:

- Lateritic or sandy soil allowing fast runoff of the rain water.
- Sloping depression in an undulating terrain.
- Embankment to hold water throughout the year
- Extensive catchment area to fill the bundh.

- ➢ Overflow weir
- ➢ In summer generally a great part of these bundhs dries up while the central part always contains water.

What is a Dry Bundh? A dry bundh is a seasonal shallow pond(Fig.6.11) enclosed by an earthen wall (embankment) on three sides.

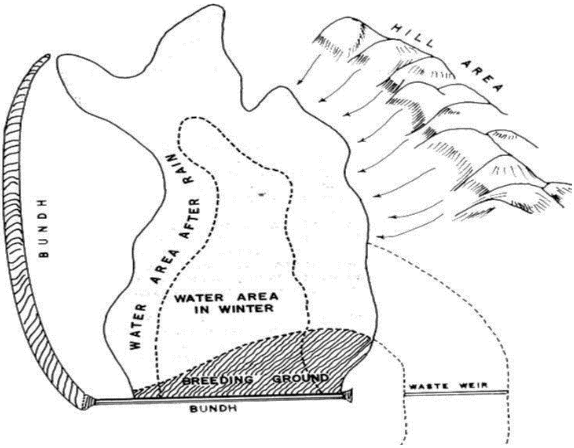


Fig.6-11: Dry Bundh

Features of a dry bundh

The basic features of a dry bundh are the following.

- Shallow sloping depression in an undulating terrain.
- Lateritic or sandy soil allowing fast running of rain water
- Large run-off area from catchment, having forest or uncultivated fields.
- Embankment to hold water of the first and subsequent rains.
- Shallow adjoining flooded breeding area
- An overflow screened weir.

Bundh Breeding Operation/Technique

Mature brooders are collected from perennial ponds before the onset of monsoon or during first showers and are kept separately sex-wise in ponds preferably on a rainy day. Sufficient quantity of freshwater in bundhs is allowed to accumulate before the brooders are released. A ratio of one female to two males is followed preferably on a rainy day.

The stocking density of brooder varies from 3000-3500 kg/ha.

It wet bundhs the brooder stock may be maintained throughout the year or replenished prior to monsoon. The brooders stimulate to spawn due to water current entering from catchment area.

Spawning in both types of bundhs occurs after continuous heavy showers, when large quantity of rain water rushes into the bundh. As soon as water accumulates in bundhs, a selected number of brooder are released spawning may occur at night.

Mrigal and rohu start breeding in the morning, while catla spawns from about noon to evening. Mrigala and rohu spawn in marginal shallow areas, while catla remain confined to relatively deeper water due to their deep body. Eggs are laid at intervals during which the pair keeps moving. After spawning the spent fish move to the deeper water.

Although Indian carps breed in bundhs, there is no information regarding breeding of Chinese carps in bundhs. It is believed that the Chinese carps which have more or less similar breeding habits as IMC can also be bred in bundhs.

Factors Affecting Carp Breeding in Bundhs

Several factors are reported to be responsible for spawning of major carps in bundhs. Generally, spawning is stimulated by heavy monsoons that flood the shallow spawning areas. It is appears that availability of shallow spawning grounds inundated with fresh rain water is an important factor in stimulating the breeders. The favorable temperature of water for spawning has been found to vary from 24-32°C, under various environmental conditions. Generally cloudy day followed by thunderstorm and rain are regarded to influence spawning. Other factors like pH, alkalinity, high oxygen content *etc.* may be of secondary importance and are associated with floods.

Collection and Hatching of Eggs

After lowering the water level, eggs are collected by dragging a piece of mosquito net cloth. Collection of all the eggs is impossible especially in wet bundhs due to its larger area. After collection of eggs, these are hatched in traditional hatching happa fixed in bundh itself or in nearly farm ponds. In west Bengal hatching of eggs is carried out in specially dug out earthen pits with mud plastered walls. However, in Rajasthan eggs are not collected, only the advanced fry or fingerlings are collected.

Problems in Bundh Breeding

The main problems encountered in bundh breeding are as follows:

- It is difficult to synchronize the collection of large quantities of eggs at a time, particularly in the case of wet bundh breeding.
- Serious problems were encountered during egg collection from wet bundh, due to entry of unwanted fishes and predatory insects.
- Although fertilization rate is high, still poor recovery is encountered. This can be improved by using modern hatcheries.
- Transportation of brooder cause great physical strain and suffer injuries. Therefore, facilities for brooder stocking ponds can be provided.

COMMON CARP BREEDING

The common carp is an exotic species, highly compatible with major carps. In contrast to major carps, it is easy to breed this species naturally in confined water. Therefore, fish seed of the common carp can be easily produced for fish culture along with major carps in ponds. It can also be stocked in small reservoirs. The culture of the common carp has become popular all over the country. It has a protracted breeding season, breeding, almost throughout the year unlike the IMC which generally breeds only during the rainy season.

Breeding Behavior & Season

The common carp breeds twice in a year, the breeding season extending from January to the middle of March and from July to August. Generally, it starts spawning during morning hours. It lays adhesive eggs. It breeds in the temperature range of 20-30°C.

Fecundity: A female weighing 1 kg gives 1.5 to 2.0 lakh eggs.

Maintenance and Selection of Brooders

Three months before breeding, the males and females are separated in two ponds (2000 kg/ha). Natural food is supplemented with artificial feed (rice bran and oil cake, 1:1 @ 2 to 3% of the body weight). The mature male shows roughness on the dossal surface of the pectoral fin and freely oozing milt when the abdomen is slightly pressed. The mature female has a bulging abdomen and a reddish vent

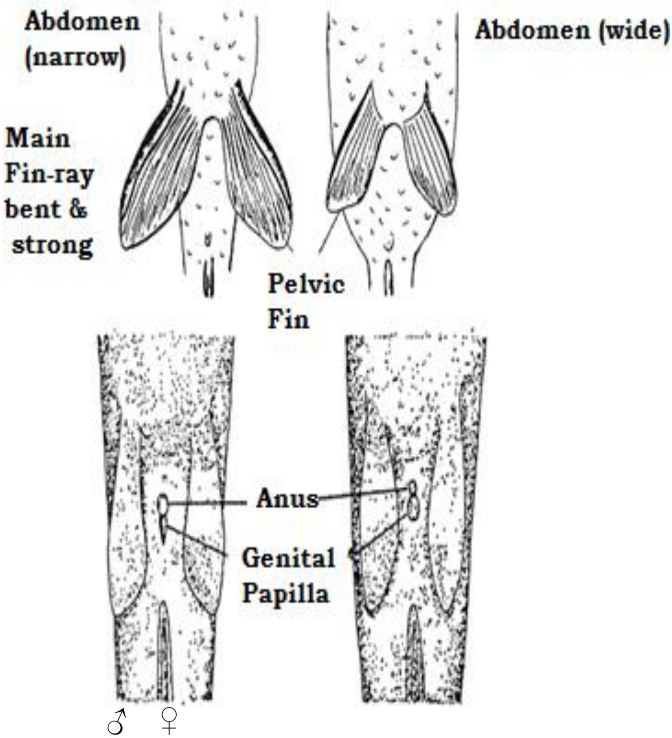


Fig.6.12: Sexual dimorphism of common carp

(Fig.6.12).

Breeding Techniques: The breeding of the common carp can be practiced in the following manner:

- By introducing the substratum in the spawning pond and releasing the breeders.
- By putting the substratum and the breeders in the breeding hapa.
- By putting the substratum and the breeders in cement cisterns.
- By collecting the substratum with eggs and transferring it to the hatching hapa.

Breeding in Ponds

- Keep male and female breeders separately for 3 months for successful spawning
- Select a small spawning pond (20 to 30 m^2 area) and dry it completely.
- Allow the water to enter the spawning pond through a screen.
- Introduce the substratum (Hydrilla, Eichhornia, etc.) after through washing.
- Maintain the depth of ½ to 1m of the water
- Introduce the breeders (1 kg / 10m square of spawning pond)
- Keep 2 males for one female.
- Observe the breeding (likely in the morning)
- Keep 2 Kakaban of 100x60 cm size and water at about ½ meter level.
- Collect the substratum with eggs after 1-2 hours and transfer to hatching hapa.

Breeding in Hapa

- Take a hapa of 2-3 m long 1-2 m broad and 1m deep
- Fix it with bamboo poles.
- Introduce fully ripe breeders (2:1 male: female).
- Introduce the substratum for attachment of eggs on the basis of the body weight of females.
    1. 1-2 kg female = 2 kg weeds
    2. 3-4 kg female = 3 kg weeds
    3. 4-5 kg female = 4 kg weeds
- Cover the hapa with a cloth.
- Observe the breeding (likely in the morning)
- Remove spent fish to stock pond.
- After complete spawning (1-2 hrs) collect substratum with eggs.
- Transfer to hatching hapa.

Breeding in Cement Cisterns

- Clean the cement cistern and fill with water upto ½m depth.
- Select healthy breeders and introduce in cistern
- Introduce substratum / Kakaban
- Maintain flow of water in cement cisterns
- Observe breeding within 6 to 12 hrs.
- Remove the spawners to stock in ponds

- Collect the substratum with eggs after 1-2 hrs of spawning and transfer to hatching hapa.

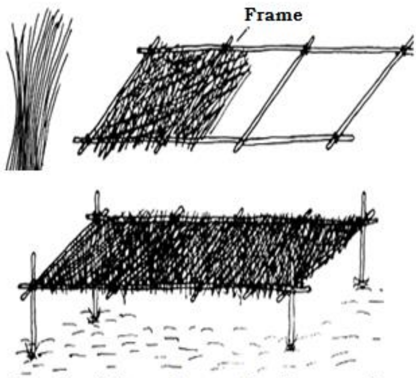
Hatching

- Take a hatching hapa of 2x1x1 m made of thin cloth.
- Fix it in the pond.
- Put fertilized eggs in hapa: do not disturb them for 3 days.
- Take out the weeds / Kakaban after compete hatching.
- Collect hatchings after 5-6 days for rearing in nursery ponds.

Precautions

- Feed selected brood fish with supplementary feed
- Sundry the pond before stocking, to get rid of aquatic vegetation and predatory insects/fish.
- Avoid entry of predatory organisms in the pond
- Wash the substratum used for the attachment of eggs.
- Don't use excess aquatic weeds for the attachment of eggs.
- Cover breeding hapa to avoid jumping of brooders
- Remove spent fish immediately after spawning.

Kakaban; A Kakaban (Fig.6.13) is square or rectangular shaped frame of bamboo. Its size varies from place to place but generally 1 x 0.6 m sized is common. The aquatic weeds like hydrilla, water hyacinth etc. are fixed in Kakaban. The fibers of coconut are also used in Kakaban. This structure is commonly used for common carp breeding. The eggs of common carp are adhesive type hence attach with the fiber or aquatic weeds. It is



Kakaban Fixed Above Bottom For Common Carp


Kakaban Fixed on Bottom of For Common Carp

most convenient to use and handle Kakaban as compare to other substratum used for eggs attachment.

MULTIPLE BREEDING OF CARPS

The availability of major carp seed only during monsoon season is a major constraint in the expansion of aquaculture. By this time scientists have successfully indeed the same fish to breed four times in a year. Thus a given brood fish can be bred four times, twice during pre-monsoon, once during monsoon and another time during late monsoon. This was achieved through careful pond management practices, selection of brood stock and scientific feeding practices.

What is Multiple Breeding? : Multiple carp breeding may be defined as to breed the some fish (Brood fish) more than one time in the same breeding season.

Selection of Brood Stock for Multiple Spacing: Breeders that have bred atleast once during previous breeding season are selected for undertaking breeding works as "Virgin" breeders is not found suitable. Such breeders are named as "PROFESSIONAL" breeders. Age of the fish should be 2 to 5 years as overaged fish do not respond well to inducing agent. They are stocked @ 1000 kg/ha and fed on a formulated diet fortified with minerals and vitamin @ 1 to 2% of body weight, 25 to 30% of the pond water is replenished at least once in a month from February to May with fresh water. Other management practices can be of routine nature. Such breeders are found to mature at least 3 monthly earlier.

Handling of breeders used in multiple spawning has to be done in such a way as to cause least stress to the animal as noted below:

- Breeders are to be transported in the canvas bags.
- Intra-peritoneal injection is preferred as it provides least injection stress when compared to intramuscular route.
- In the spawning pool, only the required flow of water should be maintained and duration of water flow also be controlled to the required time. In case of administration of PG extract, water flow may commence 4 hours after final dose and in case of ovaprium given as single dose, water

flow may start five hours after the injection. The flow of water has to be continued for 2-3 hours as within this period effective spawning is found to be over.

- As soon as the spawning is over the spent fish must be reversed from the spawning pond. There are dipped in 5 ppm potassium permanganate before releasing in pond. Further, at regular intervals they are checked and treated with said solution to avoid secondary infection or quick recovery.
- As they are used for subsequent maturity, feeding and other management practices are to be done meticulously.

Multiple Breeding

1. **Pre-monsoon Breeding**:This commences as early as March. The spawn yield is reported between 0.5 to 0.6 lacs spawn/kg body weight of fish. The spent breeders are maintained for 40-45 days and used again for induced spawning when the production of spawn was 1 to 1.5 lakh spawn per kg body weight.
2. **Monsoon Spawning**:After a lapse of 40-45 days of second spawning, a third crop can be obtained during June-July. As this is the natural spawning season of major crop the spawn yield has been seen to increase to 1.5 to 2.0 lacs spawn per kg body weight of female fish.
3. **Late Monsoon Spawning:**Though the fish breeds during August-September period, if maintained in a stress free environment and following the precautionary measure mentioned earlier, the yield of spawn will be the least (0.4 to 0.5 lacs/kg body weight). It has been also observed that the percentage of re-maturation of individuals for 2nd, 3rd and 4th breeding was 100%, 79-100% and 11-30% respectively.

Care of Larvae in Multiple Breeding: Special care is recommended for spawn produced through multiple breeding. It is found that yolk of spawn get absorbed within sixty hours after hatching but in case of traditional spawn it take 72 hours for complete absorption of yolk. So it is necessary to provide feed after sixty hours. Intermittent sprinkling of prophylactics is also recommended in spawnery to maintain hygienic condition.

Thus, through multiple breeding techniques the yield of spawn per kg body weight of brood fish is enhanced 3-4 fold than single breeding and cost of production is also reduced. This also provides seed for stocking during season other than monsoon and even for multiple cropping in the culture practices of a given water body.

CARP SEED REARING

The successful rearing of just feeding fry until they attain a size of about 25 mm is the most challenging and critical phase of fish farming. It is termed nursery management. In most hatcheries, the main bottleneck is the lack of space for nursing the fry up to 3–4 weeks of age, when the fry enter the fingerling stage. It is obvious that fry nursing is a delicate activity requiring considerable skill. The burden of nursing fry should not be left entirely to the fish farmers by supplying them with larvae or just feeding fry. Some growers can, of course, be trained to prepare their ponds to receive the tender fry. It is always best, however, that nursing fry be done by experts. Therefore, it is desirable to include nursery ponds as an integral part of the hatchery complex. Now that various factors determining the survival of fry are well known, fry rearing has become a much simpler operation than before.

Special nursery tanks. A special nursery tank is 20–40 m long and 5–6 m wide with a surface area of 100–240 m^2. On an average, 200 000–400 000 just feeding fry can be stocked in such a tank. These tanks are usually made of bricks or concrete. From past experience, it is known that one successfully propagated female fish of 4–6 kg can produce 0.5–0.7 kg of dry eggs; this could yield the required number of just feeding fry to stock a special nursery tank. If, during one week, 10 such female fish are propagated, 30–40 such nursery tanks would be needed to rear the resultant seed for up to 21–28 days.

Earthen nursery ponds. A good nursery pond should not be larger than 500–1 000 m^2 and should be rectangular in shape with a width of about 10–12 m. The bottom of the nursery pond is so shaped that for about 2.0–2.5 m from the longitudinal walls it runs flat and then gradually slopes from either side toward the middle where it forms a 2–3 m wide ditch, which is 0.5 m deeper than the flat part of the bottom. This ditch provides refuge to the fry. A nursery pond of 50 × 10 m (500 m^2) should contain about 200 m^3 of water at the time of stocking; this should be gradually increased to 300–350 m^3 as the fry grow. The stocking rate for such a nursery pond is 500 just feeding fry per m^2, or 250 000 per pound.

The number of nursery ponds required will depend on the duration of nursing activity. On an average, a brood fish that is successfully bred provides stocking material for one 500 m^2 nursery pond. At least 30 such nursery ponds will be needed if the distribution of fingerlings is to be continuous. To be on the safe side about 40 such nursery ponds are recommended for a medium size hatchery. The nursery ponds should be harvested when the fish become four to five weeks old.

Relative merits of special nursery tanks and earthen nursery ponds. The special nursery tank has the following advantages:

1. About 70 percent of the tank is shallow, the environment which is preferred by the fry to live and feed.
2. Since the shallow area is partly covered with hard bottom (about 50–60 percent), excess vegetation (grass and other plants) will not be present during the nursing period.
3. It can be easily dried, cleaned, and disinfected whenever required.
4. The fry can be easily inspected.
5. If necessary, the fry can be thinned out easily by netting the central ditch.
6. Intensive nursing is possible because of its small size.
7. Control and prophylactic treatment against parasites can be made in the tank itself.
8. Maintenance costs are low.

Perhaps the only disadvantage is the high initial cost of construction.

Earthen nursery ponds, especially if they are square and not rectangular, have several disadvantages, the more important of which are detailed below:

1. The shallow area is less, being only 40–60 percent.
2. Grass and other vegetation may become too dense, thereby impeding the development of food organisms.
3. Cleaning and disinfecting are more difficult operations, especially the prevention of silting of the deeper parts.
4. Netting operations are hampered by the dense vegetation.
5. Close observation of the fry is difficult.

Fingerling rearing-cum-production units

The objectives of the fingerling rearing-cum-production unit are to (a) rear large sized fingerlings and young fish for distribution to fish farmers, (b) raise prospective brood fish, (c) produce marketable fish, if needed.

The fingerling rearing ponds and production ponds are generally used for polyculture. The propagation activity of the hatchery and nursery does not usually extend beyond 5–6 months, while the fingerling rearing-cum-production unit functions year round. The cost of fingerling production can be minimized if the hatchery produces its own pituitary glands by raising donor fish, and if it also produces marketable fish.

The ponds of the fingerling rearing-cum-production unit are normally constructed as production ponds, with their size varying from 0.5–1.0 ha and occupying a total area of 2–3 ha.

The total land area required and the requirement of land for each unit of a medium size hatching-cum-fish seed distribution centre are shown below:

Hatchery units	Water surface required, ha	Land required, ha
Brood fish ponds	2.5–3.0	3.0–4.0
Hatchery proper and housing		0.5
Nursery ponds	1.0–2.0	1.5–3.0
Fingerling rearing	2.0–3.0	3.0–4.0
Total land required		8.0–11.0

In general, a suitable terrain of 10–15 ha is necessary to construct a medium size hatchery-cum-seed distribution centre.

Commercial Production of Carp Fry and Fingerlings

Availability of required quantity of seed of the desired species at the appropriate time is one of the prime factors that lead to success of aquaculture operation. Though remarkable success has been achieved over the years in spawning the carps, availability of seed of desired size still remains a constraint. The nursery rearing involve nurturing of 72-96 hours old spawn which have just begun to eat and continues for a period of 15-20 days, during which they grow to fry of about 25-30 mm. These fry are further reared in another pond for a period of 2-3 months to raise the fingerlings of about 100 mm in size.

Nursery Pond Management

Small water bodies of 0.02-0.10 ha with depth of 1.0-1.5 m are preferred for nurseries though areas up to 0.5 ha can be used for commercial production. Drainable or non-drainable earthen ponds and cement cisterns are the different systems used for nursery rearing of fry. The different steps involved in nursery raising of fry are discussed hereunder.

Pre –Stocking Management

Clearance of aquatic vegetation: Abundant growth of vegetation is undesirable in fish ponds as they absorb nutrients arresting the pond productivity, help in harbouring the predatory and weed fishes/insects hindering the free movement of fish and netting operations. Hence aquatic weed clearance is the first operation in pond preparation. Generally, manual methods are only used in nursery and rearing ponds, as they are shallow and small in size. In bigger ponds mechanical, chemical and biological methods can be used for eradication of aquatic weeds.

Eradication of predatory and weed fishes: Various predatory/weed fishes besides predatory animals like snakes, tortoises, frogs, birds, otters, etc present in ponds pose problems for survival of young fishes besides competing them for space and oxygen. Dewatering and drying the ponds or application of suitable pesticides are the methods adopted for eradication of predatory and weed fishes. Application of mahua oil cake @ 2,500 kg/ha-m three weeks before stocking of fish seed are suggested. The oil cake besides acting as pesticide also serves as organic manure after decomposition and adds to natural productivity. Application of commercial bleaching powder (30% chlorine) at dosage of 350 kg/ha-m of water is effective in killing the fishes. The quantity of bleaching powder can be reduced to half with the combination of urea @100 kg/ha-m, applied 18-24 hours before the bleaching powder application.

Pond fertilization: Planktons are the preferred natural fish food organisms that are produced by fertilizing the culture ponds. The ponds used for seed production are first limed after the removal of unwanted predatory and weed fishes depending on the pH of soil. After liming, the ponds are treated either with organic manures such as cow dung, poultry dropping or inorganic fertilizers or both, one following the other. Mixture of groundnut oil cake at 750 kg, cow dung 200 kg, and single super phosphate 50 kg/ha is found to be very effective in production of desired plankton. Half of the above amounts, after being mixed thoroughly by adding water to make a thick paste are spread throughout the nursery 2-3 days prior to stocking. The rest amount is applied in 2-3 split doses depending on the plankton level of the pond.

Control of aquatic insects: Aquatic insects and their larvae compete for food with the young growing fish and also cause large-scale destruction of hatchlings in nurseries. Application of soap-oil emulsion (cheap vegetable oil @ 56 kg/ha with 1/3 its weight of any cheap soap) is a simple and effective method to kill the aquatic air-breathing insects. Kerosene @100-200 l or diesel @75 l and liquid soap @ 560 ml or detergent powder @ 2-3 kg per hectare water area can be used as substitute to make the emulsion. For effective control of all air-breathing & gill breathing aquatic insects, BUTOX @ 500ml/ha is most useful.

Stocking

After three days of hatching, the spawn are transferred to the nurseries. The stocking is done preferably during morning hours by acclimatizing them to the new environment. The normal density of spawn recommended for earthen nursery is 3-5 million/ha. However, higher densities of 10-20 million/ha can be followed in cement cisterns. In nursery, monoculture of carp species is usually recommended.

Post-stocking Pond Management

The phase fertilization is done in 2-3 split doses during the culture period of 15 days as discussed earlier. Finely powdered mixture of groundnut oil cake and rice bran at 1:1 ratio by weight are provided as supplementary feed @ 6 kg/million for the first 5 days and 12 kg/million spawn per day for the subsequent days in two equal installments. With adoption of scientific methods of rearing, the fry attain the desired size of 20-25 mm with survival of 40-60% in 15 days rearing period. Since nursery-rearing period is limited to 15 days, the same nursery can be utilized for multiple cropping, at least for raising 2-3 crops in case of earthen ponds and 4-5 crops in case of cements cisterns.

Fry-Fingerlings Rearing Pond Management

Ponds of comparatively bigger in size than that of nurseries and preferably up to 0.2 ha area is used for rearing pond, i.e., for rearing fry to fingerlings. The different steps involved are as follows:

Pre-stocking Pond Preparation

The practices of pre-stocking pond preparation viz., clearance of aquatic vegetation and eradication of predatory and weed fishes are same as discussed in nursery pond management, while measures for control of insects are not necessary in case of rearing pond management. The ponds are fertilized with organic manures and inorganic fertilizers, the doses of which depend upon the fish poison used. If mahua oil cake is used as fish poison, the amount of cow dung application is reduced to only 5 tones/ha, but with other poisons having no manurial value, cow dung is applied generally at the rate of 10 tones/ha. While about one third of the dose is applied as basal dose 15 days prior of stocking, rest are applies fortnightly doses. Urea and single supper phosphate @ 200 kg and 300 kg/ha/year, respectively are also recommended for fortnight application in split doses as inorganic fertilizer source.

Stocking of Fry

Determination of the rate of stocking depends mainly on the productivity of the pond and the type of management measures to be followed. The normal stocking density of fry suggested for rearing ponds is 0.1-0.3 million/ha. While nursery phase is limited to monoculture, rearing phase involve polyculture of different carp species similar to that of grow-out production.

Post-stocking Pond Management

A feeding rate of 5-10% followed for fingerlings rearing. While in most of the cases the supplementary feed is limited to the mixture of groundnut oil cake and rice bran at 1:1 ratio by weight, non-conventional ingredients can also be used to compound the feed. When grass carp are stocked, duckweeds like Wolffia, Lemna and Spirodela are to be provided. Maintaining water levels of about 1.5 m depth and intermittent fertilization as mentioned earlier are the other management measures suggested. With adoption of scientific methods of rearing, the fingerlings attain 80-100 mm/8-10 g with a survival of 70-90% under rearing pond conditions

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.

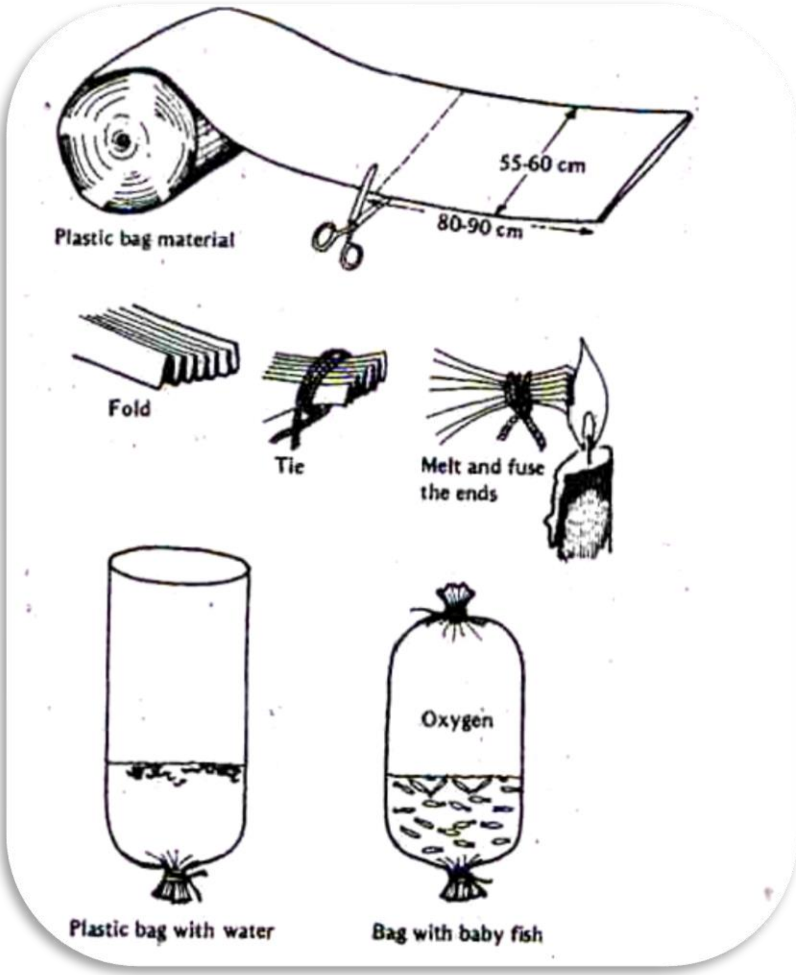
Round Tin Carriers: Round tin carriers are used for transport of fish seed from several years. The tin is made up of galvanised iron sheet. It is a round container having a diameter of 18" and height 8". The lid has a number of small holes, which are useful to get oxygen. This container has a capacity of 9 gallons of water, but is filled up only with 8 gallons of water. The seed is introduced into it and transported to various places.

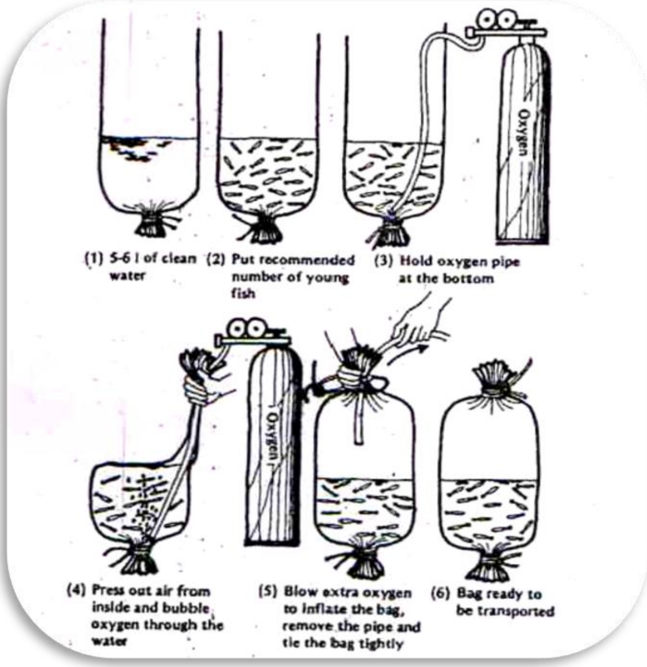
Double tin carriers:

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'' x15'' 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. 2,000 fry can allowed into the bag and the portion of the bag, about 10 cm

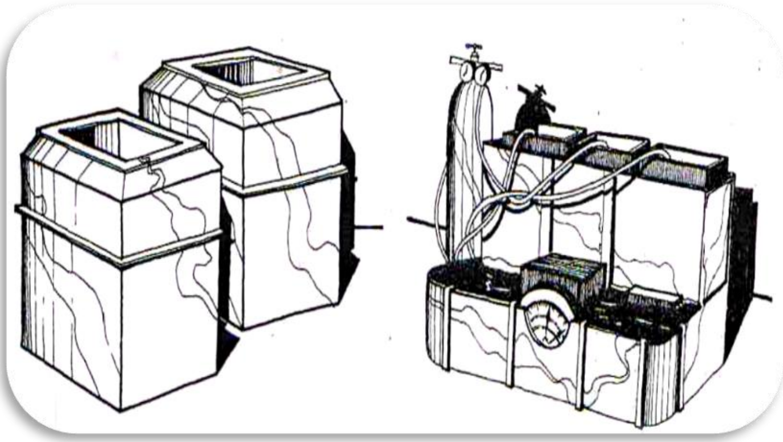
from the top is twisted and a string is kept ready for tying. The oxygen isthen drawn in from the cylinder through the tube until 2/3 of the bag is inflated or the top of the inflated bag is slightly below the top of the tin. The string is tied round and the tin is closed. The packed tins are kept in 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.
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

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 anesthetized 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 minimize the concentration of toxic gases like ammonia and carbon dioxide in the medium by lowering the metabolic rate of the fish seed. Anesthetized fish seed have been found to survive for double the time of anaesthetized 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, veronalchloroabutanal and TMS-222 (Tricaine MethanSulphonate). 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 anesthetized bag should be immediately filled with oxygen. absorbents are added to the medium during transportation to eliminate toxic ammonia from the medium and safeguard the fish seed from mortality. These absorbents are permuted, 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

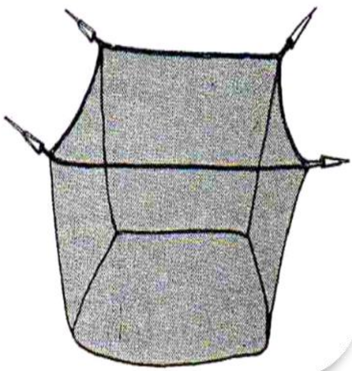
$$N = (D-2)Xv/RxH$$

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.

Transport of Breeders

Necessity of transporting adult fish and breeders has been greatly increased with the advantage of induced breeding. Breeders have to be transported without shock and injury. Metal containers, 200 litre vessels, plastic pools, open canvas carriers (1 x 1.25 m), splashless, closed and foam-lined containers are used for transportation of breeders and adult fish with compressed air. The wrapping of breeders carefully with a cloth allowing free movement of gill cover will keep them less active during transport. Splashless tanks are used for transportation for long distances. These tanks are elliptical metal tanks of about 1200 litres capacity mounted on a trailer or dragged by jeep or van. Inside the



tank a foam cushion lining is provided. The atmospheric air is supplied through a compressor fitted to the engine of the vehicle. This air is pumped through a pipe which passes through pressure tanks which eliminate oil vapours, carbon dioxide, etc. This is diffused through fine capillaries to give maximum efficiency to oxygen dilution. These are found to be excellent to transport fish. It is always better to give a dip bath to the breeders in any of the antiseptic or antibiotics, such as methylene blue (2 ppm), acriflavin (10ppm), copper sulphate (0.5 ppm), potassium permanganate (3 ppm), chloromycetin (10ppm), sodium chloride (3%) so as to protect them against infectious bacteria, fungi, etc. Before transport, the breeders have to be tranquilised using any one of the anesthetics like sodium amytal (100 ppm), TMS (0.1 ppm), m-aminobenzonate methane sulphonate (0.1 ppm), quinaldine (0.04%), veronal (50 ppm), urathan (50 ppm), tertiary amyl alcohol (0.05%) and phenoxy ethanol (0.04%).

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 depend 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 keep 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 utilize 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 occurrs 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 NH_3 .

Effect of temperature:

Temperature has a distinct effect on oxygen utilized 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.

Part 2: TECHNIQUES OF POND MANAGEMENT

Contents:*Introduction, Removal of aquatic plants, Eradication of predatory& weed fishes, Eradication of aquatic insects, Pond liming & fertilization,*Fish feeds and feeding management

Fish culture in ponds is basically a three tier culture system where the first step begins with rearing of spawn up to fry (2-3cm) stage for 2-3 weeks in nursery ponds followed by rearing of 2-3 weeks old fry for about three months up to fingerling stage (8-12cm) in rearing ponds before they are finally released in stocking ponds for growing up to table size fish. To ensure high rate of survival and growth during all the three stages of rearing a package of management practices should be strictly followed and slackness at any stage of the management procedure may affect farm productivity and profitability adversely. Seed rearing and grow-out culture are two main component of fish culture technology. The management measures for different life stages vary since several physiological modification such as structure and function of their digestive organs and differences in feed intake system. However, both the culture systems have some common pond management techniques, which are described below:

Eradication of Aquatic Weeds

The unwanted plants which grow within the water are known as aquatic weeds.Weeds do not always have harmful effects. The weed mass can be turned to some productive use which will recover some of the losses involved in controlling them. The extra advantage of the utilization method lies in producing valuable end products. Different methods of control and utilization of weeds should be seen as useful tools in an integrated system of aquatic weed management. The aquatic weeds are advantageous and help in the development and maintenance of a balanced aquatic community. The advantages are:

- Aquatic weeds produce oxygen during photosynthesis and this oxygen is utilized by the fishes.
- Weeds provide shade and shelters for small fishes.
- Weeds provide additional space for attachment as well as food for aquatic invertebrates which in turn serve as food for fishes.
- Weeds help in the precipitation of colloidal clays and other suspended matters.
- Weeds, after removal, can be used as bio-fertilizers.Weeds are used as food for fishes like grass carp.
- Weeds are also used for pollution abatement.
- Weeds are used as a source of energy production.

Though the aquatic plants have above beneficial impact on aquatic life, but at the same time their adverse impacts are more serious for pond fish culture system in particular. A few of the disadvantages of aquatic weeds are as below:

- They remove a large quantity of nutrient from the water retarding the growth of planktons.
- Prevent light penetration during over growth, thereby reducing photosynthesis.
- Cause O_2 deficiency during night.
- Harbor aquatic insect and predators.
- Reduce living space &hinders free movement of fish.
- Cause problem in netting operation.
- Increase siltation in pond.

Types of Aquatic Weeds

Common aquatic weeds creating problems in fish culture ponds are broadly classified according to their nature of occurrence (Fig.5.1), in to four major groups, they are:

- Floating weeds
- Emergent Weed
- Submerged Weed
- Marginal Weed

Floating weed: The leaves of these plants are above the surface of water and roots are free underneath of water. A few of the floating weeds are Water hyacinth (*Eichhorniacrassipes),* Water lettuce (*Pistiastratiotes),* Water fern (*Saluiniacucullata) and* Duck weed (*Lemnaminor)*

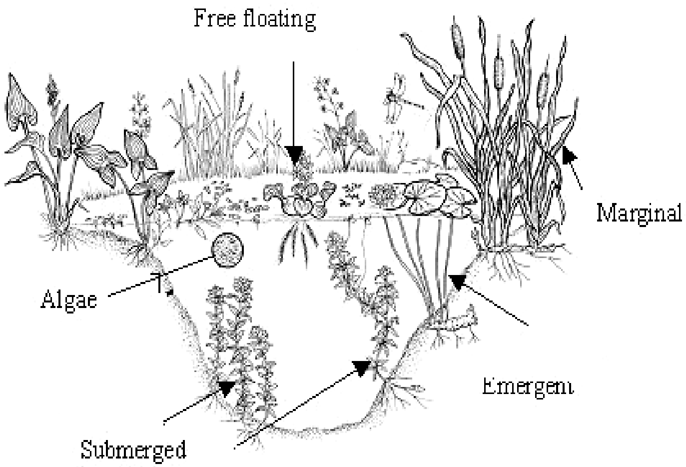


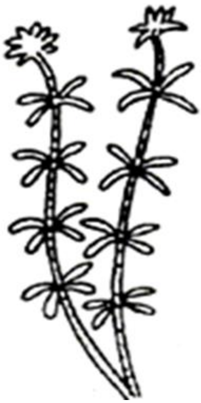
Fig.5.1: Showing Aquatic Weeds

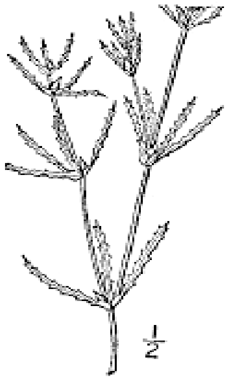
E. crassipes *Pistiastratiotes* *Lemnaminor*

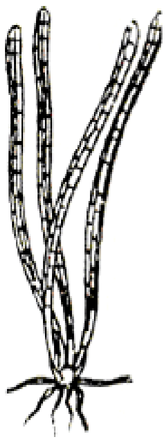
Emergent weed: It is rooted in the bottom but having their leaves and flower above the water surface.Banana water lily(*Nymphea*sp.*)*Lotus(*Nelumbo sp),* *Floating*heart (*Nymphoides sp.)* are few of the examples of emergent weeds.

*Nymphea*sp *Nelumbo sp* *Nymphoides sp*

Submerged weed: These plants are rooted or rootless in the water column.*Hydrilla (Hydrillaverticillata)Najas (Najus marina) Curly* leaf pond weed*(Potamogetoncrispus) and*Eel grass*(Vallesneriaspiralis)* are some common submerged aquatic weeds.

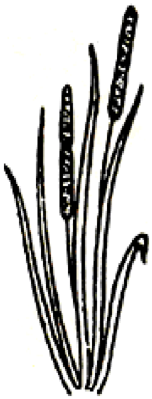






Hydrillaverticillata *Najus marina* *V. spiralis*

Marginal Weed: These plants are rooted and are available in the marginal areas or on the adjoining area of pond.*Ipomea(Ipomea aquatic)*Cat tail*(Typhaanqustata) and*Cyperus*(Cyperus sp.)*



Typhaanqustata *Cyperus sp* *Ipomea aquatic*

Control measure: Control measure fall into four major categories

- Preventive measure
- Manual &Mechanical measure
- Biological measure
- Chemical measure

Preventive measure: The preventive measures have to be taken well in advance. The measures include;

- Trimming of the pond margins.
- Dewatering.
- Desilting of old ponds.
- Uprooting or burning of dried marginal weeds during the summer.
- Providing barriers to prevent the entry of floating weeds.

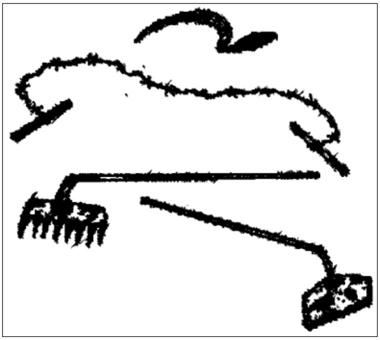


Fig.5.2: Hand tools used for manual control of aquatic weeds

Manual and mechanical control: Removal by hand picking is an age old practice for controlling or removing the aquatic weeds. Implement used for manual control of aquatic weeds are hand scythes for cutting and strong nets & bamboo poles with terminal cross piece for twisting &uprooting. Mechanical methods such as cutting, dragging, dredging, ploughing may be employed in case of heavily infested ponds.

Chemical control: Manually removal from heavily infested pond is very difficult so certain chemical are used for the control of aquatic weeds. The chemical for aquatic weed control are selected very carefully and the selection is based on certain criteria as described below:

- Low cost & easy availability.
- Effective at low dose.
- Easy method of application.
- Non -toxic to animals & human being using water.
- Short half- life.
- No residual effect on fish & pond ecosystem.

A few of the important and commonly used chemicals for aquatic weeds control are given in Table 5.1.

Table 5.1: Selected aquatic weed and chemicals used for their control.

Type of weed	Chemical	Method of Application
Floating Weed	Simazine (5g/ha), 15ppm ammonia	Spraying
Emergent Weed	2-4-D @ 7-10 kg/ha	Spraying
Submerged Weed	Anhydrous ammonia @ 20ppm	Spraying
Phytoplankton Bloom	Simazine or Diuron 0.3 -0.5 ppm	Spraying
Mat farming Filamentous algae	Simazine or Diuron 0.5 – 1.0 ppm	Spraying

Biological control of aquatic weed

Another important controlling method is by introduction of weed eating fishes, common carp, gourami, tilapia, pearl spot, grass carp etc.are the fishes of known weed eating habits. Grass carp is the most important fish for biological control of submerged and floating weed except water fern.

The time for control of weeds given below have been found to be appropriate under Indian conditions.

January-February	*Eichhornia, Lotus*
March-May	Duck weeds
June-July	*Utricularia, Ottelia*

July-August	*Trapa, , Pistia, Nechamendra*
August-September	*Najas, Myriophyllum*
October-November	*Scrispus, Nymphaea*

Eradication of Predatory and Weed Fishes

Predatory fish prey upon the spawn, fry and fingerling of carp and the weed fish compete with carp for food, space & oxygen. Therefore predatory and weed fish (Fig.5.3) should be completely eradicated from nursery, rearing and stocking ponds before these ponds are stocked.

Methods of Control

Absolute removal of these unwanted fish by through and repeated netting is not possible and hence dewatering and poisoning the pond are the only alternative methods. Dewatering should be preferences as it ensure complete eradication of unwanted fishes and disinfects offer the opportunity to desilt the pond bottom. However, in ponds where dewatering is not possible, those fishes are removal through repeated netting or application of suitable pesticide. From economic point of view the poisoning should be done during pre-monsoon season where the water level usually low. Requiring the minimum quantity of poison material. The date of poisoning, however should be fixed about three weeks before the anticipated date of stocking.

Fish toxicants

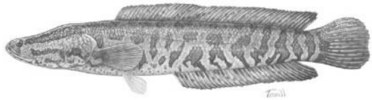
Although the number of chemicals and plant derivatives are available in the market which is poisonous for fish, only a limited number of such toxicants are safe and suitable for fish culture purposes.

Selection criteria: Based upon the following criteria a suitable fish poison is selected;

- Poisoned fish should be safe for human consumption.
- Least adverse effect on the pond biota.
- Toxicity period should be short duration.
- Should not have residual effect.
- Easy commercial availability.
- Simplicity of application&Low cost.

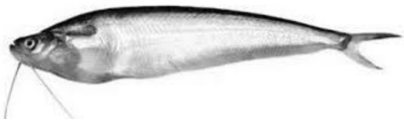
On the basis of above selection criteria, Derris root powder, Mohua oil cake, Bleaching powder and Quick lime are considered as suitable fish toxicants.

A. Predatory Fishes **B. Weed Fishes**

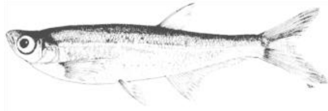


Channa spp.

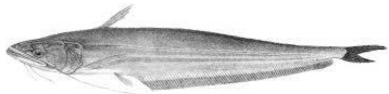
Puntius sp.



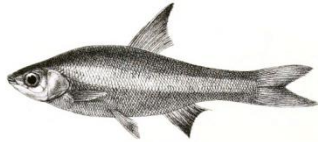
Ompok spp.



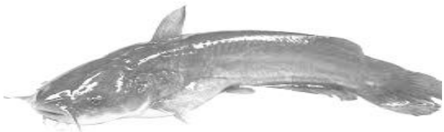
Oxygaster spp.



Wallago attu

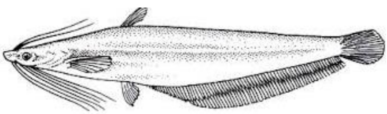


Amblypharyngodon mola

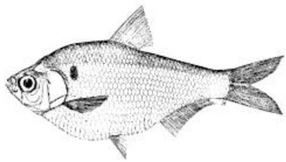


Clarius magur

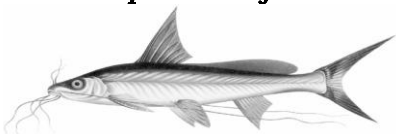
Osteobrama cotio



Heteropneustes fossilis



Gudusia chapra



Mystus spp

***Rasbora* sp**

Fig.5.3: Selected predatory and weed fishes of freshwater

Application of fish toxicants

Derris root powder: Derris root powder is plant poison with 5% rotenone ($C_{23}H_{22}O_6$) .It is commonly used for removal of weed and predatory fishes of the pond. It acts as contact poison, damaging the respiratory system of fishes of ultimately leading to their death.

Doses: It is effective for shallow ponds with 1.0-1.5m depth, especially in hot sunny day with water temperature above 25^{O}C. Dose = @15-20 ppm.

Poisonous effect: Poisonous effect of this root extract persists for 4-12 day depending on application dose. However, a time lag of about one month is usually advocated before release of spawn in the pond.

Method of application: The requisite dose of derris powder is mixed with water in bucket & sprayed over pond surface.

Mohua oil cake: Mohua oil cake is plant origin fish poison. It contains 4 - 6% Saponin (Mawrin) as toxicant, which enters into respiratory system through gills &buccal tissue &haemolyses red blood corpuscles causing death.

Dose: 2000-2500 kg/ha of water (i.e. 200-250ppm).

Application time: It should be applied at least two weeks before stocking the ponds.

Poisonous effect: Toxicity of doses up to 250 ppm lasts for about 96 hours & subsequently it serves as organic manure in the pond.

Method of application: The required quantity of Mohua oil cake should be soaked in water & uniformly broadcast over the entire pond surface.

Bleaching powder: Bleaching powder or calcium hypochloride ($CaOCl_2$) is another practical and safe fish toxicant.

Dose: Commercial grade bleaching powder with 30% chlorine applied at 350 kg/ha-m of water (10ppm chlorine) kill fishes in ponds.100 Kg urea/ha-m, followed by 175 Kg bleaching powder/ha-m after 18-24 hrs is found equally effective.

Poisonous effect: Fish kill occurs within 1-3 hours and the toxicity lasts for 3-5 days.

Methods of application: The method of application is also relatively simple. The powder is mixed with water & uniformly spread occur the entire water surface.

Chlorine killed fish are safe for human consumption.
Quick lime: It react with water to form Ca $(OH)_2$. This quickly rises the pH above 11, killing harmful organism.
Dose: 1000 Kg/ha
Method of application: It is placed in small pits dug at pond corners. As soon as the quick lime is dissolved, the solution is spread evenly around the pond.
Anhydrous ammonia: Anhydrous ammonia @ 20-25 ppm has also been found to be an effective fish toxicant.

Control of Aquatic Insects

Pond ecosystem harbour numbers of aquatic insect's species 9Table 5.3 and Fig. 5.4). Many aquatic insects in their larval and/or adult stages prey upon fish hatchlings and fry and also compete with them for food. They often kill them through devouring or pricking and sucking body fluid resulting in poor seed survival.

Table 5.3: Common predatory insects

Sr. No.	Name of the insect	Common name
1	*Notonecta*	Back swimmer
2	*Anisopsbouvieri*	Back swimmer
3	*Corixa*	Lesser water boatman
4	*Nepa*	Water scorpion
5	*Hydrometra*	Water measurer
6	*Velia*	Water cricket
7	*Ranatra*	Water sick insect
8	*Cybister*	Diving beetles
9	*Belostoma*	Giant water bug

Methods of Predatory Aquatic Insect Control

Pond treatment methods for the eradication of predatory aquatic insect are as follow:

- Oil emulsion treatment
- Insecticide
    - Malathion
    - Butox

Oil Emulsion Treatment: For the eradication of aquatic insects, it is one of the oldest and most effective methods. The eradication of air breathing insects following combination of oils is used for pond treatment method and doses

Treatment Method	Dose/ha
Soap oil emulsion	56 kg vegetable oil + 18 kg cheap soap
Kerosene	@ 100- 200 liter
Diesel	@ 75 liter
Turpentine oil	@ 75 liter

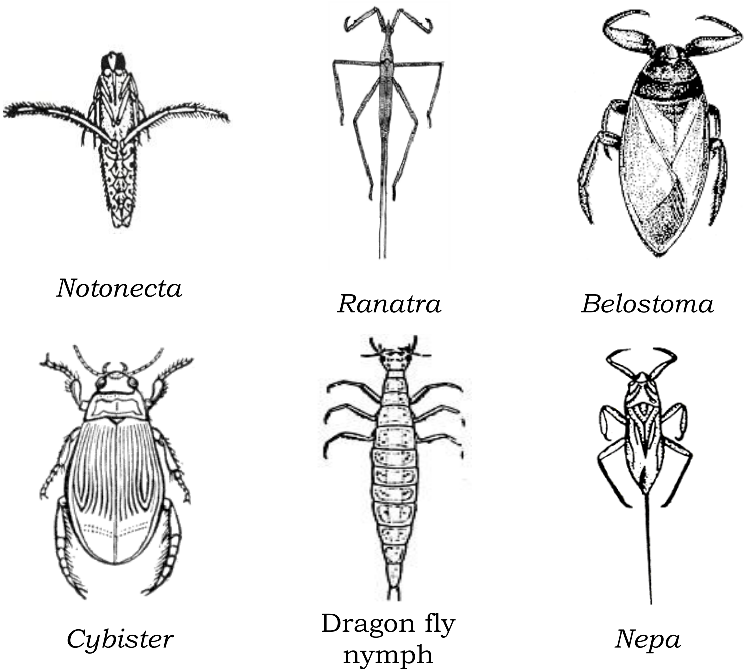


Fig.5.4: Common aquatic insects

Mode of action: Thin oil film chokes the respiratory tubes of aquatic insects. The spawn and food fish remain unaffected.

Method of application

Spray: These emulsion is applied by spraying over the pond surface about 12-24 hrs prior to stocking of spawn.

Care

- Don't disturb the film for a few hours.
- Windy day should be avoided as it will break the film.

Insecticide

Malathion: Malathion is an organophosphate insecticide. Malathion is colorless to ambar liquid with shunk or garlic like odour. It is used @ 0.25 ppm.

Mode of Action: Malathion interferes with the insect's nervous system, resulting in inability to breath and death.

Method of application: Mix the Malathion and same amount of water. This mixture is applied by spraying over the pond surface.

Butox: Butox is a well-known synthetic pyrathroide (chemically known as Deltamethren) used for the control of ecto-parasites in domestic animals. While soap oil emulsion kill only air breathing insects, but butox kill both air and gill breathers. Further, its cost of application is hardly 1/10 of soap oil emulsion technique.

Mode of Action: It is contact type insecticide.

Method of application: For one ha meter area, 500 ml butox is mixed with 50 liters of water in plastic bucket and sprayed on water surface. It should be applied at least 24 hrs before the stocking of spawn. Since, it is a synthetic pyrathroide, therefore it degrades within 6-8 hrs of application.

Care for insecticide use

- Quantity of chemical to be used should be carefully calculated on the basis of surface area and actual depth of the water.
- Avoid contact with mouth and eyes.
- Facial visor & gloves should be worn.
- Before eating/ drinking, hands & other exposed should be washed.
- If contaminated, clothing should be washed at the end of working day.

POND FERTILIZATION

Indian major carps and exotic carps at their early stages are planktivorous with zooplankton as preferred natural food. Sustained zooplankton population in a pond depends on a good phytoplankton population base, which is ensured through adequate availability of major nutrients like nitrogen, phosphorus and carbon besides certain micronutrients in the water. Such nutrients are supplied to pond water through organic and inorganic fertilizers.

Efficiency of these manures and fertilizers for stimulating pond productivity largely depends on N, P, and C availability, N: P ratio and C: N ratio in pond sediment. The N:P ratio of 2:1 to 4:1 and C:N ratio of 10:1 to 20:1 in pond sediment are desirable for sustaining productivity of pond water.

Types of fertilizers: There are two major classes of fertilizers for aquaculture. Fertilizers can be divided into organic and inorganic fertilizers. Fertilizers can as well be grouped either as liquid fertilizer or solid.

Organic: Organic fertilizers are derived from animal byproducts or garden, compost, kitchen, slaughter house or food processing plant refuse. Major organic fertilizers in use are chicken droppings, cow dropping and pigsties washout and droppings. Organic fertilizers are well suited for organic aquaculture practices.

Inorganic: In organic fertilizers are chemical fertilizers that provide nutrients' needed in aquatic by the primary producers. Inorganic fertilizers provide different elemental supplements for the ecosystem. Fertilizers like NPK provides similar amount of sodium, phosphorous and potassium, while other like triple supper phosphate provided much needed phosphorous to the aquatic ecosystem. Generally inorganic fertilizers are identified by their chemical constituents subsequently delivered to the environment. There are many commonly used fertilizers produced for a variety of applications. Fertilizer manufacturers are required to list the grade on each fertilizer container by the percent of nitrogen (N), phosphorus (P) as phosphoric acid (P_2O_5) and potassium (K) as potassium monoxide (K_2O). Therefore, a 20-20-5 grade fertilizer contains 20 percent nitrogen, 20 percent phosphorus as P_2O_5 and 5 percent potassium as K_2O. "Complete" fertilizers contain N, P_2O_5, and K_2O while "incomplete" fertilizers contain only one or two of these elements. Common incomplete fertilizer sources are normal superphosphate (0-20-0), triple superphosphate (0-46-0), diammonium phosphate (18-46-0) and liquid ammonium polyphosphate (10-34-0). Examples of common complete fertilizersare20-20-5, 4-12-12.Additions of phosphorus in ponds usually provide a much greater increase in fish production than from either nitrogen or potassium.

Action of organic manureand inorganic fertilizer: Decomposition of organic manure in pond bottom leads to slow release of nutrients to overlying water column and helps in long term maintenance of rich plankton population.Inorganic fertilizer dissociate into elemental form, which are readily available for utilization by phytoplankton.

Conditions for fertilization

- Test for pH of pond
- Acid ponds needs to be limed before pond fertilization. News inundated pond need pH test before fertilization.
- It is important to test for alkalinity before fertilization. If calcium hardness)is <20mg /l. water needs liming
- Liming could be done at least 1 weak prior to fertilization
- Liming should not be done with fertilization at same time
- Fertilizer could be applied 2 weaks after lime
- Fertilization should not be done if pond or tank is flow through or water exchange in the pond within 30 days is more than pond volume
- Fertilization should be moderately at reduced rate for shallow pond to avoid over fertilization

Turbidity is an index of fertilization rate. The turbidity of fertilized pond should be cross checked regularly with a Secchi disc. Secchi disc visibility = 20-30 cm is good. If the disc disappears too quick it shows high bloom and fertilization could be stopped.

The details of fertilization rate, time and phasing is presented in following table:

Organic fertilizer and their doses		
Name of fertilizer	Dose	Time
Raw cattle dung	10 tonnes/ha	15 day before stocking
Raw cattle dung	1st dose – 6.6 tonnes/ha 2nd dose – 3.4 tonnes/ha	1st Dose (Basal Dose) 15 Day Before Stocking, 2nd Dose After A Week Of stocking

Dose of fertilizer required for phased manuring	
Name of fertilizer	Dose

Groundnut oil cake	780 Kg/ha
Raw cattle dung	200 Kg/ha
Single super phosphate	50 Kg/ha
Total	1000 Kg/ha
Dose of phased manure and time of application	

Dose of phase manure	Time
Basal dose – 500Kg/ha	2-3 day prior to stocking
2nd dose in 2-3 splits	Depend on plankton population

SOIL & WATER CORRECTIONS

In aquaculture pond soil and water pH is generally rectified with the use of lime and gypsum.

Liming: The commonly used lime are quick lime (CaO), slaked lime ($Ca(OH)_2$) and lime stone (CaCO3).

Advantages

- It corrects acidity of soil and water.
- Decomposes bottom organic matter.
- It improves the productivity of water by taking up excess of CO_2 from the water.
- Lime from the calcium carbonate acts as buffer preventing the wide fluctuation of pH.
- It counter acts the possibly harmful effect of excess magnesium, sodium, potassium ions & fixation of harmful organic acid like H_2SO_4.

The pond liming rate/dose depends on the nature of soil (i.e. acidic or alkaline soil). According to soil quality, the dose of lime are suggested as below:

Soil pH	Soil condition	Dose of lime (kg/ ha)
4.0 – 4.9	Highly acidic	2000
5.0 – 6.4	Moderately acidic	1000
6.5 – 7.4	Nearly neutral	500
7.5 – 8.4	Middle alkaline	200
8.5 – 9.5	Highly alkaline	Nil

Gypsum: Agriculture gypsum ($CaSO_4$) is generally used in fish pond.

Advantages

- Agricultural gypsum is helpful for correction of alkaline pH.
- It is also applied to increase total hardness without affecting the alkalinity.
- It can also be used to control turbidity but without loss of alkalinity dose for control turbidity 100 – 300 mg/lit.

For the improvement of fish pond pH, gypsum is applied @ 400 -1200 kg/ acre.

Production and Maintenance of Natural Food

The main objective of manuring of fish pond is to augment the production of zooplankton (natural food of fish and fish spawn). For this the first step is liming just after removal of weed fishes. After liming, the nursery ponds are treated with manures.

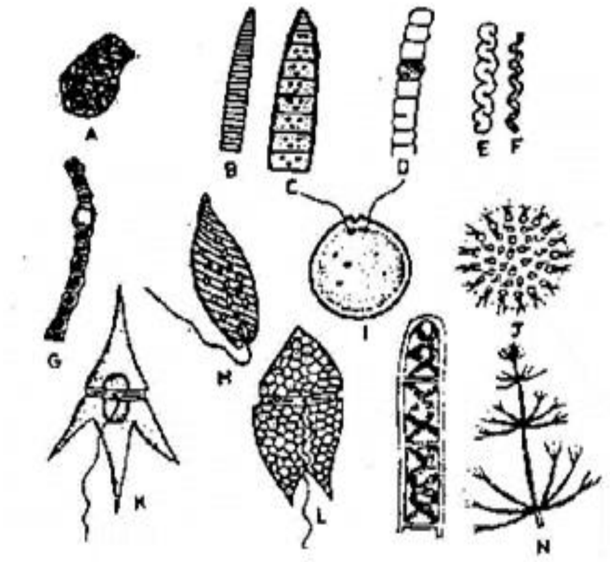


Fig. 5.5: Commonly occurring phytoplankton a*) Microcystisp c) Oscillator,* d) *Anabaena*e f) *Spirulna g) Nostoc*h) *Euglena* i) *Chlomydomonas*j) Volvox k) *Spirogyra* l) *Nitella.*

Organic manuring besides being an important mean for adding the nutrients is also equally important for improving the soil texture. A combination of organic and inorganic fertilizers is considered more effective than using either of

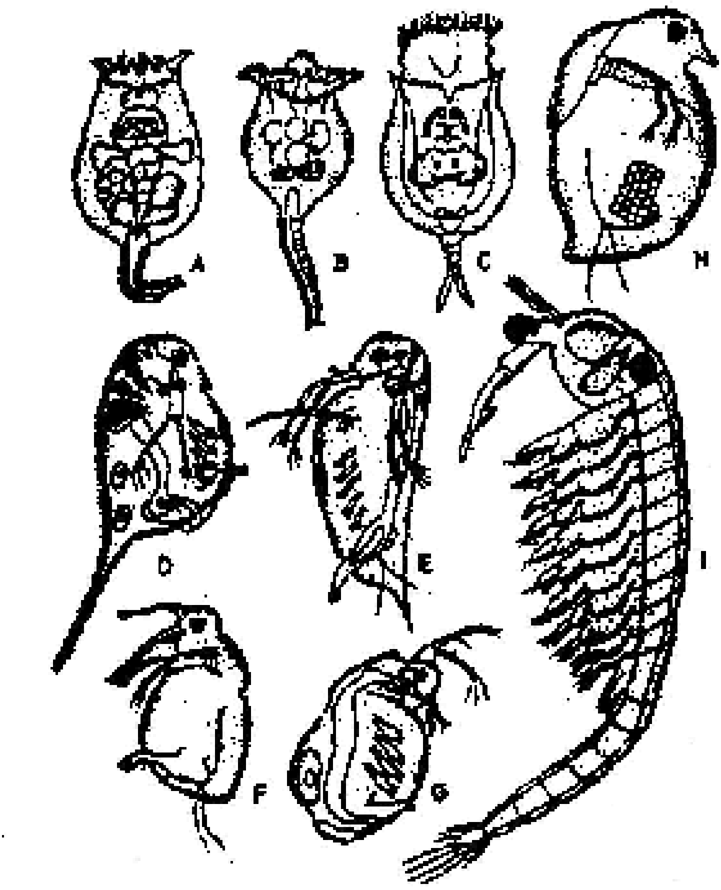


Fig.5.6: Commonly occurring zooplankton {*a) Brachionusplicatilis*b) *B. rubens*c) *Euchlanis sp.* d) *Daphnia cahnata*(male) c) *D. cahnata*(female) f) *Moina sp.* (male) g) *Moina sp.* (female)h) *Ceriodaphnia sp.* (female) i) *Artemiasalina}*

these alone. The conventional dosage followed in carp culture practice usually ranges from 10-20 tonnes of cattle dung/ha/year or 4-8 tonnes of poultry manure/ha/ year alone or in combination with urea @ 100 kg N/ha/year and superphosphate @ 50 kg P/ha/year. Bioprocesses organic manure, biogas slurry, has been standardized as a manure in carp culture @30-45 tonnes/ha /year, with distinctadvantages in terms of lower oxygen consumption and faster nutrient liberation rates.

It is necessary to continue manuring in such a way that maximum planktonic growth is maintained for prolong period. Periodic fertilization ensures replenishment of nutrients for microbial decomposition activities. The desired total quality of fertilizers are best applied in small equal doses of periodic installments throughout the rearing period so as to ensures maximum utilizations of these fertilizers. The mode, sequence and timing of application of fertilizers are important or achieving best results.

These fertilizers should be applied only when the physical conditions of water are most suitable such as plenty of sunlight, adequate oxygen, optimum temperature, adequate water level and low wind velocity.

Fish Feeds and Feeding Management

Fish feed is a major expenditure for fish farmers. Good fish feed management can reduce overall culture cost, improve fish farm environment and ensure healthy growth of fish stock. Fish feed management includes choosing the right feed, using a correct feeding method, calculating the feeding cost and ensuring the cost effectiveness of fish farm.

Nutritional Requirement of Fish

Protein, fat, carbohydrates, vitamins and minerals are the essential nutrients for fish. Protein provides energy and builds muscles. Fat provides fish with energy. A right amount of fat can improve taste and texture but excessive fat may pose a health hazard to fish. Carbohydrates provide energy but most of them are not easily digested by ordinary carnivorous. Vitamins and minerals are the essential trace elements that can enhance natural resistance and feed conversion rate

It is noteworthy that nutritional requirements of fish vary with different species, sizes, growth stages and feeding habits. For example carnivorous fish require a higher intake of protein and fat than the omnivorous and herbivorous species, while marine fish require more protein and fat than freshwater fish do. For this reason, fish feed should be specifically chosen to suit different species.

Types of Fish Feed

Generally fish feed are of two types. Natural feed and supplementary feed. This two types are described below.

Natural Fish Feed: The feed which grows naturally in the pond or stream for the natural fertility of soil and water and by applying fertilizer is called natural feed of fish. Natural feed is the main source of necessary feed for surviving. Availability of natural feed indicate the primary production capability of a stream. The natural feed of fish are below.

- Plankton and Tiny aquatic insects
- Wolffia, Eichhornia, Pistia, lemma
- Basal organic elements
- Different types of grasses (Napier, para etc.)

Supplementary Fish Feed: Fish needs some extra feed along with available natural feeds in water for their regular growth. This extra feed which are provided to fish is called supplementary feed of fish. The ingredients of supplementary feed for fish are below.

- Rice bran
- Refined pulse and wheat roughage
- Mustard or sesame cake
- Fish-meal (fish powder)
- Crop grain
- Silk kit meal
- Blood and innards of bird or animal
- Green leaves of various vegetables
- Minerals and vitamins
- Kitchen leftovers
- Maize powder and refined chaff

Common Fish Feeds

Fish feeds widely used in Asia include traditional vegetarian feed and trash fish. In recent years pellet feed is also becoming popular.

Vegetarian feed- Wheat bran, rice bran, weed, soy dregs, flour and peanut cakes are suitable for freshwater fish and especially for carps.

Trash fish-Trash fish are is suitable for marine fish and also for freshwater carnivorous fishes.

Pellet feed- There are dry and moist pellets. The former is more popular and the major ingredients are fishmeal made from grinding baked trash fish, fish oil, vitamins and binder. They are extruded. Moist pellet feed is made up of fishmeal, trash fish, vitamins and binder. The pellets are extruded bya pellet machine. Pellet feed is suitable for both freshwater and marine species.

How to Choose Feed

With so many varieties of fish feed, how can fish farmers choose one that suits the cultured fish best? One simple way is to compare the nutritional requirement of the species, availability, price, storage method, hygiene and environmental impacts of different feeds and see which one suits the needs of your fish farm best.

1. **Nutrition:** Vegetarian feed and trash fish may not have sufficient nutrients to satisfy the needs of all cultured fish. It may lead to malnutrition which will impair the natural resistance of the cultured fish and heighten the risks of diseases. Pellet feed can be added with animal or plant protein, fish oil or other fats, vitamin complex and minerals as required by specific fish species. They are highly nutritious and can effectively improve the health of your fish stock. Fish feed specially formulated for particular species (e.g. cat fish, Tilapia, grouper, sea perch and grey mullet) and size/ age group (i.e. Fry, fingerlings, Brood stock etc.) are also available on the market.
2. **Availability**: Apart from trash fish, the supply of all other fish feeds is generally stable.
3. **Price:** Vegetarian fish feed and trash fish are cheaper than pellet feed.

Feeding Rate

For good aquaculture, the knowledge of feeding rate is vitally important. The less feeding than required quantity result in loss of production. Overfeeding will cause a wastage of expensive feed and is additionally a potential cause of water pollution, a condition resulting in loss of fish. Thus, both overfeeding and underfeeding have serious economic consequences which affect the viability of aqua farming. In general a vague instruction, like 'feed 5% of biomass per day' for a dry feed. This might be applied throughout the growing cycle. This would almost certainly result in near starvation in the early stages and gross overfeeding and water quality problems later. Feeding rates should not stay steady throughout the whole of the growing cycle to market size. They must be modified according to the size and age of the fish or shrimp, and to the water conditions.

The quantity of feed to be given to a pond or cage each day should normally be based on a percentage of the biomass present (total weight of fish). Thus, if a pond contains 10 000 fish weighing 10 g on average and the recommended feeding rate is stated to be 7% per day, the amount of feed to be given daily is:

$$\frac{10000 \times 10 \times 3}{100} = 3000g\ per\ day$$

The percentage of biomass to be fed is not a fixed amount. It should decrease as the animals grow, to reflect their decreasing metabolic rate. Thus the ratio of weight of feed per day to animal weight (biomass) is high at the start of the growing period and lower towards the time when the animals reach marketable size.

Fish Feeding Method

The most effective method of feeding with respect to location, time of day and frequency varies from species to species. Its cost effectiveness depends also on other factors such as the availability of feeding labour or automatic feeders, size of pond or tank, cost of labour, and the personal preference of the farm manager, based on observations and results. Though the methods of feeding fish keep changing, the basic methods of feeding fish are as below:

Hand Feeding: Feeding is done by hand for approximately 20 minutes. In this method the feed can be distributed equally and even the person can check if the fish is getting overfed.

As it involves manpower, cost of labour will increase.

Feed Tray: This method is very cheap and at the same time very simple to use. Feed tray is a ration which is placed on a fine-meshed net. This net is situated below the surface of the water. In this feeding method, the feed would be distributed in a limited way.

Demand Feeder: This is a mechanism of releasing feed that too on demand by fish. This is accost-effective method. But the feeder to fish ratio has to be maintained to make sure that the fish are not overfed.

Automatic Feed Blower: In this method of feeding the feed is broadcasted by feed blower which is an electrically powered one. One feed blower is sufficient to feed 5000 fishes. This is a high cost machinery which does not take the appetite of fish in mind.

Whatever feed you choose, take note of the following:

- Do not feed too quickly or too much. This wastes money and pollutes fish farms.
- Observe how fish respond to feeding and portion the feed appropriately. Low consumption may be a sign of disease or deteriorating water quality.
- It is best to give frequent feeds in small quantities.
- If using dry pellet feed, consider having an automatic feeding machine installed to save manpower.
- Record the daily feed amount to detect any drop in consumption. It also helps the calculation of feeding cost and FCR.
- Keeping farm management record helps fish farmers to control cost and select the right feed and management approach. It helps to detect potential disease outbreaks at an early stage.