III. UNITS: AQUACULTURE PRINCIPLES AND PRACTICES

Types of Aquaculture

Aquaculture is the production of aquatic animals and plants under managed and partially controlled conditions.
It may be done for aesthetic or recreational purposes, e.g., aquarium keeping, water gardens, and sport fish ponds, but most **aquaculture** is for production of aquatic plants and animals for human consumption.
Definition: FAO (1988) introduced a definition of aquaculture which reduces its confusion with capture fisheries: **"Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc." Farming also implies individual or corporate ownership of the stock being cultivated.**
For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploitable by the public as a common property resources, with or without appropriate licences, are the harvest of fisheries.

1. SCOPE AND IMPORTANCE OF AQUACULTURE

Importance of Aquaculture

1. Sustainable use of sea resources: Aquaculture provides alternatives for fishing from the sea. Increase in demand for food sources and increase in globalization has led to increase in fishing.
2. Conservation of Biodiversity: Aquacultures also protect biodiversity by reducing the fishing activities on wild stock in their ecosystems. Reduced action of fishing saves the diversity of the aquatic ecosystem from extinction due to overfishing.
3. Increased Efficiency, more resources for less effort: Fish convert feed into body protein more efficiently than cattle or chicken production. It saves resources and even allows for more food to be produced leading to secure reserves and less stress on the environment.
4. Reduced Environmental Disturbance: By increasing aquaculture, fish farming in specific, there is a reduced need for the fishing of the wild stock.

Environmental Benefits

1. Creates Barrier against pollution with mollusc and sea weed: Both these organisms sift the water that flows through them as brought in by the current and clean the water.
2. Reduces fishing pressure on wild stock: The practice of aquaculture allow for alternative sources of food instead of fishing the same species in their natural habitats.

A. REQUISITES FOR SUITABILITY OF A FISH SPECIES TO FARMING REQUIREMENTS FOR FISH CULTIVATION, WHICH MAY BE LISTED AS FOLLOWS:

1. a high growth rate so that the fish attains full size in a short time,
2. a large body size, preferably with small head and high trunk and low bone-to-flesh ratio,
3. herbivorous, plankton-feeder, microphagous, or a detritus feeder, i.e. with a short food chain,
4. assurance of supporting a dense population throughout life i.e. a social and gregarious fish,
5. possibility of accepting and growing on artificial food as well as on natural food,
6. tolerance to other culturable fishes to permit mixed farming (polyculture),
7. assurance of an easy and regular supply of fish seed, i.e. the fish should reproduce in captivity or respond to induced breeding methods,
8. a fish that is hardy to withstand handling and transportation,

9. a fish that is resistant to disease, (x) a fish of high food value, and
10. a fish that suits the taste of the consumer

I.TYPE OF AQUACULTURE

Three important considerations are giver below :
Fish culture practices may be classified into three different kinds on economic and commercial consideration, depending upon the motive of farming :

- **extensive,**
- **intensive**
- **and semi-intensive**.

1. Extensive fish culture is the least managed fish farming.
Although the pond may be large, little care is taken with regard to its improvement.
A modest yield, raised on the natural food, nothing more than the natural production, is obtained.
2. Intensive fish culture on the other hand is one in which an all-out attempt is made to achieve maximum production of fish from a minimum quantity of water.
It is best managed form of fish farming, in which fish are fed on artificial food and the pond is improved by use of fertilizers.
In such a case the small size of the pond notwithstanding, the production of fish is very high (over 6000 kg,/ha/year) and of high quality fish.
Although the cost of investments is also high, the return from the yield far exceeds it to ensure a great profit in the trade.
3. Semi-intensive fish culture is anything between the first two kinds.
II. Fish culture practices may be classified into six basic categories, each with its own characteristics, depending on the nature of the waster mass used and the manner of farming :
1.Pond fish culture: In this case, the water-mass consists of natural or artificially erected freshwater ponds. It is the commonest of all methods.
2. Culture in man-made reservoirs: Freshwater mass held back by the dam on rivers is used. culture
3. Paddy-cum-fish: In this case, the paddy- fields that are inundated with water are used for cultivation of fish.
4. Brackish water fish culture: Open or embanked estuaries with waters of varying salinities, afford low lying, shallow fields under water for fish raising.
5. Coastal fish culture (mariculture): Marine species of fish are cultivated in marine coastal waters alone.
(vi) Salt pan culture: In off-seasons of salt manufacture, the salt pans are utilized for fish culture.
III. Classification of fish culture practices based on special operational techniques is as follows
1. Cage culture: Here the fish to be cultured are held in a section of water of a flowing river by being imprisoned in a cage of metal or bamboo structure, supporting wire, nylon or split-bamboo mesh mats. It is rather recent practice but with great promise.
2. Pen culture: This is simply an enclosure, often along banks and shores, of some device which utilizes the bank or the shore line as one of its sides. Fishes are
then raised in this enclosure.
IV. There is yet another way of classification based on the number of species cultivated at a time.
Following three types are distinguished:
1. Monoculture: In this case fish farming in a certain water body is confined to a single species.
2. Mono-sex culture: In this case, only one sex, either the male or the female, of a single species is cultivated in a water body.

3. Polyculture: In this case, more than one species is raised simultaneously in the same water body.

V. Fish culture practices may also be classified on considerations of climatic factors

1. Warm-water culture: This concerns water masses of the tropics and plains.

2. Cold-water culture: This involves culture practices conducted in springs, pools or lakes of hills and high altitudes.

Sewage-fed fish Culture

Sewage is a rich nutrient resource, cheaply available around big towns and cities.
It can be well-utilized for fertilizing paddies, fish ponds and horticultural crops.
Waste utilization through recycling also helps in maintaining a clean environment.
This paper is based on existent practices in Eastern India.
In areas where irrigation facilities are not available, a second crop of rice is possible by construction water storage structures within the field.
These could be in the form of lateral, central or marginal trenches or unilateral/bilateral ponds which are also utilized for aquaculture.

ADVANTAGES

1. The second rice crop contributes to additional food production,-- employment and income generation.
2. Fish crop provides a rich protein food of high market value and adds considerably to the farmer' income.

LIMITATIONS

1. Trench/pond construction is useful only in water-retentive soils.
2. Difficulties in fish seed transport, if away from the main road.

Paddy cum Fish Culture

Paddy Cum Fish Culture (PFC) is the integration of fish farming with paddy.
This system is profitable and sustainable, as two crops i.e. paddy and fish can be harvested from a unit cultivable area.
The wet terrace rice fields where surface and ground water is sufficiently available can be utilized for development of PFC.
This culture system is being practiced in the State since decades especially in the districts of Kohima and Phek.
The adoption of PFC will open avenues for self-employment , supplement the income of the agriculture farmers and enhance fish production in the State.

Advantage

- Fuller utilization of available resources, readily available paddy fields can be utilized.
- Serves as an off-season occupation for farmer.
- Fish serves as an excellent agent for integrated Pest Management (IPM).
- Fish culture increase soil productivity and boost the production of paddy.
- Boost productivity and income from unit area.
- Reduction in fish production cost.

Integrated Fish Farming

The technology involves a combination of fish polyculture integrated with crop or live stock production.

On farm waste recycling, an important component of integrated fish farming is highly advantageous to the farmers as it improves the economy of production and decrease the adverse environmental impact of farming.

ADVANTAGES OF INTEGRATED FISH FARMING

- Efficient waste utilisation from different culture practice for fish production.
- It reduces the additional cost for supplementary feeding as well as fertilisation.
- It is an artificial balanced ecosystem where there is no waste.
- It provides more employment avenues.
- It reduces the input and increases output and economic efficiency.
- The integrated fish farming provides fish along with meat (chicken, duck, beef, pork etc.), milk, vegetables, fruits, eggs, grains, fodder, mushroom etc.
- This practice has potential to increase the production and socio-economic status of weaker section of our society.

TYPES OF INTEGRATED FISH FARMING

Basically, the integrated fish farming is of two types
a) Agri-based fish farming
b) Live-stock fish farming
The fish-cum live-stock farming is realised as innovation for recycling of organic wastes as well as production of high class protein at low cost.

Composite Fish Culture

What is composite fish culture? What are the advantages of composite fish culture?
Answer:

Composite fish culture is a method in which five or six different types of fish species are grown together in a single fish pond. Fish with different food habitats are selected so they don't fight with each other for food. This guarantees that the food supplies in the pond are completely utilized. Such a system improves the fish yield.

Example: Catla feed on the water surface, rohu are feeders for the middle region, mrigal and common carp are feeders for the bottom and grass carp feeds on weeds.

Advantages:

- Increases the yield of the fish.
- Ensures the full utilization of food in the pond.

Polyculture

Poly culture is farming utilizing numerous harvests in a similar space, an impersonation of the assorted variety of characteristic biological systems, and maintaining a strategic distance from enormous stands of single yields, or mono culture. It incorporates multi-trimming, inter cropping, buddy planting, useful weeds, and alley editing. It is the raising simultaneously and spot of more than one type of plant or creature. It decreased defencelessness to malady and increment neighbourhood assorted variety.

II. FISH FARM: TYPES OF FISH PONDS: MAINTENANCE AND MANAGEMENT

- Fish Farm involves raising fish commercially in tanks or enclosures such as fish ponds, usually for food.
- It is the principal form of aquaculture, while other methods may fall nder mariculture. A facility that releases juvenile fish into the wild for recreational fishing or to supplement a species' natural numbers is generally referred to as a fish hatchery.
- Worldwide, the most important fish species produced in fish farming are carp, tilapia, salmon, and catfish.
- Fish farming refers to the commercial production of fish in an enclosure or, when located in a body of freshwater or marine water, in an area that is penned off from the surrounding water by cages or open nets.
- A fish farm is similar to a fish hatchery in that both can contain 500,000 and more fish. But, a fish hatchery is designed to raise the fish only to a young age before they are released into the wild, usually to bolster the numbers of that species.
- In contrast, a fish farm is designed to raise the fish until they are a size and age that makes them the best commercial value. The fish are ultimately retrieved and sold, typically as whole or processed food.

Types of fish ponds

Nursery ponds: The smallest and shallowest of ponds for fish culture is a nursery pond. This is about 0.02-0.05 ha. The water is about 1 m deep.

A rearing pond is larger than a nursery pond. It is 0.08-0.2 ha. The water is about 1.5-2.0 m deep. Nursery and rearing ponds can be seasonal.

A stocking pond is much larger, often 0.2-2.0 ha. It should be 2.0-3.5 m deep. This pond might be perennial or seasonal.

A marketing pond, which is small but quite deep, is used to keep fish caught from a stocking pond for sale at short notice when the demand and price are high. These ponds can be 0.05-0.10 ha in size with a water level of 3-4 m in summer.

A Broodstock ponds (0.2-0.4 ha) are perennial and have a water depth of 2 m in the summer. Fish brought in from outside are first placed in a small (0.02 ha) but perennial (1.5 m deep) quarantine pond for a time to verify that they are not infected. You can also use this pond to treat diseased fish.

I. POND MANAGEMENT: PRE STOCKING, II. STOCKING AND III. POST STOCKING MANAGEMENT OF FISH PONDS

1. Carp culture in ponds is basically a three-tier culture system where the first step begins with the rearing of spawn up to fry (2–3 cm) stage for 2–3 weeks in nursery ponds.
2. Followed by rearing of 2–3 weeks old fry for about 3 months up to fingerling stage (8–12 cm) in rearing ponds before they are finally released in stocking ponds for growing up to table size fish.
3. 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.

Techniques

Techniques of management involve:

1. manipulation of pond ecology to ensure optimum production of natural fish food while maintaining the water quality parameters within tolerance limits of the stocked fish species; and
2. the husbandry of fish through stock manipulation, supplementary feeding and health care.

Broadly, the various steps involved in the management of ponds at all the three stages of culture may be classified as **(i) pre-stocking, (ii) stocking and (iii) post-stocking management operations.**

Pre-stocking management

Pre-stocking management aims at proper preparation of ponds to remove the causes of poor survival, unsatisfactory growth, etc., and also to ensure ready availability of natural food in sufficient quantity and quality for the spawn/ fry/fingerlings to be stocked. Pre-stocking part of the management involves the following sequential measures.

PRESTOCKING MANAGEMENT OF PONDS

Before introducing fry and fingerlings into the pond, it has to bo prepared for culture as below:

1. DRYING THE POND

If possible, the pond is completely drained of water and dried in sun. This influences the physico-chemical and biological condition of the pond by improving fertility. Fish parasites, their larvae and disease producing organisms are killed. The pond can also be made deeper, if it has become shallow due to deposition of silt.

2. CONTROL AND ERADICATION OF AQUATIC WEEDS

Aquatic plants growing in the pond are undesirable and harmful for fish culture as they reduce productivity, Aquatic weeds are of the following types:

(a) Free Floating Weeds: The leaves float freely on the surface of water and the roots hang inside water. They are abundantly found in wind protected ponds and are harmful, **e.g., water hyacinth, Pistia, Lemna, Azolla and Wolffia.**

(b) Emergent Weeds: These are rooted in the bottom float on the surface and the flowers rise above the water level, **eg., Lotus., Nymphaea, Water lily, Nelumbium and Nymphoides.**

(**c) Submerged Weeds:** These weeds remain under the water and may or may not be rooted at the bottom, **e.g., Hydrilla, Najas, Vallisneria, Potamogeton,** Ceratophyllum and Utricularia.

(d) Marginal Weeds: These grow along the shallow shore and are rooted, **e.g., Typha, Ipomea and.Sagittaria.**

(e) Several species of filamentous algae form thick mats or scums on the water, or lie scattered. These are **Spirogyra, Oscillatoria, Anabaena and Microcystis.**

Advantages of Weeds

- Aquatic plants in limited quantity are useful and necessary part of the ecology of the pond as they form natural food for many herbivorous fishes.
- They oxygenate water, fertilize the pond on decay, and reduce turbidity.
- They are used as shelter by some fish and form spawning beds.
- But excessive growth of weeds is harmful to the fish, as they obstruct free movement of the fish, and cause oxygen depletion and accumulation of carbon dioxide.

- They consume nutrients of the pond, obstruct netting of fish and cause silting of the pond.

A. Preventive control

- Taking into consideration the high cost of controlling aquatic weeds, certain preventive measures are to be followed to reduce the chances of their infestation.
- The preventive measures have to be taken well in advance.
- The measures include trimming of pond margins, dewatering and desilting of old ponds, uprooting or burning of dried marginal weeds during the summer and providing barriers to prevent the entry of floating weeds.

B. Manual and mechanical control

- Manual removal of aquatic weeds is an age-old practice and holds good even today in rural areas.
- The free floating groups of weeds are either hand picked or dragged by wire or strong coir rope nets.
- In bigger ponds they should be removed part by part from the marginal areas and finally the centrally located weed mass is dragged towards the banks and lifted out.
- Certain small and light floating weeds such as spirodela, lemna, azolla, wolffia, etc., are easily skimmed out by twisted straw ropes or fine meshed nets.
- The manual removal of submerged weeds from a heavily infested water body is relatively much more difficult.
- They are either pulled by hand or hand-drawn bottom rakes or uprooted with bamboo poles having a cross piece tied strongly at the terminal end.
- Repeated cutting of the aerial shoots and leaves of rooted emergent plants are also useful. Implements used for manual control are mostly hand scythes for cutting, and hand forks, strong nets and bamboo poles with terminal cross piece for twisting and uprooting.
- Mechanical devices used for clearance of rooted submerged weeds are steel cables, cutting chains and diesel operated winches..

C. Chemical control

- The chemical to be used should be cheap and easily available, and non-toxic to fish and man. It should not have adverse effect on the fertility of the pond and should not pollute water.
- Weedicides commonly used are 2, 4-D (2,4-dichlorophenoxy acetic acid) also known as Taficide, Hexamar, Fernoxone.
- Other chemicals as Chloroxone, Simazine, Methoxane, Agroxane, Copper sulphate, Calcium cyanide, Sodium chlorate, Sodium arsenite, Diuron, etc. are also used to eradicate weeds effectively.
- Sometimes filamentous algae as the Spirogyra, Pythophora grow extensively forming thick mats.
- Anabaena, Microcystis and Oscillatoria also grow extensively and form algal blooms, which are harmful to fish and kill them by choking the gills, causing oxygen depletion or by rotting.
- Treatment with copper sulphate is effective in controlling them. Chemicals, which can be successfully used to control different types of weeds are given below.

D. Biological control of aquatic weeds

- Another important controlling method is by introduction of weed-eating fishes. Common carp, gourami, tilapia, pearl spot, the grass carp and a species of puntius are the fishes of known weed-eating habits.
- Grass carp is the most effective biological control agent against most of the submerged and floating weeds except the water ferns.
- Grass carp normally consumes choiced aquatic weeds, at least 50% of their body weight in a day.
- About 300–400 fish, each of about 0.5 kg weight, are enough to clear 1 ha of Hydrilla infested water body in about a month.

3. CONTROL OF WEED FISH AND ENEMIES

Various animals including fish are harmful to fish cultivation in so far as they either live upon the cultivated fish-species or their eggs and fry, or even compete them for food. To this category of fish enemies belong all groups of vertebrates as well as insects. Depending upon the population of any of these, a control becomes necessary as part of pond management. Some measures taken are as follows :

1. Periodical drainage of pond followed by lengthy drying of the pond bottom destroys most insects and their larvae that are harmful mostly to fish eggs and fiy (such as beetles, bugs, dragonflies etc.).

2. Use of quick lime treatment to pond bottom during the period of annual drainage and drying of pond, and subsequent control of any fresh entry from other sources (through water supply) by way of adequate measures (use of screen at the inlet etc.) are effective measures against harmful predatory fishes.

3. Destruction by quicklime, or removal with scoop net of eggs keeps a control on multiplication of harmful amphibians.

4. Use of traps is an effective measure against harmful amphibians, birds and manuals.

5. Shooting when permitted is especially effective against harmful birds

6. Use of toxic substances is quite effective in certain cases. Notonectids (back swimmers) can be easily controlled by spraying an emulsion of vanous oils (mustard, castor etc.) in washing soap in the ratio of 3:1 and at the rate of 66 pounds per acre of water surface.

Common fish enemies may be listed as follows

1. Insects: Back swimmers (Notonecta) appear in swarms in manured ponds during rainy season. These are very harmful to carp fry which they kill in large quantities. Others include dragon-fly nymphs, beetles, bugs, water stick insect and their la**rvae.**

2. Reptiles: Aquatic snakes, crocodiles and turtles are fish caters

3. Birds: Fish eating birds include cormorants, herons, pelicans, guils, ducks besides Gavifortues and Columbiformes.

4. Mammals: Otters, cetaceans pinnipedes dwell in water and cause heavy damage to fish stocks and cause heavy damage to fish stocks.

4. FERTILIZATION

Fertilization of The Pond The natural productivity of a pond can be increased by using organic or inorganic fertilizers which provide nutrients, vitamins and minerals.

A. Liming

- The Pond The first step in fertilization of a pond is the application of quick lime which raises the pH of water and is antiparasitic, killing bacteria and parasites and their Larval stages.
- Quick lime @ 200 kg/ha is generally spread on the bottom, 15 days before stocking the pond with fish fry and fingerlings.
- For getting full benefit, the pond should be left to dry for two weeks after liming.
- Liming should be done if the water is acidic (pH 4.5-6.5), soil is too muddy and organic matter high.
- Presence of calcium speeds up decomposition of the organic matter releasing CO2 from the bottom.
- Lime can be applied @ 300-500 kg/ha depending on the pH of the soil.

B: Manuring:

- Natural food production of the pond has to be enhanced to support a large number of fries stocked in it.
- Both inorganic and organic ferlilizers are used to increase the available food.
- Inorganic nitrogenous fertilizers used are sodium nitrate, ammonium sulphate, ammonium nitrate, ammonium carbonate, urea, etc.
- Super-phosphates are also widely used.
- Ponds are treated with fertilizers after liming, but these are costly and bring about phytoplankton bloom and heavy growth of zooplankton also.
- The use of inorganic fertilizers depends on the available nitrogen and phosphorus in the soil.
- Cow dung as an organic fertilizer is preferred as it supplies all the nutrients needed by the fish. A dose of 5000-10,000 kg/ha cow dung causes the production of thick swarms of zooplankton (rotifers, copepods, cladocera) in about 15 days.
- Manuring should be done 10 days after poisoning with fish toxicants.
- Cow dung is spread on the bottom or placed in heaps along the bank of the pond.
- It is considered better to apply cow dung in two doses instead of one. Good quantity of zooplankton can be maintained for a longer period, if a dose of 10,000 kg/ha cow dung is used two weeks before stocking and a second instalment of 5000 kg/ha is given one week after stocking.
- Liquid manure from stables, guano, farm manure consisting of cow and pig dung are extensively used for manuring and bring about heavy growth of zoo and phytoplankton.
- Sewage is also a good fertilizer and enhances the growth rate of fish. A mixture of superphosphates of lime, cow dung and mahua oil cake has been successfully used as a manure by the Department of Fisheries.
- Other substances used as a manure are soyabean meal, cotton seed meal, mustard oil cake, etc.
- It has been suggested that the inorganic fertilizers should be used in ten equal monthly instalments, alternately with organic and inorganic manure.
- Sometimes, use of organic and inorganic fertilizers results in excessive growth of algae and phytoplankton.
- If the water turns green due to algal bloom, cow dung is applied in the form of liquid spray, so that the water becomes turbid brown.

- This checks penetration of light, and the algae die in 4-5 days.

5. STOCKING

- High production of fish from a pond is possible if a desirable species is selected for culture considering the type of pond, its ecological conditions and facilities for supplementary food. The fry should be introduced into the pond at a suitable time when the concentration of zooplankton is maximum.
- The stocking rate varies from 10-20 lakh fry per ha, depending upon the density of zooplankton and the carrying capacity of the pond, which is related to the natural production of food, manuring, feeding, etc.
- If the nurseries are well manured and supplementary food is given, 5060 % of fry survive and grow to fingerlings in about 15 days.
- Thus, two or three crops can be raised in one season.
- Choice of a suitable cultivable species is an important factor in achieving high yield.
- As a single species can not utilize all available food in the pond, a proper combination of 3-5 species of carps gives best results.
- These should be fast growing compatible species which occupy different ecological niches. This method is called polyculture' or mixed farming,
- Generally, Indian major carps, Catla, Rohu and Mrigala are grown together in a pond and give a high yield.

POSTSTOCKING MANAGEMENT

This includes providing supplementary food, sampling and harvesting the crop

1. Feeding

- Fry feed voraciously on the zooplankton of the pound and the available food in consumed to a large extent within 4-5 days.
- To ensure proper growth of the supplementary feeding is necessary so that high density of the can be maintained.
- Natural food production in the pond is limited but provides all the sentential nutrients to the fish, and is rich in protein il consists of 200 and phytoplankton (unicellular and filamentous algae, protozoans rotifer) crustaceans.
- Insects, their larvae, worms, mollusk, ete
- Use of inorganic and organle temitizen incremen the natural food, but still this is not enough to sustain a large population of my lori long time.
- Hence, a mixture of natural and artificial load given best result
- The artificial food should be such that it is acceptable to the link is easily digestible, cheap and readily available in large quantity.
- It should have good nutritive value and high conversion rate
- Generally, artificial food is of vegetable origin and consists of rice, barley, wheat and pulses Leaven, tuber roots, oil cake, kitchen waste are also used as food,
- Finely powdered nice bran, paddy powder and all Cakes of coconut, mustard and groundnut are used as food for listen.
- The food in finely ground and sieved before feeding the fry for Indian major carpe, a mixture of rice bran and mustard oil cake or groundnut oil cake (II ly weigh is considered to be the best.

- Certain species trout, salmon) prefer animal food, which consists of fresh or dried fish, fish meal, meat, fresh or dried shrimps, waste from slaughter houses (liver, lung, spleen, blood, etc), silk worm pupae, larval insects, snails, worms, etc.
- Artificial food is given daily @ 2-3% of the fish biomass. It is either sprayed over the water surface or kept as thick paste in shallow, wide mouth earthen pots or trays at a few spots in the pond.
- Feeding is usually done in the morning or evening, and should not be changed suddenly.

2.Thinning and Harvesting

- Advanced fry of about 3-4 cm in size are netted and released in rearing ponds from time to time.
- Rearing ponds are larger than nursery ponds and have to be prepared in the same way as to eradicate aquatic weeds and predatory fishes.
- Food requirements of advanced fry are different than the young fry.
- They are given artificial food at regular intervals for maintaining fast growth.
- Proper management of the rearing ponds results in 70-80% survival of carp fry.
- In about two months fry attain a size of 8-13 cm and are transferred to separate stocking ponds which are of large size.
- The stocking ponds are also treated in the same way to clear aquatic weeds and undesirable fishes, and are manured to enhance production of fish food.
- A mixture of inorganic fertilizers (ammonium sulphate, superphosphate and ammonium nitrate) @ 1000-1200 kg/ha/yr, and cow dung @ 20,000 kg/ha/yr, is recommended for stocking ponds.
- For best utilisation of different types of food, a combination of catla, rohu and mrigala in the ratio of 3:3:4 is cultured in a pond. Silver carp and grass carp are also now included for mixed farming.
- Excessive growth of algae must be checked because they restrict the movement of the fish, cause oxygen depletion, choke the gills, and pollute water by rotting.
- The process of thinning, stocking, manuring and artificlai feeding is carried out from time to time.
- Large sized full grown fish (2535 cm or more) are harvested and transported to the market.
- The measures as described above, if adopted carefully, result in a high yield of good quality fish.

III. INDUCED BREEDING

Induced breeding is a technique whereby ripe fish breeders are stimulated by pituitary hormone. Major carps and other culturable species of fish generally breed in running water in rivers during the monsoon, when several environmental conditions are favorable for spawning. These fishes become sexually mature in ponds but do not spawn. However, the ripe breeders can be induced to spawn by administering pituitary hormones, which stimulate the fish to release eggs and sperms. This technique is based on the fact that the gonadotropic hormones (FSH and LH) secreted by the pituitary gland play important role in maturation and spawning of fishes, and is called '**hypophysation".** Now this technique is very popular and forms a rich and dependable source of fish seed for commercial purpose.

It has the following advantages in fish culture:

1. Pure spawn and fry of a desirable species is available for culture,
2. This method ensures timely availability of fish sced in required quantity,
3. It is economical as it eliminates the cost of holding potential spawners for long
4. time. The expenditure incurred on collecting fish seed from rivers is much more than on induced spawning by hormones,
5. The method is simple and can be easily practised even by a layman.

INDUCED BREEDING OF CARPS

1. Preparation of the pituitary extract

- For preparation of the extract, the pituitary gland is removed from some donor fish.
- For best results, the donor fish should be a fully ripe fish in advanced stages of its mainly just prior to spawning period.
- The donor fish may be freshly caught on preserved in ice until use.
- The common carp (Cyprinus carpio) ia a chosen donor for most countries as it breeds throughout the year and therefore mature individuals are available round the year.
- Also, this fish gives relatively larger gland.
- The gland does not show species specificity in its action of inducing breeding in the recipient fish, although glands from same or related species as the receipient species are more effective.

2. a. Removal of gland through foramen magnum.

- The foramen magnum is first exposed in the fish head by removing vertebral parts adhering to the skull.
- Fat is removed from above the brain parts by means of forceps first and then by means of a cotton piece.
- A pair of forceps are now inserted into the foramen magnum dorsally to brain.
- The anterior part of the brain is now detached, and the remaining brain is carefully lifted out through the foramen magnum.
- The pituitary gland is located and carefully removed

2. b. Removal of gland by dissection of the head.

- ✓ Using a sharp butcher's knife, a portion of the scalp (brain case) is chopped oil in a clean cut with one stroke.
- ✓ Fat surrounding the brain is now removed with the help of cotton, Olfactory and optic nerves are now severed, and the brain is lifted up and removed, locate the gland.
- ✓ The gland may come up along with the brain, or may remain behind on the floor of the brain cavity often covered with a membrane:
- ✓ In any case, the gland is carefully removed after separating it from the membrane or the brain proper.
- ✓ The gland must not be damaged or torn.

The first method is easier and less time consuming. Also it is more economical because the fish cuts heads may be still soak out after removal of the gland. The second method is not preferred because it renders fish-head useless for sale as the operation brings about complete mutilation

3. Preservation

- The pituitary gland after removal is preserved for future use.
- The gland may be immediately frozen and stored in froen condition in a refrigerator.

- In India, the gland is preserved in acetone at 50°F (10ºC),
- An easier method, not requiring use of refrigerator, is to preserve the gland in absolute alcohol and store it at room temperature.
- The gland, however, may also be usd in fresh condition.
- For preparation of extract, the preserved pituitary gland is macerated in a homogenizer with distilled water,
- The extract is freed of suspended particles by means of centrifugation.
- It is then diluted with 0.3% sodium chloride solution or a suitable physiological solution.
- The extract is now ready for use. However, if the extract is to be preserved for future use.
- It is processed differently.
- In place of sodium chloride solution, glycerine is used and the extract preserved either at room temperature or in a refrigerator (for longer storage),
- Other methods of preservation of the extract include use of porpane, and of trichloro acetic acid in place of glycerine.

4. Selection of breeders

- Proper selection of breeders is the key to success in induced breeding. the breeders should be healthy, fully ripe and of medium- size.
- They should preferably come into the age group ranging from two to four years, and have a weight ranging from one to 5 kg.
- Large-sized breeders are avoided for difficulty in handling. Fully ripe male and female carps casily distinguishable.
- The male shows roughness on pectoral fins, and when its belly is pressed milt freely oozes out. The ripe female shows a relatively soft, round and bulging belly, and its vent is swollen, protruding and pinkish in colour,
- It is wiser practice to keep a ready adequate stock of potential breeders.
- For this, a few months before breeding season potential breeders are kept away under care, and fed on supplementary food (rice bran oil cake mixture).

5. Injecting the breeders: dosage and potency of extract

- To ensure a higher percentage of fertilization during induced spawning it is necessary that there is synchronization between ovulation and milt shedding.
- The common practice is to use a set consisting of one female and two males.
- Usually the female is given a preliminary dose of 2 to 3 mg of the gland per kg of the body weight of the recipient fish.
- Males may also be given a preliminary dose but it is generally not called for if the male is already in a state of quick milt oozing. After an interval of time (about 6 hours) a second dose of 5 to 8 mg of the gland per Kg of body weight of the recipient fish is administered to the female.
- Simultaneously the males are injected with the first dose (second dose, as the case may be) of 2-3 mg per kg. of body weight of the recipient fish.
- A third dose is generally not required. The dosage is prepared in quantities from 0.1 ml to 1.0 ml at a time.

- For intra-muscular injection, the fish is laid on its side while held in a hand net and the needle is inserted either in the caudal peduncle or in the shoulder.
- For intra-peritoneal injections, the sites chosen are the bases of paired fins. "The preliminary Injection is generally given at noon and the second one in the evening. However, the injections may be given at any other time as well.

6. Spawning in breeding hapa

- After the breeders are injected with pituitary extracts, a set of breeders is released into the breeding hapa
- the hapa is a cage of fine netting, rectangular in shape, and is held on four bamboo poles, one at each corner.
- A close-meshed mosquito net-cloth is preferred for the purpose, as its meshes will allow a good circulation of water, and will also not let the laid eggs and milt escape through the meshes.
- The hapa measures about 3m x 1.5m * lm for breeders weighing in the range of 3 to 5 kg.
- The hapa is so held in water that about 20 cm of its height remains above water level.
- The roof can be opened or closed.
- Spawning takes place within 3 to 6 hours following the second dose. It turns out to be mid-night if the second injection was given in the evening.

A succesful induced breeding results in a spawn of fertilized eggs. Fertilized eggs appear transparent, pearl-like, whereas the unfertilized eggs opaque and whitish.

IV. FACTORS INFLUENCING INDUCED BREEDING

- ✓ Favourable climatic and hydrological conditions increase the chances of successful breeding. Cool weather (temperature in the range of 24°C–31°C), cloudy and rainy period is good, Flowing water is preferred.
- ✓ Turbidity should be within 100 to 1000 ppm.
- ✓ Light drizzling following heavy rains is ideal. Failures are mostly due to incorrect choice of breeders, wrong doses of pituitary extract and unfavourable climatic conditions.
- ✓ Hot, sultry or sunny days are not suitable for undertaking induced breeding.
- ✓ Light is known to bring about early maturation and spawning in fish by way of enhanced photoperiod.
- ✓ Besides, the spawning period is also extended due to delaying of resorbption of gonads when artificially increased day length is maintained.
- ✓ Prolonged spawning period will be favourable for fish culture since it extends the time period over which induced breeding is possible.
- ✓ It is believed that in induced breeding the role of environmental factoirs is put to a secondary level if not completely eliminated.
- ✓ The various environmental variables like temperature, light and rain are to some extent by-passed by the introduction of the hormone dosage in causing spawning.
- ✓ It is also believed that the response evoked by the hormone in the recipient fish is also determined by the closeness of phylogenetic relationship existing between the recipient and the donor fish

V. TRANSPORT OF FISH SEED

At various stages of fish farming, transportation of fish seed is a necessity. Unless due care is taken during transportation, there may be large scale killings of fish seed which means a waste of not only money but time and labor as well. The problems in transportation of fish seed arise from the fact that a large number of fish is held in a small amount of water during a certain period of time.

The problems include the difficulties in maintaining

(1) oxygenation of water either by an available reserve or periodical replenishment of oxygen. and (2) ambient temperature.

The nature of these problems vary according to the following factors of the fish transported:

(1) the species of fish (the relative resistance and the oxygen demands vary with the species), and (2) the size and age of fish (the oxygen demands vary with age and size). The extent of the problem varies with length of transport time (speed of transport), climatic condition of the region and the nature of the receptacle for transport. The problems however can be minimized to certain extent in the case of ordinary transport if some preparations are made for transport and **some precautions are taken during transport.**

These include:

1.Transport is undertaken cither in cold weather, or during night or in early morning in case of warm weather.

2.Water should be prevented from rapid warming by covering the receptacle either with cloth soaked in water with ice.

3.Periodical renewal of water with fresh and aerated water should be undertaken carefully,

4.Jolting should be minimal during transport to prevent shocks to fish seed,

5.Fish seed should be allowed to last 1 or 2 days in advance to prevent pollution of water from faces.

6.At the end of the journey, the Fish seed should be allowed to acclimatize slowly and progressively to the new environment, changing of water le beet done in steps.

7.First only half of water la removed and replaced with freshwater and then after waiting for some then (10-15 min) the whole water is replaced with fresh water.

8.Only well aerated water a water from a fountain or a auream) and no poorly oxygenated water (water from tap or well) should be used.

Some special measures may be taken to minimize the hazards of transport.

These are :

1.use of polythene bays Inflated with oxygen in which the oxygen above water is constant source for oxygenation of water during the transport.

2.use of a stand-by oxygen cylinder attached to the receptacle with a tubing and a pressure value.

3.use of high-speed mode of transport such aero planes.

4.use of a tranquillizer in the receptacle, such as MS 222 in concentration less than 1/100.000. will reduce the metabolism of fish seed and thus the oxygen demand of the fish seed.

5.use of quantity of fish seed to be transported that has been calculated on the basis of the volume of water on receptacle, period of transport, size, age and species of transported.
6.Fish seed, and the conditions (temperature, oxygen supply etc) and kind (rail, road) of the Transportation.

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